Earthquake Risk Reduction and Recovery Preparedness Programme for Nepal

UNDP/ERRRP – Project Nep/07/010

Report on Impact of Settlement Pattern, Land-Use Practice and Options in High Risk Areas

Pokhara Sub-Metropolitan City

Final Report

July 2009

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Preparation of Municipal Profile in terms of Earthquake Risk and Vulnerability" and "Report on impact of settlement pattern, land use practice and options in high risk areas" of five municipalities (Biratnagar, Hetauda, Pokhara, Birendranagar and Dhanagadhi)

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This document is the outcome of the study "Preparation of Municipal Profile in Terms of Earthquake Risk and Vulnerability" and "Report on Impact of Settlement Pattern, Land Use Practice and Options In High Risk Areas" of five municipalities (Biratnagar, Hetauda, Pokhara, Birendranagar and Dhangadhi) under the Earthquake Risk Reduction and Recovery Preparedness Program for Nepal (UNDP/ERRRP-Project Nep/07/010). This document presents the context of land use in the municipality and also presents the scenario of earthquake hazard to the land use changes. Based on the scenario of earthquake hazard, risk sensitive land use plan is recommended and presented in this report.

This document has been prepared by GENESIS Consultancy (P) Ltd. for UNDP/ERRRP. The opinions, findings and conclusions expressed herein are those of the authors/Consultant and do not necessarily reflect those of UNDP/ERRRP.

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Abbreviations

CBO	Community Based Organizations
DDC	District Development Committee
DAO	District Administration Office
DHUD	Department of Housing and Urban Development
DO	Division Office
DUDBC	Department of Urban Development and Building Construction
ERRRP	Earthquake Risk Reduction and Recovery Preparedness Programme
GoN	Government of Nepal
INGO	International Non-Governmental Organization
MDGs	Millennium Development Goals
MMI	Modified Mercalli Intensity
MLD	Ministry of Local Development
MoHA	Ministry of Home Affairs
NBC	National Building Code
MPPW	Ministry of Physical Planning and Works
NGO	Non- Governmental Organization
UNDP	United Nations Development Programme
UEIP	Urban Environmental Improvement Project

Executive summary

The report *"Impact of Settlement Pattern, Land Use Practice and Options in High Risk Areas"* has been prepared as a land use profile in terms of earthquake hazard. The report has been prepared with a rationale to give an overview of urban development and land use change pattern and risk of development in hazard prone areas. This study assesses the land use change pattern and models the future land use to assess the risk in a scenario of such land use change and earthquake hazard. Based on this scenario study, risk sensitive land use plan is recommended for municipal land use policy formulation and implementation of building regulations and by-laws.

Pokhara sub-metropolitan city is the capital of both the western development region and the Kaski district. Situated on the southern foot of Annapurna Himalayan range Pokhara is a second largest urban centre in the hills of Nepal. The development of Pokhara took place in an extensive and ribbon wise way in the beginning as the city was flourished in the form of commercial centre along the transportation route. Pokhara sub-metropolitan city has experienced rapid growth especially in the past decade, which might be due to the political instability of the past decade. The private plotting in the sub-metropolitan city area is becoming widespread, violating the standards and land use plan. The mixed residential and commercial areas are emerging in the sub-metropolitan city regardless to the hazard prone areas or geologically unsuitable areas, making the population more vulnerable towards disasters. Rapid urban development and land conversion is evident in areas of ward 17, 14 and 13.The city core lacks open spaces and the remaining ones are also at the risk of encroachment. The social infrastructures like hospital and other facilities are inadequate and some hospitals are themselves vulnerable and may not function at the time of disasters.

Pokhara Sub-Metropolitan City can be considered as moderately vulnerable to earthquake hazard with probability of intensity of VIII MMI earthquake in the region. In the sub-metropolitan city area high liquefaction susceptible zones are found in the banks and tributaries of Seti River and some patches of liquefaction susceptible zones are found in KI Singh bridge area, Laltin Bazar, Kamal Pokhari areas. The sinkhole collapse prone areas were identified in Chipledhunga areas, Mahendra Pul, Male Patan, Manaswar, Baidam, Simal Tunda, Bhagerthan and other areas which belong to the core areas of Pokhara sub-metropolitan city. Lama Chaur, Battule Chaur , Tersa pati and Male Patan areas were found to have high susceptibility to sinkhole hazard. The low bearing capacity areas were identified in Kamalpokhari and Mahendra cave areas, which remain grossly inappropriate for building construction. The status of land use change reveals that change in built-up area from 1979 to 1996 was of 322% increase and from 1996 to 2007 the growth of built-up area was of 116%. Simulation and modeling of built-up area in 2021 for land suitability reveals that, 52.43% of the built-up areas will be on high sinkhole hazard susceptible areas, 17.07% on medium sinkhole hazard susceptible areas if current trend of built-up expansion is permitted.

For risk sensitive land use planning, the sub-metropolis area is divided into three zones, namely restricted area, special consideration required area and suitable area for urban expansion. As the urban areas are expanding over high liquefaction and sinkhole susceptible areas, the new construction should be restricted in those areas and in inevitable cases, mandatory regulations for approval of structural design and analysis for a new construction should be enacted. The new developments should be promoted in the south-east part of the metropolitan area where the land is relatively safer for urban expansion. The building code implementation for new construction should be made and urban densification programmes should be launched in the areas stated as suitable areas with extension of adequate urban infrastructural facilities.

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Introduction

1.1. Background

Nepal is ravaged by multiple natural hazards annually resulting in significant number of loss of lives and properties. Epidemics, floods and landslides are among the most frequent natural hazards with high magnitudes and intensities occurring throughout the country. Earthquake, cyclonic wind, thunderstorm, drought, famine, cloudburst, fire, avalanche are often recurring natural disasters in the country. In terms of vulnerability to natural disasters, UNDP/BPCR has ranked Nepal as the eleventh in terms of risk from earthquakes and thirtieth in terms of risk from flood (UNDP/BCPR 2004).

Nepal's location in a highly active tectonic region of the Himalayan belt has increased the risk of earthquake disaster in the region. The subduction of Indian plate under the Tibetan plate is considered as the major source of seismicity in the region. Over the last century, great earthquakes in the Himalayan region occurred in 1803, 1833, 1897, 1905, 1934 and 1950 (Bilham, Gaur, and Molnar 2001). Seismic records showed the 1833 earthquake in Nepal, 1879 earthquake in Shilong, 1905 earthquake in Kangra, 1934 earthquake in Bihar-Nepal and 1950 earthquake in Assam also caused deaths of thousands of people.

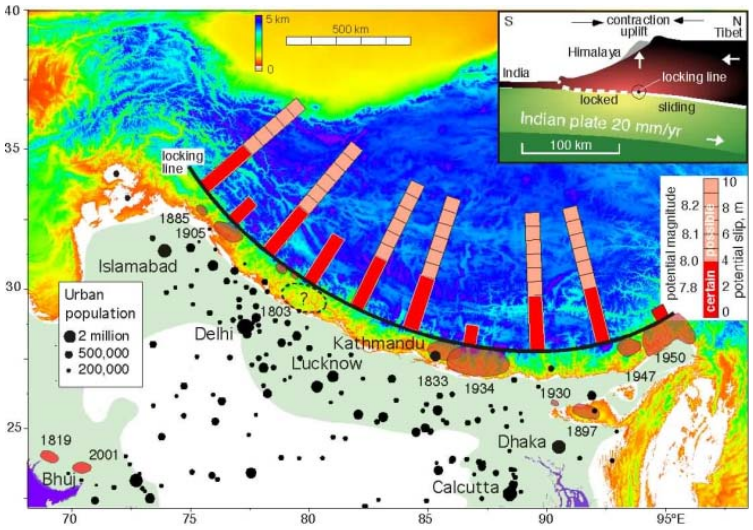


Figure 1 Estimated slip potential along the Himalaya and urban populations south of the Himalaya (Bilham, Gaur, and Molnar 2001)

Seismic records for Nepal date back to 1255 and since that time several destructive earthquakes have occurred in 1408, 1681, 1810, 1833, 1866 and 1934. The 1934 Bihar-Nepal earthquake with magnitude of 8.4 took a toll of 4,300 people, destroying about 20 percent of all structures and damaging another 40 percent of buildings in Kathmandu Valley. This earthquake was believed to rupture a 200-300 km long segment to the east of Kathmandu (Pandey and Molnar 1988). In recent decade, Nepal experienced two major earthquakes: a 6.5 magnitude quake in Bajhang district that killed 178 people and destroyed about 40,000 buildings and a 6.6 magnitude quake in Udayapur district that killed 721 people and destroyed 64,467 buildings (Earthquake and Megacities Initiative 2005).

In 2005, the Western Himalaya was hit by an earthquake with magnitude 7.4 killing more than 74,000 people in Pakistan and India. The location of ruptured areas shows a gap along the mountain range between the location of the 1905 Kangra and 1934 Bihar-Nepal earthquakes. It is believed that this region has not experienced such an earthquake since the last large earthquake. This portion of the

arc is thus refer to as a *'seismic gap'* (Figure 2), a potential location for the next large earthquake. This earthquake scenario evidently indicates that the entire Himalayan belt is one of the most vulnerable zones in terms of seismic hazard. Recent works on fault modelling (Chamlagain and Hayashi 2007) of Nepal Himalaya has shown continuous accumulation of elastic strain to reactivate older geological faults to generate earthquake of different magnitude. Moreover, several other lines of evidence (e.g. neotectonic, geomorphological, geophysical, geological, and seismological) also show that one or more mega-earthquakes may be overdue in a large fraction of the Himalaya (probably area between Kathmandu and Dehradun), threatening millions of people in the region.

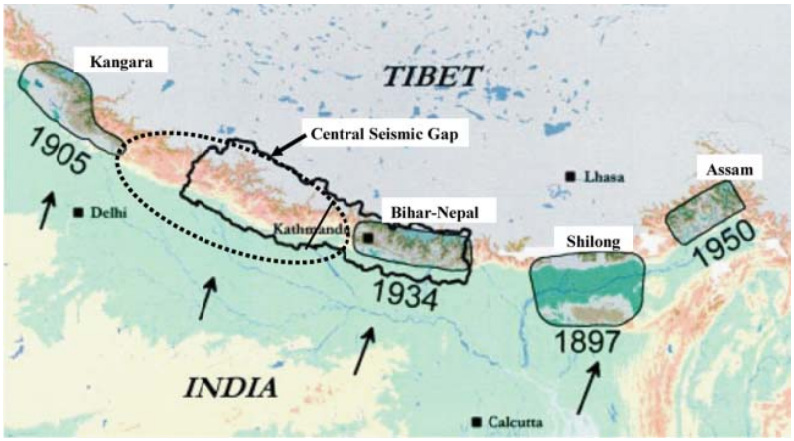


Figure 2 Distribution of probable rapture zones of 1879, 1905, 1934 and 1950 earthquakes along the Himalayan arc. Modified from (Yeats and Lillie 1991; Yeats et al. 1992)

Recently, Wyss (Wyss 2005) have calculated expected deaths and injuries for this region as the minimum fatalities of about 15,000 for an event located in sparsely populated western Nepal, to a maximum of approximately 150,000 deaths for an event located near the Dehradun segment in India, assuming the standard magnitude of 8.1. The number of injured is ex-

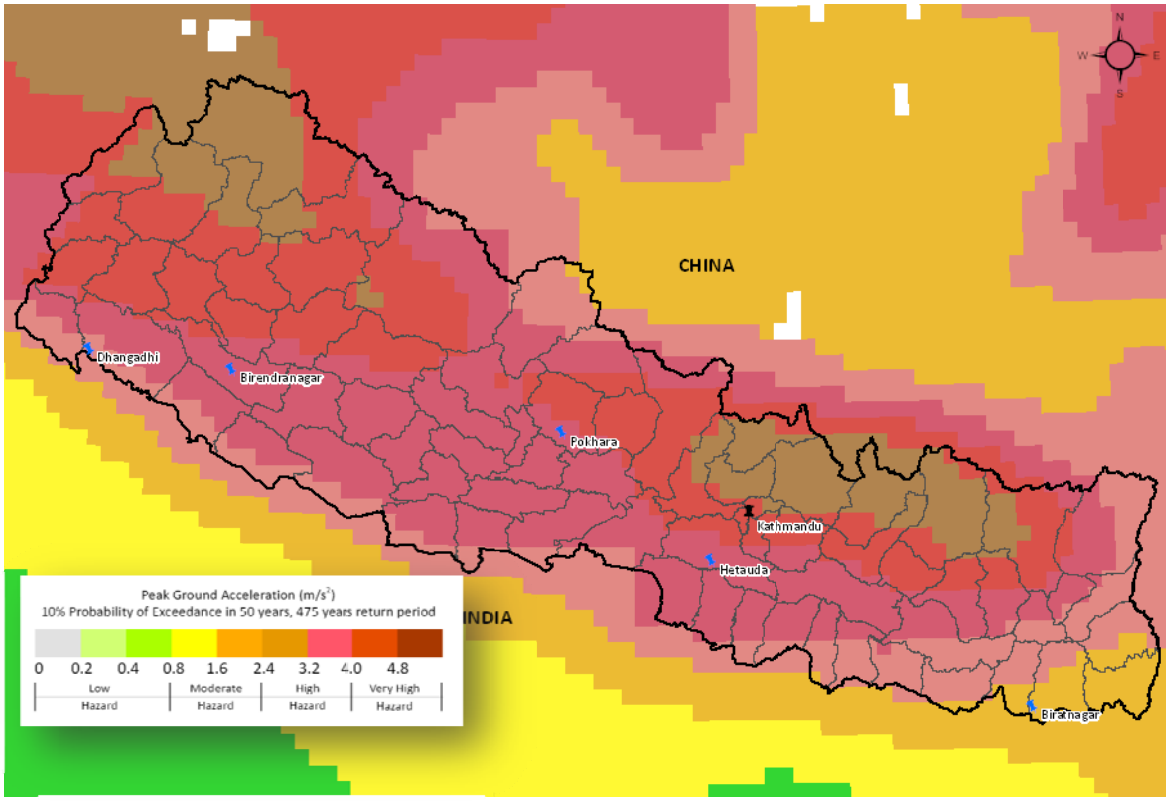


Figure 3 GSHAP seismic hazard map of Nepal [Adopted from (Giardini et al. 1999)]

pected to range from 40,000 to 250,000, approximately due to this earthquake.

This prediction also suggests that a potentially large earthquake of magnitude greater than 8 is overdue in the western half of the country. The GSHAP (Giardini et al. 1999) seismic hazard map shows that the entire country falls in a high earthquake intensity region of seismic risk scale corresponding to MMI[1] IX and X. The far western and eastern mountainous regions are the most hazardous regions with rest of entire hilly and the Terai regions lying in a high earthquake hazard zone. The hilly regions and the southern Terai region are the most densely populated areas of the country with a probability of very high population loss in an event of a major earthquake in the region.

The level of risk has been increased further in our cities due to high urban growth rates and consequent high physical exposure and lack of preparedness. There are number of factors that contribute to the configuration of risk in cities. Firstly the location of the city in terms of geology and seismological hazard; secondly the urbanisation process which leads to the concentration of populations in risk-prone cities, and risk–prone locations within cities; thirdly, in the cities with transient or migrant populations where social and economic networks tend to be loose (UNDP/BCPR 2004). This is the case in the Nepalese context, where urban cities are located in hazardous zones prone to multihazards with large number of exposed populations, augmented by population growth rate that exceeds 7 percent annually resulting in haphazard urban growth consequently resulting in the growth of urban divide in terms of economic, social and preparedness to disasters. It is often the poor, especially minority groups, who are socially excluded and politically marginalised, leading to the lack of access to resources and increased vulnerability.

There is a fourth factor relevant to the Nepalese context viz. good governance and political will to initiate and drive disaster preparedness. Appropriate governance is fundamental if risk considerations are to be factored into development planning and if existing risks are to be successfully mitigated (UNDP/BCPR 2004). However, there is a severe deficiency in mainstreaming disaster risks and preparedness in the development and land use plans at central and local levels, both politically and technically. This is the primary reason that besets our municipal organizations rendering them unprepared and in many cases incapable to cope with major natural disasters and their immediate and long term impacts on different facets of urban fabric.

1.2. Earthquake Risk Reduction and Recovery Preparedness Programme for Nepal

The World Conference Disaster Reduction held from 18 to 22 January 2005 in Kobe, Hyogo, Japan has adopted the Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disaster. This framework termed as the *'Hyogo Framework for Action (HFA)'* is a global blueprint for disaster risk reduction efforts during the next decade. Its goal is to substantially reduce disaster losses by 2015 - in lives, and in the social, economic, and environmental assets of communities and countries (International Strategy for Disaster Reduction (ISDR) 2005). The framework offers guiding principles, priorities for action and practical means for achieving disaster resilience for vulnerable communities. These priority actions include:

- Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
- Identify, assess and monitor disaster risks and enhance early warning.
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthen disaster preparedness for effective response at all levels.

The South Asian Association for Regional Cooperation (SAARC) has developed risk reduction strategies based on the recommendation of the HFA. The UNDP/BCPR with the support of Government of Japan has initiated an Earthquake Risk Reduction and Recovery Preparedness (ERRRP) program in five high risk south Asian countries: Nepal, Bhutan, Bangladesh, India and Pakistan. The project in Nepal is a part of the five country regional programme in South Asia that seeks to support regional cooperation through knowledge sharing and development of best practices in the context of the SAARC Comprehensive Framework on Disaster Management agreed in February 2006 (UNDP). The country programme for Nepal is implemented through the National Implementing (NIM) project of UNDP-Nepal under project award UNDP/ERRRP-Project Nep/07/010 under a multi-year funding framework for natural disaster reduction from the Government of Japan.

The country programme is designed, in the context of the International Recovery Platform (IRP) for the fulfillment of HFA with a primary goal to reduce the impact of potential earthquakes on seismically vulnerable communities in Nepal. The programme aims to strengthen national capacity (at institutional and community levels) for pre-disaster preparedness and mitigation and post-disaster recovery planning with focus on targeted earthquake-prone urban areas of Nepal. The key activities the programme aims to implement are:

- Conduct earthquake risk, vulnerability and capacity assessment in the project areas, especially from gender and poverty perspective, to support the government and communities.
- Enhance capacities of government institutions and communities living in high risk areas to adapt and implement earthquake preparedness planning and safe construction practice using appropriate earthquake resistant construction guidelines.
- Strengthen capacities of the government in disaster recovery preparedness to support enhanced recovery operations in post-disaster situations.
- Develop capacities of the government to implement national disaster management framework by supporting locally appropriate solutions for earthquake risk reduction proposed by Nepal.

These program activities to achieve the overall goal are being implemented by the Government of Nepal (GoN) through different ministries.

- Ministry of Physical Planning and Works (MPPW), Department of Urban Development and Building Construction (DUDBC), responsible for the overall implementation of the project as the focal agency in GoN for implementation of National Building Code (NBC).
- Ministry of Home Affairs (MoHA), responsible for inter-ministerial coordination as the nodal agency in GoN for disaster management.
- Ministry of Local Development (MLD), responsible for inter-municipality coordination as the focal agency in GoN for all local development coordination.
- Selected programme municipalities, responsible for the implementation of municipal level activities of the programme.

The programme has selected five urban municipal areas in five different development regions of Nepal. These municipalities are Dhangadhi Municipality in the Far-western region, Birendranagar Municipality in the Mid-western, Pokhara Sub-Metropolitan City in the Western region, Hetauda Municipality in the Central region and Biratnagar Sub-Metropolitan City in the Eastern region of the country.

Under the programme, the UNDP/ERRPP has initiated the study for assessing the earthquake hazard, risk and vulnerability in the programme municipalities and to develop a framework for earthquake disaster preparedness planning. The programme has also aimed to study the land use trends and impact of earthquake hazard in the settlement pattern and land use practice. With these aims, the

programme has aimed to prepare *"Municipal Profiles in terms of Earthquake Risk and Vulnerability"* and *"Impact of Settlement Pattern, Land Use Practice and Options in High Risk Areas" for* its programme municipalities.

Figure 4 UNDP/ERRRP program municipalities

1.3. Report on Impact of Settlement Pattern, Land Use Pracitce and Options in High Risk Areas

The report *"Impact of Settlement Pattern, Land Use Practice and Options in High Risk Areas"* has been prepared as a land use profile in terms of earthquake hazard. The report has been prepared with a rationale to give an overview of urban development and land use change pattern and risk of development in hazard prone areas. This study assesses the land use change pattern and models the future land use to assess the risk in a scenario of such land use change and earthquake hazard. Based on this scenario study, risk sensitive land use plan is recommended for municipal land use policy formulation and implementation of building regulations and by-laws. The study for the preparation of the land use report has undertaken the following tasks:

- Review of the existing documents and literatures and best practices
- Review of literatures and documents on regional geology and past earthquake scenarios
- Discussion and interaction with stakeholder municipality, key informants and local senior citizens
- Historic land use pattern mapping and urban morphology land use dynamic assessment
- Mapping of current land use and trend assessment
- Modelling of land use change and settlement pattern and prediction of future land use
- Assessment of earthquake hazard in land use and settlement pattern
- Recommendations for risk sensitive land use development plan

This report is expected to serve as a road map for land use planning and formulation of building-bylaws at the municipal levels and provide guidelines to integrate risk sensitive land use plans in municipal level development and periodic plans.

1.4. Methodology

1.4.1. Historical Land Use Study

Historical land use trend study involved multiple analysis techniques such as key informants meetings, focus group discussions, collection of secondary data and aerial photo interpretations, which are briefly described hereunder.

Aerial Photo and Satellite Image Interpretation

The aerial photographs of different time period viz.1978 and 1999 are interpreted for land use study in historical context and for the detection of change and identification of catalysts for change. The aerial photographs have been acquired from the Survey Department for the study. The aerial photographs were scanned and photogrammetrically processed (orthorectified and mosaicked) for visual interpretation of land use of the years 1978 and 1999. Land use GIS database was developed for the years 1978 and 1999 with relevant attributes of various land use classes.

Focus Group Discussion

Focus group discussions were held in each municipality that involve senior citizens, historians, retired governmental officers and native residents of the municipality. The discussions were held in order to detect temporal changes, historical development pattern, catalysts for change and socio-economic characteristics of the municipality. The participatory mapping techniques were used for visualizing the scenario and extracting data from the informants.

Collection of Secondary Data

All the available published data related to the history of the municipality, its initial settlement pattern and temporal changes are collected from various sources such as old newspapers, published literatures from the historians and researchers that provide the historical glimpse of the settlement and its formation.

1.4.2. Current Land Use Study

Satellite image interpretation

High resolution Quickbird 0.6m satellite imagery of 2006 were used for interpretation of land use for the year 2006/7. This satellite ortho image was obtained from DUDBC/Statistical and GIS Section for the study.

Field Observations

Field observations were made on every municipality that covered entire of the municipal area for collection of data related to socio-economic pattern of settlement, newly built-urban spaces for the field verification of the changes in the land use and built-up pattern.

Land Subdivision and Land Price Study

The study team conducted the survey of newly developed urban areas and areas with rapid land sub-divisions. Similarly the land sub-division and land price fluctuation are the indicators for the land use change which are monitored throughout municipality for identification of areas that are liable for fastest conversion. Private land developers and governmental developed land are also identified through this process.

Existing Urban Density Study

The existing urban density map of municipality is generated using GIS, where Kernel density estimation function was used with 100m of search radius and 1sq.m pixel size of output raster. The existing urban density map, which is the indication of closeness of existing built-up, is necessary for post disaster recovery measures in the municipality as high casualties tend to result from the denser areas.

Key Informants Meetings

Key informant's meetings and Interviews were held with the acting Executive Officer, project focal person, municipality engineers, DUDBC/Division Office personnel, as well as I/NGOs such as personnel of Red-Cross Society of Nepal for documenting the current building practices, institutional framework for implementing and regulating the building code, municipal policy for land use, institutional capacity for pre and post disaster mitigation, emergency response. The interviews was also conducted with responsible personnel in hospitals, district administration office and District Development Committee (DDC) and other related organizations regarding the preparedness and post disaster planning strategies.

1.4.3. Future Land Use Prediction

Study of land use change factors: Future projection of land use is done basically regarding the urban sprawl that is most likely to be expected under several conditions. The basic factors that affect the change in land use are outlined here under:

a. Demographic factors

- Population Density
- Annual Population growth
- Migration

b. Topographical factors - Availability of the areas for expansion, slope land, dry land
c. Access to Infrastructural facilities- Road Network
d. Economic Development

- Market availability and Distance

- Cost of Conversion and opportunity cost

e. Private land Developers- plotting.
f. Governmental Policies- Future projects and policies
g. Social factors

- Affluence
- Human Attitudes and Cultural Values
- Food Security

h. Policies related to land use control

- Zoning and byelaws
- Land use Plan
- Subdivision regulations

i. Growth of a city as a Commercial and administrative Centre
j. Weather and Climatic factors

Ranking of Factors

From the evaluation of each and every factors listed above are evaluated for the project municipalities and based on the incidence of the factor, the weight age is given to each and every factors which varies according to municipalities. While analyzing the future land use, river, road, sand, water body, religious areas, institutional area, educational areas and industrial areas are assumed to be static while built-up area is assumed to be variable over time.

Use of Land Use Change Forecast Tools

The weighed factors and the chronological land use map of different years are feed into the land use prediction and forecast tools such as "What-If analysis" for analyzing the current trend of land use change and for the future land use prediction.

1.4.4. Analysis of Earthquake vulnerability scenarios under future land use practices

Scenario development

The scenario development was done in two stages, to identify the vulnerability status in current stage as well as future trend. The existing land use map of the municipality is overlain on the sensitivity map, which is a composite of liquefaction susceptibility map, geological formation map, and peak ground acceleration map. The GIS based analysis of the existing land use vis-à-vis land use sensitivity map reveals the current vulnerability scenario of built-up area. The same method is applied for the projected land use, for the identification of future vulnerability scenario if the current trend is permitted in municipality.

Hazard area identification

The identification of hazard areas such as areas susceptible to liquefaction and sinkhole hazards, slope areas and areas that are unsuitable for building construction due to topography is identified for mu-

nicipalities in GIS environment. The hazard areas area either defined as restricted areas for urban development or areas that require special considerations for the construction purpose.

1.4.5. Recommendations for risk sensitive land use plan

Land suitability analysis

The land suitability analysis is done in the form of classification of land into suitable areas for urban expansion, unsuitable areas for urban expansion, unsuitable areas due to topography and areas that require special consideration for built-up areas. The categorization is based on several categories such as sustainability of land use, earthquake safety and socio-economic perspectives.

1.4.6. Identification and Mapping of Open Spaces

Identification of open spaces: The available open spaces in municipalities are identified and mapped. The selection of the available open spaces is based on the criteria, which are listed hereunder:

a. Condition of locale

- Centrality of the Space- within or adjacent to urban built-up areas
- Proximity to target population- Residential distribution and density
- Accessibility-Mild topography and no obstruction
- Linkage- Road linkage and wider roads

b. Quantitative measures

- Size of open space- Area
- Accommodation- Number of evacuees

c. Types of facilities

- Proximity to Water supply facility
- Proximity to security services- Police station
- Proximity to health care facilities- Hospital, ambulances
- Proximity to social institutions- INGOs, NGOs, CBOs
- Site design
- Ease of access

Ranking of Open Spaces

The selected open spaces are ranked based on its suitability or functionality. The open spaces are ranked from 1 to N, where the rank 1 symbolized the best suitable open space according to its size and facilities that are within its proximity. While ranking the available open spaces, the weight of 60 percent has been given to available area of the open space and 10 percent each to the security services available, social services available, health facilities and water supply sources.

1.5. Pokhara Sub-Metropolitan City – An Overview

Pokhara sub-metropolitan city is the capital of both the western development region and the Kaski district. Situated on the southern foot of Annapurna Himalayan range Pokhara is a second largest urban center in the hills of Nepal. Pokhara is known for its panoramic views of Annapurna, Dhaulagiri and lamjung Himalayan ranges.

Pokhara sub-metropolitan city covers an area of 55.66 sq. km and covers 2.7 percent area of the district and 0.04% area of the nation. The sub-metropolitan city shares its border with lekhnath municipality, Kahun and Arwa village development committees in the west, Armala, Chhahrepani, Lamachaur and Hemja VDCs in the north and Kristi Nachne Chaur, Nirmal Pokhari and Bharat Pokhari VDCs in the south. The Pokhara sub-metropolitan city is divided into 18 wards. The Major River of the sub-metropolitan city is Seti River and the major lake is Phewa Lake. The average temperature in Pokhara sub-metropolitan city ranges from 31°c to 6°c with an average annual rainfall of 3880mm. The elevation ranges from 6501m to 963m above sea level.

The sub-metropolitan city constitutes of tectonic valley between main Himalayan range and Mahabharat range and constitute of gravelly surface slanting from northwest to southeast. Elevation in Pokhara ranges from 627 to 980 amsl. River seti with deep gorges and its tributaries and lake Phewa are prominent drainage in Pokhara. Pokhara was proclaimed sub-metropolitan city in the year 1996. According to the 2001 census, the total population of Pokhara was 156,312.

Figure 5 Location of Pokhara Sub-Metropolitan City

Chapter 2
Land Use – A Context

2.1. Land and Land Resources

"Land is a delineable area of the earth's terrestrial surface, encompassing all attributes of the biosphere immediately above or below this surface including those of the near-surface climate the soil and terrain forms, the surface hydrology (including shallow lakes, rivers, marshes, and swamps), the near-surface sedimentary layers and associated groundwater reserve, the plant and animal populations, the human settlement pattern and physical results of past and present human activity (terracing, water storage or drainage structures, roads, buildings, etc.)." *(Khanal, 2002)*

Land is defined as a physical entity in terms of its topography and is spatial in nature. The broader integrative view includes natural resources: the soils, minerals, water and biota that the land comprises. These components are organized in ecosystems which provide a variety of services essential to the maintenance of the integrity of life-support systems and the productive capacity of the environment. Land is a finite resource, while the natural resources it supports can vary over time and according to management conditions and uses. Land is associated with the economic values and change in the use of land for maximum commercial profit and competition has resulted sub optimal use of land and land resource.

2.2. Land Use/Land Cover

Land cover is the biophysical state of the earth surface and immediate subsurface, which includes biotic diversity, soil quality etc. Land cover is the distribution of physical characteristics of earth's surface in the form of vegetation, water-body, desert, ice, forest and other coverage features on the earth surface including human activities such as mine exposure and settlement (Baulies and Szejwach, 1998, cf: Khanal, 2002). Land use involves the manner in which the natural land cover is manipulated by a human agent as well as the intent of manipulation or the purpose for which the land is utilized. The Land use pattern is a resultant of the interaction of various physical, socio-economic, environmental and political factors and people's responsiveness towards these forces. The shift in the intent and utilization of the existing land use in response to the economic, physical, environmental or other factors constitute the land use change.

The process of land use change is very complex phenomena and takes the pathways with different magnitude and pace. Among the factors responsible for land use change, economic factor is seemed as a most predominant one. In economic terms, land is valued as per its utility and return from it and the competition exists for the best use of land which will yield maximum profit. Ricardo in 1951 has postulated the rent theory to explain the land use change in economic terms. According to him, if land is intensively cultivated, the law of diminishing return is applied and increase in demand makes it necessary to bring in new and inferior land into use. This suggests that human beings seeks to maximize their gains by obtaining the highest possible return for any given resources or seek to economize using the smallest quantity of resource to obtain certain result. Similarly, Chayanov in 1966 postulated a theory that major determinants of the land use change are the market availability and prospects for the higher rate of return. (Khanal, 2002)

2.3. Models of Urban Land Use

Land use models have been put forward on the basis of the idea that urban areas tend to develop in a distinctive patterns of land use. Relative context to distance cost and time has high influence in the flow of commodities, labour, capital, goods, through which production, consumption and distribution of commodities takes place and as a result determines the land use. According to the Von Thunen (1825), the economic return of land varies with respect to location from the market. The model explains that the land rent decreases proportionately to the distance from urban centre.

Similarly Jonasson and Van Volkengurb and Held applied the Von Thunen model and found out that, with the improvement of the transportation, the radius of land use zones becomes greater but the concentric zone is still recognized in the model. A uniform transport system results in a transport cost directly proportional to distance from the town. These two factors together exert influence upon the spatial pattern of land use.

Burgess (1925) observed that there was a correlation between the distance from the urban centre and socio economic status of the inhabitants. Burgess also observed that the urban centre would cause it to expand outwards from the urban centre, as the city grows making the pattern outward growing concentric rings.

Hoyt (1939) while accepting the existence of urban centre and central business district suggested that various socio-economic groups expand outwards from the city centre along the main transportation arteries and theorized that cities tend to grow in a wedge shaped patterns emanating from the city centre and centreed on the main transportation routes.

The multiple nuclei model as applied to urban areas was first suggested by R.M. Hurd and R.D. Mckenzie and later elaborated upon by C.D. Harris and E.L Ullman (1964). The basic notion of the multiple nuclei model is that urban land uses concentrate around several nuclei rather than a single core. The model is the amalgam of Burgess and Hoyt's model with the addition of multiple nucleuses. The model suggests the several growth centres for a particular kind of land use such as industry, retail or high-quality housing and these nuclei expand and merge to form a single urban area.

The influence of multiple urban centres and flow of goods and services, information and technology has been suggested by spatial interaction models such as gravity model based on Newtonian physics. The model of interaction between two centres is shown by Zipf in 1949 suggesting that interaction between two centres is directly related to the product of their mass and inversely related to the square of the distance between them.

Haggerstand in 1968 developed a model to describe the diffusion of innovation over space and time. Based on the theory of distance decay, he pointed out the probability of information being passed decline with the distance between two individuals. So the adoption of new technology is likely to be more in a nearby area of city core than in the peripheral region (Aribigbola 2007).

Allan in 1986 illustrated in his model with the combination of economic activity and how the access and infrastructure overcome altitudinal zonation and diffusion. He suggested that with the advent of road network and bridge connection, the gradient and barrier elements are removed. Diffusion of technology and economic integration into marketing network bring changes in land use in accessible areas as the agricultural land use becomes most intense and commercialized close to the road. Similarly, many schools of thought have been developed in order to explain the processes of the change due to income inequality, flow of people, goods and services and its effects.

2.4. Factors Affecting Land Use Change

The land use change incorporates several factors including the exogenous ones such as advancement in technology, Migration, market availability, infrastructural availability, governmental policies, and natural hazards etc. similarly the endogenous factors such as regional economy, socio-economic and cultural trend, demography, geographical condition and road accessibility, site and ecology contribute significantly in combination of the exogenous ones for the land use change.

The drivers that determine land use change are proximal drivers (those factors most immediate to the actual change), social drivers, and biophysical drivers; which are flows of energy or materials or information that arise from identifiable systems or agents. The complexity of the problem deepens with the understanding that three dimensions of drivers, among which two of which involve adaptive agents and systems that respond and anticipate changes in the other spheres. To identify and measure the effect of these drivers, an approach is required, that integrates the three spheres putting into the historical and cultural contexts at various scales. Each of the dimensions is implicitly multi-scalar.

Three dimensions of the driving forces indicate that each of the dimensions is implicitly multi-scalar and land use changes in multiple ways. It can change as a result of independent changes in biophysical drivers (e.g., climate and atmospheric change, natural erosion and deposition), human activity, either direct alteration (e.g., deforestation) or mediated through the biophysical realm or a more complex chain of human activity in the biophysical world which directly alters land cover. (Turner et.al, 2005)

2.5. Land Use Change and Its Impact

The existing demand of land for multiple urban uses and urban expansion is always greater than the land resource available, and there is bound to be a conflict over land use. In a developing country like Nepal, the demand is increasing every year in a present rate of population growth and urbanization in the urban areas. The haphazard urbanization has lead to the resource depletion, degradation of the urban environment, unsustainable and unhealthy living conditions and more importantly risks to multiple hazards.

Most urban areas of Nepal face the growing problems of urban sprawl, loss of natural vegetation and open space, and risk to multiple hazards. The residential and commercial development is replacing undeveloped land around them. The current rate of urban growth and the consequent land use change if left unabated or unchecked leads to the major complexities for the future generations.

Land use change has various socio-economic implications. It has profound effect on land cover and its capability and leads to degrade the land's capacity for the sustained use and capacity to regain its original cover of land. Land degradation lowers the potential capability of soil and not only affects the option of people in the affected area but also people in the downstream and future generation. It reduces crop yields, soil fertility, increase soil erosion, frequent floods and greatly damage to aquatic life through increased siltation in rivers, lakes, water reservoirs, soil water acidification and increased pollution.

Land use and land cover change has important influence on water and energy balance. The conversion of natural systems to agriculture and other use has resulted in a net release of carbon dioxide and other trace gas dynamics to the atmosphere. In turn the regional climatology and hydrology is influenced by the change in land use and land cover.

Change in land use and land cover may lead to the loss of bio-diversity and fragmentation of landscape. It affects biological diversity in three ways; the destruction of habitat, isolation of fragments of formerly contiguous habitat and edge effects within a boundary zone between forest and deforested areas. Bio diversity loss takes place at multiple levels -landscape, ecosystems, species and gene and in multiple dimensions-structure, function and process.

Land-use and land-cover change plays a pivotal role in global environmental change. It contributes significantly to earth-atmosphere interactions and biodiversity loss, is a major factor in sustainable development and human responses to global change, and is important to integrated modeling and assessment of environmental issues in general. These diverse roles have been recognized in a large number of research publications and international conferences, symposia, and workshops devoted to the subject over the past few years as well as the United Nations Agenda 21.

2.6. Land Use Planning

Planning is a systematic process in which a problem is identified, data are analyzed, and proposals are formulated to initiate desired changes and guide inevitable changes to occur in a preferred manner. The logic of land use planning is compatible with disaster risk reduction because both are systematic, future-oriented, decision-oriented, and proactive (Reyes 2007).

Land-use planning is the systematic assessment of land and resource potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a different pattern of land use dictated by changing circumstances (FAO, 1993).

Land use must be economically viable, so one goal of development planning is to make efficient and productive use of the land. For any particular land use, certain areas are better suited than others. Efficiency is achieved by matching different land uses with the areas that will yield the greatest benefits at the least cost. Another dimension of land use planning is equity and acceptability. Land use must be socially acceptable and the broader goals include food security, employment and security of income in rural areas. Land improvements and redistribution of land may be undertaken to reduce inequality or, alternatively, to attack absolute poverty. Sustainability is the another dimension of land use planning which requires a combination of production and conservation: the production of the goods needed by people now, combined with the conservation of the natural resources on which that production depends so as to ensure continued production in the future. A community that destroys its land forfeits its future. Land use has to be planned for the community as a whole because the conservation of soil, water and other land resources is often beyond the means of individual land users.

The Land use planning combines analysis, synthesis, and consensus formation. On the analytical side, the methods are primarily quantitative and statistical. On the synthesis side, the methods are primarily interactional and based on conflict management. Managing land use change is not simply preparing and adopting an “end state” master plan and expecting it to be built-out at the end of the twenty-year planning period. The approach includes an advanced planning aimed at guiding future development, it also includes actions to monitor and respond to change, to build consensus for planning goals and objectives, and to enlist public building and spending powers in plan implementation.

The externalities complicate the process of change management and it involves not only the social and technological change but also an apparent decrease in the ability to predict the change. The characteristics of the externalities are identified as accelerating rates of change, increasing scale of perturbations or shifts in conditions, increasing unpredictability of events, a continuing sense of crisis, frequent confrontations with problems so complex as to be inaccessible to normal intervention strategies and increasing time required to respond to the unanticipated consequences of actions.

To account for the externality and volatile nature of public domain, planning can be seen as a learning process in which the future is treated as an emergent state not completely predictable from present knowledge. Instead, plans are viewed as a series of approximations to be adapted to future conditions as those conditions become more evident. The techniques are both rational in attempting to project and guide the future on the basis of factual analysis and adaptive in responding strategically to unforeseen changes as they occur. The processes are regularly monitored and interpret in order to understand the stocks and flows of urbanization and to estimate the impacts of public intervention policies.

The consensus is built and community is engaged in dialogues in response to the changing demands and needs. Typically the incremental additions of new urban land and infrastructure at the fringe and deterioration of older neighbourhoods and public facilities at the core must be seriously dealt in the program ensuring that cumulative impact of these incremental changes does not disturb community continuity but does foster progressive change. No single theory of planning or urban change adequately describes the full and complexity of land use planning practice but the community need based, frequently modified, outreaching and inclusive planning practice is required for the sustainable land use practice. It involves the interest of the whole community in a sustainable basis and incorporates the anticipation of the need for change as well as reactions to it. The objectives are set by social or political imperatives and takes account of the existing situation with the best possible alternatives.

The precursor for any land use plan is the need for change in the present state of land use by people of that area, willing consent and involvement of people for the land use planning, and political will and ability to put the plan into effect. Where the conditions are not met, it may be appropriate to mount an awareness campaign or set up demonstration areas with the aim of creating the conditions necessary for effective planning.

Current trend of planning in developing countries have shown that long range projection of plans and end state allocation of land use may fail due to the error in decision-making due to unforeseen changes in economic or social conditions. It is required to have a holistic regional development strategy in perspective and have both long as well as short range goals integrated in a planning process itself is in a continuous stale of flux. The intermediate evaluator steps seek to refine and at times redefine the long range planning goals to meet the current demands and at the same time making the development sustainable.

2.7. Rationale for Land Use Plans

The urban areas in Nepal are proliferating with haphazardly constructed and substandard buildings, non-engineered dwellings as well as uncontrolled land use. Environmental degradation, urban poverty and increasing vulnerability towards natural calamities due to urban expansion in high earthquake prone areas, floods and landslide prone areas and others has exacerbated the existing urban areas.

Urban vulnerability is largely a consequence of improper urban management, inadequate land use planning, ill-regulated population density, poor construction practices, ecological imbalance, infrastructure dependency, and inadequate provision for open spaces. The accumulation of risks because of all of the pervasive situation and inappropriate decisions made in the past aggravate the vulnerability.

The worsening vulnerability of urban areas is one of the primary reasons for rising disaster losses. The concept of vulnerability recognizes that a natural hazard alone by itself does not cause a disaster, but a disaster happens as an outcome of the interaction of biophysical condition or the presence of a natural hazard, and vulnerable conditions of people exposed to such hazards (Smith, 1996; Blaikie et al., 1994 cf:(Reyes 2007)).

The utility of land use planning in disaster risk reduction is still not so widely recognized much less taken advantage of by policy makers and local planners themselves and it is a high time to methodologically integrate risk reduction in land use planning. Reducing the risk of urban areas towards disaster is a systematic development and application of policies, strategies, and practices to minimize vulnerabilities and risks throughout a society, to avoid or to limit adverse impacts of hazards, within the broad context of sustainable development.

The process of land use planning offer many opportunities and options to reduce human, economic, and physical losses due to natural disasters.

- Land use planning can identify and mitigate the root causes of disaster risk that are entrenched in the current land and settlements development practices.
- It can modify and reduce existing vulnerable conditions of people and places that have accumulated through years.
- It can reduce disaster damage before they happen instead of cleaning it up in the aftermath of a disaster.
- Land use planning may also modify the source of hazard, when possible, as in cases of floods and droughts.
- By reducing vulnerability and potential losses, people and places increase their resilience to disasters, enhance their ability to recover, and hasten the process of reconstruction and rehabilitation.
- Mainstreaming risk and vulnerability reduction in land use planning helps achieve urban growth and development without generating new risks.

Integrated vulnerability assessment and land use planning procedure combines the assessment of hazards, vulnerability and risk with the standard planning process. It is only possible when vulnerability assessment procedure that seeks to reduce risks have a factual and scientific basis. In order to use planning tools and techniques for risk reduction, it is necessary to evaluate the factors contributing to those risks. Integrated land use planning incorporates hazard identification and evaluation (e.g. analysis of frequency, severity/magnitude, return period or probability of a hazard of seismicity of given severity), vulnerability analysis (e.g. loss of life, injury, building damage, economic impacts), and potential damage assessment (e.g. loss estimation), or collectively termed as vulnerability assessment.

Applying land use planning techniques in vulnerability assessment and risk reduction includes a comprehensive analysis of the land use behavior and translation of those risk assessment into location of land uses, functions, facilities and into land use regulations and policies. Land use planning offers a wide range of techniques and tools that can help mitigate and prevent adverse impacts of seismicity and other disasters and enhance the resilience of urban areas to disasters. Some regulatory and non-

regulatory planning tools involves location and structural approaches, e.g. land subdivision regulations, design of critical facilities and lifelines, zoning, building code implementation, and taxation. The commonly use planning tools and techniques used for risk reduction include:

- Zoning and zoning ordinances
- Building codes and subdivision regulations
- Infrastructural improvement plans
- Project development reviews such as EIA
- Parks and open space planning and development

2.8. Land Use Zoning

Land use zoning seeks to regulate and control the use of land by practicing the designated and permitted use of land based on governmental development plans. Land use zones separate one set of land uses from another based on the optimum and sustainable use of resources. Zoning may be used for building height regulation, building type and lot coverage regulation or other characteristics based on the location.

Theoretically, the primary purpose of zoning is to segregate uses that are thought to be incompatible. In practice, zoning is used to prevent new development from interfering with existing physical and geological setting. Zoning may include regulation of the kinds of activities which will be acceptable on a particular land (such as open space, residential, agricultural, commercial or industrial), the densities at which those activities can be performed, the height of buildings, the amount of space structures may occupy, the proportions of the types of space on a lot, such as how much landscaped space, impervious surface, traffic lanes, and parking must be provided. Zoning is commonly controlled by local governments such as municipalities, though the nature of the zoning regime may be determined or limited by national planning authorities or through enabling legislation.

2.9. Land Use Planning and Hazard

Urban planning is potentially powerful mitigation tool as it seeks to mitigate the risks and vulnerability form several geological and other hazards. Seismic hazard zonation is a component of planning which promises stronger linkages in science, structural solutions and urban planning.

Mitigation is sustained action to reduce or eliminate long term risk to human life and property from natural, human-caused and technological hazards. Examples generally include reducing risk from hazards through physical measures such as strengthening structures to withstand earthquakes, limiting development in flood and landslide prone areas, placing development away from geologically unstable areas. Common natural hazards mitigation actions through land use planning includes avoiding development in hazardous areas after the identification of the geological conditions and natural hazard prone areas and avoiding development in those areas. The population residing in hazardous locations is minimized and future development is restricted in those areas. Adequate street circulation is encouraged in the area and planned with proper street widths and continuity and redundant access points for emergency access and evaluation and provision of proper open spaces with adequate access for the emergency use.

Land use planning involves implementation tools for safety such as land use zoning, which consists of detailed regulations for use, mass, height, setbacks and signs. Similarly specific action plans and specific regulations for particular areas of importance, Subdivision design that consists of approval of

layout and design of parcels, street, parks, schools, other facilities. Development plan review consists of approval of project design for access, convenience and safety and environmental assessment consisting of review of impacts. Another aspect of land use planning is building permit review which consists of maintenance of existing structures, retrofitting of existing vulnerable buildings, upgrading existing structures and redevelopment of structures replacing unsafe development.

Chapter 3
Land Use Practice in Pokhara Sub-Metropolitan City

3.1. Urbanization

Pokhara sub-metropolitan city has experienced rapid growth especially in the past decade, which might be due to the political instability of the past decade, the people have migrated to the city from its peripheral districts and VDCs for security reason or other reasons for better livelihood and easy life compared to the peripheral rural areas. The 1991 census records the population of Pokhara to be 95,286 while according to the 2001 census, the population of Pokhara was 156,312 and the projection of population to 2009 estimated the population of Pokhara to be 232254. The annual population growth rate of Pokhara sub-metropolitan city was found to be 5.07%. Following the trend, the rate of building construction was estimated to increase from 1600 buildings a year to almost 5200 buildings a year including renovation and renewal in the 2021(PEIP, 2000).

The general pattern of location preference is observed as migrants from Syangja district tend to prefer and settle at ward no 17, while migrants from Lamjung district and Parbat district tend to reside in ward no. 13 and ward no. 1 respectively. Similarly, the private plotting in the sub-metropolitan city area is rapid in areas with vacant land and relatively cheaper land prices, violating the land use plan. The mixed residential and commercial areas are emerging in the sub-metropolitan city disregarding the hazard prone areas or geologically unsuitable areas for such purpose, making the population more vulnerable towards disasters. The plotting of land can be seen more prominently in Birauta, Margaida and Ram mandir area in ward no. 17, Bijaypur and Chauthe area in ward no 14 and Kudahar Plains in ward no 13.

The infrastructural facilities such as roads, sewer and storm water drains, water supply, electricity and other public facilities like waste management needs to be developed to meet the current rate of development, which remains the major future concern. Similarly the quality of environment has to be protected as lake is endangered due to the heavy siltation and the being polluted due to the rapid urbanization around the lake area. The city core itself lacks open space and the remaining ones are also at risk of encroachment. The social infrastructures like hospital and other facilities are also inadequate in the Pokhara sub-metropolitan city and some hospitals are themselves vulnerable and may not function at the time of disasters. The time is high for reducing the risk by adopting the best practices for the coordinated urban development to limit the adverse impacts of hazards before it strikes in the Pokhara Sub-Metropolitan City.

3.2. Historical Perspective of Land Use and Development Trend in Pokhara

Several ancient articles suggest that Pokhara might have derived its name from "Pokhari" or a pond to the summer palace at Kaskikot. At that stage only rural dwellings were existed in the valley, while up the hills most of the people stayed. Overtime the name may have stuck to the emerging settlement near the Bindebasini temple.

Pokhara is in the literature often referred to as the crossroad in the trade routes between India and Tibet and in Nepal, between Kathmandu and jumla. It was a transfer station with brisk trade in the winter months and almost a ghost town in the summer months. This because the valley bottom was a

breeding place for malaria mosquitoes, while the valley soil was poor and highly porous, making non irrigated agriculture possible only near the foot of the hills. The Pokhara area is referred to by some as Magar land and others as Gurung land, still it became Kaski state under Malla reign in the 12th century. It is reported that the Bindebasini temple was brought from Bindhyachal (India) to Pokhara by Khadga Bhuwan Malla, making the temple the oldest site in Pokhara.

The Kaski state of Malla time had a summer place in Kaskikot and winter place at Batulechaur. Supportive to the claim of Batulechaur is the fact that there is small settlement housing person of the "Gainey" caste who are entertainers/singers and may have served at the court. The Kaski kings brought Brahmins to the court of Pokhara In the 17th century. King Siddhi Narayan shah granted north of the Bindebasini temple "Birta" land to one of the Brahmin families of Parajuli caste. These herewith became early settlers of Pokhara.

Prithivi Narayan shah the Gokha king annexed the Kaski State and continued to conquer of the Kathmandu valley. After the siege and capture of Bhaktapur in 1752, King Prithivi Narayan shah sent some of people of Newar Community to Pokhara to setup a market and he kept military garrison to guard the area. These people from Newar community established business and introduced new architecture designing the city. Also they brought and introduced many cultural dances like Bhairav dance, Taya Macha, Lakhe dance and many more to Pokhara. Their Heritage can still be seen in the architecture along the streets in Ramkrishna Tole and Bhimsen Tole in Old Pokhara. Hindus again brought their culture and customs from Kathmandu and settled in the whole Pokhara valley. The city has also emerged from a periodic religious place of fairs and gatherings in Dhungesangu and Sunpandeli jatra during the medieval period.

In 1786 Prithivi Narayan shah added Pokhara into his kingdom. It had by then become an important trading place on the routes from Kathmandu to Jumla and from India to Tibet. Following the unification of Nepal in 1769, it took a shape of permanent bazaar. It grew as a catering place to caravan traders with limited infrastructure facilities located at the break of build point along the Trans-Himalayan trade routes. From 1959 to 1962 some 3000 refugees came to Nepal from neighboring Tibet and four refugee camps were established in the Pokhara valley which was Taaashipalkhel, Tashiling, Palijorling and Jambling. These camps have evolved into settlements.

Jang bahadur who established the Rana prime minister-ship reign was raised in Pokhara and the Ranas kept a strong interest in the region. The military constructed the water supply system in 1924 by capping some nearby sources. Pokhara as the administrative headquarters of district west no. 3 in Rana regime supported to flourish the Pokhara bazaar. The political change of 1951 further accelerated the development process. The introduction of airplane in 1952 and Gypsy 1957 increased the linkage with Kathmandu, the capital city, and surroundings. Establishment of Indian pension paying camp in 1960 and British pension paying camp in 1966 has attracted migrants to Pokhara

In 1954 a census was held reporting for Pokhara 3755 citizens, in 1959 Pokhara was made a municipality. However with a total census population of with a total census population of 5413persons in 1961 the town was still not counted as urban as most of the municipal area was still rural.

In the fifties the malaria eradication program effectively freed the valley of malaria while damming of the Phewa Lake and Seti River made irrigation of the Pokhara valley possible. With abundant water supply and application of fertilizers, fair crops may be grown. As a result Pokhara started to develop improved access by air and land triggered development to the south, while Pokhara became the regional center for the health and education sectors, with the setting up of the Prithivi Narayan campus and the western Regional Hospital. Other health and education institutes had already been built or followed soon.

In the process of development, Pokhara grew from the 27500 citizens in 1971 to 46650 persons in 1981 and 95300 persons in 1991. In 1958, it was formally declared as a municipality and resumed into town Panchayat in 1965.Highways were constructed i.e. Sunauli to Pokhara highway in 1969 and Prithivi highway in 1972 linked Pokhara with the Terai and Kathmandu. Progress, functional establishment and growth as a center of trekking tourists contributed to its development. Designation of Pokhara as the headquarters of the western Development region of Nepal in 1972 contributed to upgrade Pokhara sub-metropolitan city in the present status of sub metropolitan city in 1996.

3.3. Urban Development and Land Use Plans in Pokhara Sub-Metropolitan City

The development of Pokhara took place in an extensive and ribbon wise way in the beginning as the city was flourished in the form of commercial center along the transportation route. In 1920 General Babar Shamsher Rana is reported to have brought piped water to Pokhara by having his soldiers capping the Balbhadra springs, some 2km from town. The first population data of 1954 state 3755 inhabitants for Pokhara, corresponding with some 600-650 households, settled around old bazaar with approximately 350 housing units and dispensed as ribbon development along the trade routes with some 300 units. In 1969 when population has grown to more than 60,000 inhabitants a regional study was carried out in order to analyze the effective utilization of excess electric power generated by the dam at Lake Phewa. The other study was to initiate a regional plan for mustang, Pokhara and Bhairahawa corridor.

The power could be supplied to two major projects, Lumle agricultural center and the agricultural project at Khaireni and the villages along the supply lines to these two locations. Apart from these excess power was to be used by Pokhara and villages in Pokhara valley. The study furthermore suggests stimulation of industry and setting up of an industrial estate in Pokhara and suggests further extension of the irrigation network to boost agricultural production in the Pokhara valley.

In 1974 a study results in a physical development plan for Pokhara valley that was presented and subsequent accepted and turned into law. The objectives of the plan are to develop Pokhara as a green garden city, to develop into the major urban center of western region, to preserve the natural landscape of Pokhara and to make Pokhara a healthy and better place in which to live. The plan incorporated the industrial estate and new highways (Siddhartha highway and Prithivi highway) and proposed a new airport location on the east bank of Seti River. The Baidam area received a special attention while south of the existing airport induced tourism development was planned. Substantial urban development was expected on the east bank crossing the Mahendra Bridge or the bridge in the Prithivi highway.

Enforcement of the land use rules and by-laws at the outset was done strictly, but gradually the control slackened the development in 1989. After the 13 years following the adoption of the plan, it became clear that actual developments had overtaken most of the principles of the plan, that growth had been far faster than originally foreseen and the rigid separation of land use zones needed adaptation.

A study was made to revise the 1974 plan in order to meet the objectives to designate an urban development zone of approximate 1700 ha, preserve good irrigated agricultural land and flood plains and to determine priority areas to absorb growth. Of the estimated 71,000 inhabitants in 1987, some 38000 people were thought to be absorbed through the densification of existing urban areas and the remaining were thought be accommodated in newly developed land.

To support the revision of the Pokhara structure plan, an analysis was carried out of the existing infrastructure and its present and future deficits. Sanitation/drainage improvements, especially in the center core area were seen as the most urgent need for development followed by road maintenance, replacement of the Mahendra bridge and a solid waste management scheme. The plans seemingly proved to be ineffective and a second effort was made in 1989 to revise the 1974 Pokhara land use plan.

The land use categories used in the 1974 plan were reconsidered critically against the new land use classification set were developed jointly by MHPP and UDLE and against the prior decisions on deviation as approved by PVTDC, the new set more clearly spelled out which activities/uses are permitted or permissible was allowed by PVTDC. it furthermore provided more differentiation in land use to protect valuable irrigated agricultural land, to preserve heritage (Old Bazaar area) while it also lifted restrictions of the area south of the existing airport destined as "controlled Tourist Development". a detailed area plan was prepared separately for lake side in the same year(1989). The plan was developed based upon guided land development and land pooling principles. The 1987 plans proved to be useful tools for PVTDC and for the municipality but none have adopted formally and are turned into law. Administratively Pokhara was made primary Nagar Panchayat in 1958. In administratively Pokhara was made full Nagar Panchayat and in 1989 following the introduction of democracy it was made a municipality. In1995 it was made sub-metropolitan city.

In1993 the ADB co-funded environmental protection study of Phewa Lake submitted its final report after having studied the environmental impacts on the lake in depth. The place of siltation, the most visual deterioration has been reduced somewhat given the watershed developments.

The reviews of the Pokhara land use plan of 87 and 89 could fall back on two studies made of the land use pattern in Pokhara Nagar Panchayat tried to sense the trend of existing housing conditions in the urban area of Pokhara based upon a survey of 452 households selected from ten wards on the west bank of the Seti river.

In 1998 in a combined effort of the local and central government an integrated action plan was formulated as a result of a participating consultation of the community at ward level. The action plan collected information on problems and suggestions for improvement at ward level. Hereupon the problems were analyzed, categorized and specific actions identified to overcome the problems and stimulate positive developments. The actions were prioritized and cost estimates were prepared upon assessment /evaluation of the monetary, physical and human resources of the municipal and sectoral agencies a multi sectoral investment plan was formulated. The plan was presented to the board and received a positive reception. As such the IAP is to be taken as starting point for the land use concept plan. The Rural Urban Partnership Project (RUPP) finally assists the sub-metropolitan city with the identification of development problems at Tole level in some 6 wards of the sub-metropolitan city. A feasibility study has been finalized June 1999 hat assessed the feasibility of a ring road for Pokhara. In June 1999 a proposal was received for the development of the new Pokhara airport on a Build, operation and Transfer (BOT) basis.

Land use concept plan was prepared in 2000, which has the range of up to 2021. The Concept plan provided the framework for the future development of an urban area in such a way that it guides the authorities in managing the development processes. It also provides the guidance and security to the developers, the intention is that in this way positive developments may be promoted, while negative developments are restricted or prevented. To achieve such an objective the plan recommended that, fixing the land use only could not be efficient as this could suffocate new developments that might be positive too and the development processes would be also difficult to predict. Instead, the plan

would formulate if it is focused on the specific locations, preferred, allowable and not allowable land uses. And the report pointed out the importance of evaluating the history, present situation, the trends and projection of the various sectors governing the Pokhara land use and The physical conditions and environmental considerations would allow identifying areas for future development and will determine if certain land uses in the old and new areas could not be tolerated, either alone or in combination with other land uses

3.4. Existing National Plans and Policies

3.4.1. Tenth Plan

Chapter 22, Clause 22.3.1 of the Tenth Five Year Plan of Nepal is related to population environment and natural disaster management. It states about the requirement of the large scale preparedness to minimize the earthquake and other natural disasters. Furthermore the tenth plan states that main challenge of natural disaster management is the lack of coordination among the authorities involved in it, adaptation of the controlling type of attempt by the management instead of preventive measures, the lack of modern technology that provides pre-information and warning about the possible natural disaster, lack of topographic survey of possible disaster areas, the lack of awareness in the management of natural disaster as well as lack of appraisal of natural disaster while selecting development projects and lack of adherence to building codes . The Tenth Plan in its objective (22.3.2.a) states to contribute substantially to make public life secure by managing the natural and manmade disaster systematically and effectively and by making the development and construction related programs n the country sustainable, reliable and highly gainful. The tenth plan in its policy and program section states the use of technologies to minimize natural disaster and environmental impact in the formulation of plans and policies.

3.4.2. Three Year Interim Plan

In the Three Year Interim Plan, in Chapter 26 related to the natural disaster management has sated about the Nepal being located in earthquake prone zone, it has become necessary to provide adequate and necessary provisions for the mitigation of natural disaster including earthquake and provision of preventive and curative efforts should be put forth for the natural disaster mitigation. The three year interim plan clearly describes the long term vision to minimize social and economic loss and damage caused by disasters and the objective to promote the security of life and property from natural disasters through sustainable, environment-friendly and result oriented development by making disaster management practices efficient, competent strengthened and effective. The plan further put forwards the strategies for the management of disasters by emphasizing development and construction works in environmentally friendly manner, mitigation of risks due to natural disaster through appropriate information flow and pre-disaster preparedness and strengthening the collaborative works between the government, non-government and private sector for providing relief an rescue to those affected by disasters. The three year interim plan has put forward the policies related to disaster management such as:

- provisions relating to EIA and natural disaster assessment to be carried out before the infrastructure construction
- timely reforms of policy and institutional mechanisms related to the mitigation of risk of natural disasters

- development of appropriate mechanism for strengthening the collaborative works among the government, non-government and private sector in order to provide relief and rescue and rehabilitation of those affected by disasters,
- running awareness programs to enhance the participation of the community organizations and the general public in order to mitigate the risks of natural disaster
- Emphasis on pre-disaster preparedness by advancing the process of identifying areas with high risk from disasters and their mapping works.
- Capacitating the ministry of homes as a competent central coordinator for the disaster management by enhancing the capacity of agencies and human resources associated with disaster management.

Similarly the programs as mentioned in the three year interim plan are related to the implementation of the national strategy formulation and implementation unit, launching the awareness raising activities, disaster competence enhancement program; rescue, relief and rehabilitation preparedness program for the disaster affected, study and research program, identification and mapping of disaster prone zones, storage of relief and rescue materials, enhancement of the involvement of local bodies and communities in the prevention works on landslide, river control and soil erosion.

3.4.3. National Urban Policy

National Urban Policy 2064 in its Clause 4.2.9 related to the strategy 3.2.9 deals with the mitigation of loss due to natural disasters by adopting the trend of developing disaster management plan at local level and states the responsibility of local bodies to prepare the disaster management plan to mitigate the loss during the natural hazards. Similarly article "Ka" under the same clause deals with the role of the local body to develop the methodology for construction of safe, affordable and environmentally viable buildings. Article "kha" states the role of local body to foster the locally available traditional knowledge and skills in relation to alternative building construction materials and alternative technologies. Article "Ga" deals with updating the existing building codes in periodic manner and implementing it for the construction of governmental, private and public service buildings. Article "Gha" states the role of local body to restrict development in environmentally sensitive areas and article "Na" states the role of municipality to encourage and direct all the local bodies for developing their own action plan and implementation of the plan against vulnerability due to disasters such as earthquake, landslide and fire. Finally article "Cha" states about community mobilization and rising awareness in local level in relation to mitigation of natural hazards in local level through the initiation of local bodies.

3.4.4. Municipal Level Policies

Local Self Governance Act (LSGA) 2055 empowers the municipality to be a local autonomous body. LSGA in Chapter 6, states about the role of municipality in formulation of plans and process of implementation. Act 111 of LSGA empowers municipality to formulate periodic and annual development plans for the development of municipal area, and in formulating the plans, the municipality shall, as per necessity, have to launch plans such as land use, land pooling and guided land development for balanced and planned development of the municipal area. It also states that while formulating the plans, municipality shall have to give priority to contribute to protect and promote the environment. The LSGA, do not mention about the natural disasters and planning related to earthquake risk reduction and mitigation measures in the building structures in the municipality.

Policies and recommendations related specifically to the earthquake vulnerability mitigation or post disaster mitigation and management plan has not been developed solely by any municipality and neither has been implemented. It is noteworthy that due to the absence of elected local body representatives, the municipalities could not function properly as certain roles are still restricted only under elected representatives such as plans and policies adoption and implementation. Although the LSGA describes the role and responsibilities of the municipality, there are overlapping roles of different institutions and the municipality itself could not function and make decision on its own.

Some preparedness activities as awareness rising and training activities such as mason's training and house owner's awareness are being carried out by municipality with the initiation of donor agencies, Similarly the earthquake day is being celebrated in 2nd of Magh and symposiums are organized targeting on the same day.

3.5. Institutional Capacity

Institutions are the building blocks for policy development, which affects the implementation of policy into practice. How the policies are made, reviewed and how it is implemented is crucial factor that largely depends upon the institutional capacity. A horizontal separation of power among government organs, such as the separation of executive, legislative and judicial organs can ensure that the policy making process is subject to review and constraints from multiple centres of government power. Bureaucratic and administrative hierarchies with distributed and circumscribed responsibilities foster decision-making inertia and sound institutional capacity can promote the credibility of any policy. Relating to the post disaster recovery measures, the municipality is equipped with 11 health services, 4 social organizations related to the service delivery in case of hazards including CBOs, 8 security related institutions and one fire brigade is identified in Pokhara sub-metropolitan city that are in proximity to the urban core.

Chapter 4
Land Use Pattern and Earthquake Hazard

4.1. Geological formation in Pokhara Sub-Metropolitan City

There are altogether 13 geological formations found in Pokhara sub-metropolitan city, namely Active alluvial fan, Begnas Formation, Colluvium, Gahachowk Formation, Kunchha Formation, Lacustrine Deposits, Lakes, Non active alluvial fan, Pokhara formation, recent deposits, soil colluviums, soil residual and Tallakot formation. Active and non-active alluvial fan deposit is composed of poorly sorted gravel, sandy gravel, sand and silt, susceptive to medium to low bearing capacity and medium to lose density. Flood plain and lower alluvial terrace deposit is dominantly found to have composed of gravel, silt and clay deposits and consisting of low bearing capacity. The undifferentiated lake deposit is characterized by soft to stiff calcareous silty clay to clayey silt and has low bearing and soft to firm consistency. Pokhara formation is mainly a debris flow deposits, which constituents of limestone, schist, gneiss and granite with wide variation in bearing capacity observed and risk of underground karstification. Tallakot formation is a debris flow deposit showing low bearing capacity and is prone to sinkhole development. Kunchha formation comprises of phyllite, quartzite and gneiss .Gahachowk formation is also a debris flow deposit and has widely developed karst structures in the form of sinkholes, caverns and sub-soil pinnacles.

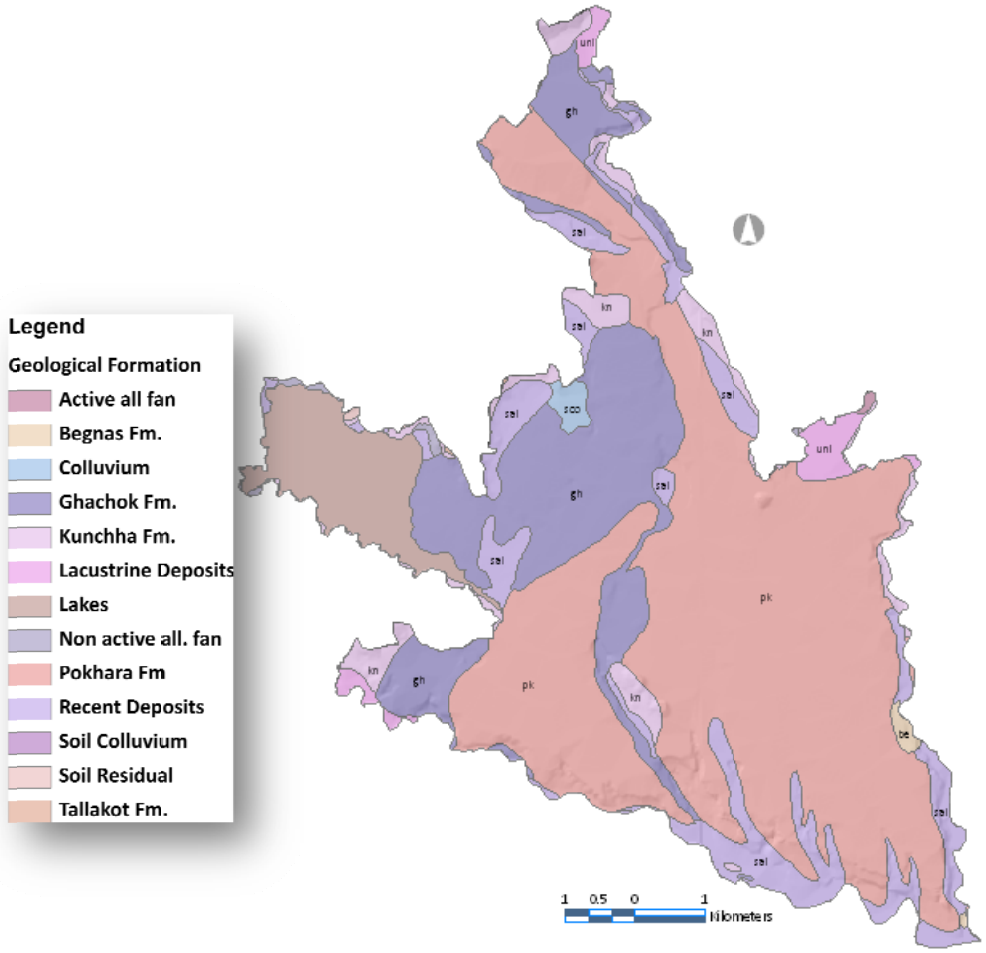


Figure 6 Geological map of Pokhara sub-metropolitan city

4.2. Liquefaction Susceptibility

Liquefaction is a phenomenon by which the bearing capacity of soil is greatly reduced by earthquake shaking and thereby making structures vulnerable due to earthquake hazards. Liquefaction occurs in the soils that are saturated with water, and on shaking due to earthquake, the water pressure inside the soil particles increases to the point where the soil particles can readily move with respect to one another and can cause settlement of the structure.

In Pokhara sub-metropolitan city, the liquefaction potential zones are found in the banks and tributaries of Seti River and some patches of liquefaction susceptible zones are found in KI Singh bridge area, Laltin Bazar, Kamal Pokhari areas. The sinkhole collapse prone areas were identified in Chipledhunga areas, Mahendra Pul, Male Patan , Manaswar, Baidam, Simal Tunda, Bhagerthan, SoS Village and Golf Place areas.

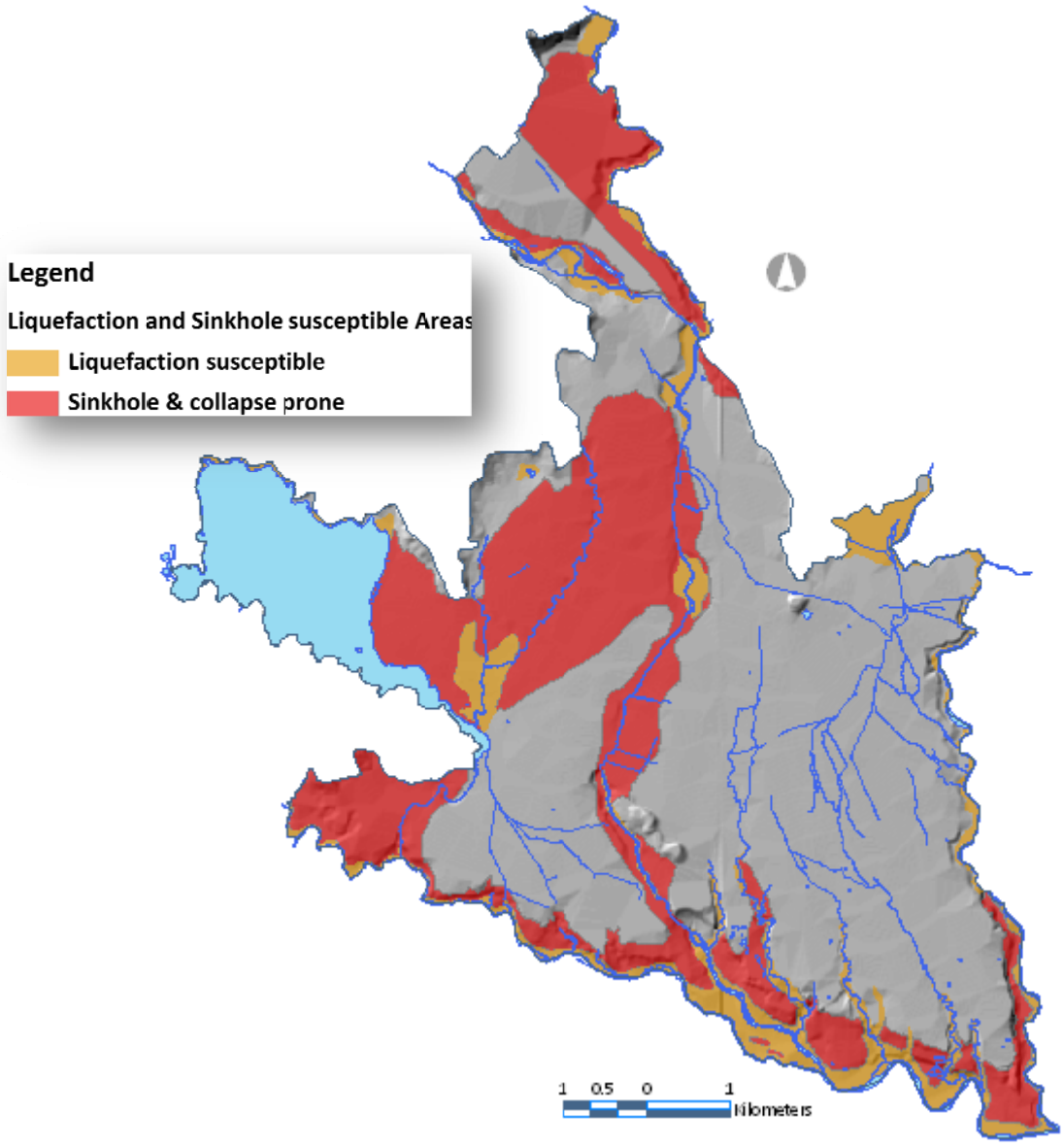


Figure 7 Liquefaction susceptibility map of Pokhara Sub-metropolitan city

4.3. Sinkhole Susceptibility

Sinkholes are the phenomenon by which land suddenly collapses causing a depression or hole in the surface of topography causing catastrophic damage to buildings, roads and other infrastructures. Sinkholes are common where the rock below the land surface is limestone, carbonate rock, salt beds or rocks that can naturally be dissolved by ground water circulating through them. As the rock dissolves, caverns develop underground and if the caverns become too big or the underground support for land becomes less to support the land above, then sudden collapse of land take place. These collapses are also triggered by earthquakes, where the underground support fails due to the earthquake movement. Sinkholes are instantaneous phenomena, where the ground surface stays intact until the underground spaces becomes too big and without any signs of warning sudden collapse takes place.

The sinkhole susceptible areas are categorized into high sinkhole susceptible areas, medium sinkhole susceptible areas and low sinkhole susceptible areas. Among which Lama chaur and Batule chaur areas, Tersa pati area and Male patan areas were found to have susceptibility to high sinkhole hazard, Police area, Parshyang, Biruwa phant and laltin bazaar area were found to have medium sinkhole hazard susceptibility while Pokhara industrial area, Ramghat, Tallo Simal Bot, Bhedi farm, Chinne Dada areas were found to have low sinkhole hazard susceptibility. The low bearing capacity areas were identified in kamalpokhari and Mahendra cave areas.

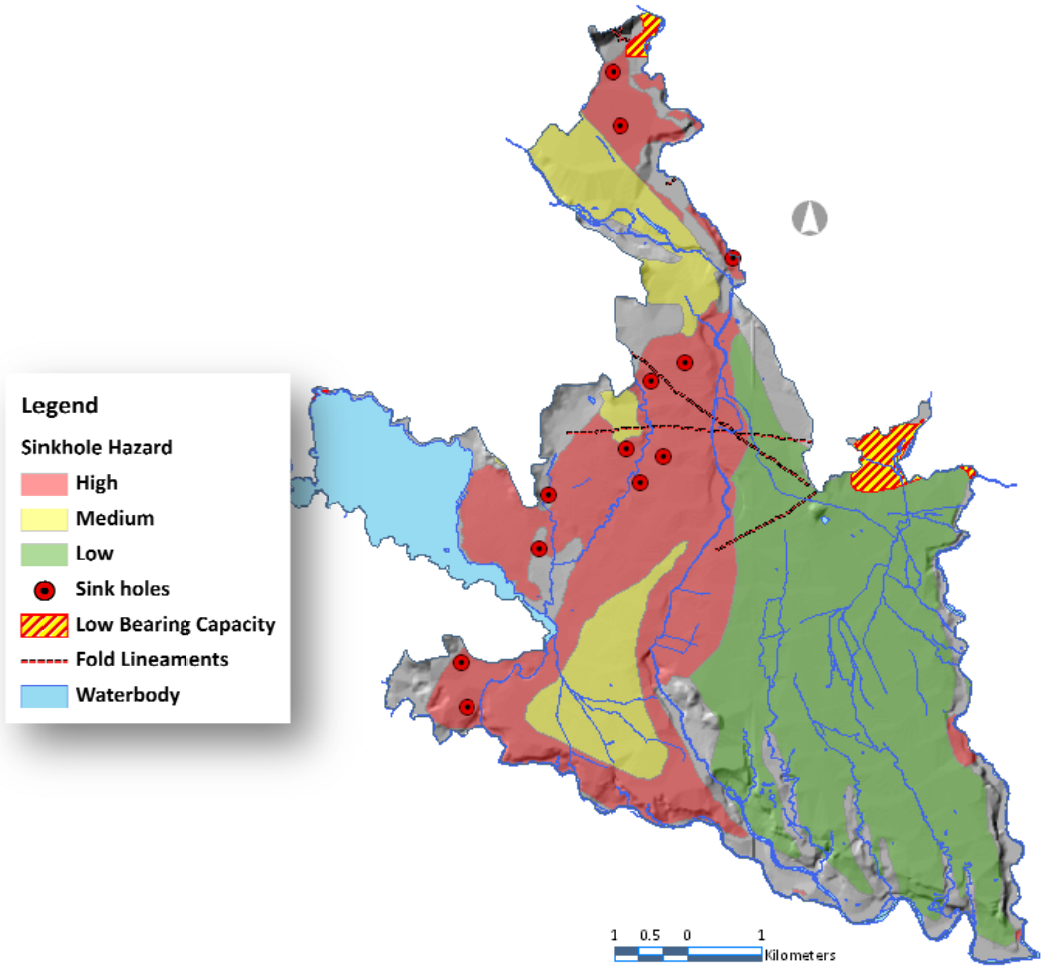


Figure 8 Sinkhole hazard and low bearing capacity areas

4.4. Land Use map

4.4.1. Land use map (1979)

The land use map of Pokhara Sub-metropolitan city at 1979 suggests that there were very few sparse settlements mainly at parts of ward, 6, 16,,1,2,3,4,5,8,9,11,12 and 13 that is approximately 7.06% of the municipal area and covering around 379.03 hectares of land very sparsely. The settlement was predominantly linear along the roadside. The predominant land use was agriculture with 75.78% coverage of municipal area, followed by built-up. The land use trend of 1979 suggests that mainly agriculture was the main occupation at that time and mostly the settlements of farmers and business men were identified in those sparse built-up areas and construction of airport can be observed at 1979.

Table 1 Land Use Pattern in 1979 A.D

Land Use 1979	Area (ha)	Percent
Airport	37.89	0.67
Barren Land	26.22	0.47
Built-up	397.03	7.06
Bush	30.04	0.53
Cultivation	4264.19	75.78
Forest	112.66	2.00
Grass	72.78	1.29
Orchard	1.16	0.02
Pond	5.78	0.10
Sand	134.38	2.39
Tree Cluster	66.91	1.19
Water Body	478.16	8.50

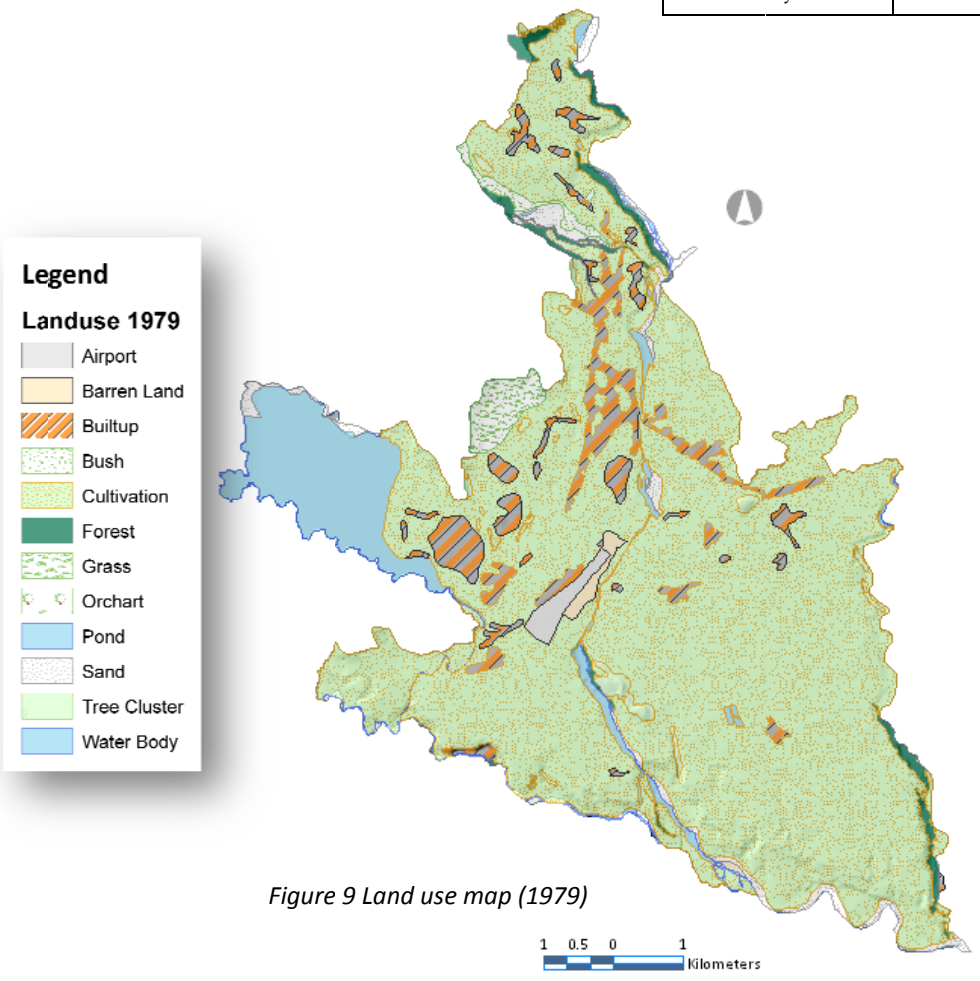


Figure 9 Land use map (1979)

4.4.2. Land use map (1996)

The land use map of 1996 reveals that there is a dense built-up area formation in the wards 6, 7,8,9,10,3,4 areas while patches of settlement were observed more prominently than 1979 land use map. The total built-up areas 22.74% of the municipal area composed of 1179.86 hectares of land. Similarly, 2.19% of the barren land, 1.09% of the forest area, 50.33% of the agriculture area, 12.06% of the vegetation and 9.34% coverage of the water body was found in the 1996 land use map. Comparing the land use map of 1996 with 1979 land use map, the increase in built-up area was from 7.06% to 22.74% and at the same time reduction of cultivation area was about 25%. From the land use map of 1996, intense densification has been observed in wards 6, 8 and 4.

Table 2 Land Use Pattern in 1996 A.D.

Land use 1996	Area (ha)	Percent
Airport	32.33	0.57
Barren Land	123.25	2.19
Built-up	1279.86	22.74
Bush	56.40	1.00
Cliff	5.01	0.09
Cultivation	2833.07	50.33
Forest	61.33	1.09
Grass	554.29	9.85
Orchard	17.65	0.31
Pond	417.64	7.42
Rock Cliff	5.36	0.10
Sand	82.13	1.46
Swamp	2.25	0.04
Tree Cluster	50.45	0.90
Water body	108.32	1.92

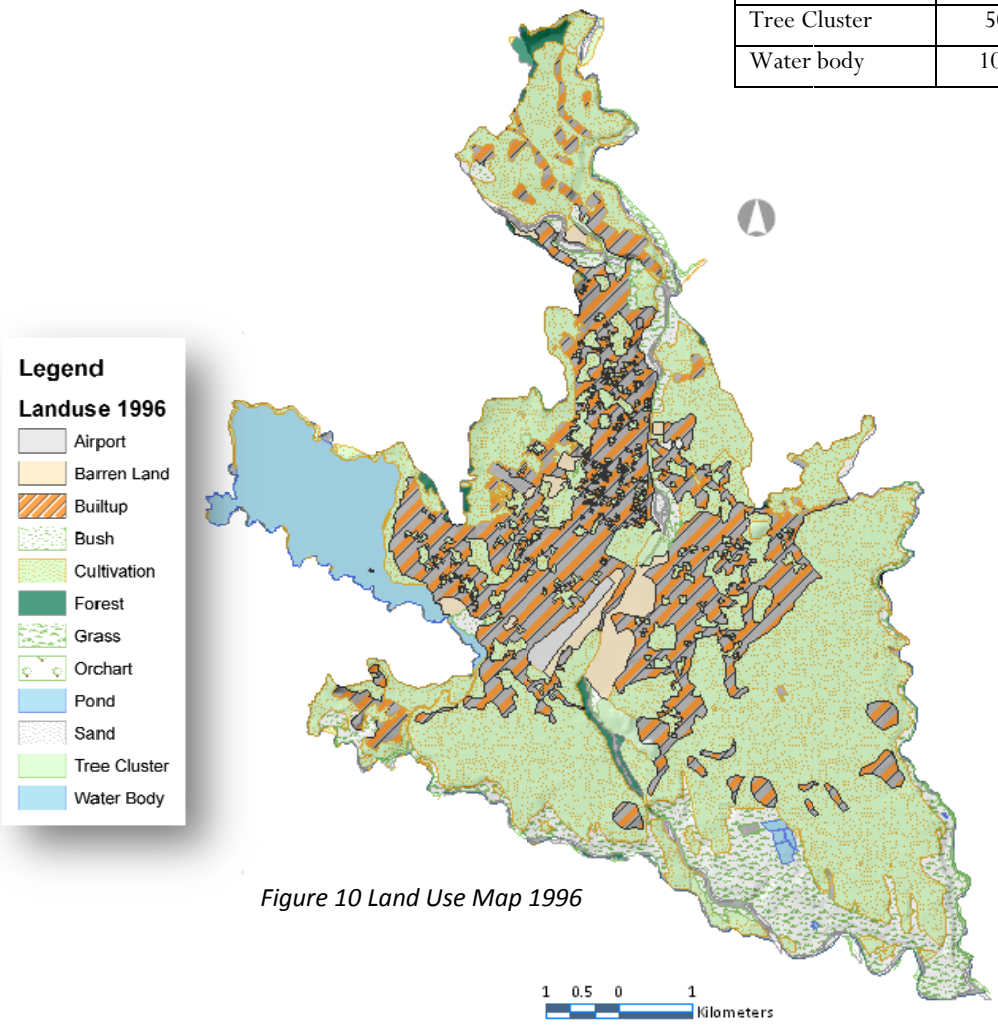


Figure 10 Land Use Map 1996

4.4.3. Land Use Map (2007)

The land use map 2007 of Pokhara Sub-metropolitan city reveals the dense settlement with 26.88% of municipal area and 1494.33 hectares of area which was 1279.86 hectares in 1996. The agricultural area was found to be of 39.64% with the coverage area of 2203.58 ha was observed in 2007 which was a decrease from 50.33% in 1996 and 75.78% in 1979. This trend suggests that the agricultural areas in Pokhara sub-metropolitan areas are fast depleting, giving rise to the built-up areas. The 2007 land use map of Pokhara sub-metropolitan city is presented in fig 6.

Table 3 Land Use Pattern in 2007 A.D

Land use 2007	Area (ha)	Percent
Airport area	38.65	0.70
Barren land	684.80	12.32
Built up	1494.33	26.88
Bus park	2.71	0.05
Canal	15.31	0.28
Cultivation	2203.58	39.64
Traffic Island	1.00	0.02
Palace area	6.23	0.11
Park	15.58	0.28
Plantation	222.32	4.00
Pond	399.89	7.19
Religious area	0.23	0.00
River	59.63	1.07
Road	203.57	3.66
Runway	6.32	0.11
Sandy area	48.99	0.88
Stadium	3.84	0.07
others	152.54	2.74

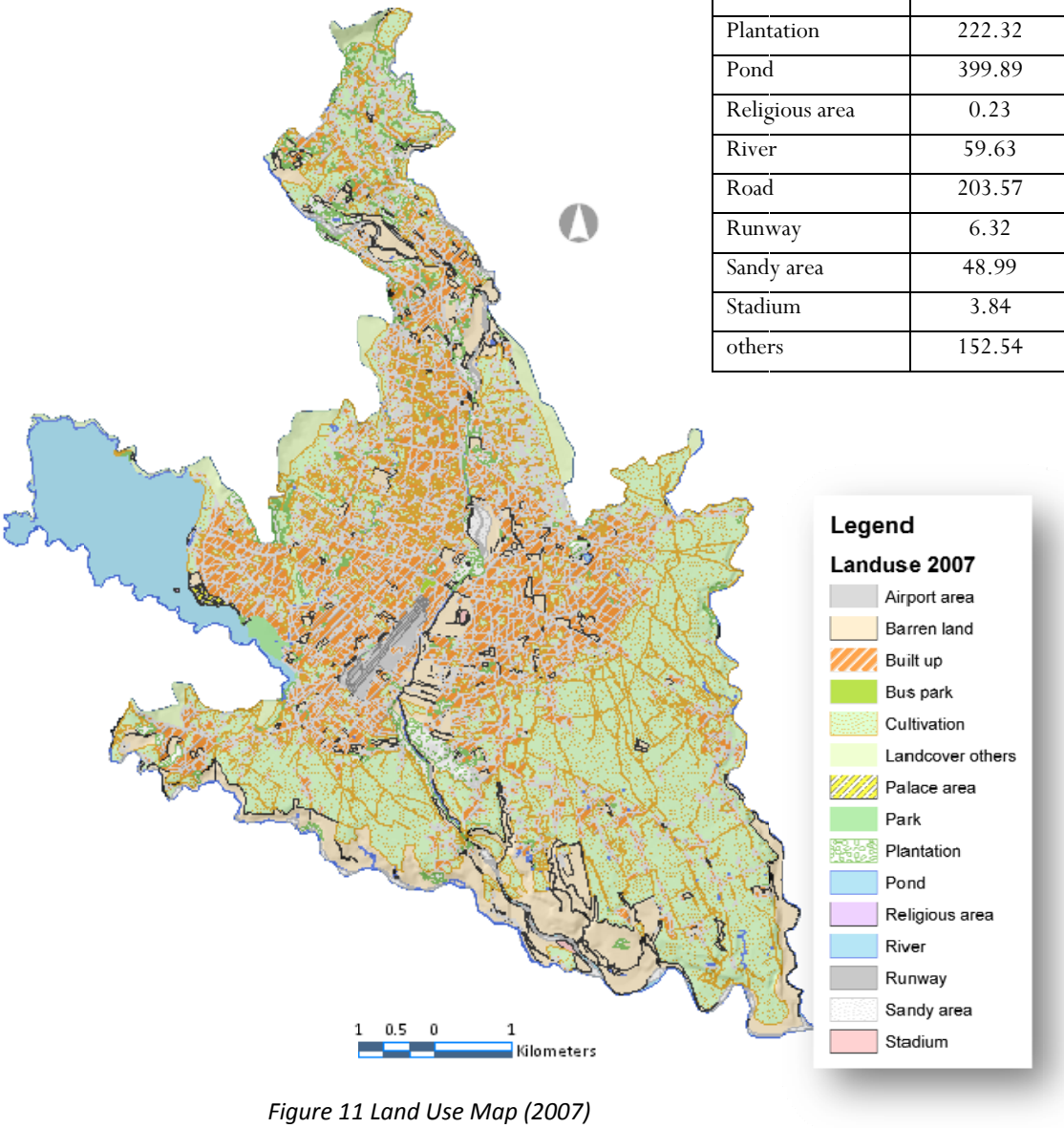


Figure 11 Land Use Map (2007)

4.5. Scenario of land use change from 1979 to 2007

Since earthquake hazard and vulnerability mainly focuses on the inhabitants living in the area, the land use change scenario has been analyzed primarily focusing on the built-up area. The built-up area of 1979, 1996 and 2007 has been overlain in a GIS in order to analyze the trend of land use change as well as future projection. The status of land use change trend reveals that after the malaria eradication programme launched in Pokhara sub-metropolitan city, the development trend took its pace, which was later bolstered by administrational and regional support as Pokhara was declared as the headquarters of the western development region of Nepal. The analysis reveals that change in built-up area from 1979 to 1996 was of 322% where the coverage of built-up area grew from 397 hectares to 1290 hectares and from 1996 to 2007 the growth of built-up area was of 116% where the growth of built-up area was from 1280 to 1494, whereby some densification of the sparse settlements also was observed.

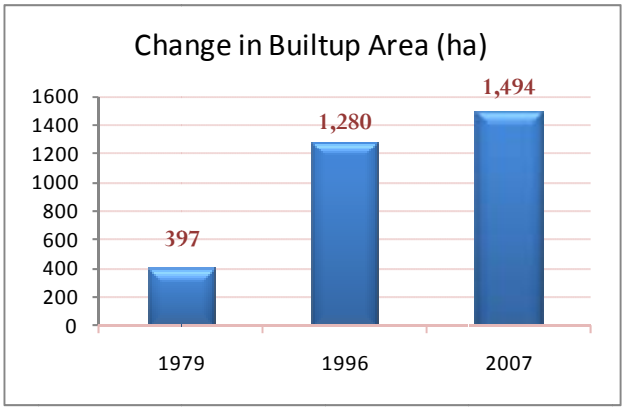


Figure 12 Change in Built-up Area

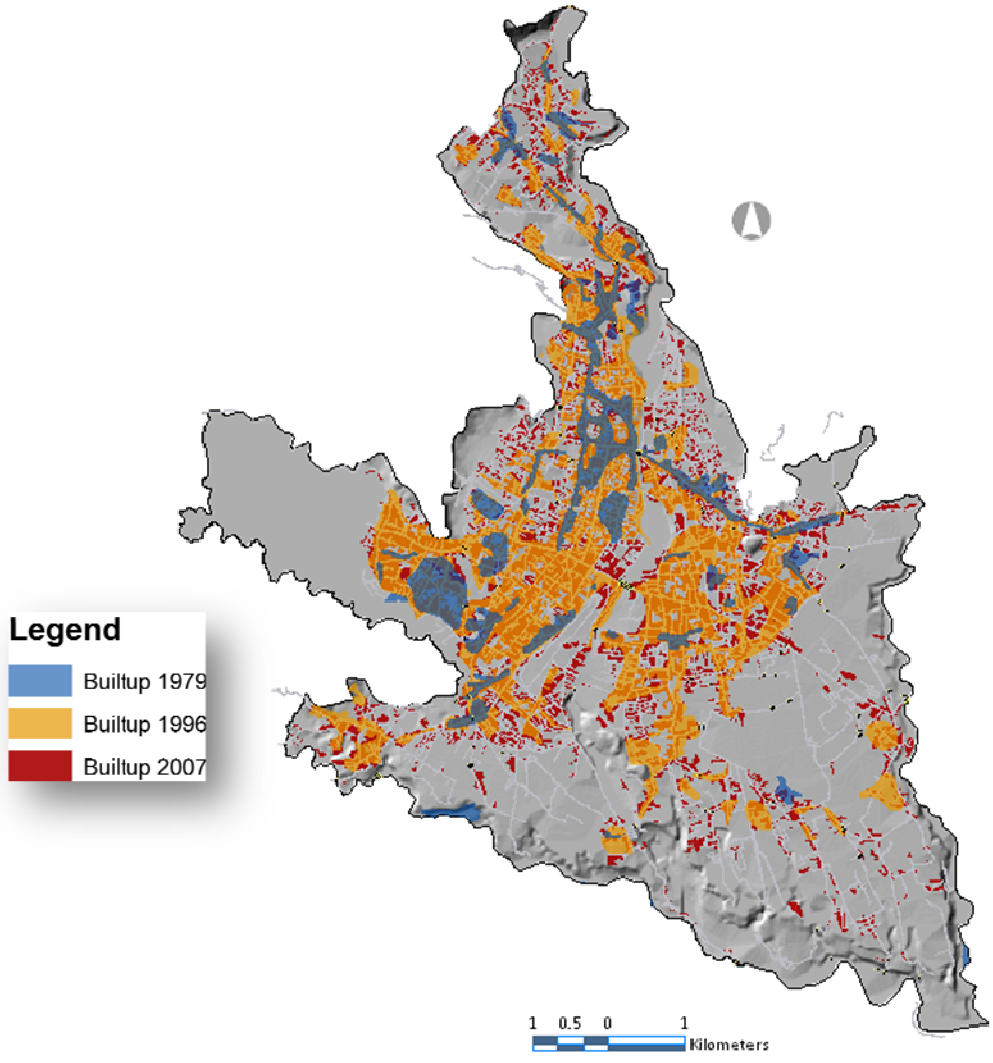


Figure 13 Change in Built-Up Area from 1979 to 2007

4.6. Urban Density

The existing urban density of Pokhara sub-metropolitan city was calculated in GIS using the kernel density estimation method with radius of 500m was used and for the output pixel size of 5 sq. m, which estimates the magnitude of urban built-up per unit area from a feature using kernel function. The analysis reveals that the urban growth of the municipality is predominantly radial type extending around the main economic and administrative centres growing outer wards, few patches of sparse linear settlements were also observed in Pokhara sub-metropolitan area at the periphery. The highest urban density of 75-90 was observed in Ram Bazaar area, followed by Himali chowk, Lakshmi chowk, Kalika chowk areas with density of 60-75. Srijana Chowk, Ratna chowk, Simalchaur areas, Baidam areas, Birendra chowk areas, Birauta Chowk and Chhorepatan areas were observed to have the density of 45-60.

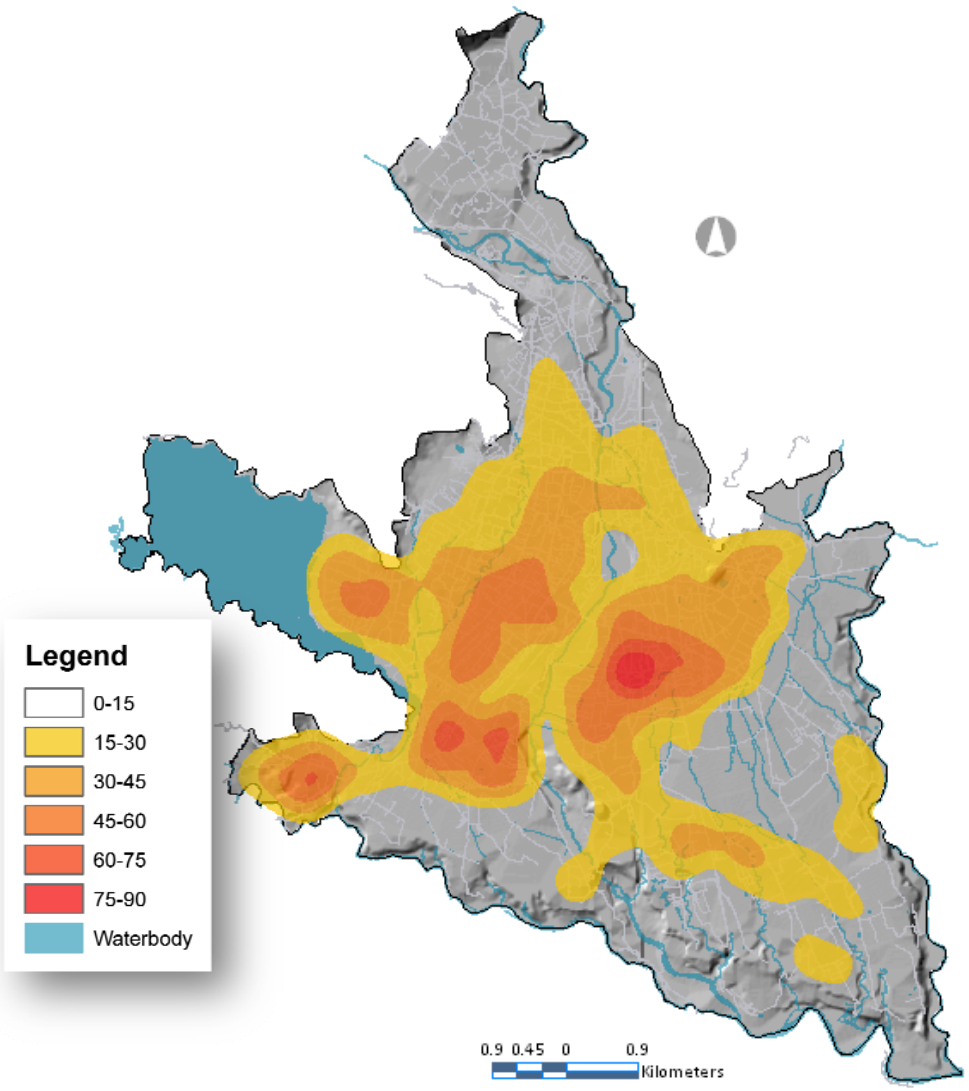


Figure 14 Urban Density Map of Pokhara Sub-Metropolitan City

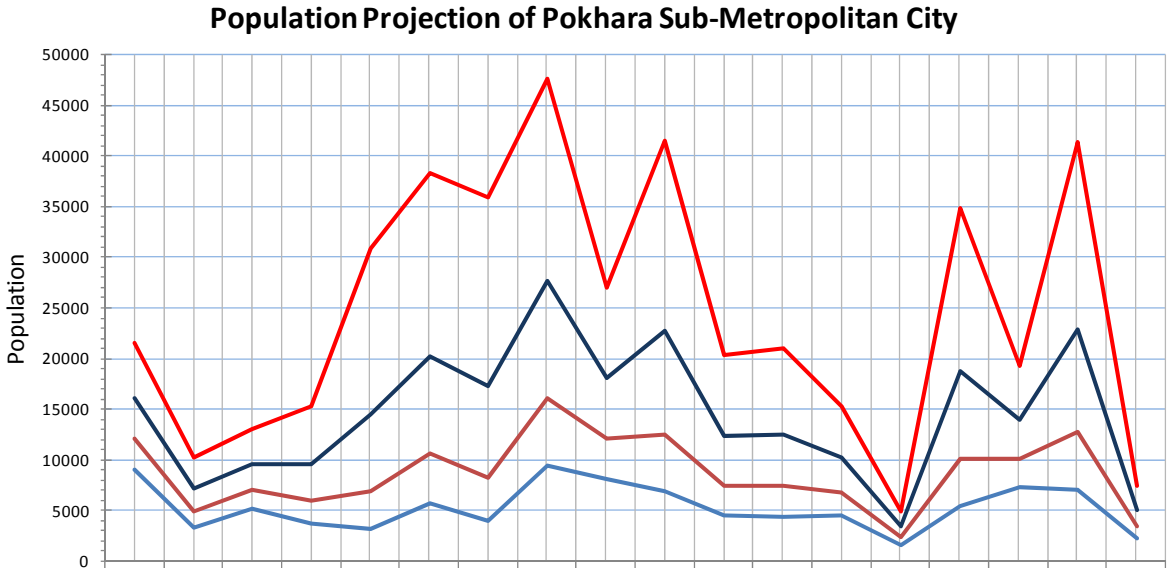
4.7. Population Projection of Pokhara Sub-metropolitan city

The projection of the population was done by geometric growth method i.e. ([$P_t = P_0 (1+r)^t$]) and it was found that total population at 2011 and 2021 will be 261,264 and 444,830 respectively using the current growth rate of 5.07% from the 1991 and 2001 census. The highest growth rate is observed in ward no 5 with 7.82%. Detailed growth rate and projection has been presented in table 1

Table 4: ward-wise population distribution and projection

Ward	Population (1991)	Population (2001)	Growth Rate	Population (2011)	Population (2021)
1	9,017	12,037	2.93	16,068	21,450
2	3,352	4,859	3.78	7,044	10,210
3	5,101	6,962	3.16	9,502	12,969
4	3,749	5,988	4.79	9,564	15,276
5	3,217	6,829	7.82	14,497	30,773
6	5,633	10,663	6.59	20,185	38,208
7	3,951	8,241	7.63	17,189	35,853
8	9,382	16,112	5.56	27,670	47,518
9	8,112	12,111	4.09	18,081	26,995
10	6,816	12,433	6.20	22,679	41,368
11	4,472	7,408	5.18	12,272	20,328
12	4,364	7,369	5.38	12,443	21,011
13	4,472	6,739	4.19	10,155	15,303
14	1,591	2,314	3.82	3,366	4,895
15	5,438	10,099	6.39	18,755	34,830
16	7,289	10,068	3.28	13,907	19,209
17	7,055	12,706	6.06	22,883	41,213
18	2,275	3,374	4.02	5,004	7,421
Total	**95,286**	**156,312**	**5.07**	**261,264**	**444,830**

The population projection chart shows that there will be maximum population density in ward 8and followed by ward 10 and ward 17. The existing dense settlement of the Hetauda core belongs to the Ram Bazaar area of ward 10, Birauta Chowk area of ward 17 and others are expected to have the population pressure in 2021. The population projection chart is shown in fig 9.



Wards	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Population (2021)	21450	10210	12969	15276	30773	38208	35853	47518	26995	41368	20328	21011	15303	4895	34830	19209	41213	7421
Population (2011)	16068	7044	9502	9564	14497	20185	17189	27670	18081	22679	12272	12443	10155	3366	18755	13907	22883	5004
Population (2001)	12037	4859	6962	5988	6829	10663	8241	16112	12111	12433	7408	7369	6739	2314	10099	10068	12706	3374
Population (1991)	9017	3352	5101	3749	3217	5633	3951	9382	8112	6816	4472	4364	4472	1591	5438	7289	7055	2275

Figure 15 Population projection chart of Pokhara Sub-Metropolitan City

4.8. Future land use at 2021 at current trend

Future projection of land use is done basically regarding the urban sprawl that is most likely to be expected under several conditions. The factors that affect the land use change in Pokhara sub-metropolitan city for future projection are outlined here under:

- Demographic factors
  - Population Density
  - Annual Population growth
  - Migration
- Topographical factors - Availability of the areas for expansion, slope land, dry land
- Access to Infrastructural facilities- Road Network
- Economic Development
  - Market availability and Distance
  - Cost of Conversion and opportunity cost
- Private land Developers- plotting.
- Governmental Policies- Future projects and policies
- Social factors
  - Affluence
  - Human Attitudes and Cultural Values
  - Food Security

- Policies related to land use control
  - Zoning and byelaws
  - Land use Plan
  - Subdivision regulations
- Growth of a city as a Commercial and administrative Centre
- Weather and Climatic factors

From the evaluation of each and every factor listed above, future land use map of Pokhara sub-metropolitan city is prepared. While analyzing the future land use, river, road, sand, water body, religious areas, institutional area, educational areas and industrial areas are assumed to be same while built-up area is assumed to be variable over time. The future land use map of Pokhara sub-metropolitan city is presented in fig 16.

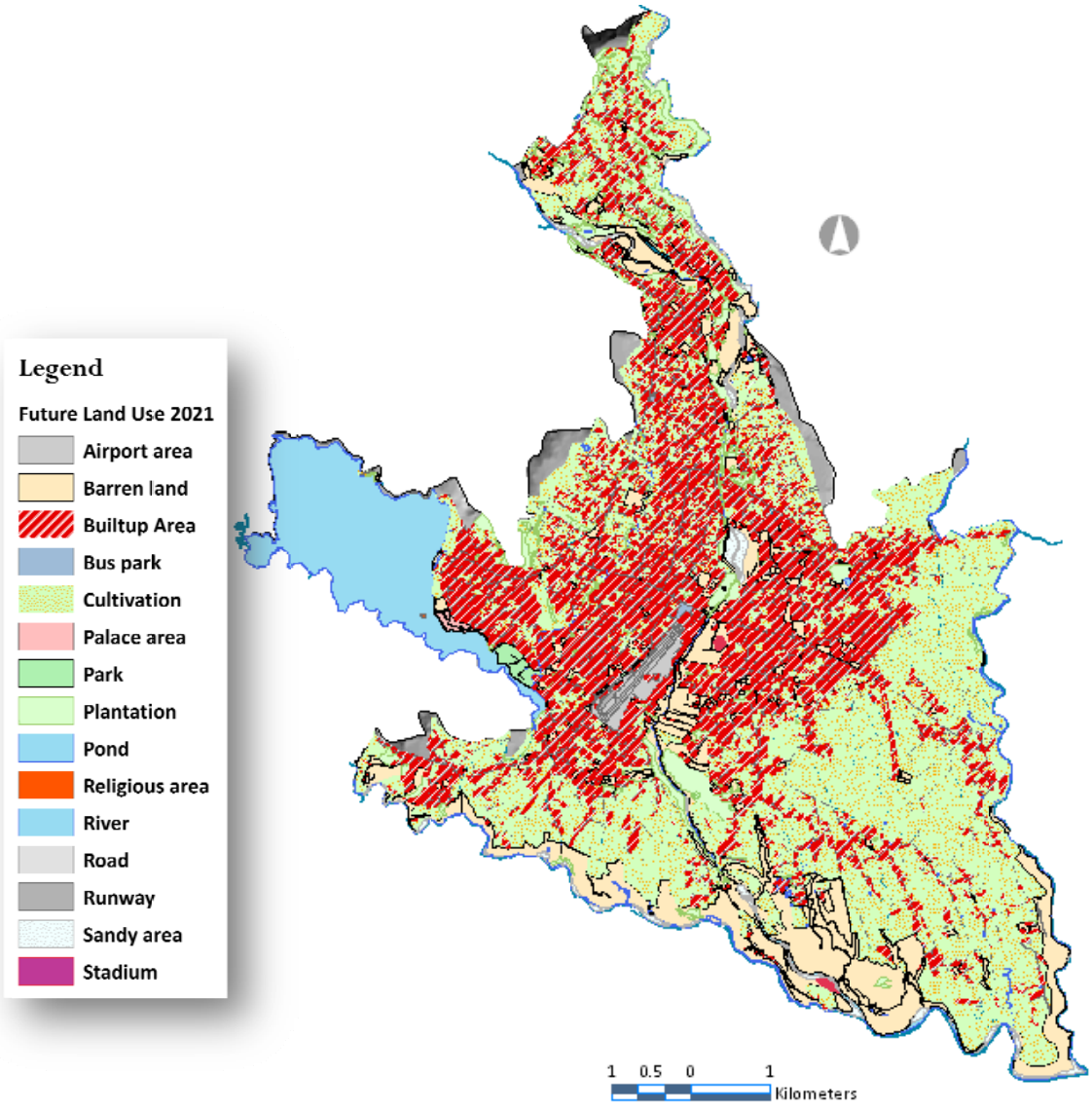


Figure 16 : Future land use map of Pokhara sub-metropolitan city at 2021 A.D

4.9. Vulnerability Scenario at 2021

The vulnerability scenario of 2021 has been analyzed by making the sensitivity map of Pokhara Sub-metropolitan city, which is composite of geological sensitivity analysis, Liquefaction susceptibility analysis map, sinkhole susceptibility analysis map and earthquake scenario intensity maps. Local earthquake scenario with magnitude of 6.5 Richter scale with epicentre within 30km around the municipality region resulting in earthquake intensity of VIII MMI (Modified Mercalli Intensity) has been considered for the land use scenario study. The built-up area at 2021 regarding the vulnerability scenario at 2021 reveals that, if the current trend is followed, 52.43% of the built-up areas will be in high sinkhole hazard susceptible areas, 17.07% of the built-up area in medium sinkhole hazard susceptible areas and 0.11% of the built-up areas at sinkhole and collapse prone areas. The built-up area in 2021 with respect to land suitability is presented in table 5 and vulnerability scenario map at 2021 is presented in figure 16.

Table 5: Built-up area with respect to land suitability

Built-up Area WRT Land Suitability	Area (ha)	Percent
High Sinkhole Hazard Susceptible Areas	946.06	52.43
High Sinkhole Hazard and Liquefaction susceptible Areas	0.02	0.00
Low Sinkhole Hazard Susceptible Areas	533.28	29.55
Liquefaction susceptible But Low Sinkhole Hazard Prone Areas	0.32	0.02
Medium Sinkhole Hazard Susceptible areas	307.95	17.07
Liquefaction susceptible but Medium Sinkhole Hazard Prone Areas	1.20	0.07
Sinkhole and collapse prone areas	1.99	0.11

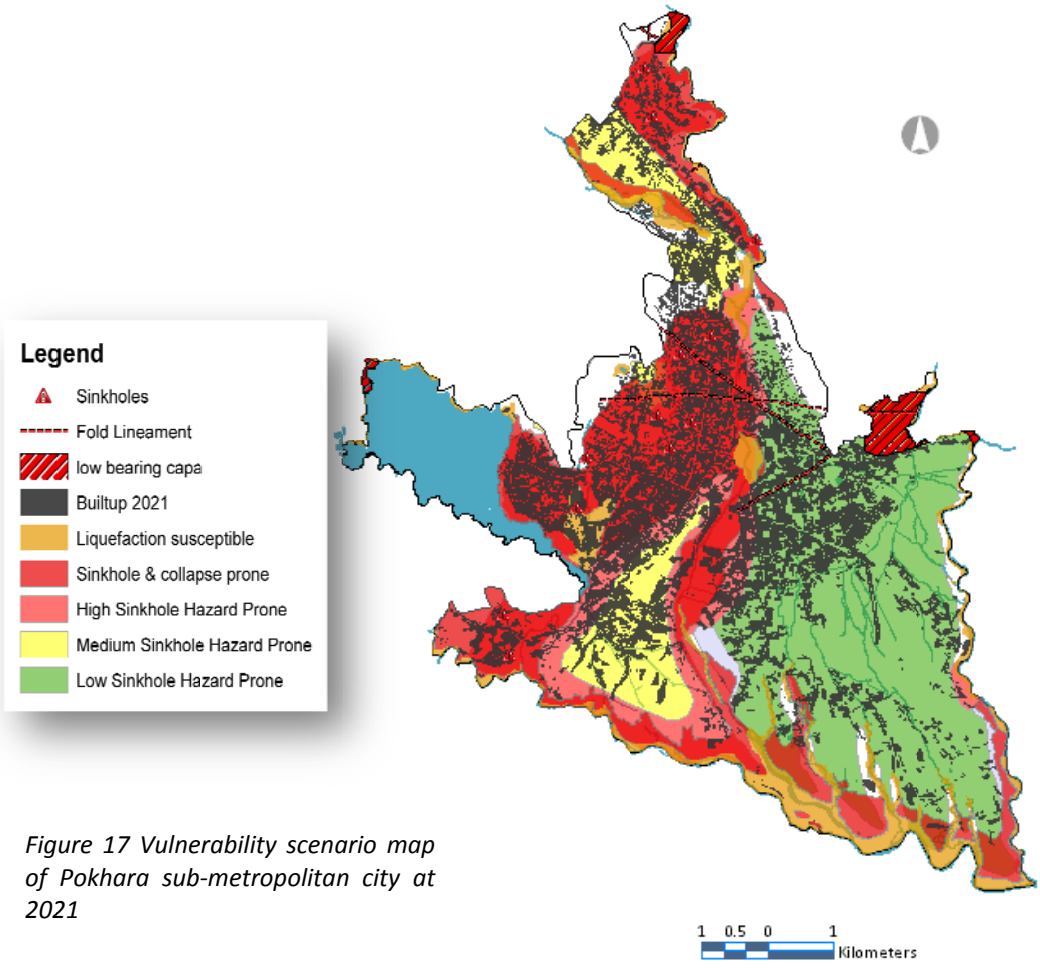


Figure 17 Vulnerability scenario map of Pokhara sub-metropolitan city at 2021

Chapter 5
Open Spaces

5.1. Land Use Planning and Open Spaces

The open space is regarded as an integral part of the land use planning decisions and importance of open spaces to urban environment and quality of life is increasingly recognized over the cities of developed countries. However in developing countries like Nepal, there is no general agreement on the desirable planning criteria as to how much open space is needed, where the open space is to be located and how the open space should be used. Moreover there are no such standards for the placement and quality of open space in Nepalese context.

The term open space refers to the any open area of land that is owned by government or other organization and dedicated for conservation or the social motives. Open space is defined as land that is, or will be managed in an undeveloped or developed form for a range of natural and human purposes. The open spaces in a urban areas are also recognized as the "green infrastructure" which has immense role in the environment and urban ecology.

The main purposes of open space are:

- Provision of recreational opportunities
- Protection, preservation and enhancement of biodiversity, conservation, habitat and heritage places;
- Protection and enhancement of landscapes and amenities
- Educational, scientific and other research opportunities,
- Provision and management of utilities and services
- Ensuring opportunities exist to meet unforeseen and emergency needs and
- Contribution to the liveability and appeal of the municipality for residents of the municipality.

Typically, open spaces includes parks, gardens, trails, habitat corridors, utility reserves, sports grounds and conservation reserves. Some open space sites may have buildings and services on them to enhance their capacity to meet the needs for which they are reserved or because their uses are compatible with the open space purposes. The importance of open space ranges not only in the provision of opportunity for recreational activities but also providing a range of social, economic and cultural benefits or values to the community. Although open space itself seems as a simple concept, it has complex interaction with physical, social, economic environmental factors of the community and plays crucial role in planning process.

5.1.1. Open Space and Emergency Planning

Understanding the information related to buildings and infrastructure as well as geological information is the key issue in developing earthquake mitigation and preparedness techniques, and policies as well as overall emergency management that could minimize the effects of a major disaster event such as an earthquake. Open space has immense importance in post disaster phase of emergency planning. These publicly owned open spaces serves as the area for temporary relocation as well as healthcare and rescue activities can be done efficiently for the earthquake evacuees from these areas.

While identifying and selecting areas for emergency planning, the criteria are broadly divided into four categories i.e. condition of locale, quantitative measures, type of facilities and site design. The condition of the locale refers to the centrality of the space, that is within or adjacent to the urban built-up areas which is close to the dense residential distribution is given preference. Similarly the mild topology without any physical interference or obstruction as well as linkage with wider roads is taken into consideration for the selection of open space. The quantitative measures refer to the size of the open space that is available centrally that can relocate the evacuees at the post disaster phase as well as the number of evacuees. Type of facilities refers to the available urban social-infrastructure and services such as water supply facility, tube wells, police stations, hospitals ambulances, INGOs, CBOs, NGOs and others. The fourth criteria of site design refer to the quality of site such as level of intervention required for the emergency management motives, visibility and design for intensive use etc. Table 2 shows the Planning aspects and guiding principles for selection of site for emergency management.

Table 6 Guiding principles for selecting open space for emergency planning

Planning Aspect	Guiding Principles
Condition of locale	▪ Centrality of the Space- within or adjacent to urban built-up areas ▪ proximity to target population- Residential distribution and density ▪ Accessibility-Mild topography and no obstruction ▪ Linkage- Road linkage and wider roads
Quantitative measures	▪ Size of open space- Area ▪ Accommodation- Number of evacuees
Types of facilities	▪ Water supply facility ▪ Proximity to security services- Police station ▪ Proximity to health care facilities- Hospital, ambulances ▪ Proximity to social institutions- INGOs, NGOs, CBOs
Site design	▪ Minimal intervention ▪ visibility ▪ Design for intensive use ▪ Compliant for supply of emergency rescue material as well as airlift – Space for helicopter landing

5.1.2. Selection of Open spaces

In Pokhara sub-metropolitan city the open spaces were identified using the guiding principles as mentioned in the Table 3. The identified potential open spaces with their actual area for relocation purpose and the capacity of the open space in terms of accommodating people were then analyzed. For the purpose international literatures were reviewed related to the space design and space standards for general circulation and amenities as well as for emergency planning purpose. In continuation to the basic circulation features the ease of ingress, egress and utilization is of priority during the emergency period is of main concern. Similarly, addressing special needs of physically challenged people and safe movement and convenient access to all the locations and services within the facility is the basic point to be highlighted, hence study of social infrastructure for dual purpose that is integrated community facility for multipurpose uses such as for earthquake and emergency shelter is referred for the project, in which space required for a project was taken as 3.5 Sq. m per person including circulation area, which is approximately 38 sq ft of area per person (Sphere Project,2004). Similarly for the purpose of relatively long term resettlement of the evacuees of the earthquake due to the total collapse of the building, 45 Sq. m area is allocated per family for the period until the reconstruction

of the building. The list of identified potential open spaces in Pokhara sub-metropolitan city, with its area and capacity to relocate people during the emergency of earthquake hazard is shown in Table 6.

Table 7 Identified potential open spaces in the Pokhara sub-metropolitan city

S.No	Location	Area (sq. m)	Capacity (Number of Persons)
1	Tundikhel Ground	9,362.37	2,675
2	Amar Singh Chowk Ground	14,948.43	4,271
3	Hario kaharka Ground	36,051.72	10,300
4	Fewa Tal Park Area	22,596.60	6,456
5	Pokhara komagane Friendship Park	65,181.45	18,623
6	Male Patan Ground	14,226.32	4,065
7	Pokhara Stadium	194,994.43	55,713
8	Prithivi Chowk Ground	16,334.63	4,667
9	Baidam Park	49,739.17	14,211
10	Simalchaur Open Space	2,062.56	589
11	Nagdhunga Open Space	3,226.23	922
12	Nepal Water for Health	879.83	251
13	Malepatan-2	5,831.16	1,666
14	Prithivi Narayan Campus	38,059.77	10,874
15	Amar Singh Ground 2	23,468.13	6,705
16	Open space near nursing c	11,554.79	3,301
17	Department of Road Ground	13,775.18	3,936
18	Food Corporation Ground	6,446.83	1,842
19	Prithivi Narayan Campus	34,076.74	9,736
20	License Trial Ground	4,793.92	1,370
21	Lamachaur open space	7,886.97	2,253
22	Gandaki Boarding School Ground 1	2,811.93	803
23	Gandaki Boarding School Ground 2	9,881.39	2,823
24	Majheripatan open space	6,675.23	1,907
25	Sukhraraj Bhalbhadra Scho	1,565.24	447
26	Bhedifarm open space	7,382.84	2,109
27	License Trial Ground	20,334.31	5,810
28	Siddhartha School Ground	4,120.09	1,177
29	Kalika Chowk open space	8,045.10	2,299
30	Chhorepatan school	5,527.24	1,579
31	Khasi bajar open space	11,370.25	3,249

32	Indu chowk, stadium side	10,054.62	2,873
33	Indu chowk Open space	1,191.96	341
34	Hospital Area Ground	3,352.20	958
35	Ram Ghat	14,536.84	4,153
36	Nursing Campus Ground	6,167.91	1,762
37	Ranipauwa open space	11,645.45	3,327
38	Chorephatan School Ground	3,795.07	1,084
39	Gupteshwor Open Space	5,803.18	1,658
40	Belghari chowk open space	1,896.65	542
41	Devkota school ground	1,589.67	454
42	SOS School Ground	3,632.17	1,038
43	Lakshmi chowk open space1	2,501.56	715
44	Lakshmi chowk open space2	1,081.00	309
45	Trafic Island	1,594.91	456
46	Pardi School Ground	878.79	251
47	Annapurna Chowk Open Space	3,944.12	1,127

5.1.3. Ranking of Open Spaces

The potential open spaces in Pokhara sub-metropolitan city was then ranked based on the spatial analysis methodology, where, the 500 m coverage buffers of each open spaces is created and the services facilities such as hospitals, clinics, police station, CBOs that are within the 500 m buffer area of the open space is then analyzed in a GIS base for the evaluation of the suitability and functionality of the open space. The analysis of open spaces involves both quantitative and qualitative procedures. While evaluating the open space, size of the open space, proximity to urban infrastructure and services and other facilities were taken into consideration. The ranking for the evacuation site or relocation area was done based on the weight of 60% given to the available area of the open space and 10% each to the security services available, social services available, health facilities and water supply sources. The fragmented spaces that are smaller and could accommodate less than thousand populations are not included in the ranking. If earthquake casualties exceed the available area of relocation, then the open spaces which are not listed in the ranking will also be used for the relocation purpose. The ranking of open spaces and its corresponding number of social and infrastructural facilities are listed in table Z.

Table 8: Ranking of the open spaces

S. no	Space location	Area sq. m	Capacity (persons)	Number of Facilities				Rank
				Water supply sources	Social organizations	health facilities	Security Services	
1	Pokhara Stadium	194,994.40	55,713	0	0	0	0	1
2	Pokhara Komagane Friendship Park	65,181.45	18,623	0	2	0	2	2

3	Baidam Park	49,739.17	14,211	0	2	0	2	3
4	Prithivi Narayan Campus	38,059.77	10,874	0	0	2	1	4
5	Hario kaharka Ground	36,051.72	10,300	0	0	1	0	5
6	Prithivi Chowk Ground	16,334.63	4,667	0	0	2	0	6
7	Tundikhel Ground	9,362.37	2,675	1	0	0	0	7
8	Prithivi Narayan Campus	34,076.74	9,736	0	0	0	0	8
9	Ram Ghat	14,536.84	4,153	0	0	1	0	9
10	Male patan Ground	14,226.32	4,065	0	0	0	1	10
11	Department of Road	13,775.18	3,936	0	0	1	0	11
12	Ranipauwa open space	11,645.45	3,327	0	0	0	1	12
13	Open space near nursing c	11,554.79	3,301	0	0	1	0	13
14	Amar Singh Ground 2	23,468.13	6,705	0	0	0	0	14
15	Food Corporation Ground	6,446.83	1,842	0	0	1	0	15
16	Fewa Tal park Ground	22,596.60	6,456	0	0	0	0	16
17	Nursing Campus Ground	6,167.91	1,762	0	0	1	0	17
18	Malepatan-2	5,831.16	1,666	0	0	0	1	18
19	License Trial Ground	20,334.31	5,810	0	0	0	0	19
20	Annapurna chowk	3,944.12	1,127	0	0	1	0	20
21	Amar sing Ground	14,948.43	4,271	0	0	0	0	21
22	Khasi bajar open space	11,370.25	3,249	0	0	0	0	22
23	Indu chowk, stadium side	10,054.62	2,873	0	0	0	0	23
24	Gandaki Boarding School G	9,881.39	2,823	0	0	0	0	24
25	Kalika Chowk open space	8,045.10	2,299	0	0	0	0	25
26	Lamachaur open space	7,886.97	2,253	0	0	0	0	26
27	Bhedifarm open space	7,382.84	2,109	0	0	0	0	27
28	Majheripatan open space	6,675.23	1,907	0	0	0	0	28
29	Gupteshwor Open Space	5,803.18	1,658	0	0	0	0	29
30	Chhorepatan school	5,527.24	1,579	0	0	0	0	30
31	License Trial Ground	4,793.92	1,370	0	0	0	0	31
32	Siddhartha School Ground	4,120.09	1,177	0	0	0	0	32
33	Chorephatan School 2	3,795.07	1,084	0	0	0	0	33
34	SOS School Ground	3,632.17	1,038	0	0	0	0	34

The open space in Pokhara sub-metropolitan city along with its rank, and available critical infrastructures and emergency services at its proximity is shown in fig.17.

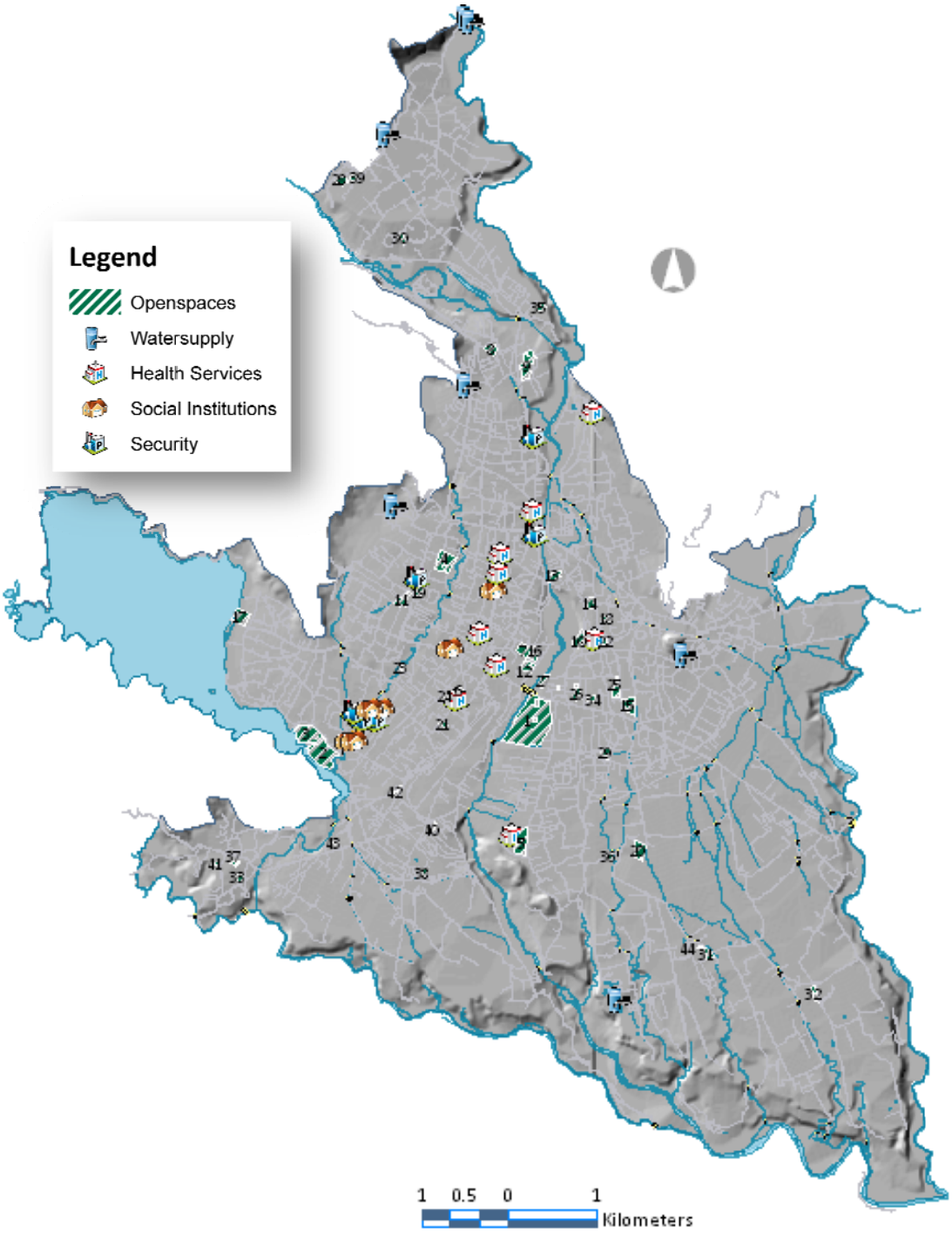


Figure 18 Location of Open Spaces and Service Facilities in Pokhara sub-metropolitan city

Chapter 6
Risk Sensitive Land Use Planning

6.1. Earthquake Risk Sensitive Land Use Plan

Earthquake risk sensitive land use planning seeks to adopt the best land-use options and translate the assessment of risks into appropriate location of land uses, functions, facilities and into land use regulations and policies. For Pokhara sub-metropolitan city, the metropolitan areas are divided into three zones, namely restricted area, special consideration required area and suitable area for urban expansion. As the urban areas are expanding over high liquefaction and sinkhole susceptible areas, the new construction should be restricted in those areas and in inevitable cases, mandatory regulations for approval of structural design and analysis for a new construction should be enacted. The new developments should be promoted in the south-east part of the metropolitan area where the land is relatively safer for urban expansion.

The building code implementation for new construction should be made mandatory in the Pokhara sub-metropolitan city and urban densification programmes should be launched in the areas stated as suitable areas for urban expansion, with the extension of adequate urban infrastructure and services.

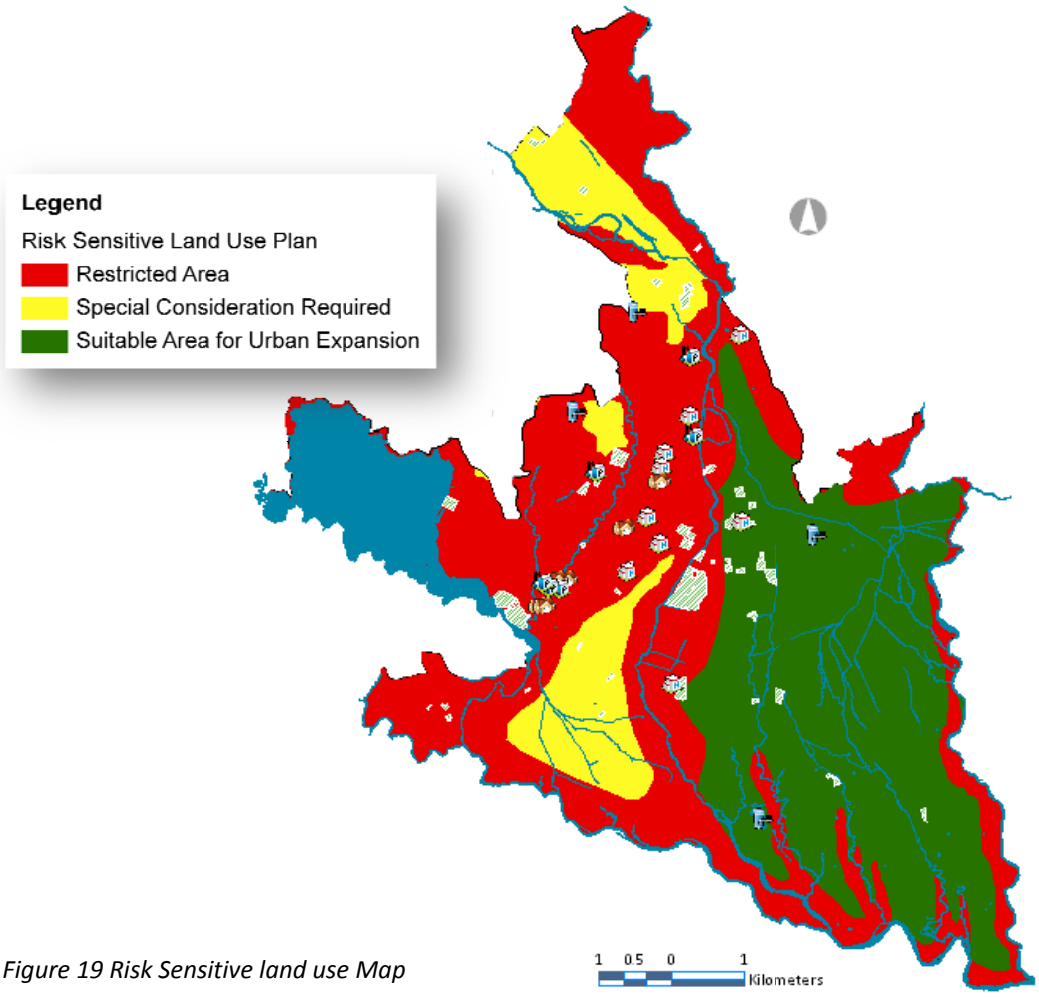


Figure 19 Risk Sensitive land use Map

6.1.1. Strategies to be Adopted for the Implementation Land Use Plan

Risk sensitive planning approach, sustainability in the environmental resource use, improved livelihood conditions of the people are the focus areas, which are bounded by the current strategies adopted for land use plan. The strategies to be adopted are as follows:

- Efficient use of land: The efficient land use encourages the balanced growth and development consistencies with the conservation of the natural environment. Concentrating development and new growth in appropriate locations such as vacant land inside the urban core and conserving the land outside the core area for planned development. It provides basic foundation for the efficient use of land and will revitalize existing service centres, protects natural resources, maintain an efficient transportation network, provide better quality services and facilities and help each community protect its cultural values and identity.
- Balanced development: Current development trend shows the centralization of all the development initiatives as well as population pressure being felt in the city in search of employment opportunities and access to infrastructural opportunities. This has created acute infrastructural deficiency and population pressure in cities. Hence equitable distribution of urban infrastructural services and amenities has been a prominent need for land use development.

- Development according to the infrastructural capacity: The development initiatives are to be taken in each land uses according to the capacity of the infrastructural services available to ensure the equitable access to the infrastructure. Extension of the infrastructural services such as programs related to road widening, extension of water supply and electricity mains, security services are to be launched before the development intensification is initialized in a specific land use.
- Guided development: The development process is guided by providing the infrastructural service and facilities only to the proposed land uses and thereby constraining the haphazard urban sprawl. The facilities provided only to the proposed land uses intensify the coordinated and compact development. The phase-wise development programs are to be launched in the area separated for present urban development and future urban development for the gradual planned development.
- Restricting development in hazardous areas and environmentally sensitive areas: The areas that are identified as geologically unstable for development such as high liquefaction potential areas, slope lands, fault lines and other environmentally sensitive areas are restricted for development. Restriction helps in both mitigating the vulnerability of the population towards natural hazards and protects the ecological and environmental balance in the urban areas.
- Conserving the sites of historical, religious or culturally importance: The sites identified as the areas of historical, religious or culturally importance are provided with special land use zoning with development constraints such as height restrictions, vehicular traffic restriction and building quality and setting restrictions in order to preserve the cultural essence of the important sites.
- Regional perspective and holistic approach: for a land use plan, municipality cannot be cannot be regarded in isolation as a single entity, rather the regional perspective is required. Geological conditions, natural resource management and socio-economic context cannot be viewed in isolation limiting only the municipal boundary. The problems related to related to air, water and land pollution, traffic congestion, conflicting land uses and natural hazards and vulnerability of the people living in the area are the geo-regional problems which cannot be solely alleviated by the single effort of the municipality hence holistic approach is required.
- Development nodes and its hierarchy: Detailed knowledge of the hierarchy of the service centres and relationship with its hinterland is important for the implementation of the land use plan. Information about service centres of primary order, secondary and tertiary orders with its popula-

tion, socio-economic opportunities and services are important factors which provides opportunities for relieving the population pressure and employment demand in the main city by providing the employment and housing opportunities in the secondary and tertiary cities or in local level.

- Land use and transportation: Land use and transportations are interrelated and cannot be isolated transportation causes the land use change as well as type of land use is responsible for the transportation demand. Hence integrating land use and transportation planning and development is commonly considered in any planning approach. Integrating land use and transportation fosters to preserve and even enhance valued natural and cultural resources and facilitate sustainable communities. In addition, the consideration of long term and broader impacts of land use decisions on natural and urban environment, including transportation systems and facilities, is critical for mitigating the vulnerability towards natural hazards.
- Access to open space: Access to open space is vital to the urban environment, social and economic life of a community. Open space provides healthier environment by serving to mitigate the effects of pollution and providing recreational facilities as well as provides safe place at the time of emergencies as a potential evacuation sites at the time of earthquake and other hazards. Equitable access to open space is a key towards mitigating the urban vulnerability and at the same time containing urban sprawl in coordinated manner. Spaces such as slope lands, river banks or other land that is unsuitable for development can be preserved by tree plantation for environmental balance in urban areas.
- Access to infrastructure, social services and amenities: Infrastructural and social services and amenities define the vitality of the any land use. For planned development of urban space, equitable distribution of infrastructure and social service and amenities such as educational facilities, health services, security services, water supply, electricity etc are necessary. Similarly, the health and security services are factors that are related to the risk sensitive land use planning and are of predominant importance in the post disaster phase of natural hazards.
- Improving the Carrying capacity: Carrying capacity of a city can also be referred as an "ecological footprint" of the city defined in the third law of human ecology as, population that be supported indefinitely in a certain habitat without permanently damaging the ecosystem upon which it is dependent. The carrying capacity of the city can be improved by facilitating the compact settlement, utilizing vacant and waste land, promoting urban environment and sustainability by increasing green and open areas.
- Proper guided transition between rural and urban settings: For the guided urban development, proper transition between rural and urban settings is required. In order to contain the haphazard urban growth, the optimum use of the infrastructural resources and planned urban development is of immense importance. Reserving the plots for future urban expansion, clear demarcation between the urban and rural land and conservation of agricultural areas at the periphery of urban areas are the key concept behind the urban containment and planned growth.
- Demarcation between urban and rural areas: The clear demarcation of land use between urban and rural land use is necessary as the extension of infrastructural facilities in the rural areas unnecessary promote haphazard development in the urban fringe. The clear demarcation between urban and rural areas guide the intense use of urban land while preserve the environment of urban fringe. Stage wise development approach in the reserved land for urban expansion in urban fringe provided planned development in the future.
- Conservation of the agricultural areas: In order to promote the sustainable development and preserve the environment of the urban areas, the agricultural areas in the urban fringe should be conserved. Haphazard building construction in the urban fringe and land speculation has led to fast conversion of the urban area into residential and commercial areas. The development has taken

place without proper standards related to buildings or infrastructures this has created adverse impact on the environment. For constraining the urban sprawl in the urban fringe and containing the fast depleting agricultural areas, conservation of agricultural areas in the urban fringe should be initiated.

- Reserved land for future urban expansion: The plots reserved for future expansion will only be permitted for the urban development. The areas with low agricultural productivity, low risk to hazards, relatively cheaper for infrastructural extension and not sensitive to the ecology or environment are selected for the future urban expansion.
- Reserved land for emergency evacuation: Open spaces in the urban centres in several areas which are accessible to most of the people will be reserved for emergency evacuation. While reserving the land for open space, several lands will be identified for emergency evacuation of certain communities and evacuation routes will also be identified in case of emergency.

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