Land use changes in the city hinterland: A Bengaluru case study

1Nagendra M, 2Ashok D Hanjagi

1Research Scholar, Department of Geography, & Geoinformatics, Bangalore University Bangalore, Karnataka, India.
2Professor, Department of Geography & Geoinformatics, Bangalore University Bangalore, Karnataka, India.

ABSTRACT

Bangalore City Hinterland forces responsible for development and growth of urban in a social, economic and environmental space where Agricultural, Urban and the Natural interact. Peripheral areas are most dynamical regions passing through both horizontal and vertical urban expansion of metropolitan region. Among metropolitan city’s in India the Bengaluru is one of the fastest growing and enlarged by an area of 1005%, 100 times in the past 40 years. Geographically Bangalore lies in the southeast of south Indian state of Karnataka. Bangalore City Hinterland has been classified in three zones from Bruhat Bengaluru Mahanagara Palike (BBMP) boundary, consists of five kilometers each zone falling in Ramanagara and Bengaluru rural districts. The paper analyses the changing pattern of land uses in three zones located in the Bangalore City Hinterland and makes a link between the results to socio-economic developments and to changes in the rural policy at the national level. This involves understanding the land use by processing remote sensing data and Geo-informatics and acquisition of spatial data and generation of False Color Composite of 3 bands Green, Red and NIR. Creation of FCC directly helps in identifying heterogeneous patches in the landscape. Supervised Gaussian Maximum Likelihood Classification was employed to assess quantitatively land uses in the region. GMLC algorithm considers cost functions as well as probability density functions and proved to be efficient among other classifiers. we observe changing land use patterns in three zones, out of three zones built-up area shows 500% increase in first zone between 1991 and 2018 in the meantime second zone 10.0% to 43%. In rural area falling in third zone is consists 73% area under new layouts were found. Unplanned rapid urbanization during post 1995’s intense growing activities due to IT parks and special economic zone’s development in the peripheral areas has led to drastic and unrealistic land use changes. Outlaying land use shows that it is reaching moderate saturation with respect to lateral development, whereas the scope of built up area development remains in horizontal growth, but this will have telling influences on the city infrastructure like road, drinking water and sanitation facilities. Vegetation in the fringe has decreased by 60% and water bodies declined by 48%. Vegetation cover, other land uses has decreased about 30.85% between 1991 and 2018. In three different rural–urban belts along the BBMP boundary, is identify basic trends of specialization and intensification of agricultural land use as well as expansion of built up structures for residential and commercial purposes. These trends which are rather similar for all three zones reflect economic and social changes in rural settlements in general and in the Bangalore City Hinterland in particular. The evolving patterns in the Bengaluru rural and Ramanagara districts in the Bangalore City Hinterland can be understood as adjustment measures at the household level to development and changing policies at the macro level, particularly towards the rural sector. There are two major domains of change. First, a transition from dependence on farming to a more diversified economic base suggesting newly shaped interrelationships with the urban space. Second, a new residential development program which has rejuvenated failing and ageing rural settlements.

Key Words: Bruhat Bengaluru Mahanagara Palike (BBMP), Supervised Gaussian Maximum Likelihood Classification (SGML), False Color Composite (FCC), Information Technology (IT)
Introduction

Rapid urban development and increasing land use changes due to increasing population and economic growth is being witnessed in India and other developing countries. The measurement and monitoring of these land use changes are crucial to understand land use dynamics over different spatial and temporal scales. Today, with rapid urbanization, there is increasing pressure on land particularly in the metropolitan cities. Bangalore City Hinterland land surrounding rapidly growing cities is often at risk of being swallowed up as a city expands. This is mainly caused by migration of people from neighboring states. The changes in land use to meet the increasing housing demand, industrial infrastructures and commercial establishments have resulting in change in land use. Growing population, changes in lifestyle and rapid urbanizations changing the land use pattern significantly around the globe (Hubacek and Vazquez, 2002). The World Urban population is projected to increase by 2.9 billion, from 3.4 billion in 2009 to 6.3 billion total in 2050 and 75% people will be living in urban areas (Comprehensive Assessment of Water Management in Agriculture, 2007, UN-HABITAT: 2013).

Among its 30 districts in Karnataka, Bengaluru district attracts large population of 9.6 m for urban Bengaluru alone (Census, 2011). It is continued to be one of the fastest growing cities in India and Asia. The population of Bengaluru grew by 35.09 % in 2001 to 47.18 % in 2011 (Census, 2011). Such steep changes in population impact the environment much higher resulting in loss of arable land (Lopez et al., 2001).

The Bengaluru city is expanding in all directions resulting in large scale urban sprawl and changes in urban land use. The spatial pattern of such changes is clearly noticed on the urban fringes or city peripheral rural areas, than in the city centre. This has made the fringe area of the city to be the most dynamic landscape. In the modern age of urban expansion ‘fringe’ is of much significance. The term ‘fringe’ suggests a border – line case between the rural and the urban and it actually lies on the periphery of urban areas, surrounding it and distinguishing it from the truly rural countryside. The Bangalore City Hinterland, in the real sense is a narrow zone with varying width outside the political boundaries of an urban unit which is neither urban nor rural in character. The fringe of an urban complex forms a pattern depending upon the physiography and transportation facilities of the area. Thus Bangalore City Hinterland zone is an area where various rural and urban characteristics are mixed together. Around major urban centers the physical expansion of built-up areas beyond their municipal boundaries has been very conspicuous. As one moves out of a major city along one the roads, one observes new residential colonies and a considerable amount of vacant land with partially developed residential land use. An important problem in the rural urban fringe area is the problem of land use. The pattern of land use in the area is dynamic and changes from rural land use to urban land use over short periods of time and distance.
Review of Literature

Aruna Saxena (2000) explains that the fringe zone has complex problems of adjustments in between rural and urban ways of life. This led to serious land use problems, loss of agricultural land, unauthorized urban sprawl, high land values, speculation in land and related problems. For solving these problems, there is an urgent need of development of an information system. The usefulness of Remote Sensing and GIS in such a situation has been explained.

Pradhan and Perera (2006) studied Bangkok metropolitan region and discussed the relationship between urbanization, industrialization and the continuous exploitation of natural resources such as land and water resources for non-agricultural uses in the urban fringe areas.

Schenk (1993) focuses on the urban fringe around Bangalore city. It is suggested that fringe may be approached from two directions and two perspectives. The first one reflects the urban view of the immediate countryside whereby somewhere a zone of mixing exists while the second one looks the other way round.

Nigam (2000) evaluates the effectiveness of High-Resolution satellite data and computer aided GIS techniques in assessing the land use change dynamics in the fringe areas of Enschede City from 1993 to 1998. The methodology adopted involved the visual interpretation of land use on acetate overlays according to land use classification. Satellite images were used for the year 1993 and 1996 at the scale 1:25000. This land use/land cover change analysis using remotely sensed has been applied to discover the trend of development of the rural urban fringe of Enschede city.

Sudhira and Ramachandra (2003) focus on the urban sprawl pattern recognition and explore the causal factors for urban sprawl of Udupi and Mangalore area. Survey of India Toposheets, IRS satellite data and GIS are used for developing a model of sprawl in urban environment.

Study Area

The study area comprises of Bengaluru City and fringe villages. It extends geographically from 12°49' to 13°9' N latitude and 77°27’to 77°47’ E longitude at an average elevation of 2953 ft. Bengaluru due to its high elevation enjoys a more moderate climate throughout the year. The coolest month is December with an average low temperature of 15.4 °C and the hottest month is April with an average high temperature of 32.8 °C and it has a semi-arid subtropical climate. The average annual rainfall in the study area is about 850 mm. The major portion (i.e., around 65%) of the rainfall is received during the south-western monsoon period (June to September); and, the pattern of rainfall in the rural-urban fringe shows a decreasing trend with wide variation. It is in the heart of the Mysore Plateau (a region of the larger Precambrian Deccan Plateau) and covers an area of 2481 Sq. km.

Figure 1: Location Map of the Study Area
Data and Methodology

The Survey of India toposheets (1:50000 scale) were geometrically registered through polyconic projection technique in compatible format for subsequent analysis. Further, the Indian Remote Sensing Satellite data from Karnataka State Remote Sensing Centre (KSRSAC) Land sat MSS image (1991), Land sat 7, IKONOS and Quick Bird (2001), Land sat 7 ETM+ panchromatic with multispectral images (2011) and Landsat-8 and Sentinel-2 sensors (2018) acquired with the different resolution and employed in this study. The images are analyzed by using data images processing techniques in ERDAS Imagine© 10.1 and ArcGIS10.4 software. Dynamic land use changes classified according to the NRSA (national State Remote Sensing Agency). Furthermore, the image analysis results are confirmed by the field verification. Besides, a number of geospatial data including municipal boundaries, road networks, geomorphic units and elevation units have been constructed as GIS layers from diverse source.

Image classification method

Image classification methods are very useful in identifying different features from the given image. Features like built-up, water, vegetation and barren land can be used for exploring in order to understand the multi-temporal variations. Multi-temporal satellite images provide excellent temporal variations which can be used for urban growth analysis. Different combinations of bands are generated in order to identify built-up, vegetation, water and barren land signatures from the satellite images (signatures means similar spectral values).

The supervised classification methods are used for pattern classification. Supervised Gaussian Maximum Likelihood Classification identifies class information in the satellite images and similar pixels are used as ‘training samples’ (signature values). The classifier system is used to determine the statistical characterization of reflectance for each information class and this stage is called ‘Signature analyses’. Signature analyses involve statistical characterization of the range of reflectance on each band. The statistical characterization has been achieved for each information class. Then the image is classified by examining the reflectance for each pixel and making a decision about which of the signature it resembles accurately.

Primary data collected during the period of fieldwork, various strategic locations were visited and were geo-tagged using the GPS machine. This has been mainly for the purpose of identifying landmarks and to provide inputs for Bangalore City Hinterland maps.

Transect walks were conducted all over the study area. For the purpose of transect walk, the study area was divided into three zones.

Main Objective of Study

To conduct a detailed study of Bangalore City Hinterland areas decadal land use and its change to overcome the problems plaguing the fringe area of Bengaluru.

Given the above-stated aim, following objectives are:

- Land use change in 1991.
- Land use change in 2011. and
- Land use change in 2018.
Result and Discussion

Bangalore City Hinterland villages have spread in three zones consists of Zone-1 5 km., Zone-II is 5 to 10 km., and Zone-III is 10 to 15 km. on either side of Bengaluru city. The total 15 km zone covers an area of 2481 sq. km. Zone-I 656 sq.km (270 fringe villages), Zone-II 830 sq.km (304 fringe villages), and Zone-III 995 sq.km (346 fringe villages). Ramangara and Bengaluru rural districts are the prominent administrative boundary which falling in the study area.

Bangalore City Hinterland area is well connected Bengaluru city has good transport and communication facilities. The study area comprises the following National High ways: (1) National Highway 4–connecting Tumakuru district. (2) National Highway 48–connecting Hassan district, (3) National Highway 209–connecting Mysuru district.

Land use Change in 1991

For the 1991 imagery Supervised Classification was done by using Gaussian Maximum Likelihood algorithm. For this a set of homogenous pixels were selected and algorithm was trained to classify the data based on ‘training sites’. Size, shape, location, number of pixels, number of training sites for a particular class, placement, and uniformity were some of the characteristics considered while assigning the training sites.

The change detection analysis reveals that the land transformation has primarily been on account of increasing demands of the main city. The Figure 4 reveals that agriculture has major area in all the three respected zones registered as 67.0%, Built up land is 10.0%, Forest is 7.0%, Grass / Grazing is 8.0%, Waste lands is 4.0%, and Water bodies are in 3.0% respectively.
Land use Change in 2001

The Figure 5 reveals that agriculture has major area in all the three respected zones registered as 63.0%, Built up land is 13.0%, Forest is 6.0%, Grass / Grazing is 9.0%, Waste lands is 6.0%, and Water bodies are in 3.0% respectively.

Land use Change in 2011

The Figure 7 reveals that agriculture has major area in all the three respected zones registered as 49.0%, Built up land is 18.0%, Forest is 5.0%, Grass / Grazing is 12.0%, Waste lands is 13.0%, and Water bodies are in 3.0% respectively.
Land use Change in 2018

The Figure 9 reveals that agriculture has major area in all the three respected zones registered as 67.0%, Built up land is 10.0%, Forest is 7.0%, Grass / Grazing is 8.0%, Waste lands is 4.0%, and Water bodies are in 3.0% respectively.

The expansion of the city strongly influences the villages in terms of land use and population, both physically and in a socio-economic sense. Its influence stretches far beyond the immediately adjacent area as it enjoys the position of primacy within the region. This expansion has mainly been in terms of residential land use, as during the period under study huge number of residential colonies and commercial apartments have come up in the periphery and the city. These developments have mainly been at the cost of productive agricultural land and precious wetlands of the rural-urban fringe of the city.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Land use Class</th>
<th>Zone - I</th>
<th>Zone - II</th>
<th>Zone - III</th>
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<tr>
<td>1</td>
<td>Agriculture land</td>
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<td>-26</td>
<td>-29</td>
</tr>
<tr>
<td>2</td>
<td>Built up land</td>
<td>35</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Forest</td>
<td>-2</td>
<td>-3</td>
<td>-4</td>
</tr>
<tr>
<td>4</td>
<td>Grass / Grazing</td>
<td>10</td>
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<td>9</td>
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<tr>
<td>5</td>
<td>Waste lands</td>
<td>13</td>
<td>13</td>
<td>13</td>
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<tr>
<td>6</td>
<td>Water bodies</td>
<td>-0.6</td>
<td>-1</td>
<td>-1</td>
</tr>
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</table>

Table: 1 Zone wise % of Area Changes

Conclusion

A spatial analysis of the present land use structure of the rural-urban fringe,
keeping in view the geo-ecological and socio-economic framework of the region has been carried out to model the future directions of growth and the potential land use categories threatened by the urban sprawl of the city in near future is depicted in Table 1.

Bangalore City Hinterland area is well growing fallowed by National High ways: (1) National Highway 4-connecting Tumkur district. (2) National Highway 48–connecting Hassan district, (3) National Highway 209–connecting Mysuru district.

References


