Chapter: 1
Introduction

Introduction:

Urban expansion has become a universally observable fact. While in 1900, only 9.2 per cent inhabitants of the earth were living in the localities of more than 20,000 inhabitants (Davis & Heartz, 1957). In 1990, the number went up to 45.7 per cent. It is quite likely that by 2025, 65.2 per cent population (5.3 billion) of the world will be living in cities (Diwakar, 1991). Cities and towns most often develop on the surrounding prime agricultural land, and, therefore, the physical expansion of urban areas invariably makes inroads on the country’s agriculturally productive land. So, surrounding land of the cities and towns provides a base to urban expansion.

Undeniably, land is one of the critical natural resources generating most of the developmental activities in a state (Kumar, 2011). It has always been an area of interest for geographers and other scholars interested in analysis of spatial phenomena. Changes in land use have been taking place continuously but the recent rapid urbanisation has impacted it at a much faster and uneven rate (Bhardwaj & Kalkal, 2013). It is determined by both economic and non-economic factors (Njungbwen & Njungbwen, 2011). Over the last some decades, India has witnessed rapid and uncontrolled urban expansion on account of phenomenal progress in industries, trade and population growth. The expectation of services and opportunities in cities fuels this growth (Sulochana, 2005). It is of great concern for the local governments because the rapid growth in urban population creates various types of environmental problems (Mandal, 2000). It appears to have direct effect on the available agricultural land in and around the urban areas, which in turn affects food supply to the urban neighbourhood. Food scarcity and increasing losses of agricultural lands have become issues of global concern (Bender, 1997; Brown, 1995; Gajraj, 1981).

Urbanisation is an age old phenomena, traces of which can be found even in Indus Valley Civilization. It has taken place all over the globe during the past; however, processes and patterns of urbanisation have been varying both across space and time. Urbanisation is an inevitable process due to economic development and rapid population growth (Shalaby & Tateishi, 2007). The west witnessed it well before the developing world.
The process of urbanisation is moderately contributed by population growth, migration and transportation initiatives resulting in the growth of villages into towns, towns into cities, and cities into metros. However, in such a situation for economically feasible development, planning requires growth dynamics. Nevertheless, in most of the cases there are lots of inadequacies to ascertain the nature of uncontrolled urban sprawl. Sprawl is considered to be an unplanned outgrowth of urban centers along the periphery of the cities, along the highways, and along the roads connecting cities etc. Due to lack of prior planning, these outgrowths are devoid of basic amenities like water, electricity, sanitation, and transportation facilities like new roads and highways. Such sprawls ultimately result in inefficient and extreme change in land use affecting the ecosystem. The role of technology in urbanisation, has illustrated a new linkage between transport infrastructure development cycles and spurts in urbanisation. Urban infrastructure development is not able to keep pace with urban population development factors such as soil characteristics, climate, topography, and vegetation. But it also reflects the importance of land as a key and a finite resource for most of the human activities including agriculture, industry, forestry, energy production, settlement, recreation, and water catchments and storage.

The twentieth century has witnessed rapid industrialization and urbanisation of the world population. As a result of high population growth and migration due to industrialization occupying 0.2 per cent of the land area, the global proportion of urban population increased from a mere 13 per cent in 1900 to 29 per cent in 1950 and reached 54 per cent by 2014. About 3.3 billion people live in urban areas, and as the world is projected to continue to urbanize, around 62 per cent of the 8 billion global population, i.e. about 5 billion, is expected to live in cities by 2030.

The striking differences in change in urban population between developed and developing nations is that in 2005 around 74 per cent of population of developed nations was urban compared to 43 per cent in developing nations, but by 2030, while the developing nations are projected to have 56 per cent of their population in urban areas the developed nations will have around 81 per cent living in urban areas (NRSA, 2008). The developed nations also differ from developing nations with regard to number of megacities (with population of 10 million and more). Out of 20 largest cities in the world, 17 would be in the developing world by 2010, and by 2015, out of 35 cities, around 23 would be megacities (Fig. 1.1). Such a demographic trend in the developing countries would mean a greater stress on natural resources, environment and
infrastructure and quality of life, both within and outside the urban areas. Over the next decades, the urban areas of developing countries are projected to absorb a major share of global population growth for various reasons. Thus, the speed and scale of urbanisation would pose important challenges for urban planners and government in developing countries. Further, as the urban areas are considered as drivers of economic, social, political and cultural changes, they are also viewed as a phenomenon with mainly negative consequences as far as quality of life is concerned. Throughout much of the developed and developing world, one of the central concerns of planners has been to manage the encroachment of urban areas into the countryside to prevent negative impacts such as the degradation of natural ecosystems, loss of productive agricultural land and reduction of availability of land for agriculture (Johnson, 1974; Bryant & Johnston, 1992). The developmental initiatives must address the enormous challenges and make the best of the opportunities brought by the growing urbanisation scenarios to provide sustainable solutions to urban problems in the 21st century (NRSA, 2008).

Figure: 1.1

Source: National Remote Sensing Centre (NRSA), 2008
1.1 Urbanisation in India:

Being a part of developing world India has majority of its population living in rural areas. But during the last few decades, the country has witnessed fast and unrestrained urban expansion due to progress in industries, trade and population. This expansion has led to a massive urban spread out (Bhardwaj & Kalkal, 2013). Both because of exceptional population growth (>1 billion) and migration an increased urban population and urbanisation is expected. The share of urban population is continuously increasing in India. Thus, while in 1911 the proportion of urban population was only 10.29 per cent it went up slightly in 1941 to touch 13.85 per cent. In 1951, this figure touched 17.3 per cent followed by 17.9 per cent in 1961, 19.9 per cent in 1971, 23.3 per cent in 1981, 25.7 per cent in 1991, 27.8 per cent in 2001 and 31.16 per cent in 2011 (Table 1.1). It has been estimated that by 2021 the urban population will be about 40 per cent of the total population (Census of India, 2001). More and more towns and cities (3,697 in 1991 to 4,369 in 2001) are blooming with change in the land use along the highways and in the immediate vicinity of the cities. This dispersed development outside of compact urban and village centers along highways and in rural countryside is defined as sprawl (Singh, 2012). As per 2011 census of India, 377.1 million people live in urban centers, which is just 31.16 per cent of the country’s total population. However, this percentage was much less (10.29) at the beginning of the 20th century. As far as growth of urban population is concerned, it has been fluctuating from decade to decade. The growth of urban population was below the rate of natural increase up to 1931, but exceeded after 1931 (Table 1.1). This significant decline in the growth rate of urban population can be attributed to the decline in the magnitude of rural to urban migration as well as in the rate of natural increase (Chandna, 2009).

1.2 Urbanisation in Haryana:

Haryana has been predominantly a rural part of India. The urbanisation trend in state almost follows the pattern of India: it started with 10.77 per cent in 1911 followed by 11.3 per cent in 1921, 12.38 per cent in 1931 and 13.39 in 1941. In other words, it can be said that up to 1941, the level of urbanisation was less than 15 per cent with a highly fluctuating decadal growth rate. Only one- sixth of its total population lived in urban areas at the time of independence in 1947. In 1951, the urban population was 17.07 per cent rising to 17.22 and 17.66 per cent in 1961 and 1971 respectively. This proportion reached 21.88 per cent in 1981 and 28.92 per cent
in 2001. In 2011 census, the urbanisation share has been recorded 34.88 per cent, and is more than the all-India share (Table 1.1). The low level of urbanisation was associated with the subsistence nature of agricultural economy. Industries, commerce and service sectors, which combine to provide the major stimuli for urban growth, had not made any breakthrough in the state. The partition of the country in 1947 stimulated the process of urbanisation in this part of the country. A large number of people migrated from Pakistan to the Indian Punjab and settled down in towns of Punjab and Haryana. It was this factor that led to the explosive growth of cities and towns in the state.

Table 1.1

Urban Population and its Growth Rate in India and Haryana, 1901-2011

<table>
<thead>
<tr>
<th>Census Year</th>
<th>India</th>
<th>Haryana</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1901</td>
<td>2.59</td>
<td>-----</td>
<td>-----</td>
<td>5,74,074</td>
<td>-----</td>
<td>--</td>
</tr>
<tr>
<td>1911</td>
<td>2.6</td>
<td>10.29</td>
<td>0.35</td>
<td>4,49,704</td>
<td>10.77</td>
<td>-21.66</td>
</tr>
<tr>
<td>1921</td>
<td>2.81</td>
<td>11.17</td>
<td>8.22</td>
<td>4,81,195</td>
<td>11.3</td>
<td>7</td>
</tr>
<tr>
<td>1931</td>
<td>3.35</td>
<td>11.99</td>
<td>19.14</td>
<td>5,64,743</td>
<td>12.38</td>
<td>17.36</td>
</tr>
<tr>
<td>1941</td>
<td>4.42</td>
<td>13.85</td>
<td>31.97</td>
<td>7,05,945</td>
<td>13.39</td>
<td>25</td>
</tr>
<tr>
<td>1951</td>
<td>6.24</td>
<td>17.29</td>
<td>41.38</td>
<td>9,68,694</td>
<td>17.07</td>
<td>37.19</td>
</tr>
<tr>
<td>1961</td>
<td>7.89</td>
<td>17.97</td>
<td>26.41</td>
<td>13,07,680</td>
<td>17.22</td>
<td>35.02</td>
</tr>
<tr>
<td>1971</td>
<td>10.91</td>
<td>19.9</td>
<td>38.23</td>
<td>17,72,959</td>
<td>17.66</td>
<td>35.58</td>
</tr>
<tr>
<td>1981</td>
<td>15.97</td>
<td>23.31</td>
<td>46.02</td>
<td>28,27,387</td>
<td>21.88</td>
<td>59.47</td>
</tr>
<tr>
<td>1991</td>
<td>21.76</td>
<td>26.1</td>
<td>36.19</td>
<td>40,54,744</td>
<td>24.63</td>
<td>43.41</td>
</tr>
<tr>
<td>2001</td>
<td>28.61</td>
<td>27.81</td>
<td>31.5</td>
<td>61,15,304</td>
<td>28.92</td>
<td>50.82</td>
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<td>2011</td>
<td>37.71</td>
<td>31.16</td>
<td>31.8</td>
<td>88,42,103</td>
<td>34.88</td>
<td>44.59</td>
</tr>
</tbody>
</table>


However, in 1961 the level of urbanisation in the state (17.22 per cent) was still low as compared to that of Punjab (23.10 per cent) and the national average of 17.97 per cent. After its formation as a separate state in 1966, Haryana experienced a rapid acceleration in its process of urbanisation (Table 1.1). Rapid developments in the agricultural sector during the Green Revolution period led to the establishment and growth of ‘Mandi Towns’ in various parts of the
state. Thus, with 28.92 per cent of its population as urban, Haryana has ranked 8th among all the states of India. The state has a total urban population of 61,15,304 persons living in 106 urban centers of all classes (Census of India, 2001).

1.3 Urbanisation in Sonipat District and Sonipat City:

Coming to Sonipat, the urban population in 1901 was 19,957 persons which came down to 17,452 persons in 1911 showing a decline of 2505 persons. In the next decade (1911-1921) the urban population increased marginally by 636 persons— from 17,552 in 1911 to 18,088 in 1921. In 1951, 38,965 persons were living in urban area of the district.

Table 1.2

<table>
<thead>
<tr>
<th>Census Year</th>
<th>Sonipat District</th>
<th>Sonipat City</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Urban Population</td>
<td>Variation in Population</td>
</tr>
<tr>
<td>1901</td>
<td>19,957</td>
<td>------</td>
</tr>
<tr>
<td>1911</td>
<td>17,452</td>
<td>-2,505</td>
</tr>
<tr>
<td>1921</td>
<td>18,088</td>
<td>636</td>
</tr>
<tr>
<td>1931</td>
<td>20,095</td>
<td>2,007</td>
</tr>
<tr>
<td>1941</td>
<td>24,599</td>
<td>4,504</td>
</tr>
<tr>
<td>1951</td>
<td>38,965</td>
<td>14,366</td>
</tr>
<tr>
<td>1961</td>
<td>56,958</td>
<td>17,993</td>
</tr>
<tr>
<td>1971</td>
<td>87,546</td>
<td>30,588</td>
</tr>
<tr>
<td>1981</td>
<td>1,52,046</td>
<td>64,500</td>
</tr>
<tr>
<td>1991</td>
<td>1,78,025</td>
<td>25,979</td>
</tr>
<tr>
<td>2001</td>
<td>3,21,375</td>
<td>1,43,350</td>
</tr>
<tr>
<td>2011</td>
<td>4,53,364</td>
<td>1,31,989</td>
</tr>
</tbody>
</table>


During the period of twenty years (1961-1981) the urban population rose enormously from 56,958 persons to 1,52,046 persons. The census of 2011, shows 4,53,364 urban population, marking an addition of 1,31,989 persons over census 2001. A look at the statistics of Sonipat City reveals that there was no significant increase in urban population up to 1941 and it varied between 12,990 in 1901 and 17,781 in 1941. After that there was a continuous increase in
urbanisation and the urban population increased from 30,189 in 1951 to 1,09,369 in 1981 and 2,78,149 in 2011. In regard to the decadal growth rate of urban population a highly irregular trend of the growth in city as well as district also is observed (Table 1.2).

1.4 Causes or Driving Forces behind the Urban Expansion:

Urban growth, particularly the movement of residential and commercial land use to rural areas in the periphery of cities, has long been considered a sign of regional economic vitality. This expansion is affected by many factors or driving forces and it may be difficult to determine which factor or driving force has the greatest influence. Furthermore, driving forces behind urban sprawl vary from one place to another and from one period of time to another. The major factors are land, transport, political or government policy, economy, society and infrastructural facilities.

Among these, land is one of the most prominent factors. The selection of land is always based on local topography and their surrounding environment at the meso and micro level. If all conditions are suitable then the city grows very fast on its fringe areas. After this, transport is needed to connect the people. Regulatory framework and political factors can be both a determinant behind urban expansion and a factor against urban sprawl. Inadequate management may, therefore, be an important parameter of urban sprawl, while planned political control can play a critical role in preventing or limiting such development. Globalization is another forceful factor which affects on macro level. The tremendous economic growth may draw people to cities and concentrate activities. The social issues and facilities also generate push factors such as pollution, crowd, narrow streets and roads, etc. which induce people to move to the outer parts of the city (Bhardwaj & Kalkal, 2013).

1.5 Research Problem and Relevance of Study:

Consequent upon fast development, the urban areas are growing into bigger agglomerations with ever increasing influx of people creating demand for basic amenities, viz. water supply, transportation, drainage/sewerage, garbage collection and disposal etc. that is far exceeding the supply of these services. This imbalance in developmental activities and lack in facilities results in unsustainable land use compatibility. The haphazard and uncontrolled developmental activities lead to overuse, congestion, incompatible land use and creates high risk for the city residents in the form of deterioration of natural and socio-economic living conditions, such as overcrowding, congestion, lack of sufficient water supply, unhygienic living conditions,
air and noise pollution, slum development, etc (Datta, 2006). Due to industrialization and urbanisation, there has been a migration from rural to urban areas. This has raised the urban expansion problem all over the world. Due to the rapid process of urbanisation, the haphazard growth of cities has become one of the challenging situations for any country. Developing countries like India are facing the critical problems like population growth, poverty, unequal income distribution, unemployment, urbanisation and internal migration, agriculture and rural development and quality education.

One distinctive feature of India’s urbanisation is increasing metropolitanization. India’s big cities now account for a large share of total urban population. In 2001, the share of metropolitan cities was 37.8 per cent which increased from 32.5 per cent in 1991 and 26.4 per cent in 1981 (Shekher, 2005). The trend clearly implies that with rapid growth of million plus cities, the problem of land management will be more and more complex as the years pass by. Not all cities in India are able to respond quickly to the demands of these new service industries. Urban expansion due to horizontal spreading of city and population growth leads to intense pressure on surrounding rural hinterlands.

This urban expansion has caused drastic land use changes in Sonipat and its hinterland. Shifting of schools and big industrial units outside the city has transformed the whole land use scenario of the city and its surrounding. The rural and urban fringe is most rapidly changing element in the urban landscape mapping; land use/land cover of the rural urban fringe in a timely and accurate manner is thus of great importance for urban land use planning and sustainable management of land resource.

To make any scientific plan and its implementation thereof, one needs accurate information on sprawling urban areas. Urban planners require information related to the rate of growth, pattern and extent of sprawl to provide basic amenities such as water, sanitation, electricity, etc.

In the absence of such information, most of the sprawl areas lack basic infrastructure facilities. Urban planners in our developing country feel like running behind the true facts. In such real time data vacuum, the planner or administrator is forced to take policy decisions concerning vital urban development policies without sufficient and reliable information. But there is a serious lack of information in this regard in most of the Indian cities (Bhardwaj & Kalkal, 2013). The present study intends to provide required information in GIS format on
various temporal and spatial dimensions of sprawl of the study area. These alarming issues provide a major scope for further analysis.

1.6 Objectives:
The objectives of the present study are:

- To analyze the spatial expansion in Sonipat city during the period of 1991 to 2011.
- To examine the land use/land cover changes within M.C. limits during 1991 to 2011.
- To study the impact of urban expansion and land use/land cover changes on socio-economic conditions of the population of study area.

1.7 Research Questions:
The present study tries answers the following research questions:

- What are the factors responsible for the land use changes and land transformation in study area?
- Does the urban expansion is a consequence of population growth?
- Does the urban expansion grow more rapidly than its population?
- Does the land transformation adversely influence the surrounding agriculturally fertile land and food production?

1.8 Review of Literature:
It is generally believed that urbanisation has direct as well as indirect and both positive and negative impacts on land use transformation. Many scholars have studied these issues with different perspectives. Kulkarni (1981) studies Nasik city to analyze the urban structure, development, spatial mobility and association pattern as well as to provide the detailed depiction of urban land use functions. It has been observed that oldest part of the city particularly Budharpeth, Somwarpeth, Tiwandha and Main Road have high density of population. The workers population is located in periphery of the city and engaged in construction, trade and other activities. The internal structure of the city shows the evidence of old and new contrasts and the loose association of the functional zones. The study also found that at the corner sites of road junctions, small local complexes are situated to supply the daily needs of localities.

Lal (1987) studies the city and urban fringe with special reference to Bareilly to delineate the transitional zone as well as to analyze the impacts of city on adjoining villages. He observes that expansion of built up area as the result of urbanisation has taken place on surrounding agriculture land. The general land use pattern of the study area shows the primacy of agricultural
and rural activities as well as prevalence of industries in northern side. Encroachment on roads and unsatisfactory housing condition which later leads to slum development is main problems of the area.

Sengupta (1988) examines the process of urban development and changing land use pattern in and around Ahmedabad city and indicates that the demarcation of urban fringe has been done on the basis of combined indicators as distance from CBD, Transportation frequencies, population density and daily commuters’ figure. The results of his study show that the agriculture land use is converting into non-agricultural use due to the increasing pressure of population in peripheral area. Sokhi, Sharma & Uttarwar (1989) have investigated the process of sprawl by GIS technique using LANDSAT satellite image, toposheet and guide map of Delhi from 1975 to 1987 and visual interpretation technique for elucidation of satellite data. This study shows that most of the residential colonies like Vivek Vihar, Uttam Nagar, Mayur Vihar and some parts of Saket Vihar have been developed the duration of this time as the result of low land value. Shukla, Kumar & Ray (1990) observe that due to further industrialization and urban sprawl, Kanpur is experiencing enormous problems of almost every kind of urban disorder and that evolutionary changes are occurring in squatter settlements which are linked to work places like industries, trade and commercial activity centers. Chutiratanaphan, Chanthanaroj, Otsuka & Katusta (1995) in their study of land use/land cover changes in Phuket Island, Thailand and using SPOT, Land sat-TM data and ground truth survey, find that the island is facing the lumber of rapidly increasing population and encroachment of mangrove forest for shrimp farming.

Mohan (2005) studies urban land use/land cover change detection in Faridabad district of National Capital Region (NCR) Delhi. He makes the observation that an urban economy is the engine of economic growth in terms of productivity and development. So, the economic activity diffusion from centre to periphery has been largely responsible for economic growth and urban land change.

Examining the pattern of urban land use of Bhopal Singh & Dharmajog, (1998) conclude that the city has mainly five types of urban land use in developed area with the dominance of residential and followed by industrial, public and semi-public, recreation and transportation. In spite of extensive commercial land use in the city, there are small shopping centers in the residential areas to meet the daily requirement of locality. There are a number of recreational places and the city has good transport network which helps in better functioning of the urban
activities. It has been also exposed that other services, industrial and trading and commercial activities are major functions in the city.

Kumar & Tripathi (2011) study the urban sprawl in and around Gurgaon city with the help of remote sensing technique. They observe that in the fringe of the city, built up area is going to extend in linear pattern along with transport network. Their study also draws attention towards ecological imbalance (lack of fertile agricultural land and drinking water) generated by decreasing agricultural land and forest area as a result of urban expansion in the fringe area.

Hooda, Singh & Arya (2004) study desertification status mapping using satellite data in dry sub humid region of Punchkula District of Haryana and point out that 47.5 per cent of the total geographical area of the district faces desertification. This study observes that five major land uses viz. dry land, agricultural land, irrigated agriculture land, land with scrub, forest areas and urban areas were affected by desertification.

Dewan & Yamaguchi (2009) reveal that Dhaka’s rapid urban growth has led to huge loss of rural and arable lands. There is rampant sprawling and environmental degradation due to rapid urban encroachment over other land categories such as water bodies, cultivated lands, vegetation and wet land/low lands. They comment that much of the city’s rapid growth in population has been accommodated informal settlements but little attempt has been made to limit the risk of environmental impairment. They suggest that a holistic approach to the management of urban area and its environment should be initiated so that sustainable urban development strategy can be formulated. Iyer, Kulkarni, & Raghavaswamy (2007) opine that in India, working as magnets big cities and urban agglomerations attract financial investment, which leads to development of industrial and service sector, employment generation, and migration and population growth. Expanding industries like manufacturing, construction, trade and service of all kinds open avenues of employment and have become the pull factors for the ever-increasing migration.

Ji et al. (2001) conclude that in China, open policy and economic reforms have forced a profound impact on dynamic changes of land-use patterns in many areas of the country over the last two decades due to urbanisation and industrialization. Their results show that urban development in southern and coastal areas is fastest, and the speed of urban expansion is as high as 30 per cent per year. Urban growth is estimated at 1.2 million hectares for the whole country during this period, and 0.867 million hectares of arable land have been lost due to urban expansion. Mundia & Aniya (2005) have discovered that the built-up area in Nairobi has
expanded by about 47 km$^2$ and the road network has influenced the spatial patterns and structure of urban development, so the expansion of the built-up areas has unspecified and accretive as well as linear growth along the major roads. The urban expansion has been accompanied by loss of forests and urban sprawl. The transportation routes have been the major factors promoting urban expansion. Chen, Chen, Shi, & Tamura (2003) during their study of assessment of urban expansion impact on arable land loss in China find that this loss could have an adverse impact not only on China’s sustainable development but also on the world food market.

In their study “Urban growth and change analysis using remote sensing and spatial metrics from 1975 to 2003 for Hanoi, Vietnam”, Pham & Yamaguchi (2011) observe that after the ‘Doi Moi’ policy in 1986, Hanoi has undergone important changes in its urban areas. They used Landsat and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data to identify built-up areas. The results show that the expansion of urban areas along major transportation routes in the latter 1980s was identified as the main form of urbanisation in Hanoi. Likewise, Kamh, Ashmawy, Kilias, & Christaras (2012) maintain that the rapid urban development in the Hurghada since the 1980s has radically altered due to human activities. Landsat Thematic Mapper (Landsat 5 TM), Landsat Enhanced Thematic Mapper Plus (Landsat 7 ETM+) and Terra/Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) data were used during 1987, 2000 and 2005 respectively, in this study. Five change detection techniques were tested to detect areas of change. The techniques considered were image differencing, image rationing, image overlay, multi date principal component analysis (PCA) and post-classification comparison. The results show that the built-up area has expanded by 40 km$^2$ in 18 years (1987–2005). In addition, 4.5 km$^2$ of landfill/sedimentation was added to the sea as a result of the coastal urban development and tourist activities.

Kumar (2011), while studying the land use changes in Kanpur, comes to the conclusion that the existing land-use/land cover of Kanpur is diversified and scattered distribution of land-use throughout the city space which is the result of historical legacy and existing industrialization, growth of population and transport activity, etc.

Tong, Zhang, & Liu (2010) maintain that urban sprawl results in the complex process of land use and land cover change, which has a compound impact on the structure and function of ecosystems in urban areas. Jat, Garg, & Khare (2008) have looked over on urban growth of Ajmer city (India) in the last 29 years. Their results show that land development (200 per cent)
in Ajmer is more than three times the population growth (59 per cent). To Peiman (2011), the province of Pisa has significantly experienced a high rate of deforestation and urban development over past decades. Deng et al. (2008) have studied Hangzhou City using multi temporal and multi sensor images (SPOT-5 and Land sat data) to detect land-use changes in an urban environment. The results show that land use changes have occurred in Hangzhou City from 2000 to 2003, which may be related to swift economy development and urban expansion. It is indicated that most changes occurred in cropland areas due to urban encroachment. In their analysis of the impact of land use/cover change on temperature and air quality in Atlanta, Yang, Yang, Lo, & Lo (2002) describe a slew of techniques that have been used to develop an operational approach, which will ensure high accuracy and compatibility in image classification from the satellite images.

Onur, Maktav, Sari, & Sönmez (2009) study how the land use converted a quiet, small village (Kemer, Turkey) into an internationally popular touristic place on account of suitable climatic conditions as well as rare natural and cultural resources. Their study shows that from 1975 to 2003, permanent crops decreased by 75 per cent and most of these areas were structured. During the same period, a 55 per cent decrease was seen to arise in heterogeneous agricultural areas.

Ram & Chauhan (2008) find agriculture land as the leading land use constituting 84 per cent (including 38 per cent irrigated cropland) area, and that the land use over the last four decades has caused significant changes in land use and land cover not only in nature’s best gifted regions but also environmentally sensitive arid regions.

Alaguraja et al. (2010) find out that in Madurai District, the area of crop land is higher than others. They conclude that Land with or without scrub occupies second place in this district, Plantation has 309 sq. km. and Fallow land has 227 sq. km. and dense forest occupies 160 sq. km. while rest of other have lower than 100 sq. km. area. Nc et al. (2011) find out that harbour area of Visakhapatnam has remained unchanged during 1998-2010, and opine that this can be considered as a positive trend. Kumar & Kumar (2012) have analyzed that the agriculture based landscape has turned into an urban landscape dominated by urban functions and services which are continuously increasing in peripheral zone along with national and state highways in Rohtak city. Their analysis indicates that the city has experienced rapid changes in land use, particularly
in terms of built-up area which is increased about 5 times in last 38 years, resulting in a substantial reduction in the area of agricultural land from 11.60 sq. km to 2.59 sq. km.

Batty & Howes (2001) analyze how remote sensing technology, especially considering the recent improvements, can provide a unique perspective on growth and land-use change processes. They reveal that remote sensing can help to describe and model the urban environment, leading to an improved understanding and can apply for urban planning and management. Farooq & Ahmad (2008) aim at analyzing Landsat IRS and Quick Bird data to delineate the extent, pace and pattern of growth of the city area of Aligarh. The study reveals that the urban area has increase almost three times since 1971. The rate of land consumption for urban purposes was substantially moderate till 1980s, but in the 1990s witnessed a sharp increase in land consumption as compared to population growth. Bhardwaj & Kalkal (2013) examine the extent and direction of sprawl of Rohtak city over a period of nearly five decades (1960 -2010). The total built-up area in 1960 was just 13 km$^2$ which increased to 15 km$^2$ in 1973 thus recording only 2 km$^2$ increase in thirteen years. So the total increase of sprawl of Rohtak city during 1960-2010 has been 530.76 per cent. Their study shows that Transport network of the city has played a key role in the changing pattern of the city. Bhardwaj & Kumar (2012) have sought to find out the changes in landscape of Karnal City in Haryana from 2000-2011. Four major categories identified are: built up, water bodies, cropland/vegetation, and open/bare land. It has been found out that sprawl of the city has taken place in two main areas. One is the area between Delhi-Ambala main railway track and National Highway No.1 and the second is along National Highway No.1 in the eastern part of the city. It is found that transport facilities are the main motivating force behind this sprawl in the city. Kumar & Kumar (2012) have analysed that expansion of town is mainly at the cost of agricultural land. The Jhajjar town has not witnessed rapid change like other towns of NCR region of Delhi, but the process of urban expansion will be seen in the coming times because of its location, and active role of Haryana Urban Development Authority (HUDA) in well-organized sectors of industrial, commercial and residential purposes.

Kumar, Mahima, & Kumar (2013) have analysed the pattern of built up area over the five decades in Rohtak city. It has been found that the built up area has not recorded rapid transformation in 1960 to 2000 like other towns of NCR region but after 2004 the built up area rapidly increased with the impact of government influence in study area.
Chatterjee, Dey, Prakasam, & Biswas (2012) have attempted to identify the spatio-temporal changes of land use land cover in Purbasthali region over the time span of 86 years, using the topographical maps and satellite images of the years 1918, 1973, 1990 and 2004. This study reveals that agricultural land use has dominated the other land use /land cover categories and that it covers almost half of the study area but, very recently it has slowed down. Vegetation cover of the region is almost wiped out. Built-up land is extending quite significantly with growing population pressure. But recently, due to river bank erosion of Bhagirathi along the eastern margin of the region, has shifted to some other areas. The major negative changes occurred in current fallow category due to proficiency in agricultural practice, farm mechanization, and other socio-economic causes. Panigrahy et al. (2010) have attempted to measure change in forest area of the Western Ghats of Maharashtra over a 20 year time period (1985–87 to 2005) using visual interpretation technique at 1:25000 scale. The study was conducted using the Forest Survey of India vegetation maps for 1985–87, prepared using Landsat TM data and IRS LISS III imagery for 2005. The results reveal loss of dense forests at an annual rate of 0.72 per cent and that of open forest at 0.49 per cent. It also reports an increase in mangrove vegetation and water bodies in the study area. In addition, it also reports district wise pattern of change in forest cover in study area. Chandrasekar, Sivasubramanian, & Soundranayagam (2010) have identified the various land uses, their various transformations over a period of seven years between 1999-2006 and their related environmental impacts in Tirunelveli city. The study reveals that settlement area has enhanced by about 39.19 sq.km and agricultural land has declined by about 72.65 sq.km in this period. It also revealed that water bodies have also drastically reduced by 20.93sq.km. Tamilenthi, Punithavathi, Baskaran, & ChandraMohan (2011) have found that sprawl normally takes place in radial direction around the city centre or in linear direction along the transport network in Salem city. Saha (2010) has tried to find out the land use/land cover changes in Rishikesh and its surrounding area. His conclusion is that the town is congested with the excess of hotel and dharmashalas as well as numerable tourists and pilgrims. So, built up area of Rishikesh at the right bank of river Ganga has expanded speedily at present. Such growth and development of urban space is taking place at the cost of deforestation, environmental pollution which is quite prominent in the study area. Zhao et al. (2006) have analysed how Shanghai has experienced rapid expansion and urbanisation. Here urban expansion has led to a decrease in native plant species. Despite its severe environmental
problems, Shanghai has also seen major economic development. Manonmani & Suganya (2010) have detected that the built up area of Villivakkam increased between 1990 and 2005 by 15.83 per cent from 6513.29 hectares to 9300.97 hectares. This is due to shifting of agricultural land to built up area.

Farooq & Rashid (2010) have investigated that there isn’t any change in the area of forest during the time but the density of forest has changed. The open forest has been converted to blank areas and very dense to moderately dense forests. Loss of forest cover can be easily attributed to the human interventions. Mani (2012) observes the volume of deterioration of forest cover during 1922, 1977 and 2004 in the Devikulam Taluk, Idukki district, Kerala using Survey of India topographic maps of 1: 63360 scale and 1: 50000 scale published in 1922 and 1977 and the satellite imagery of IRS P6 5.8m multi-spectral imagery attained during 2004. The result reveals that migration, plantation agriculture, tourism, construction of roads, and other physical infrastructure are the major causes of forest deterioration in the study area. Makhamreha & Almanasyeha (2011) have investigated the current pattern of land use and urban servicing and monitor the trends of urban growth in Amman between 1972 and 2009 using satellite images and GIS. The results show that the urban core of Amman changed continuously over time with high rates of population growth. Considerable urban expansion was identified with the total settlement areas increasing from 36 km² to 250 km² at the expense of agricultural land over the time period. Wondie, Teketay, Melesse, & Schneider (2012) have analysed the quantitative data on the occurrence of the land cover classes of Erica dominated forest, mixed forest, scrubland, agriculture and grassland as a function of altitude, slope and aspect. Forests were found mainly on north and northwest facing slopes of medium and high inclination. The study also investigates the significance of these findings for wildlife habitat distribution and, subsequently, for park management. Fazal (2000) have analysed the urban expansion and land use transformation mapping of Saharanpur city and its surrounding area. They claim that the urban expansion of the city (both built-up and non-built-up) has destroyed fertile agricultural land which cannot be recovered, and the study area is losing agrarian characteristics. Canals and their tributaries which used to flow through agricultural fields are now encroached upon and are used for the disposal of garbage and wastes. Gajbhiye & Sharma (2012) in their study of Indra river watershed over 14 year’s period through remote sensing approach have brought to light that forest area that occupied about 15.01 per cent
of the study area in 1992 has increased to 25.57 per cent in 2006. Built up area, water body and waste land also have experienced changes. Farm land (Agricultural land/open land) has decreased from 84.16 per cent to 68.40 per cent of the total area.

Chaudhary, Saroha, & Yadav (2008) have summarized that there is substantial increase in the area under settlements of northern part of Gurgaon District, which has increased almost four times over this period. The double crop area shows a decline; however there is an increase in the area under closed forest. The wasteland has also decreased drastically due to its conversion to settlements and other categories. The expansion of Gurgaon city is due to increasing population and industrial/ infrastructural development pressure of National Capital, as Gurgaon is the most preferred and favourable destination. Chawla (2012) has analysed that land use changes result from population growth and migration of poor rural people to urban areas for economic opportunities. The study reveals that changes in land use has direct influence on the regional air quality, energy consumption and climate at global regional and local levels. Controlled, coordinated and planned urbanisation is a gift to the human society. However, unplanned urbanisation can be a disaster. Urban sprawl refers to some types of uncoordinated land use resulting from lack of integrated and holistic approach in regional planning. The study provides a valuable basis to understand the major issues faced by urban citizens in India as a consequence of land use changes. The suggested solutions are very helpful for the strategic planning in future.

Yadav, Kapoor, & Sarma (2012) investigate the status of ecological corridors between Nagzira Wildlife Sanctuary and Navegaon National Park through primary survey using Landsat TM and ETM+ imagery. It has been found that 6.22 per cent dense forest is converted to open forest and 6.66 per cent open forest to non-forest from 1990 to 1999. Water bodies have been decreasing continuously in both decades. Forest loss and degradation occur due to human interference, urbanisation, cattle grazing, noise pollution, and air pollution and so on. Due to high frequency of traffic on roads/railway, wild animals often divert from their original dispersal route and enter these hamlets leading to conflict situations.

Ohri & Poonam (2012) focus their study on urban growth pattern in Varanasi city using Toposheet at 1:50,000 Scale, 1976, No. 63 K/1 and 63 O/3 and Google earth image (2011 at 5500ft.). Their study reveals that in Varanasi there is a significant decrease in agricultural areas and tremendous growth in Built-ups. About 37.57 per cent of agricultural land is transformed to other land use features. Rate of change from agricultural land to other land use is 210.80 hectares.
per year. There is no brick kiln in city area during the 2010, while in 1976 it covered an area of 143.14 hectares. Built-ups increased by 7325.72 hectares, with change rate of 215.46 hectares per year. Study showed decreased in water bodies by 15.13 hectares. Kadi, Halingali, & Ravishankar (2012) have found out that urbanisation in India is growing at a rapid pace from 17 per cent (1951) to 28 per cent (2001) and is estimated to approach 41 per cent by 2030. The technological and industrial boom has brought enormous problems to urban citizens causing degradation of the environment. As a result a number of slums have mushroomed in metropolitan cities and shortage of space for housing, lack of sewage treatment facilities, polluted water and transport constraints are serious concerns of the urban population. Poor sanitation and contaminated drinking water arising from human activity and natural phenomena create serious problems on human health.

A geographical study made by Gupta, (2015) has analysed the growth and development of Unchahar city. This study reveals that the city development is taking place in centripetal pattern besides transportation routes. As the analysis of sector theory with regard to city, it has been observed that old and urban high residential area has emerged as CBD area. In their study, Kumar & Tripathi (2014) attempted to monitor the urban growth of Nagpur city using Landsat Thematic Mapper imagery of land use/land cover. The study examines that there is a remarkable increase in built up area of the city but it is not uniform in all sides.

The maximum expansion has taken place eastern part while it is lowest in west. It has been also disclose in the study that built up area has encroached the other land use categories like vegetation cover and barren land use category and as a result a noticeable decrease of 5.2 and 10.43 per cent in both has been recorded respectively.

While pursuing the study of causes, forms and issues of urban sprawl, Luthra & Sharma (2014) reveal that the outward expansion of city beyond its boundaries is mainly the result of increase in population, decay of central part as well as availability of better infrastructural facilities in peripheral areas. Ravinder & Kaushik (2014) conducted a study of Kaithal to analyse the land use change in urban environment. The study finds out that after 1990 no remarkable increase has been noticed in the city while the process of urban growth has risen significantly due to establishment of administrative setup. The results also show that maximum increase of built up area has taken place in north-eastern part of the city and in different types of land use,
and that agricultural category has recorded highest increase followed by residential use during the study period.

1.9 Data Sources and Methodology:
The present study is based on primary as well as secondary data obtained from different sources. Following data sources have been used for present work:

- Landsat-TM (Thematic Mapper) Image with path/row 147/40 dated October 9, 1989.
- Google Earth image February 2, 2002.
- GeoEye satellite Image downloaded from Google earth, October 14, 2011.
- Census data published by Census of India.
- Municipal Committee office, Sonipat and Department of Town and Country Planning, Haryana.
- Primary Data: Socio-Economic Survey.

The present study is based on both primary and secondary data obtained from various sources like Survey of India, Dehradun, M.C. office and Department of Town and Country Planning, Haryana. A primary survey has been conducted to analyse the impact of urban expansion on cityscape and socio-economic conditions of the respondents. In proportion of population of the study area, 120 households of different caste groups from selected villages namely Jatwara, Fazilpur, Bandepur and Garhi Brahaman have been chosen for field observation. Simple random sampling method has been adopted and the information has been collected through a well-structured questionnaire (Appendix-1). The required statistical methods have been used for analysis of demographic attributes.

The satellite data of the study area for 1989 has been downloaded from the www.glovis.usgs.gov/ site, 2002 and 2011 satellite Image was downloaded from Google earth pro. Topographic sheets nos. H43Q16, H43R4, H43W13 and H43X1 at scale of 1:50,000 are used for the geo-referencing of M.C. map of study area in different time periods. Urban expansion of the study area for 1968, 1989, 2002, and 2011 has been mapped with the help of satellite data and toposheet. The layers of different land use categories have been created using
ArcGIS 9.3 following the modified classification of National Urban Information System (NUIS) 2008. The study is based on supervised classification and visual interpretation of different time satellite imagery. The 1991 and 2002 land use pattern could not be checked in contradiction of the ground truth, but the existing chronological data for the study area has been used to detect the interpretation made.

However, the 2011 data was directly tested against ground observation all the way through the study area. Analysis of data and key findings of the study have been presented through suitable cartographic techniques and various statistical methods. Master Plan of Sonipat for 2021 prepared by Town and Country planning department has also been analysed and necessary suggestion have been made for better environmental condition for future.

1.10 Data Gathering:

Satellite data of the study area for collection 1989 has been downloaded from the www.glovis.usgs.gov/ site. Topographic sheets bearing nos. H43X1, H43R4, H43W13 and H43Q16 at a scale of 1:50,000 (Survey of India, Dehradun, dated 2005-06) have been used for the geo-referencing Google Earth Pro image (GeoEye image, dated Feb 2002 and 14 Oct. 2011) download from Google Earth Pro in the form of 82 photo clip which cover the study area. M.C. boundary map representing different time has been collected from M. C. Office of Sonipat city to measure the aerial expansion of city area.

1.11 Scanning:

The hard copy of maps such as Survey of India (SOI) toposheet, MC map of study area (different time), and Town directory map of study area have been converted to digital maps by scanning using HP scanner. Scanned data are stored in JPEG (Joint Photographic Expert Group) format.

1.12 Geo-referencing, Rectification and Mosaic:

Geo-registration or geo-referencing is the process of registering and transforming a raw map or raw satellite image in order to allocate it real-world coordinates system. It is a key to making aerial and satellite imagery, usually raster images, useful for accurate and reliable various types of mapping. A raw map can be geo-registered in two ways.

- If the hard copy map contains coordinate information in it (mostly written as latitude/longitude on the border of map at regular intervals), for example it can be SOI Toposheet geo-referenced using its own coordinates. After scanning such map,
we import it in GIS software and assign same coordinates on the same places as marked on it.

- If we don’t have a map as discussed above then we have to geo-reference it using another map which is already geo-referenced. In such cases, we have to identify same features in both maps and need to take control points on both of them one by one. After taking sufficient points, we geo-reference the raw map. Control points are those features which are identifiable on raw map/image and on corresponding geo-referenced map/image (as well as on ground). During this study, we have used the second type of geo-registered way.

1.13 Visual Interpretation:
Visual interpretation technique has been used for the mapping of land use/land cover of study area and prior to interpretation of multi date satellite data, a survey was conducted to develop a classification scheme based on local knowledge and ancillary information. The various land use categories have been interpreted with the help of standard photo-elements like tone, texture, size, shape, association, pattern, location, etc.

1.14 Land Transformation:
The land transformation has been analysed through the overlapping of study area polygon layers of two different time periods in ArcGIS 9.3 to recognize the conversion of one land use category to another.

1.15 Ground Truth:
All the unsure land use categories were listed for ground verification and their geographical features were recorded on ground truth proforma with the help of Google earth pro and historical evidences.
## Table 1.3

**Land Use Classifications of Study Area**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Land Use Categories</th>
<th>Description</th>
</tr>
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| 1       | Built-up Area           | **Unplanned Residential Area**<br>The area which is used for accommodation without proper planning is known as unplanned residential area. There is lack of uniformity in housing structure, drainage, roads/streets forms.  
**Planned Residential Area**<br>The planned residential area is a type of housing development within a regulatory process under homogeneous arrangement. It is a designed grouping of both varied and compatible land uses, such as housing, recreation and commercial centers.  
**Public & Semi-Public Area**<br>These are the areas used for place of work, educational institution, bus stand, railway station, Mini Secretariat, jail, water works and government offices.  
**Recreational Area**<br>This category includes areas which are devoted for recreational purpose. It includes parks, amusement parks (Water Park) picnic spot, view point, playground, stadium, cinema halls and in cultural features historical buildings are considered.  
**Commercial Area**<br>Commercial area has the dominance of wholesale and retail selling activities of manufactured goods and services on and these types of area is developed near inhabited areas along with the main roads/streets.  
**Industrial Area**<br>It includes the area which is used for manufacturing of goods and services at small and large scale.  
**Plotted Area**<br>It comprises areas which are reserved for residential, commercial and other purposes and cover with a boundary as form of a plot at present. |
| 2       | Non Built-up Area       | **Open/Vacant Land**<br>The unutilized open area, preserved for future development is termed as open/vacant land. It covers the prior existing area under trees as well as afforestation.  
**Forest Area**<br>It includes the area which is used for production of foodstuff and some of the structures linked with this fabrication.  
**Agricultural Land**<br>The waste land is defined as the land having poor or degraded soil. This type of land is not utilizing at present but its productive capacity (in term of vegetation cover and other uses) can be retrieved with rational efforts.  
**Waste/Scrub land**<br>Whereas the area with a dominance of tiny trees and bushes usually developed on deprived land, is known as scrub land.  
**Water Bodies**<br>It comprises areas with surface water, either impounded or in the form of lakes/ponds, tanks/reservoirs or cooling ponds and abandoned quarries with water. |

1.16 Chapterization Scheme:

The present study is divided into seven chapters as given below:

**Chapter 1**
Introduction, Research Problem and Relevance of the Study, Objectives, Research Questions, Review of Literature, Data Sources & Methodology, and Chapterization Scheme.

**Chapter 2**
Study Area and its Geographical Setting.

**Chapter 3**
Urban Growth and Extension of Spatial Limits of Sonipat City.

**Chapter 4**
Pattern and Changes of Demographic Attributes in Sonipat City.

**Chapter 5**

**Chapter 6**
Impact of Urban Expansion on Socio-Economic Conditions of Study Area.

**Chapter 7**
Conclusions and Suggestions

**References and Bibliography**