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URBAN GROWTH AND LAND USE/LAND COVER CHANGE OF POKHARA SUB-METROPOLITAN CITY, NEPAL

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ABSTRACT

Urban development has enlarged the modification of natural resources and has changed land use and land cover patterns. Urbanization is a process of increase of modernization system which modifies the socioeconomic activities and revolutionizes the land use practice according to time frame. Due to the proximate and underlying causes, land use and land cover change has become the main challenge of the present world. Due to the huge course of urbanization, the major cities of the world are compelled to face the severe threats. Various causes of the urbanization process bring the unrestrained impact on land use and land cover change. An unplanned urbanization process is becoming the major problem in the developed and developing countries. Population growth, migration, political instability, economic opportunities, centralized plans and policies of the government, accessibility of physical infrastructure, globalization are some of the major causes of the high level of urbanization in Nepal. This paper presents the historical urban growth phenomenon and analysis of land use and land cover change of Pokhara sub-metropolitan by utilizing remote sensing imagery and GIS. In the study, Markov chain model has been used to predict future changes based on the rate of past change in IDRISI GIS. The landsat images of 1977 MSS, 1990 TM, 1999 ETM+ and 2010 TM are rectified and registered in Universal Transverse Mercator (UTM) zone 44N. Supervised classification system has been used to classify the images of different land use categories. Six land use classes have been identified: Urban (Built-up), water body, open field, forest cover, cultivated land and sandy area. Urban land use change for the year 2021 was modeled using a Markov chain based approach. For the projection of 2021, transitional probability matrix table from the land use land cover map of 1999 and simulated map of 2010 is derived. Projected land cover changes show a growing tendency in urban land use, which might threaten the areas that are currently reserved for forest and agricultural lands.

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

1. INTRODUCTION

Urbanization is an inevitable process due to economic development and rapid population growth [1]. Urban growth, particularly the movement of residential and commercial land use 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]-[4]. It is generally believed that urbanization has both direct and indirect impacts on land use transformation. Urban sprawl is one of the most noticeable effects of urbanization on land use. The extent to which urbanization affects land use change and the ways in which they interact to yield [5].

Urban areas and their urban rural linkages are characterized by high dynamics of human influence and the associated land use patterns. To effectively deal with these land use change processes a well-founded knowledge of underlying causes and driving factors is needed. Spatially explicit land use modelling techniques have successfully been applied to model the present and likely future land use patterns of urban areas [6].

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According to 2009 Revision of World Urbanization Prospects, Northern America, Latin America and the Caribbean, Europe and Oceania are highly urbanized, with proportions urban ranging from 70 percent in Oceania to 82 percent in Northern America, and their level of urbanization is expected to continue rising, even if slowly, so that by 2050 all of them, except Oceania, are expected to be more than 84 percent urban. In contrast, Africa and Asia remain mostly rural, with just 40 percent and 42 percent of their respective populations living in urban settlements in 2010, and even by 2050 they are expected to be significantly less urbanized than the other major areas, reaching a proportion urban of 62 percent in Africa and 65 percent in Asia [7].

Urban growth remains a major topic concerning GIS and remote sensing applications. Remote sensing and GIS have proved to be effective means for extracting and processing varied resolutions of spatial information for monitoring urban growth [8] . The spatial and temporal dimensions are major concerns of GIS and remote sensing. Modelling spatial and temporal urban growth enriches the spatial science of GIS. Methodological research into urban growth can contribute in improving current GIS, in particular its spatial analysis and modelling functions such as exploratory spatial data analysis and spatial econometrics [9]-[10]. Urban areas contain very complex land use structures. It is not enough to study urban growth as a spatial description that is normally captured in a Geographic Information System (GIS). To better understand the complexity of urban systems and its spatial and temporal dimensions, urban growth models need to be linked with land use change model [11].

Urban growth modeling and prediction history essentially started in the 1950s, showed less activity in the 1970s and 1980s, but has been revived vigorously in the 1990s, thanks to the improvement in spatial data availability and advancements in computer technologies and geographic information systems (GIS) [12]-[13] .

In the case of developed countries, there is intense use of urban areas. Non-commercial functions occupy space mainly in the peripheral zone. But in the developing countries like Nepal, core area of the city is still devoted to agriculture. Consequently, urban economy is primarily based on agriculture. However, the present scenario of the major towns of Nepal shows a rapidly changing pattern of urban land use [14].

Due to the proximate and underlying causes, land use and land cover change has become the main challenge of the present world. Due to the huge course of urbanization, the major cities of the world are compelled to face the severe threats. Various causes of the urbanization process bring the unrestrained impact on land use and land cover change. An unplanned urbanization process is becoming the major problem in the developed and developing countries. The process of urbanization has been influenced mainly by the combination of driving forces: geographical location, population growth, public service accessibility, economic opportunity, government plans and policies, land market, globalization, tourism activities and political activities.

The study focuses on the analysis of urban growth trend, examines the land use land cover change and predicts the urban growth patterns by using the Markov Chain models at Pokhara Sub-Metropolitan city of Nepal over the time period of 30 years and prediction of 2021 has been adopted. The results of the simulation can be effectively used to understand the relationship between the spatial pattern and urban growth in Pokhara Sub-Metropolitan area. The correlation between population growth and growth in urban land area as determined from the Landsat-derived change maps was also examined.

2. STUDY AREA

Pokhara is a beautiful and historical town of Nepal which was made town municipality in 1962. Designation of Pokhara as the headquarters of the Western Development Region of Nepal in 1972, contributed to upgrade Pokhara Municipality in the present status of Sub Metropolitan City in 1995 with 18 wards. Pokhara Sub-Metropolis lies in the broad valley of Seti River covering an area of 55.31 sq.km (some study shows 56 sq.km) located on the southern foot of the Mt. Annapurna and Mt. Fishtail Himalayan region 83° 58' 30" to 84° 02' 03" east longitudes and 28°10' north to 28° 16' north latitudes. Fewa Lake and Seti River have drained the city. Seti River dissects it into two parts. Enchanting natural beauty and its unique social and cultural heritage are responsible for the present development of town. Pokhara is a remarkable place for natural beauty at an elevation ranges from 627 mete to 980 meter above the sea

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level. Being the regional headquarters of western region and the second tourist center after the Kathmandu, it has attracted a large population from the surrounding areas. It accounts for the highest growth rate of population among the designated towns in the country. Pokhara Sub-Metropolis is selected as the study area because of its rapid process of urbanization and fast change in land uses.

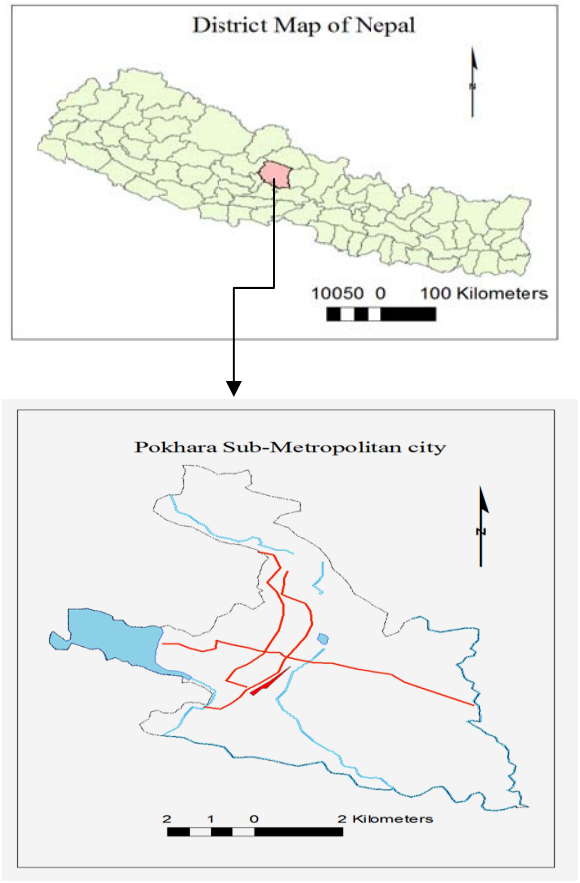

Figure 1: Location Map of Study Area

3. MATERIALS AND METHODS

The study is based on both primary and secondary information. Primarily satellite images were used for this study to classify the land cover of the region. This included both field survey and map studies and computer based analysis. In primary session, fieldworks were conducted to acquire first hand data required for the research. Most of the essential data for improving mapping accuracies of spatial changes were collected through the fieldwork. Landscape observations, meetings with experts, and structured interviews also were conducted in the sub-Metropolitan. To analyze the population growth and urban development process, various types of data were collected from publication of Central Bureau of Statistic (CBS),Government offices, ICIMOD (International Centre for Integrated Mountain Development), IUCN (World Conservation Union) other various websites for the fulfilment of objectives. 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 153/40) March 22, 1977,Landsat Image 5, Thematic Mapper satellite image (hereafter TM image with path/ row 142/40) November 10, 1990 and Landsat 7 Enhanced Thematic Mapper (hereafter ETM+ with path/ row 142/40) December 13, 1999 and Landsat Image 5, Thematic Mapper satellite image (hereafter TM image with path/ row 142/40) December 3, 2010. All data used in this study were projected to the Universal Transverse Mercator (UTM) projection system (zone 44n, World Geodetic System 84).

Topographical maps, 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 have been 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 has been applied to find out the future change of LULC in study area. The land-use information for the year 2021 is predicated. 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 (1977,1990, 1999and 2010).

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3.1. Image Classification Schemes

There is no one ideal classification of land use and land cover, and it is unlikely that one could ever be developed. There are different perspectives in the classification process, and the process itself tends to be subjective, even when an objective numerical approach is used. There is, in fact, no logical reason to expect that one detailed inventory should be adequate for more than a short time, since land use and land cover patterns change in keeping with demands for natural resources. Each classification is made to suit the needs of the user, and few users will be satisfied with an inventory that does not meet most of their needs. In attempting to develop a classification system for use with remote sensing techniques that will provide a framework to satisfy the needs of the majority of users, certain guidelines of criteria for evaluation must first be established (Anderson et al. (1976). The post-classification image comparison method has been adopted in this study to achieve a better classification result. The classification system utilized in this study is a slightly modified classification system for remotely sensed data as recommended by Anderson et al. (1976) and the system utilized by the Land Information Centre in the study area. Visual interpretation of the images determines the land use types. For simplicity, Six types of land use: Urban/Builtup, Water body, Open field, Forest cover, Cultivated land, Sandy area were selected for the study (Table 1).

Table 1 : Land cover classification scheme (Level I)

Land use type	Descriptions
Urban/Builtup	Residential, Commercial and Services Industrial, Transportation, Communications, and Utilities, Industrial and Commercial Complexes, Mixed Urban or Built-up Land, Other Urban or Built-up Land
Water Body	River, Streams and Canals, Lakes, Reservoirs, Bays and Estuaries
Open Field	Government protected land for new air port, playground, Mixed Barren Land
Forest Cover	Evergreen Forest Land, Mixed Forest Land, Park, garden, Grass Land
Cultivated Land	Cropland, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas, Other Agricultural Land
Sandy Area	Sandy and gravel pits,

4. ANALYSIS AND RESULT

4.1. Growth Pattern of Urbanization in Nepal

The problems of definition in the study of Nepal's urbanization are considerable because the areas designated "urban" have been defined and redefined over the years and there is evident lack of consistency in the definition. The 1952/54 census provides data on 10 "prominent" settlements with a population of over 5,000 but refrained from defining an urban area. The 1961 census for the first time defined an urban area or a 'sahar' as "an area with a population cluster of 5,000 and over and having an urban environment such as high school, college, judicial and administrative offices, bazaar, communication facilities, mills, factories etc." but also indicated that the definition was not strictly followed [16]. The *Nagar Panchayat* Act of 1962 provided the nomenclature of Nagar as the local level urban administrative unit or a municipal area as distinct from a local level rural administrative unit. It stipulated the population size criteria of "not less than 10,000" as a generally necessary, but not a sufficient condition, for providing the municipal status to a locality.

Since 1962 an urban area has been interpreted in Nepal not as a settlement unit *per se* but as a unit of local self-government. Since 1971 the *Panchayat* (now Village Development Committee or VDC) has been taken as the basic unit of census enumeration. As a result the concept of settlement configuration as a unit of census enumeration has been lost as the areal extent of a VDC (*Panchayat* before 1990) includes many, often far flung, settlement units. Indeed the concept of localities included in censuses since 1971 are a misnomer because these in fact are not "localities" in the sense of settlement units but only *Panchayats* or VDCs. Further, the decision regarding the designation and determination of the areal extent of localities is not made by the Central Bureau of Statistics but by the Ministry of Local Development. Since 1971 areas with municipal status have been *ipso facto* considered urban.

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The fact that the population size criteria was not consistently followed in the designation of *Nagar Panchayat* is revealed from the fact that at least four of the newly classified *Nagar Panchayats* in 1971 had a population of less than 10,000 while 12 other 'localities' in the country had a population of over 10,000 but were not classified as *Nagar Panchayats* [17]. In 1976 the population size criteria to receive the municipal status was reduced to 9,000. In 1990 with the reestablishment of the multi-party system the *Nagar Panchayats* were renamed *Nagarpalika.* The Municipality Act of 1992, and the Local Self Governance Act of 1999 redefine and classify municipal areas. This is the first time that municipal areas have been classified into categories in Nepal. But the universally accepted criteria of population size, density, contiguity and occupational structure of population are given scant attention. Political ad- hocism in the designation of municipal urban areas is quite evident.

Municipalities according to the Local Self-Governance Act 1999 are classified into three categories: Mahanagarpalika (Metropolitan city), Upa-Mahanagarpalika (Sub-Metropolitan city), and Nagarpalika (Municipality). Mahanagarpalika is a municipality with a "minimum population size of 300,000, annual revenue of at least Rs. 400 million, facilities of electricity, drinking water, communication, paved main and subsidiary roads, provision of specialised health services, essential infrastructure for international sports events, adequate opportunities for higher education in different fields, at least one established university, adequate urban facilities, and an area that has already received the status of a upamahanagarpalika". Similarly a Upa-Mahanagarpalika is a municipality with a "minimum population size of 100,000, annual revenue of at least Rs. 100 million, facilities of electricity, drinking water, communication, paved main roads, education and health services of a high standard, general infrastructure for national and international sports events, provision of public parks and a city hall and similar urban facilities, and an area that has already received the status of a nagarpalika". The Act lays down (a) minimum population size of 20,000 in the Tarai and 10,000 in the hill/mountains, (b) annual revenue of 5 million in the Tarai and 500,000 in the hill/mountains and "minimum urban facilities such as electricity, road, drinking water, communication and other similar urban facilities" as necessary conditions for the designation of municipal status or a Nagarpalika. Today, Nepal has one metropolitan city, four sub-metropolitan cities, and 53 municipalities. More than 120 other emerging urban settlements are in pipeline to be declared as municipalities.

4.2. Growth of Urban Population and Urban Places in Nepal

Nepal has low level of urbanization in terms of both urban population and number of towns. According to the population census 2001, out of the total population of the country only 13.9 % out of the total population live in the urban areas [18]. In 1975 about 90% of Nepal's population lived in rural areas; the economy was dominated by the agricultural sector which accounted for 71% of gross national product. Urban settlements were few in number and Kathmandu, the largest of them, did not exceed a population of 200,000. Especially in the last 15 years, the picture has changed dramatically. Although the majority of the population still lives in rural areas, the process of urbanization has gained momentum. Even though the level of urbanization is low in comparison to other countries in Asia, the cities and towns have experienced rapid growth due to several "push" and "pull" factors. The weak security situation in rural and remote mountainous areas, natural disasters - especially floods - and the general attraction of cities as centers of potential employment and income have enforced migratory flows towards the urban settlements. In search of improvement of the individual socioeconomic situation, access to education and healthcare but also a less conservative or traditional environment, more and more people have been coming to the cities. The fastest growing urban centers are located within the Kathmandu Valley, in the Terai region and Pokhara.

Table 2 and figure 2 provide a list of urban areas and included the percent of population in censuses since 1952/54 and the year 2001 accordingly, the number of designated urban areas has gone up from 10 in 1952/54 to 58 in 2001. In the five decades since the 1950s, urban population increased from 0.238 million to 3.23 million while the number of designated urban places increased from 10 to 58. In the decade of 1952/54, urban population observed 238275, but this number has been increased in 336222 in 1961 and reached 461938 in 1971. Likewise, population trend

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increased rapidly in 1981, 1991 and 2001 it observed 956721, 1695719 and 3227879 respectively. The percent of urban population in the country has grown from 2.9 percent to 13.9 percent. It may be noted that average annual change in the percent of urban population has been steadily increasing since the seventies.

Table 2 : Total number of urban places and percent of urban population of Nepal 1952/54 – 2001

Census Year	1952 /54	1961	1971	1981	1991	2001
Urban Places	10	16	16	23	33	58
Percent Of Urban Population	2.9	3.6	4.0	6.4	9.2	13.9

Source: Sharma, 2003

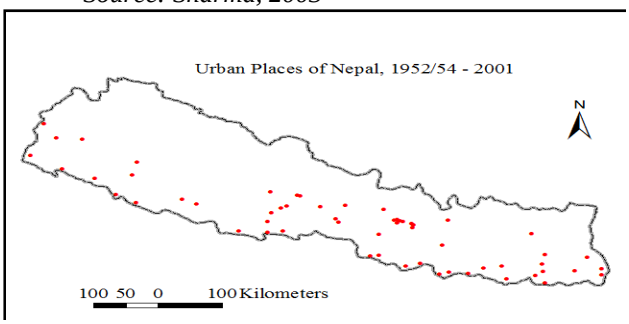

Figure 2 : Number of Urban places in Nepal 1952/1954-2001

4.3. Population Growth and Urbanization in Pokhara

The process of urbanization has been influenced mainly in Pokhara by the combination of various driving forces: geographical location, population growth, public service accessibility, economic opportunity, globalization, tourism activities and political activities. Pokhara city has the good access of public service accessibility. Normally, Pokhara municipal area was populated and popular after the Anglo-Nepal war. But rapid urbanization can be marked after the declaration of municipality as well as the headquarter of western development region. Various governmental offices are situated in the area. All sorts of trade and business carry good market. It is the focal point of education, health, business, electricity, transportation, communication and tourism where people from different districts of Gandaki zone are taking direct benefit. The city has good availability of colleges, Universities, schools as well as hospitals and the services of daily needs. The respondents also opine that the easy access of the public service is the main cause of migration and population growth of Pokhara.It is the valley surrounded by snowcapped mountain peaks. Thousands of tourists from several nooks and cranny of the world arrive Pokhara every year. Due to the various causes people's attraction in Pokhara increasing day by day.

Population distribution of Pokhara Sub-Metropolis (Table 3) in 1952/54 was 3755, which has increased to 95286 in 1991. In between 1952/54 and 1961, the population increased by 5.36 per cent but in 1971, it increased to 14.30 per cent. This high growth rate was mainly due to migration of population from its peripheral villages. Extension of the city area boundary was an equally important factor to increase the urban population. From 1971 to 1981, the rate of growth of urban population increased to 8.51 percent. In this inter-census period, the influx of migrants slowed down; however, extension of the city area boundary and natural growth caused the increase the growth rate. In between 1981 and 1991, the growth rate of population accounted for 7.41 %and its growth rate in between 1991-2001 is 5.6 %. According to the population census 2001 the total number of population is 156312 with 79563 male and 76479 female.

Table 3: Population Growth Pattern of Pokhara Sub – Metropolitan City,Source: : Poudel, 2008

Year	Population	Growth Rate %
1952/54	3755	-
1961	5413	5.36
1971	20611	14.30
1981	46642	8.51
1991	95286	7.41
2001	156312	5.6

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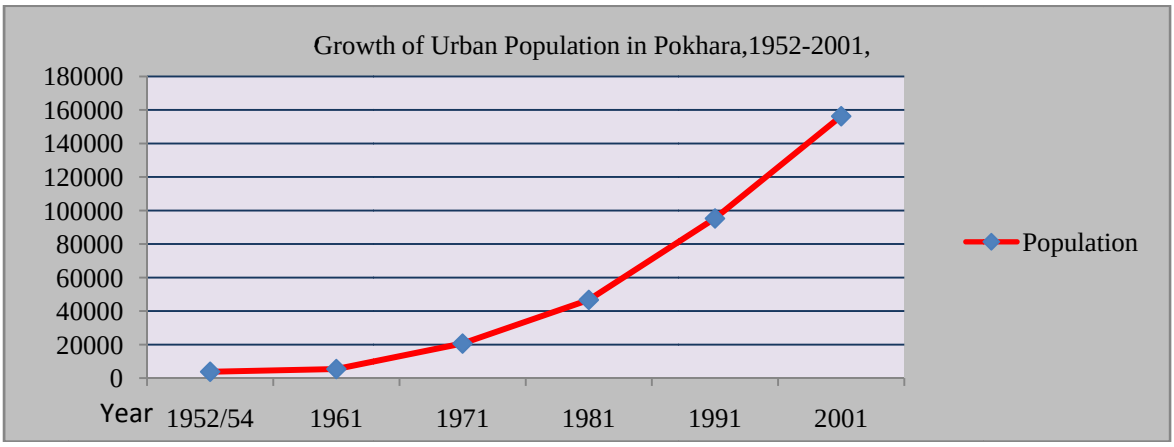

Figure 3 : Growth of Urban Population in Pokhara 1952/54-2001

4.4 Land Use Change Pattern in Pokhara

Land use /land cover (LULC) change was quantified for the last 33 years within and in the vicinity of a fast growing city of Pokhara using remote sensing and geographic information systems (GIS). LULC change was projected for the next 11 years by using Markov chain. The study has analyzed the relationships between urban growth and land use change, and between urban growth and population growth. Thus, research on this subject is important in order to understand patterns of LULC change as well as their social and environmental implications at different spatial and temporal scales.

From the mentioned table 4 and figure 4, 5, 6, and 7 of Pokhara, observed that urban area is growing day by day. According to the classification, 3.50 Km² (6.33%) of area has been covered by urban in 1977 but 11.11 Km² (20.08%) of urban area has been sheltered in 1990 and this area increased to 18.62 Km² (33.66%) in 1999 which meets 28.44 Km² (51.42%) in 2010. Analysis has mentioned that, water body in Pokhara in 1990, 1999 and 2010 has been observed in constant way which area has occupied 6.85 Km² (12.38%) and 7.10 Km² (12.84% and 7.02 Km² (12.69%) respectively but this area has covered 7.73 Km² (13.97%) in 1977. Open field had covered the large portion of the city especially in eastern and western-south part of the city in 1977. But open field of the western part of the city rapidly changed in cultivated and urban area in between 1977 to 1990. Open field had covered 6.46 Km² (11.68%) in 1977, which decreased to 4.44 Km² (8.03%) in 1990 and 3.53 Km² (6.38%) in 1999. So, during this period (1977-1999) open field had altered in cultivated, urban area and other area. It is because local people captured of this part from different sides. Small part of the city has been covered by forest area from the beginning. The forest cover area was found 0.84 Km² (1.52%) in 1977, 0.75 Km² (1.36%) in 1990, 0.87 Km² (1.57%) in 1999 and 1.22 Km² (2.21%) in 2010. Meanwhile, rapid decline of the cultivated land can be observed by the analysis of image since 1977 to 2010. In 1977, it seems to have covered 33.59 Km² (60.73%), which reached 29.18 Km² (52.76%) in 1990, 21.40 Km² (38.70%) in 1999 and 11.21 Km² (20.27 %) in 2010. Cultivated land has been transformed around 75% area into other land types in between 1977 to 2010. Increasement of sandy area can be seen through the calculation in between 1990 to 1999 and it has been slightly decreased in 2010. This area has represented 3.19 Km² (5.77%), 2.98 Km² (5.39%), 3.79 Km² (6.85%) and 3.16 Km² (5.71%) in 1977, 1990, 1999 and 2010 respectively.

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Table 4 : Land use statistic of Pokhara Sub- Metropolitan, 1990-1999

Years	1977		1990		1999		2010	
Land use type	Km²	%	Km²	%	Km²	%	Km²	%
Urban/ Builtup	3.50	6.33	11.11	20.08	18.62	33.66	28.44	51.42
Water Body	7.73	13.97	6.85	12.38	7.10	12.84	7.02	12.69
Open field	6.46	11.68	4.44	8.03	3.53	6.38	4.26	7.70
Forest Cover	0.84	1.52	0.75	1.36	0.87	1.57	1.22	2.21
Cultivated Land	33.59	60.73	29.18	52.76	21.40	38.70	11.21	20.27
Sandy Area	3.19	5.77	2.98	5.39	3.79	6.85	3.16	5.71
Total	55.31	100	55.31	100	55.31	100	55.31	100

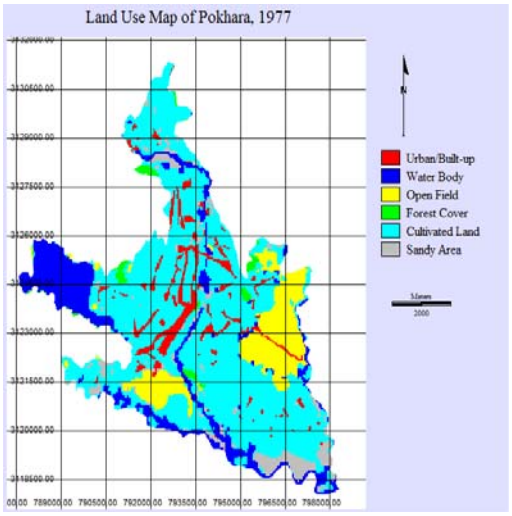

Figure 4: Land Use Map of Pokhara 1977

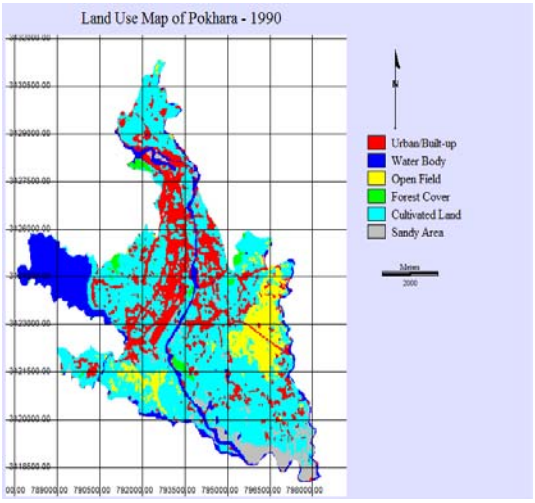

Figure 5: Land Use Map of Pokhara 1990

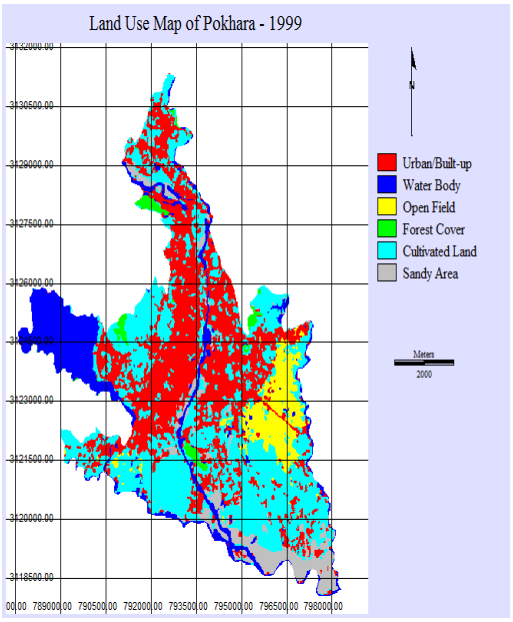

Figure 6: Land Use Map of Pokhara 1999

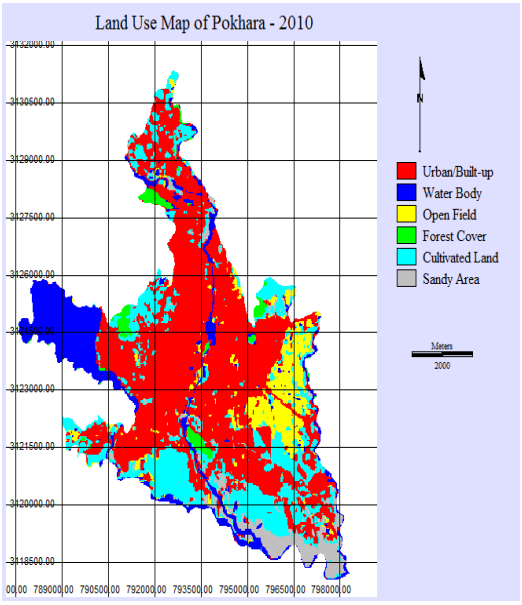

Figure 7: Land Use Map of Pokhara 2010

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4.5 Markov Model of Change Detection of Land Use Change in Pokhara

Markov chain models are particularly useful for 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 [4]-[19]. This type of change detection technique is one application of change detection that can be used to predict future changes based on the rates of past change. The method is based on probability that a given piece of land will change from one mutually exclusive state to another [20]-[21]. Land use change transition probability in Markov analysis indicates the probability of making a transition from one land use class to another within two discrete times.

In this study, transitional probability matrix table derived from the two time periods land use land cover map of 1999 and 2010 to predict the change of 2021. Six by six (6 by 6) matrix table is presented below, the rows represent the older land cover categories and the columns represent the newer categories. The Transitional Probability Matrix shows the probability that a land pixel will change from one land use category to another.

Table 5 shows the transition probability matrix of land use land cover in between 2010-2021. By examining the land-use transition probabilities of both time periods, it can be recognized that the urbanization will continue to increase rapidly. Urban area has been increased in 2021 than 2010 year. According to the analysis, urban/built up land has 0.8945 probability of remaining urban land and 0.0194 will be changed into water, 0.0243 in open field, 0.0028 in forest cover, and 0.0496 urban land will transform in cultivated and 0.0095 in sandy area in 2021. Mean while, 0.8327 water body area will remain in same class and other area transformed into open field, forest, cultivated land and sandy area. In this period, 0.7162 open field will remain in same position but 0.1702 area will be changed in urban, 0.0572 will transform in water and 0.1571 in cultivated land. In the mean time, 0.9242 forest cover will remain in same position but minor areas will be changed into in urban area, water, cultivated and sandy area. In the transition matrix, 0.4694 cultivated land will be converted into urban, 0.0204 in water, 0.0446 in open field, 0.0127 in forest, 0.4251 area will remain in cultivated and 0.0278 will be changed in sandy area in 2021.

Table 6 shows the land use / land cover change of Pokhara in between 2010 to 2021. According to the analysis, 28.44 (Km²) 51.42% area has been covered by urban in 2010 but this area will have covered 32.45 Km² (58.67%) in 2021. Projected table of 2021 defines that cultivated land will have decreased. Cultivated area has covered 11.21 Km² (20.27 %) in 2010 but it will have covered 7.35 Km² (13.29%) in 2021. Forest coverage and open field areas will have increased by minor ratio. Sandy area will be decreased in 2021 and will cover 2.60 Km² (4.70%) of the total land. During this period, 4.01 Km² (7.45%) urban area will be increased but 3.86 Km² (6.98%) cultivated land will have decreased. Similarly, 0.29 Km² (0.53%) open field and 0.22Km² (0.39%) forest area will have expanded in 2021.

Table 5 : Transitional Probability Matrix table derived from the land use land cover map of 1999 and 2010

	Urban	Water	Open	Forest	Cultivated	Sandy
Urban	0.8945	0.0194	0.0243	0.0028	0.0496	0.0095
Water	0.0838	0.8327	0.0286	0.0128	0.0233	0.0198
Open	0.1402	0.0209	0.7162	0.0000	0.1128	0.0099
Forest	0.0196	0.0215	0.0000	0.9242	0.0327	0.0019
Cultivated	0.4694	0.0204	0.0446	0.0127	0.4251	0.0278
Sandy	0.1702	0.0572	0.0324	0.0006	0.1571	0.5824

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Table 6 : *Land use statistic of Pokhara Sub- Metropolitan,2010-2021*

Years	2010		2021 Projection		Magnitude 2010-2021	
Land use type	Km²	%	Km²	%	Km²	%
Urban/ Builtup	28.44	51.42	32.45	58.67	+4.01	+7.45
Water Body	7.02	12.69	6.92	12.51	-0.10	-0.18
Open field	4.26	7.70	4.55	8.23	+0.29	+0.53
Forest Cover	1.22	2.21	1.44	2.60	+0.22	+0.39
Cultivated Land	11.21	20.27	7.35	13.29	-3.86	-6.98
Sandy Area	3.16	5.71	2.60	4.70	-0.56	-1.01
Total	55.31	100	55.31	100		

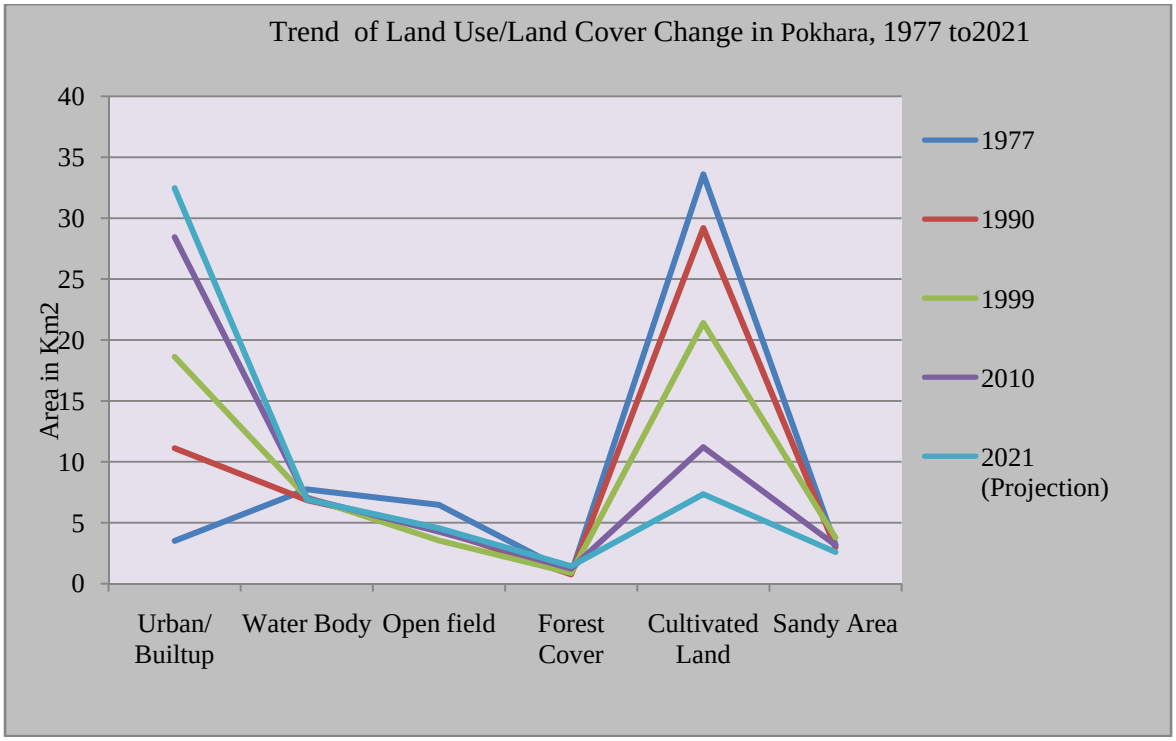

Figure 8 : Trend of Land Use Land cover Change in Pokhara, 1977-2021

5. CONCLUSION

From the above study it can be concluded that there is remarkable increase in urban area in Pokhara city. Urban accessibility is vitally responsible for the development of urbanization. In the last five decades or so, the population of Pokhara has increased by the factor of 41.62 times (1952/54/2001). The land use in the city experienced rapid changes since the urbanization process. Current data models in GIS provide inadequent support for the tasks of modeling the land development processes. Urban planning concerns actions located in space and time. It comes as no surprise, therefore significant progress in the quantification and understanding of land-use/land cover changes has been achieved over the last decade. The use of remotely sensed data showed that Pokhara has had a significant change in land use cover over the last 33 years. The study has mentioned remotely sensed data can provide information for effective routine tasks related to environmental inventorying and monitoring. Pokhara, the fast growing city of western Nepal is now undergoing a major land cover change through the conversion of

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agricultural land into residential and commercial developments. Migration is a very complex phenomenon and a tremendous challenge for Pokhara city and its local authorities, who are at the sharp end of integrating many different groups of people. Due to the rapid urbanization process, huge transition in land use and land cover has occurred. It has created imbalance in the biological and social environment. In the name of utilization, people are blindly destroying the natural resources.

This study has assessed and modeled the trend of urban land cover changes in the area by using an integrated approach including GIS, RS, and modeling tools. LULC maps of the study area for the years 1977, 1990, 1999and 2010 were obtained with the help of an object-oriented approach. The derived maps have provided new information on spatial-temporal distributions of built-up areas in the region. The information presented in this report not only presents urgent and needed statistical information but also provide a spatial context to this information. This complete task set can serve as a tool for policy-formation and evaluation, planning and natural resource management in the city. The model has provided a vision of the future, good or bad, that it is hoped will draw public attention and increase environmental awareness.

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