Monitoring urban expansion and land use/land cover changes in Rohtak City using Remote Sensing and GIS technique

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Abstract: Urban expansion and land use/land cover change of Rohtak city within the last 38 years is observed in the present study which points out the dramatic change in the cityscape. The change was based on satellite imagery of LANDSAT TM (1973 and 1989) and LISS-III (2002 and 2011), toposheet at a scale of 1:50000 and ground truth. Census data have been integrated into the analyses to know the scenario of population growth at different time periods. Socio-economic, political and regional settings are some of the aspects which are responsible for the specific development, urban expansion and land use change. Result reveals that the agriculture based landscape is turned into an urban landscape dominated by urban functions and services which continuously increasing in peripheral zone along with national and state highways. Analysis indicate that 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.

Keywords: Land use/land cover, Urban Growth, LANDSAT TM and LISS-III.

1. Introduction

Land is one of the critical natural resource on which most development activities are based (Kumar, 2011). Spatial information of land use/land cover types and their change detection in time series is an important means for city planning and undertaking development activities. Analyzing the spatial and temporal changes in land use/land cover is one of the effective ways to understand the current environmental status of an area and ongoing change. Urbanization is a major cause of land use changes and land conversion (Singh and Kumar, 2012). Rapid urban development and increasing population and economic growth has changed the urban landscape which is being witnessed all over the world. It is an important component to understand the human intervention with the environment (Anil et. al., 2011) which depends upon the natural setting of an area as well as the socio economic status of population.

Land use changes’ mapping with modern technology of remote sensing and GIS is of paramount importance to urban planners, geographers and policy makers for sustainable development. A serious problem for modeling urban land use change has been the lack of spatially detailed data. The emergence of geospatial technology has provided an easy way to detect land use/land cover change over the time. Remote sensing is an important tool of change detection because it provides satellite data after short and regular interval, which is useful in detecting even small changes in land/land cover. This technique has the potential to support such models, by providing data and analytical tools for the study of urban environments. Urban land cover types and their areal distributions are fundamental data required for a wide range of studies in the physical and social science, as well as by municipalities for land planning purposes (Stefanov, et. al, 2001).

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Population growth has both direct and indirect impacts on land use changes in the city in terms of land use transformation and urban sprawl which are the most noticeable effects on land use change. NCR region is growing very fast in terms of urban growth and economic development since Independence. Rohtak is one of the important city in NCR region of Haryana which land use transformation takes place vigorously in recent time.

2. Study Area

The present study is a case of Rohtak city which is located at the intersection of 28°41'1" North latitude and 76°12'42" East longitude in the NCR region of Haryana on National Highway No. 10. It is an educational city and hub of administrative office which is spreads over 31.24 km² as per 2004 Municipal Council boundary. It is located 77 km to the north-west of Delhi.

3. Objective

The aim of the present study is to identify changes taking place in the land use/land cover pattern due to urban expansion of Rohtak city between 1973 to 2011.

4. Material and Method

Present study is based on geo-referenced satellite data for the years 1973, 1989 (LANDSAT TM) and 2002 and 2011 (LISS-III), Topographic maps with scale of 1:50000 which covers the municipal council boundary.
boundary of 2004 of Rohtak city and census data. The goal of using these images is to identify the long term change in land use pattern of the cityscape. The images with resolution of 30 meter (LANDSAT TM) and 23.5 meter (LISS-III) are enhanced using histogram equalization to increase the volume of visible information. This procedure is required to identify the various features in the image classification scheme. Land use/land cover pattern for the year 1973, 1989, 2002 and 2011 are classified by the use of satellite imageries with different ground resolution. First, each satellite image is classified using unsupervised classification with maximum likelihood classifier, which is an appropriate classification method. MLC has been per-pixel classifiers which able to handle and show the spatial distribution of land uses/land cover types. Second, forty land use/land cover classes are classified which are finally converted into five prime land use/land cover types and changes of these are investigated, these are; built up area, agriculture land, bare/open land, vegetation and water bodies. LANDSAT TM and LISS-III satellite data from 1973 to 2002 could not be checked against the ground truth but the available historical evidence were used to validate the interpretation made. Field survey was performed for LISS-III images of 2011 for each land-use class included in the classification scheme throughout the study area. ERDAS 9.0 and ArcGIS 9.3 software were utilized for image processing, image classification and map layout respectively.

5. Result and Discussion

Urban growth is a global phenomenon that comes with the land use change, population growth and economic development. Urbanization is an important factor for the Rohtak city where rate of urban expansion has occurred very fast in the recent time. The city landscape is likely to expand at a very rapid rate. It is a growing city which increases its population nearly five-fold in last five decade. City offers many employment opportunities and amenities to its residents that are not always available in rural areas.

Figure 2: Land use/land cover map based on LANDSAT TM and LISS-III satellite data.
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Figure 3: Built-up area extracted from LANDSAT TM and LISS-III satellite data

Table 2: Land use/land cover statistics from 1973 to 2011

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>1973</th>
<th>1989</th>
<th>2002</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area in Km²</td>
<td>Percent Area</td>
<td>Area in Km²</td>
<td>Percent Area</td>
</tr>
<tr>
<td>Agriculture</td>
<td>11.60</td>
<td>37.12</td>
<td>6.04</td>
<td>19.33</td>
</tr>
<tr>
<td>Water bodies</td>
<td>1.68</td>
<td>5.38</td>
<td>2.75</td>
<td>8.8</td>
</tr>
<tr>
<td>Vegetation</td>
<td>3.57</td>
<td>11.42</td>
<td>6.19</td>
<td>19.81</td>
</tr>
<tr>
<td>Built up</td>
<td>3.58</td>
<td>11.46</td>
<td>7.43</td>
<td>23.78</td>
</tr>
<tr>
<td>Bare/open land</td>
<td>7.64</td>
<td>24.45</td>
<td>7.80</td>
<td>24.96</td>
</tr>
<tr>
<td>Other land</td>
<td>3.17</td>
<td>10.15</td>
<td>1.03</td>
<td>3.30</td>
</tr>
<tr>
<td>Total</td>
<td>31.24</td>
<td>100</td>
<td>31.24</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Calculated from the LANDSAT TM and LISS-III images.

5.1 Land use/land cover analysis from 1973 to 2011

Land use/land cover analysis of Rohtak city is evaluated by the unsupervised classification for different years. Land use/land cover map of 1973 shows that the agriculture was the dominant land use which occupies an area of 11.60 sq. kms i.e. 37.12 percent of the study area followed by the bare land and built up area i.e. 24.45 and 11.46 percent respectively. This shows that the city was an agriculturally dominant. The most dominant land use in 1989 was built up area which was increased from 7.43 sq. km to 3.58 sq. km in 1973. Land use map of 2002 and 2011 shows that the built-up area increased and agricultural land has reduced substantially, giving way to urban development of Rohtak city. The most dominant category of
land use in 2011 is urban built-up (57.18 %) followed by bare land (12.93 %) and vegetation cover (10.21 %). Urban core, which represents the traditional part of the city, is high-dense area, is used for the residential, commercial, public and semi-public. Table 2 shows that the vegetation cover is increased in the last decade which is good for the human health and environmental conversation of the city space.

**Table 3: Land use/land cover change statistics from 1973 to 2011**

<table>
<thead>
<tr>
<th>Land use Type</th>
<th>Area Change (in sq. km)</th>
<th>Percent Points Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>-5.56</td>
<td>1.81</td>
</tr>
<tr>
<td>Water bodies</td>
<td>1.07</td>
<td>-0.89</td>
</tr>
<tr>
<td>Vegetation</td>
<td>2.62</td>
<td>-3.73</td>
</tr>
<tr>
<td>Built up</td>
<td>3.85</td>
<td>3.63</td>
</tr>
<tr>
<td>Bare/open land</td>
<td>0.16</td>
<td>-3.52</td>
</tr>
<tr>
<td>Other land</td>
<td>-2.14</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: Calculated from table 2.

**Figure 4**: Land use/land cover from 1973 to 2011

5.2 Land use change analysis from 1973 to 2011

Change detection statistics calculated from the processed image of year 1973, 1989, 2002 and 2011 which covers a period of 38 years. Table 2 reveals that built up area increased from 11.46 percent in 1973 to 57.18 percent in 2011 which is five times during the period. The change in land use has largely been between built-up and agricultural land. It is more evident from the fact that area under agricultural land use was about 37.12 percent in 1973 which declined to 8.29 percent in 2011. People utilize the land for agricultural purposes. Under utilization, mismanagement could be observed in the field as a result of bare land. It is also noticed that the low density urban area was also changing in higher density in particularly the core area/old city centre. Generally, the land use types that are subject of major changes are urban built up and agricultural land which is matter of concern. Urban built-up area shifting from the inner core/older part of the city to the peripherally zone over the agricultural land reflect the natural growth and in migration from
the surrounding areas. However, the highest increase is in the urban built up due to the conversion of vacant land and agricultural land to residential and commercial activities in the low density areas and along major roads in the city. Some small scale industries and Industrial Model Township was established which provided the employment and economic development of the city.

6. Conclusion

Present study demonstrate the combined methodology of multi-spectral, multi-temporal remote sensing image interpretation and GIS spatial analysis to quantitatively portray the dynamics of urban expansion and land use/land cover change in Rohtak city during the 1973-2011. Result reveals that city has experienced rapid changes in land use, particularly in terms of built-up area which is increased 3.58 km$^2$ to 17.87 km$^2$ over the past 38 years, about 5 times from the built-up area in 1973, resulting in a substantial reduction in the area of agricultural land from 11.60 km$^2$ to 2.59 km$^2$ during the period. In the recent time development of Industrial Model Township, education institutions, tourism, hospitals, new residential setup and quality of road network has contributed the rapid urban development and land use transformation in Rohtak city which affect sustainable use of land. Fertile agricultural land is converted into residential, commercial and industrial uses which can be easily accredited to the human interventions with the environment. The extent and pace of urban transformation have led to concern about the city sustainability. Therefore, effective urban planning and management with a goal of long term sustainability is required for the healthy city.

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References