APPLICATION OF REMOTE SENSING AND GIS, LAND USE/LAND COVER CHANGE IN KATHMANDU METROPOLITAN CITY, NEPAL.

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ABSTRACT

The land-use and land-cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Land-use and land-cover change has become a central component in current strategies in managing natural resources and monitoring environmental changes. Urban expansion has increased the exploitation of natural resources and has changed land use and land cover patterns. Rapid urbanization, therefore, brings opportunities for new urban developments, however, it also has brought serious losses of arable land, forest land and water bodies. Land cover change is a major concern of global environment change. The modelling and projecting of land cover change is essential to the assessment of consequent environmental impacts. In Nepal, speedy urbanization took place in the last two decades due to population growth. This growth has significantly changed the landscape of many cities. In the context of urbanization, a large amount of agricultural land has been converted to built-up or urban land uses. Kathmandu,the capital city of Nepal , has been experiencing a lot of land-use and land-cover changes due to both socioeconomic and natural factors. Remote sensing and Geographical Information system (GIS) provide fundamental tools which can be useful in the investigation at the village district as well as the city levels. Remote sensing becomes useful because it provides synoptic view and multi-temporal Land uses / Land cover data that are often required. All landsat images of Kathmandu city including Kathmandu Metropolitan and Lalitpur Sub-Metropolitan city (1976 MSS, 1989 TM, 2001 ETM+ and 2009 ETM+), are rectified and registered in Universal Transverse Mercator (UTM) zone 45 N and Supervised image classification system has been observed to classify the images in different land use categories. Five land use classes have been identified: Urban (Built-up), Water body, Forest area, Open field and cultivated land. GIS is the technology which has been used to view and analyze data from a geographic perspective. In study, Markov chain model has been applied to predict future changes which are based on the rates of past change using IDRISI GIS. The land-use information for the year 2017 is predicated in Kathmandu City. The past, current and possible future land-use dynamics of the study area has been described and analyzed.

Keywords: *Land use/Land cover, Satellite imagery, Markov Chain Model, GIS.*

1. INTRODUCTION

Land-use and land-cover change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. Landuse and land-cover changes have impacts on a wide range of environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and function, and the climate system itself through greenhouse gas fluxes and surface albedo effects [1].

Urban growth, land use and land cover change study is very useful to local government and urban planner for the betterment plan of sustainable development. Urban growth, particularly the

Land use and land cover change is scalar dynamic. The change is land cover occurs even in the absence of human activities through natural processes where as land use change is the manipulation of land cover by human being for multiple purposes- food, fuelwood, timber, fodder, leaf, litter, medicine, raw materials and recreation. So many socio-economic and environmental factors are involved for the change in land use and land cover .Land use and land cover change has been reviewed from different perspectives in order to identify the drivers of land use and land cover change, their process and consequences.

movement of residential and commercial land to rural areas at the periphery of metropolitan areas, has long been considered a sign of regional economic vitality. But, its benefits are increasingly balanced against ecosystem impacts, including degradation of air and water quality and loss of farmland and forests, and socioeconomic effects of economic disparities, social fragmentation and infrastructure costs [2]-[3].

Geographical information systems (GIS) and remote sensing are well-established information technologies, the value of which for applications in land and natural resources management are now widely recognized. They are, however, still essentially separate technologies and practitioners still generally consider themselves primarily involved with one or the other [4].

Current technologies such as geographical information systems (GIS) and remote sensing provide a cost effective and accurate alternative to understanding landscape dynamics. Digital change detection techniques based on multi-temporal and multi- spectral remotely sensed data have demonstrated a great potential as a means to understanding landscape dynamics- detect, identify, map, and monitor differences in land use and land cover patterns over time, irrespective of the causal factors [5] .Recent improvements in satellite image quality and availability have made it possible to perform image analysis at much larger scale than in the past. GIS has enormous possible as an environment for the conception of dynamic models of physical environmental processes.

Markov process models are a class of probability models used to study the evolution of a system over time. Transition probabilities are used to identify how a system evolves from one time period to the next. A Markov chain is the behavior of the system over time, as described by the transition probabilities and the probability of the system being in various states.In this paper combined the remotely sensed data to investigate urban growth dynamics of Kathmandu Metropolitan area from 1976 to 2009. The main objective of this study is to trace out the land use/land cover changes of city. The specific objectives are(1) to analyze the changing land use and land cover pattern from 1976 to 2009 and (2) and predict land use/land cover in the year 2017 using Markov model.

2. MATERIALS AND METHODS

Four pairs of, cloud-free Landsat images have been used to classify the study area: Landsat Image 2,Multi Spectral Scanner satellite image (hereafter MSS image with path /row 152/41) October 28, 1976, ,Landsat Image 5, Thematic Mapper satellite image (hereafter TM image with path/ row 141/41) October 31, 1989 and Landsat 7 Enhanced Thematic Mapper (hereafter ETM+ with path/ row 141/041) December 27, 2001 and Landsat 7 Enhanced Thematic Mapper (ETM+ with path/ row 141/41) January 15, 2009. All data were used in this study were projected to the Universal Transverse Mercator (UTM) projection system (zone 45n, World Geodetic System 84).

Topographical map, first, 1978 data are obtained from land use maps (1:50,000 scale) compiled from ground-verified aerial photographs (1:50,000) by the Land Resources Mapping Project (LRMP), a collaboration between His Majesty's Government of Nepal (HMGN) and an external consultant (Kenting Earth Sciences Ltd, Ontario, Canada).The topographic map (1:25,000) compiled from the ground-verified 1992 aerial photograph, which was prepared by Land Resource Mapping Project (LRMP), Nepal and land references map was taken as the topographical map and used of land use map prepared by Survey Department of Nepal from 1998/2001 based on Aerial photography taken in 1996 at the scale of 1:25000.

The IDRISI GIS Taiga version has been used for the analysis of image. Markov Chain model applied to find out the future change of LUCC in study area. The land-use information for the year 2017 is predicated in Kathmandu. According to the land use classification scheme supervised approach with the maximum likelihood parameter (MLP) system was applied to improve the accuracy of the land use classification for the images for all four dates (1976, 1990, 1999and 2009).

3. RESULTS AND DISCUSSIONS

3.1 Land Use Change Pattern in Kathmandu.

There is no doubt that human activities have profoundly changed land cover in the City area during the last half centuries. Land is one of the most important natural resources. All agricultural, animal and forestry productions depend on the productivity of the land. The entire eco-system of the land, which comprises of soil, water and plant, meets the community demand for food, energy and other needs of livelihood. The land-use and land-cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often undocumented and unrecorded landuse change, observations of the earth from space provide objective information of human activities and utilization of the landscape.

Land use statistics and transition matrices are important information to analyze the changes of land use. The change analysis presented in this paper is based on the statistics extracted from the four land-use/land-cover maps of the Kathmandu Metropolitan with using GIS. The urban/built-up areas in the Kathmandu had a noticeable increase, from the table 1 and figure 1-5 we observed that the urban development change is very high in the city area, from 16.85% (10.90sq.km) of the total land in 1976 to 66.61 (43.10 sq.km) in 2009, statistic mentioned that 10% urban growth in between 1989 to 2001, population migration in city area is the causes of increase the urban area. On the other hand study observed the dramatic decrease of the forest area in the years between 1976 and 2009. It seems 13.90% in 1976, 8.80 in 1989, 2.93 in 2001 and 2.32 in 2009. But the decrease of the forest area seems constant in 2001 and 2009. Analysis shows that water covered area seems 2.90%, 1.10%, 4.33% and 3.71% in 1976,1989, 2001, and 2009 respectively which signifies the fluctuating ratio of water covered area. Cultivated land represents 59.35 % in 1976 but this area has been increased 1 % and reached 60.43% in 1989 due to the rapid decline of forest. Cultivated land covers 59.35%, 60.43%, 49.30% and 26.74% in the year 1976, 1989, 2001 and 2009 respectively. Open field has been largely decreased between 1976 and 2009. This area has been changed for urban and agriculture purpose.

Table1: *Land use statistic of Kathmandu City, 1976 – 2009*

Years	1976		1989		2001		2009	
Land use type	Km²	In %	Km²	In %	Km²	In %	Km²	In %
Urban/ Builtup	10.90	16.85	17.70	27.35	27.60	42.66	43.10	66.61
Water Body	1.90	2.90	0.70	1.10	2.80	4.33	2.40	3.71
Forest Cover	9.00	13.90	5.70	8.80	1.90	2.93	1.50	2.32
Open Field	4.50	7.00	1.50	2.32	0.50	0.78	0.40	0.62
Cultivated Land	38.40	59.35	39.10	60.43	31.90	49.30	17.30	26.74
Total	64.70	100.00	64.70	100.00	64.70	100.00	64.70	100.00

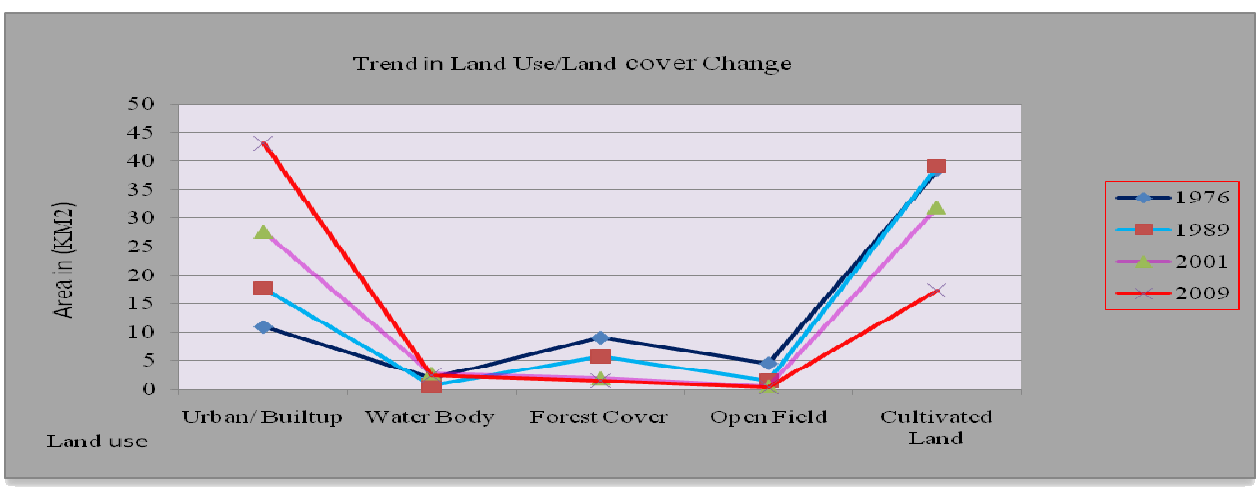

Figure 1: Trend of Land Use Land cover Change, 1976-2009

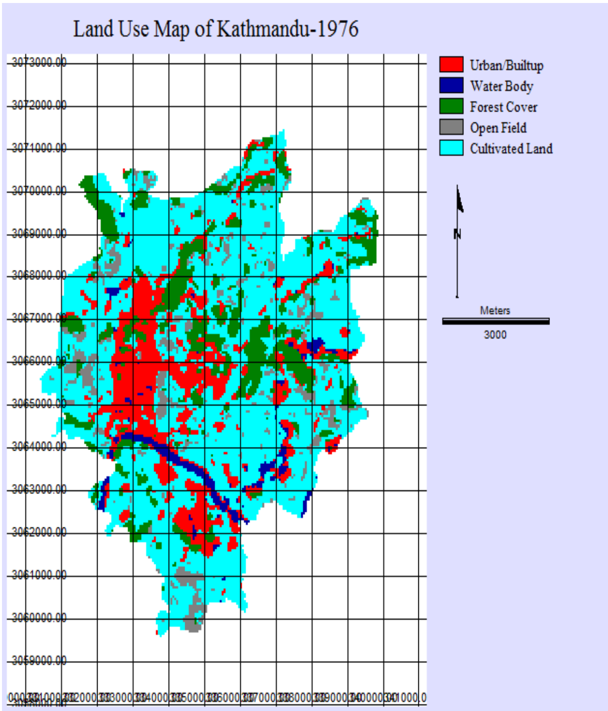

Figure 2: Land Use Map of Kathmandu, 1976,

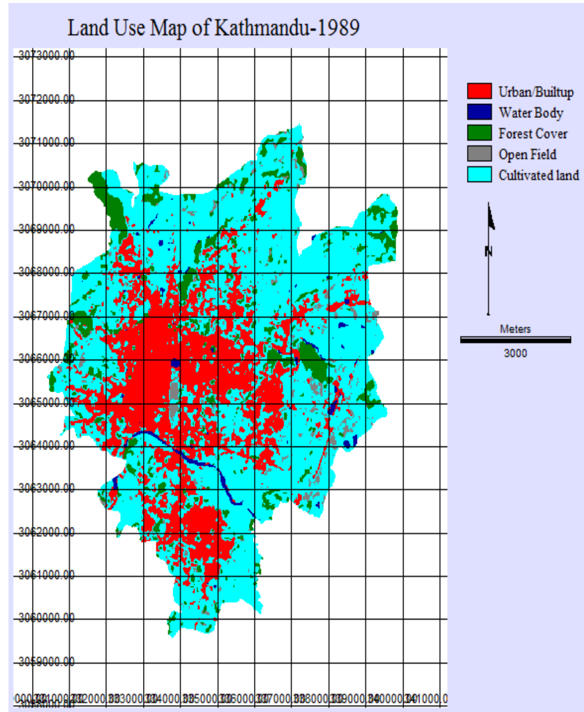

Figure 3: Land Use Map of Kathmandu, 1989

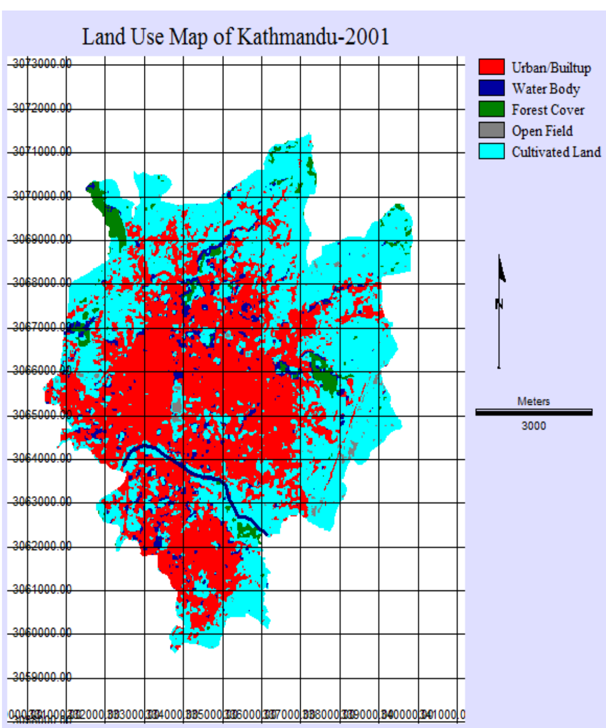

Figure 4: Land Use Map of Kathmandu, 2001

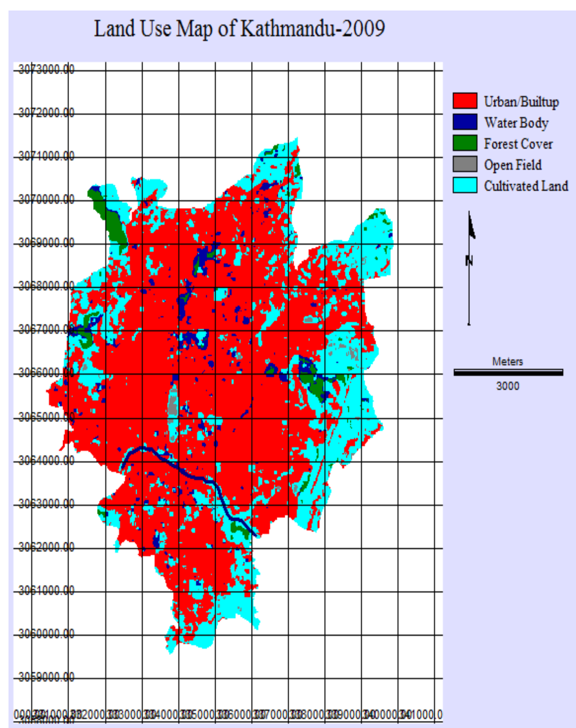

Figure 5: Land Use Map of Kathmandu, 2009

4. FUTURE CHANGE OF KATHMANDU

4.1. Markov Chain Analysis

Urban growth dynamics attracts the efforts of scientists from several disciplines with the objectives ranging from theoretical understanding to the development of carefully tuned realistic models that can serve as planning and policy tools. Theoretical models are often abstract and of limited applied value while most applied models yield little theoretical understanding. Urban growth modeling has evolved over recent years to capture increasingly well the details of urban morphology and structure on a qualitative as well as a quantitative level [6].

Markov chain models are particularly useful to geographers concerned with problems of movement, both in terms of movement from one location to another and in terms of movement from one "state" to another. "State", in this context refers to the size class of a town, income classes, type of agricultural productivity, land use, or to some other variables [7].

Land use change transition probability in Markov analysis indicates the probability of making a transition from one land use class to other one within two discrete times. The Markov transition probabilities of the observed landscape changes from 2001 and 2009. From using this two classified image of 2001-2009. I found out the future land use change of Kathmandu. The transition probability matrix records the probability that each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix be the number of cells of corresponding land use in the later image. For the 5 by 5 matrix table presented below, the rows represent the older land cover categories and the column represents the newer categories. Although this matrix can be used as a direct input for specification of the prior probabilities in maximum likelihood classification of the remotely sensed imagery, it was however used in predicting land use land cover of 2017.

In the probability transition matrix table 2 of Kathmandu row categories represent land use land cover classes in 2009 whilst column categories represent 2017 classes. We can observed from the matrix, urban built up land has a 0.9461 probability of remaining urban land and a 0.0155 of changing to water body in 2017 and 0.0380 urban land transformed in cultivated in same year. The calculation mentioned that in 2017 urban built up area will increase than 2009 and must of the land use classes will be converted into urban area in 2017. Mean while 0.3239 water body remaining in same position but 0.5680 areas changed into in urban area in 2017. On the other hand, the 0.0207 and 0.1681 probability of change from forest land transformed in urban built-up and water body respectively. In the transition matrix 0.4798 cultivated land changed into urban built up in 2017 and 0.0232 in water 0.0135 in forest and 0.0095 in open field and 0.4741 is remaining in cultivated land in same period.

According to the analysis of Table 3 and figure 6 land use change will reach in extreme point of Kathmandu. In 2017 Urban area will increase and it cover 72.24 % to the total land of Kathmandu by the contract cultivated land will remain only 20.90 %.From table and figure it can be noted that urban land, water body, open field will increase respectively by 3.64 km² (5.65%), 0.32 km² (0.59%), 0.11 km² (0.19%) between years 2009 and 2017 whereas forest and cultivated land will decrease respectively by 0.3 km² (0.47%) and 3.79 km² (5.84%).

Table 2: Transitional Probability table derived from the land use land cover map of 2001-2009

Classes	Urban/Built up	Water	Forest	Open field	Cultivated
Urban/Built up	0.9461	0.0155	0.0000	0.0004	0.0380
Water	0.5680	0.3239	0.0218	0.0012	0.0851
Forest	0.0207	0.1681	0.5659	0.0000	0.3453
Open field	0.0819	0.0018	0.0036	0.1762	0.7367
Cultivated	0.4798	0.0232	0.0135	0.0095	0.4741

Table 3: Statistic and Magnitude of Land use/Land Cover change 2009-2017

Years	2009		2017		Change Area 2009-2017	
Land use type	Km²	In %	Km²	In %	Km²	In%
Urban/ Builtup	43.10	66.61	46.70	72.17	+3.60	+5.56
Water Body	2.40	3.71	2.72	4.20	+0.32	+0.59
Forest Cover	1.50	2.32	1.20	1.85	-0.3	-0.47
Open Field	0.40	0.62	0.53	0.81	+0.11	+0.19
Cultivated Land	17.30	26.74	13.51	20.90	-3.79	-5.84

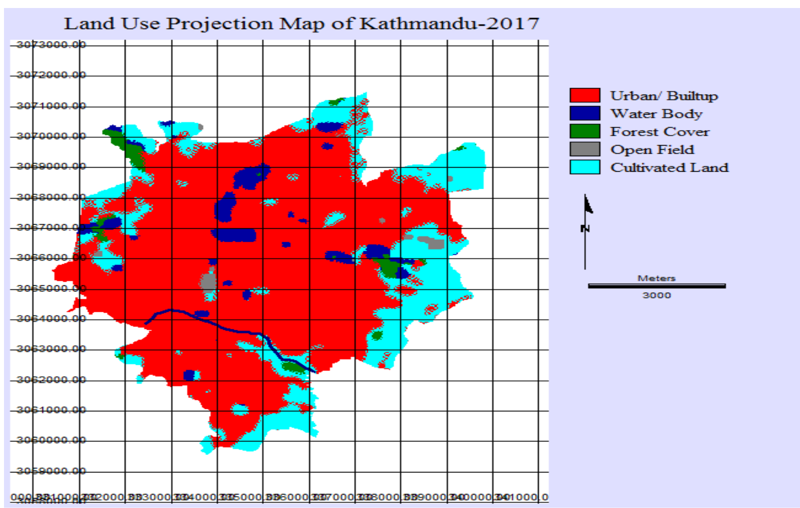

Figure 6: Land use projection map of Kathmandu 2017

5. CONCLUSION

The urban/built-up areas in the Kathmandu had a noticeable enlarge, from the analysis we can see that the urban development amend is very high in the city area, from1976-2009. Land cover is a critical element in change studies, affecting many aspects of the environmental system. Accurate and updated land cover change information is necessary for understanding main factors causes and environmental consequences of such changes. While remote sensing has the capability of monitoring such changes, extracting the change information from satellite data relies on effective and accurate change detection techniques. The classification achieved in this study produces an overall accuracy that fulfils the minimum accuracy threshold. The Markov transition probabilities of the observed landscape changes from 2001 and 2009. From using this two classified image of 2001-2009. I found out the future land use change of Kathmandu in 2017. It is assumed that this application of the techniques of remote sensing and GIS in urban research as demonstrated in this study can open up new arena of comparative research so that a broad and full picture can ultimately be outspread to shed light over the pattern and processes of land use change in Nepal in the global context.

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REFERENCES

[1]. E.F Lambin, M.D.A. Rounsevell, and H.J.Geist, "Are agricultural land-use Models able to predict changes in land use intensity?" *Agriculture, Ecosystems and Environment,* Vol .82, 2000, PP.321– 331.

[2]. G.D. Squires, "Urban Sprawl and the Uneven Development of Metropolitan America" Urban Responses. Urban Institute Press, Washington, D.C.2002, pp.1- 22.

[3]. Fei Yuan , Kali E Sawaya,. Brian C. Loeffelholz, Marvin E. Bauer "Land cover classification and Change analysis of the Twin Cities (Minnesota) Metropolitan Area" By multitemporal Landsat remote Sensing, *Remote Sensing of Environment, Vol*. 99, August 2005, pp. 317-327.

[4]. [Qiming Zhou, "The Integration of GIS and Remote Sensing for Land Resource and Environment Management" *Proceedings of United Nation ESCAP Workshop on Remote Sensing and GIS for Land and Marine Resources and Environment Management*, School of Geography, The University of New South Wales Sydney, NSW 2052, Australia.February 13-17, 1995, pp.43-55.

[5]. Jensen, J.R. (1996). "Introductory digital processing": A remote sensing perspective (2n edition). Upper Saddle River, NJ: Prentice-Hall.

[6]. Claes Andersson, Steen Rasmussen and Roger White, "Urban settlement Transitions" Environment and Planning, Vol.29, 2002, pp.841-865.

[7]. Lyndhurst Collins, "An Introduction to Markov Chain Analysis ", the Invicta Press Ashford Kent and London,1995, pp. 1-33

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