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LAND TRANSFORMATION: A THREAT ON BANGALORE'S ECOLOGY - A CHALLENGE FOR SUSTAINABLE DEVELOPMENT

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Abstract
Land constitutes the most important character for sustainable development in a region. Rapid urbanization has become an area of crucial concern against the bonanza of urban ecology. The land use pattern of any urban area hints not only its immediate current space requirements of the inheriting community but rather the cumulative requirements over a period of year. Thus, the way a land use changes into, reveals a physical transformation of its economic use that indirectly unveils the demand for built-up space and as a result, the urban ecology is in imbroglio. For much of human existence, the available land for human use has appeared limitless. Wherever population densities have risen too high, there is a decline noticed in resource base. People moved on to occupy new lands by extending the urban area into rural fringe. Land transformation as the word suggests, traces the change of form in the land use. Land use change is an inevitable phenomenon in an urban space. How the use of land changed from one to another is a problem that has interconnections with various entities and the interaction between them in spatio-temporal environment. Bangalore over the years has grown as a robust technology hub, and has been ever- growing in terms of urban space with its inhabits. How this growth has affected its ecological space is the thrust of the study. The ecology of this urban land constitutes of agricultural plantation, forest area and lakes which comprise the green and blue spots. The objectives are accomplished through Geoinformatics which is able to apprehend statistics of ecological to the urban environment.
Keywords: Environmental Degradation, GIS, Remote Sensing, Digital Image Processing, Urban Land Transformation Analysis.

1. Introduction

Bangalore over the years has grown as a robust technology hub, and has been ever-growing in terms of urban space with its inhabitants. Bangalore with its rich flora and renowned botanical gardens, is rightly called Garden City of India. Bangalore city bagged the Central Government sponsored "Indira Priyadarshini Vruksha Mitra" award in the late 1980 in recognition of its extensive green cover. But today, lung space is shrinking in the city and core areas have lost green cover with increase in concrete structures. Sustainable land management is a central challenge here. This metropolitan should ensure growing supply of food and other resources to increasing population. Ironically, these agricultural and

plantations lands are being victimized for the growth of Bangalore metropolitan. Bangalore is also known for its lakes which are havens of ecology. Though many of these lakes are artificial tanks, they play a leading role in providing home for varieties of habitats and for recharge of the underground water with which the city's demand for water is being met. But loss of these lakes are also debated and attributed to rampant urban growth. Urban ecology loss has serious consequences on the micro-climate of the city and indirectly affects the health of its population. A scientific way of arguing for the urban ecology is through land transformation. Land transformation denotes to qualitative change in land, the act of change of form, shape, structure, appearance or nature of land that have put into some use. Loss of ecology is primarily traceable to land transformation through fragmentation of natural habitat and has often vandalized by urban sprawl. The comparison of sprawl can be with disease process, calling it cancerous growth or a virus (DiLorenzo, 2000). Land use/Land cover study has been attracted a great deal of attention in urban geography. But land transformation is a function and a sub-component of land use which could quantify the interchange in the functionality of land.

2. Objectives

The prime objective of the study is to account the geographical spread of ecological areas especially agricultural plantations, forests and lakes with in Bangalore. Through satellite image processing techniques to assess the spatio-temporal transformation to these ecological areas, categorizing and quantifing transformations and predicting the future threat of ecological areas spatially as well as temporally.

3. Methodology

The technological advances in remote sensing products and Digital Image Processing software are surely blessing to analyze bio-geo degradations and urban ecological stress studies. The Indian Topographic Maps of 1:50,000 scale are used as the base line data for comparison. Indian Remote Sensing Satellite (IRS) I C imagery with LISS IV data of 23.8 meter spatial resolution is obtained for two time periods i.e., 2001 and 2005. The transformations are phased into two slots, Phase-1 studies the transformation between 1970 and 2001 which could be inferred by comparing the topographic map and satellite imagery of the year 2001. Phase-II transformations are traced by comparing the satellite imageries of 2001 and 2005. Various classes of transformation are obtained by analyzing the spectral reflectance curves and values. The result gives a clear delineation of different classes of transformation.

3.1. Phase- I. Transformation of Forest

BangaloreUrban District covers an area of 2184.14 sq.km. The forest area spreads to an aerial extent of 64.61 sq.km in the year 1975 in which good belts of Reserve forest and State forest can be seen. There is 9.53 sq,km of Reserve forest and 55.08 sq.km of State forest present in the year 1975. Satellite image of 2001 reveals that, the forest cover accounts only 44.25 sq.km, which confers a loss of 20.36 sq.km of natural vegetation. It also depicts that the loss are converted into built up environs, attributing to the urban sprawl and encroachments of urban built-up structures. The forest loss is leading to decay of the green belt of the city. Changes are hardly noticed in the forests which extends away from the city in the north but the health of the vegetation shows degradation. Sprawl does not only create concerns on land transformation but also alarms about the pollution that are caused due to the inhabitants in various forms (Barnes et al, 2000; Doyle et al., 2001; NWF, 2001). This stretch of unhealthy vegetative cover is a good example of effects of sprawl on health of vegetation. The table-1 represents a detailed transformation of forests between 1975 to 2001 which terms as Phase-I transformation. The corresponding figure-1 explains the same in comparative bar diagram.

TABLE- 1 - PHASE I. TRANSFORMATION OF FOREST 1975 – 2001

Forest	Transformation 2001 (in Sq.Km)
Existing Forest	29.84
Degraded Forest	14.41
Built-up	20.36
Total	44.25

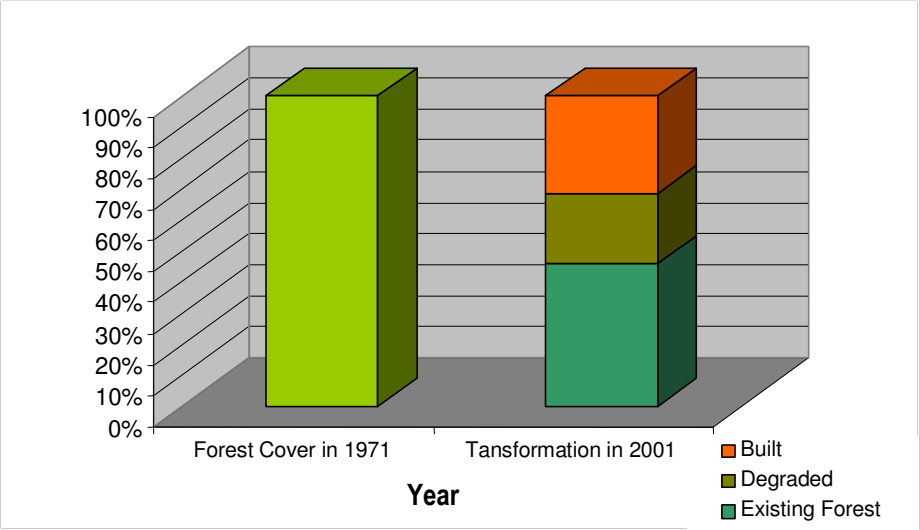

FIGURE -1 – PHASE I. LAND TRANSFORMATION OF FOREST

Theoretical and Empirical Researches in Urban Management
Special Number 1S/April 2009: URBAN ISSUES IN ASIA

3.2. Phase- II. Transformation of Forest

Decreasing trend can bee seen in forest area in comparison with year 2001 (table-2). There was loss of 12.95 sq.km of forest area from the existing and 17.84 sq.km of the then forest area transformed and added to built-up structures and which can be addressed as discontinuous sprawl (Weitz and Moore, 1998) or low density sprawl (Pendall, 1999). The degraded forest was reduced by 4.89 sq.km, which is a positive sign when viewed as a single entity, but a serious concern of what transformation occurred to this reveals that these were converted to built up structures. It could be concluded from figure-2 that it took a period of 15 years for 20.36 sq.km of area to be converted to built up but with-in 4 years time 17.84 sq.km of forest area was transformed into built up which means that the rate of transformation is high in spatio-temporal context.

TABLE- 2 - PHASE- II TRANSFORMATION OF FOREST-2001-2005 (IN SQ.KM)

Land use	Transformation 2001	Transformation 2005
Existing Forest	29.84	16.89
Degraded Forest	14.41	9.52
Built-up	20.36	38.2
Available Forest area	64.61	64.61

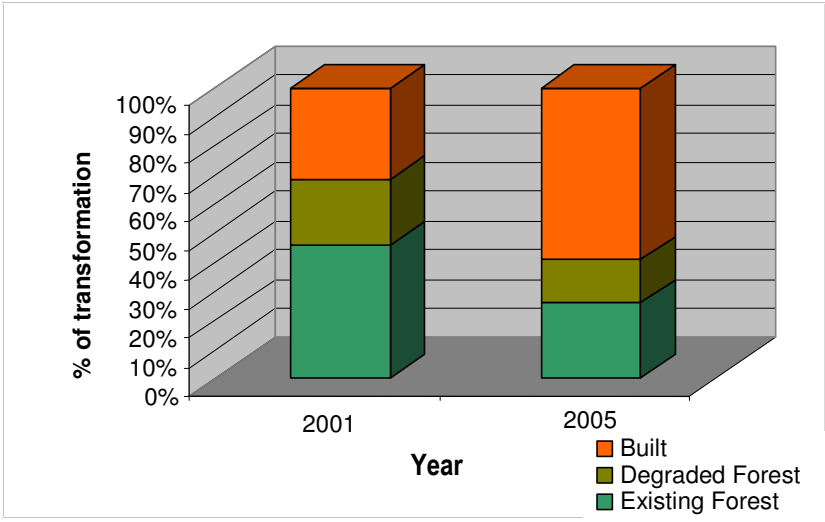

FIGURE -2 – PHASE - II. TRANSFORMATION OF FOREST COVER

3.3. Phase- I. Transformation of Lakes

Lakes are large water surface of impounded water, natural or artificial with in the land mass. Tanks are small lakes or pounded water which are man made features used for irrigation and water supply for domestic use. Bangalore is known for its lakes and tanks and it appears to be studded with 771 lakes in

and around the Bangalore Urban District. Most of the lakes were artificially created and they serve the purpose of irrigation and meet the city's water demand. Around 227.7 sq.km of lake area can be accounted from the Indian topographic sheet.

Five categories are derived from the transformation analysis of the lake. Spectral signatures and Digital Reflectance Values (DRV), are also used to distinguish the class. Thus, signature profiles are generated and the image is classified. When the lakes are occupied by human habitation developed by cover of buildings, transport and communication, they were termed as Built up. The next class being wetlands, which are transitional area between aquatic and terrestrial ecosystems, where the water table is at or near the surface of the land covered by shallow water for full or part of the year. These are dynamic ecosystem having complex interrelationship of hydrology, soil and vegetation. Vegetative is the next category where the lake is completely eutrophicated by sewage drains and weeds like *hycarnia* species and *Buffalo Grasses* grow up here. Dry lands are the category where there is marked absence of vegetation and moisture and can be termed as open lands, which are very vulnerable for convenient occupation of human habitants. Table-3 and figure-3 depicts the statistics of transformation of lakes in Phase-I between 1975 to 2001.

TABLE-3 TRANSFORMATIONS OF LAKES (IN SQ.KM)

Lakes	Transformation 2001
Built-up	18.3
Dry lands	37.03
Vegetation	36.9
Wetland	30.05
Existing Lake	105.42

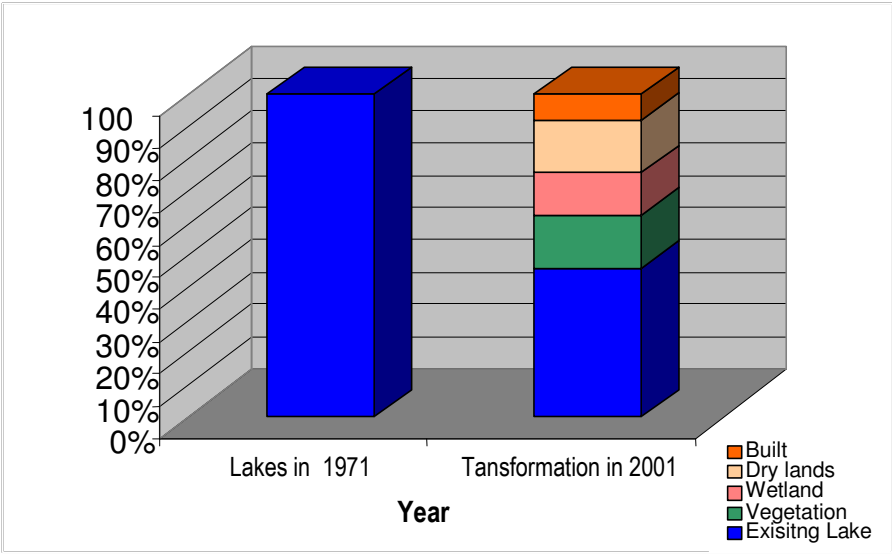

FIGURE- 3 – PHASE-I. TRANSFORMATION OF LAKES

Theoretical and Empirical Researches in Urban Management
Special Number 1S/April 2009: URBAN ISSUES IN ASIA

In 2001, out of 227.7 sq.km of lake area, only 105.42 sq.km remained as lakes and 18.3 sq.km are transformed into built-up area. All the lakes around the city are the victim of urbanization and urban sprawl. The piecemeal growth that happens in the city, is a typical type of urban sprawl which has its immediate effects on converting the lakes into built-up area. This is an irreversible change and cause great ecological loss. An area of 37.03 sq. km of lake is transformed into dry lands. Such transformations is limited to very small tanks in the south and is scattered in the north of the city. Wetlands and vegetative lands are found encroached to larger lakes and scattered around, 30.05 sq.km of area were accounted as wetlands and 36.9 sq.km vegetative lands.

3.4. Phase- II. Transformation of Lakes

Due to urban sprawl, tanks suffered the greatest loss. There was an increase of 72.78 Sq.km to the built up category of transformation of lakes with in 4 years.

TABLE- 4 – PHASE- II TRANSFORMATION OF LAKES (IN SQ.KM.)

Lake Transformation	Transformation 2001	Transformation 2005
Built-up	18.3	91.08
Dry lands	37.03	24.41
Vegetation	36.9	33.7
Wetland	30.05	42.06
Existing Lake	105.42	36.45

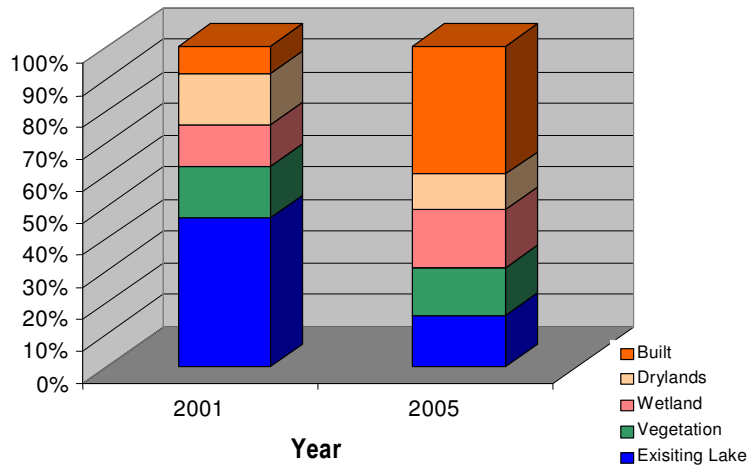

FIGURE- 4 – PHASE-II. TRANSFORMATION OF LAKES

Dry lands decreased by 12.62 sq.km but this cannot be taken as positive sign owing to these lands being converted into built-up area. Vegetative area remains less but the same accounting for 3.2 sq.km reduction in size, and the existing lake/tank area reduced to 36.45 sq.km out of 104.42. This accounts

for 41% of reduction in the lake loss. This is a considerable loss to urban ecology and thus calls for a great concern. Table-4 and figure-4 give a clear statistis of transformation in 2001 versus 2005, the same being represented by percentage bar- diagram in figure- 4.

3.5. Phase- I. Transformation of Agricultural Plantations

The scattering of urban settlements on rural landscapes, rural by means of the economic activities are the most alarming of its forms (Harvey and Clark, 1971). Agricultural space in terms of Agricultural plantations are scattered in the north south and east. There were marked absence of agricultural plantations in the West owing to ruggedness of land. To the south of Bangalore, Vegetable Gardens, Wine on trellis, Casuarinas Plantations, Mango garden, Medicinal Herb plantations are cultivated and Horticulture gardens were in south. Wine on trellis was seen scattered in patches, and were very high in number that there were wine festivals celebrated here. In some places of south, Casuarinas Plantations can be seen. Mango garden, medical herb plantations, Research Farm can also be found in the south. Of all the plantations, coconut plantations are large in number in Urban Bangalore.

TABLE- 5 : PHASE- I. TRANSFORMATION OF AGRICULTURAL PLANTATION (IN SQ.KM)

Plantation	Transformation 2001
Built-up	128.50
Fallow	7.24
Existing	406.57
Of the Total Plantation Area	542.31

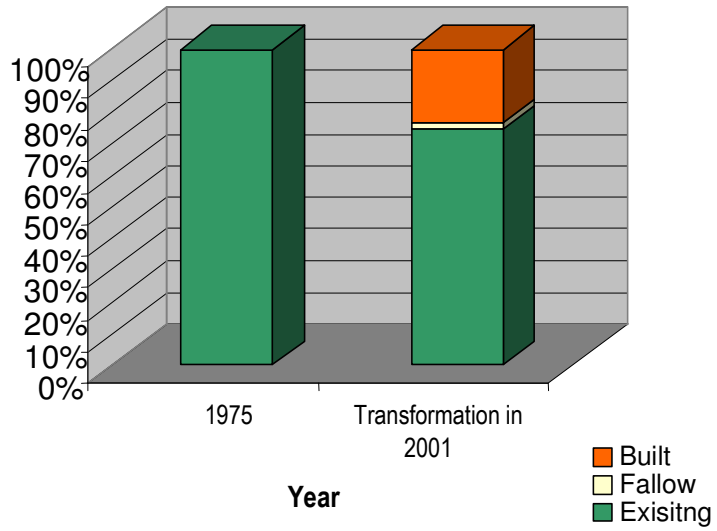

Figure- 5 – Phase - I. Transformation of Agricultural Plantations

Theoretical and Empirical Researches in Urban Management
Special Number 1S/April 2009: URBAN ISSUES IN ASIA

Agricultural plantations are also major victims of urbanization and the resultant transformations are classified under three categories i.e.,built, fallow and no-change (table- 5 and figure- 5). No change is the category which was resistant to urbanization and has not change over years. Fallow shows a serious threat and uncertainty for conversion or non-conversion but, is vulnerable under the threat of sprawl. The next category being built where, the agricultural plantations are victimized for urban growth. This is an irrevocable transformation and calls for serious attention of urban planners. In 1975, the agricultural plantations are 524.31 sq. km, but shrunk to 406. 57 sq.km in 2001 and by 2005 the agricultural plantation measured only 103 sq.km which alarms that there were serious transformations occurred due to urban influence. Of the 524.31 sq.km of agricultural plantations, 7.25 sq.km were fallow lands and 128.5 sq.km are converted to built- up structures. This built up conversion are seen all around the proximity to the city.

3.6. Phase- II. Transformation of Agricultural Plantation

TABLE- 6: PHASE- II TRANSFORMATION OF AGRICULTURAL PLANTATION (IN SQ.KM)

Agricultural Plantation Transformation	Transformation 2001	Transformation 2005
Built-up	128.5	419.64
Fallow	7.24	19.67
Existing Plantation	406.57	103
	542.31	

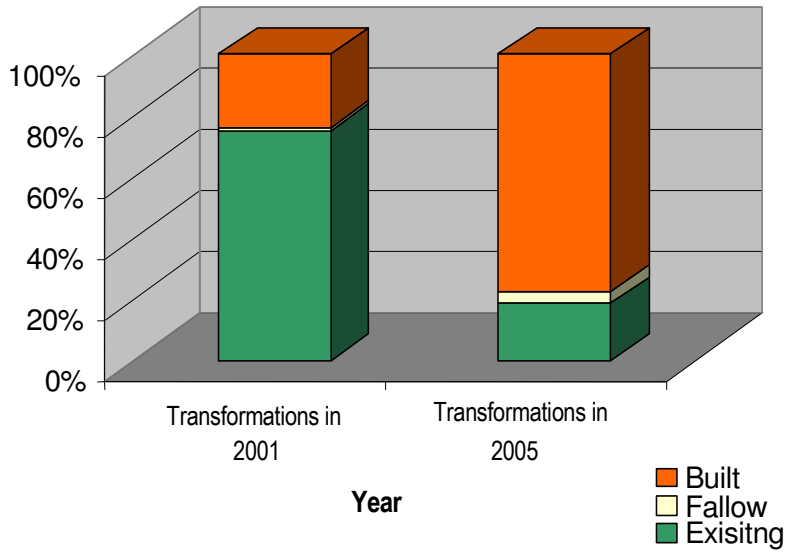

FIGURE- 6 – PHASE- II. TRANSFORMATION OF AGRICULTURAL PLANTATIONS

There is an alarming transformation that has taken place in the case of agricultural plantations during 2001 and 2005. Built-up area raised 3.3 folds on the agricultural plantations. This transformation is very well pronounced in the south and well coincides with the urbanization. Increase in fallow lands generates chances for negative transformation. Thus, existing plantation area reduced from 406.57 sq.km to 103 sq.km which accounts for about 72% loss of plantation area towards built-up and fallow lands. This scenario clearly underlines the future threat on food security of the city and inevitably makes the city to depend on its neighborhoods for its food. This also signifies the rampant growth of urbanization and its pressing demand for space. Table- 6 and figure- 6 denote the aerial transformation that has occurred in Bangalore Urban District.

4. Results and Suggestions

The results are pose serious concerns of urbanization against urban ecology. Changes to ecology, when they are transformed to built up remains permanent and irreversible.

- The loss of ecology also alters the climate of an area and also gives impact on the lung space of the city totally effecting the health status.
- This research also suggests that the amount of transformation that took place in 30 years (phase-I) is taking place just within 5 years (Phase- II) which means the acceleration of changes are faster every year. So, rate of change in ecological spaces and bio-geography of the area is also faster and negative.
- This calls for the attention of environmentalists and common man on the protection of the left ecology of Bangalore.

5. Conclusions

At a metropolitan scale, sprawl occurs at the rate at which land is converted to non-agricultural, non natural uses exceeding the rate of population growth (US EPA, 2001). Such kind of transformation is a threat to urban ecology.

- The vegetative area in terms of forest distribution has seen drastic changes to its geographic extensions. The immediate threat lies with the degraded forest area which can easily altered into built-up. Reclamation measure has to be ensured in these areas in order to regain the density of the grooves.
- In the case of Lakes, the challenge is on to the dry lands, wet lands and vegetative covers, which can easily be modified into built up to pacify urbanization and resultant demand of land. The agricultural plantations had also seen its part of effects.

- Unlike the other cases of lakes and forests, in agricultural plantations encroachments do not take place, but mass construction rise up completely consuming a given unit of agricultural plantation and transforms it into apartments and residential layouts. This accounts for major loss of vegetation and food security. This can be prevented only by the government's interventions and strict implementation of the land conversion acts.
- Strict vigilances from forest, land records and lake development departments can only curl this urban ecological loss.
- The Bangalore Mahanagara Palike and Bangalore Development Authority which are the key governing authorities of Bangalore can take mesures to protect the ecological spaces by keeping them away from land promoters.

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