Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

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MUNICIPALITY PROFILE

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CHAPTER - I
AN OVERVIEW

1.1 Naming and Origin

Ilam is a municipality of Ilam District, which is in the hilly region of Mechi zone, in the Eastern Development Region of Nepal. Ilam also acts as the headquarters of Ilam District and Mechi zone. Ilam also acts as the headquarters of Ilam District and Mechi zone. Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of the important town in Mechi zone and one of the major place in Nepal for tea-production. It is famous for natural scenery and landscapes, tea production, and diverse agricultural economy. It is one of the major horticultural crop production districts of Nepal. Ilam municipality is sub-divided in 9 different wards; the major governmental and district office lies in ward number 1 and ward number 2. Ilam also is a major hub for transportation and communication for VDC that lies in the upper part of the discrict. The municipality was established in 2015 B.S.

Formally, the name of Ilam is documented by institutional attempt. According to institutional attempt, before the unification of Nepal, the firtile land Ilam was Kirats' Kingdom and Limbu majority was there. Thus, the name of this district was derieved from Limbu language. The word ‘Ilam’ comprises two words-‘I’ and ‘Lam’. In Limbu dialect, the word ‘I’ means ‘winding’ and ‘lam’ denotes to the way. Upon looking at the topography of this land, we can actually see several winding paths crisscrossing on the way. Thus it is aptly named ‘Ilam’.

1.2 Location

Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal. It is extended from 87 ^{o}53’30” to 87 ^{o}57’46” Eastern Longitude and 26 ^{o}51’58” to 26^{o}56’46” Northern Latitude have an area of 27.0 Square Kilometer. The municapility is surrounded by Mai Khola (River) to the east, Puwa Khola (River) to the west, Barbote VDC (Village) to the north and Mai Khola & Puwa Khola (Rivers) to the south.

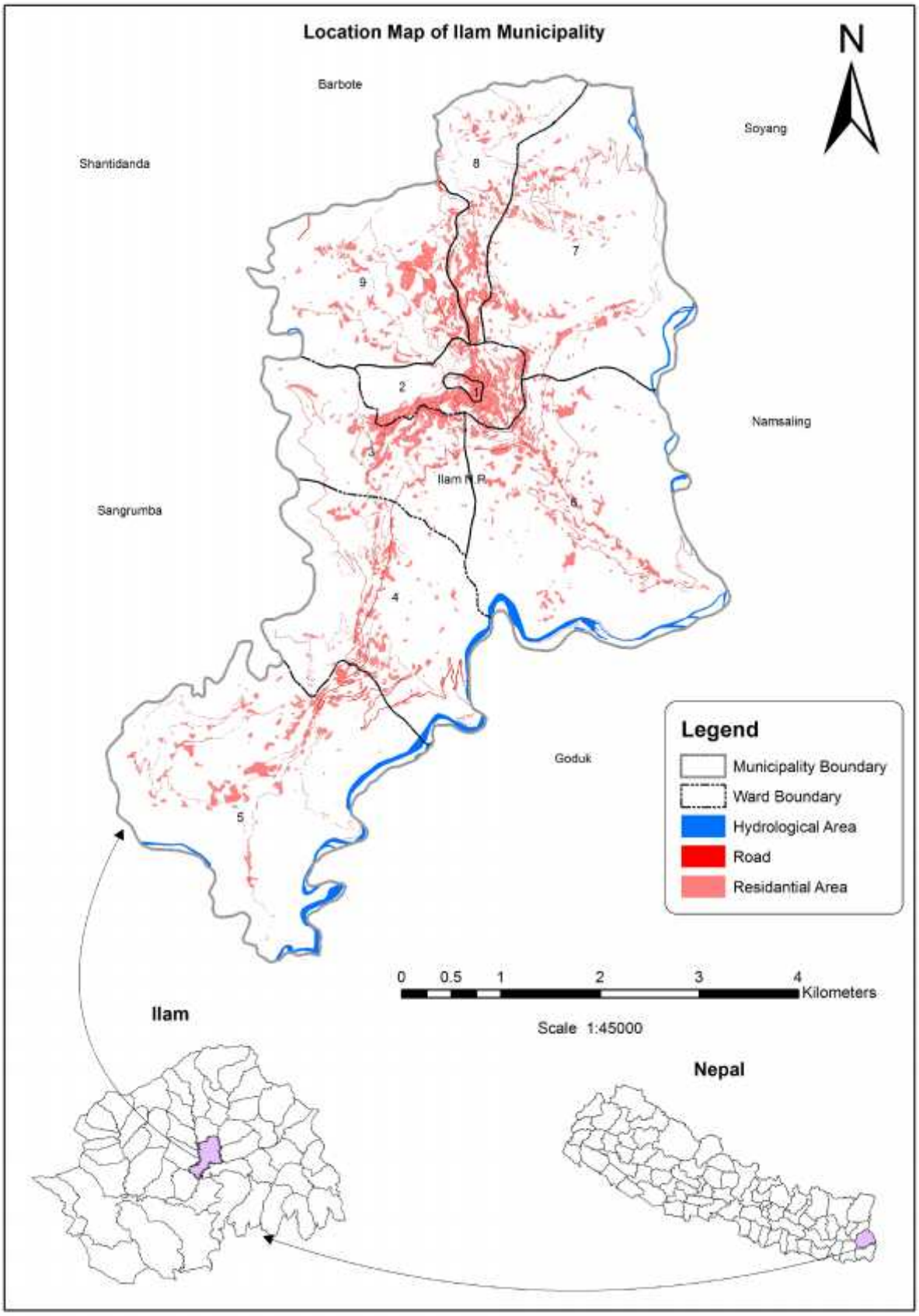

Figure 1.1: Location Map of the Municipality

1.3 Settlements and Administrative Units

The municipality is sub-divided in 9 different wards, the major governmental and district office lies in ward number 1 and ward number 2. It also is a major hub for transportation and communication for VDC that lies in the upper part of the district. The wards vary in their land area and population.

Wards are comprised of many settlements. These settlements are referred as *gaun* or tol or *chok* or Bhanjyang. Generally, settlement hamlets located along the cross roads are referred as *chok*. Likewise, the linear settlements along the main roads are referred as *tol*. Other isolated or agglomerated settlements are normally called *gaun* here although the distinctions are rather blurred. Major settlements of this Municipality are shown in Table.

Table 1: Ward-wise distribution of main settlements in Ilam Municipality

Ward No	Name of Settlement	No of Households
1	Malapath	
2	Ratnechowk, Hakimtole, Tudikhel, Suntalabari, Chiyabari, Kuldhara	
3	Sera, Sajbote, Thinggaun, Sinhabahini, Golbasti	
4	Golkharka Bhanjyang, Bistagaun, Khalte, Sadhewa	
5	Nigure, Keureni, Puwajung, Bhangtar, Gewadanda, Pragatinagar, Golkharka	
6	Taragaun, Tilkeni, Ranigaun, Beninagar	
7	Mahabhir, Singfring, Majhuwa, Tamanggaun	
8	Pipalbote, Ghosgaun, Buddhanagar, Chureghanti	
9	Balangaun, Setidevi, Gagithumka, Barbhaiya	

Source: Field Survey, 2073

CHAPTER - II

PHYSICAL SETTING

2.1 Physiography

Topographically Ilam is mostly a hill district with altitude ranging from 140 meter to 3636 meter from the mean sea level. It extends from the low land of the Bhabar in the south to the higher mountain of Mahabharat range to the north. This district has a very small area of Bhabar zone to the southwest which covers only 2.35% of total area of the district. Its altitude is up to 250 meter. Most of the southern part is occupied by the Siwalik hill covering 29.53% area of the district. The altitudinal range of Siwalik is 250 to 600 meter. Siwalik region of Ilam is lower than its western counterpart of Nepal. Remaining 68.12% is lower and higher hills of Nepal. It covers whole of the central and northern part of this district. This area has the altitudinal range from 600 meter to 3636 meter. This area is known as Mahabharat range. This mountain range is rugged in form and has steep face toward the south. Since its elevation is lower than that of the mountains of the higher Himalayas, it is free from permanent snow cover. It has several spurs extending towards south with deep and narrow valleys in between them forming the major features of the mountain ranges. Many rivers and streams originate from the springs at and various sections they have carved out fairly deep valleys. Mai river valley extends from east to west direction just north of Siwalik region with the similar characteristics of major river valley of Nepal. Some small river valleys have been formed by the Mai River and its tributaries. Wider valleys lie at the southern Siwalik regions. The physiography of the municipality is basically hilly terrain of this municipality. The micro topographic variations are depicted in the terms of Shaded Relief Map, Slope Map and Digital Elevation Map which are shown below and following sub-chapters.

Ilam District is situated most area in the Mahabharat and some part of the district belongs to the Siwalik. The project area is distributed south of the Siwalik Range.

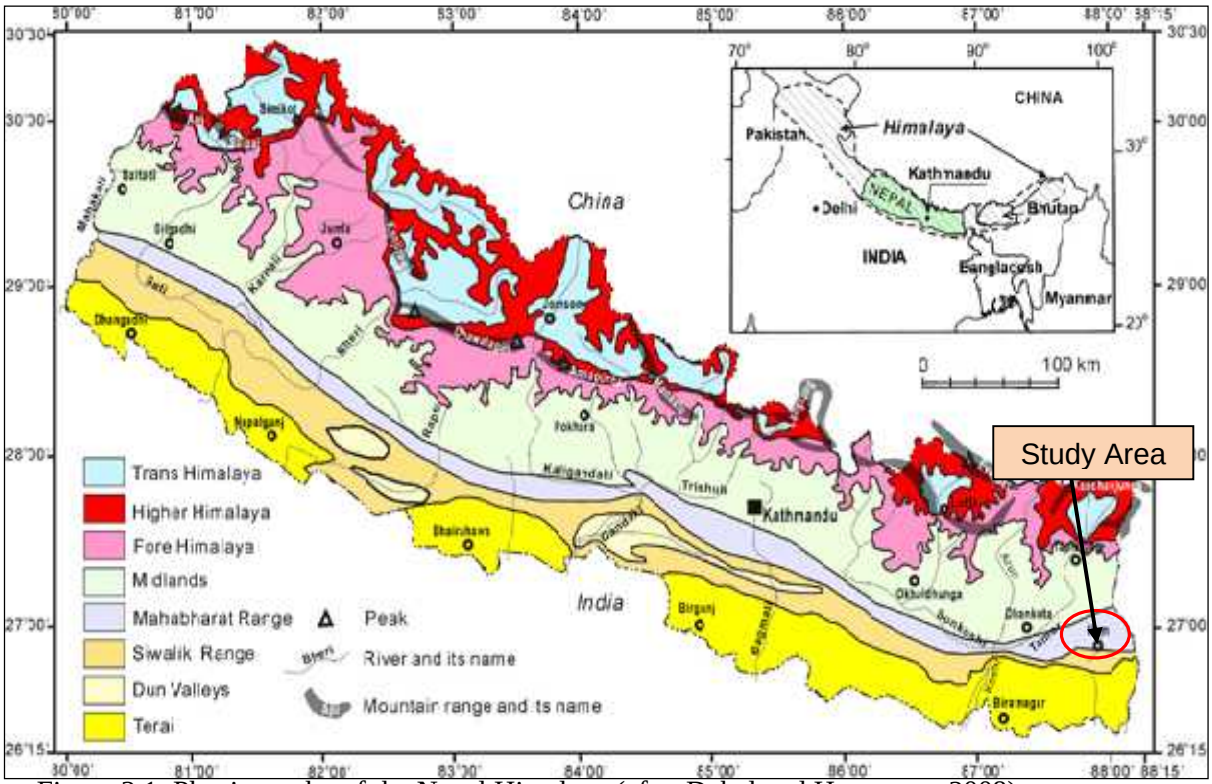

Figure 2.1: Physiography of the Nepal Himalaya (after Dahal and Hasegawa, 2008)

2.2 Geology/Geomorphology

Most of the northern part of Ilam district is in the Mahabharat Range which is also known as the Lesser Himalayan Zone. The geology in the Mahabharat Range is complicated. Stoecklin (1979) explains, “Stratigraphic work in the thick, slightly metamorphosed argillo-arenaceous and calcareous deposits is hampered by the almost total lack of palaeontological control.” A series of geomorphic processes including metamorphism and migmatization (partial melting of rock through extreme metamorphism) has caused folding, faulting, and thrusting; as well as interesting features such as nappes, klippes and windows (Skoecklin, 1979). This geological structure causes thick landslides and rockslides creating a colluvial cover on crystalline rock sequences common in the Lesser Himalayan zone (Schramm & Uhlir, 1998). Extreme precipitation from monsoon season and weathering processes hinder the stability of these soils causing massive gully erosion and landslides. Southern Siwalik region has deposit of huge quantity of calcium carbonate and sub-economic grade of important minerals such as iron, sulfur, copper etc. The tectonically active zone of the Himalaya, Siwalik Hills are considered as the most dynamic formation where they annually rise up by 3 to 4mm. Being very young in geological formation and tectonically active, the hills exhibit a very conspicuous fragile terrain. They stretch east west forming the north boundary of plains of Terai and southern boundary of Middle-hill Mountains. The Bhabar zone with an altitude ranging from 140 to 250 meters is an area of sediment deposits transported from the Siwalik and is tectonically active zone which is considered as the most dynamic formation. This area is geologically very young and tectonically an active and exhibits a very conspicuous fragile terrain. This area is the prime source of sediments. A number of steep torrents transport them downstream to the Bhabar and plain of Tarai leading to the rise of streambed level further aggravating the flooding and inundation problems in the plains. The weak geological formation, intense rainfall and tectonically uplifted phenomenon have contributed to the geo-morphological development of these instabilities. To the north of the Main Boundary Thrust (MBT) Mahabharat ranges are however composed of mainly limestone, sandstone, shale, marble, granite, slate and other metamorphic rocks of varied geological ages.

The study area belongs to the Sarung Kh. Formation and south of the Shiprin Khola Formation. The area is mainly composed of fine texture, darkgray to greenish white quartz biotite schists, quartz feldspar biotate schists in the Sarung Kh. Formation and coarse textured highly garnetiferous muscovite biotite schists, calc.silicate rocks light gree chlorite schists and meta basic rocks in the Shiprin Khola Formation. The figure shows the geology condition of study area.

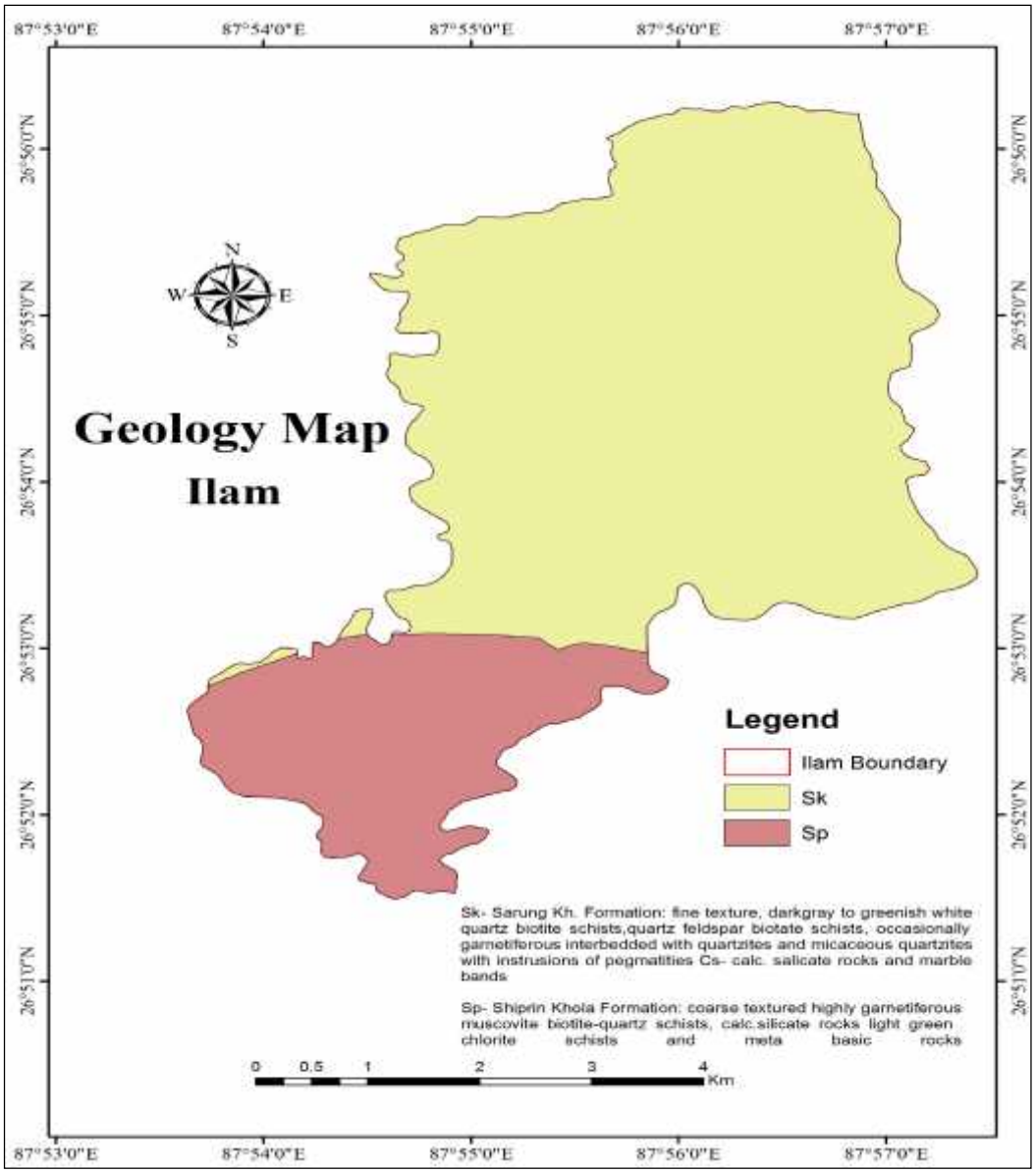

Figure 2.2: Geological Map of the Study Area

2.4 Drainage/Hydrology

The Mai Khola and Puwa Khola is the major river in the municipality. The major river flows here from north to south. Basically it originated in Mahabharat and flows to southern part of municipality. Beside these there are some local streams originated within the study area itself. In the summer season, these small rivers and streams are filled with huge volume of water creates the situation of floods.

2.5 Terrain

Terrain is the vertical and horizontal dimensions of land surface. It determines the drainage pattern, depth and profiles of soil, land use pattern and susceptibility of land surface to denudation and natural hazards. Terrain of Ilam municipality comprises of fan aprons and complexes and flat areas, micro-ridge, terraces, spur and floodplains built by river shifts and deposits. The topography comprises dissected to rolling topography in piedmont region and very gentle with poor drainage conditions. The terrain covers the mixture of forests, settlements and cultivated agriculture land.

2.5.1 Elevation

The elevation of this municipality ranges from 382 to 1388 meters above from the sea level. Southern part of the municipality has lower elevation. Northern part of the municipality has higher elevation.

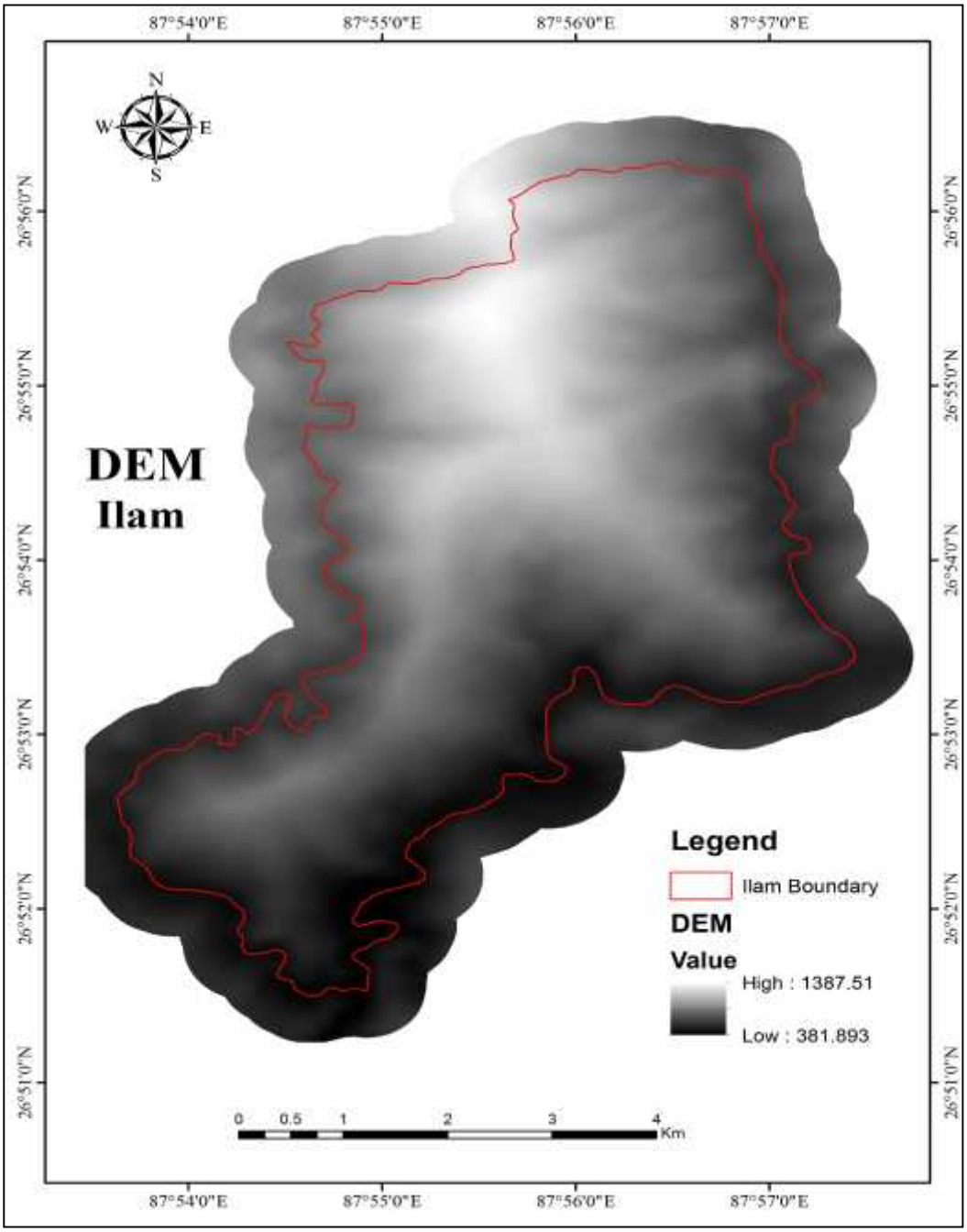

Figure 2.3: Elevation Map

2.5.2 Slope

Slope has a major influence on the distribution of water on and within the soil, as well as on the rate at which water moves during and after rainfall; gradient also influences the processes and rates of soil movement down the slope (Selby, 1991). Areas with steeper slopes are less stable, all other factors being constant. The steeper the slope, the shallower the unconsolidated material on the slope, which is likely to be removed by erosion processes. Conversely on the gentler slopes landscape is stable, the

soil forming processes is relatively less hindered. The slope of this Municipality ranges from 0 to 48 degree. 15-28 degree slope covers around 65% of the total geographical area of the Municipality.

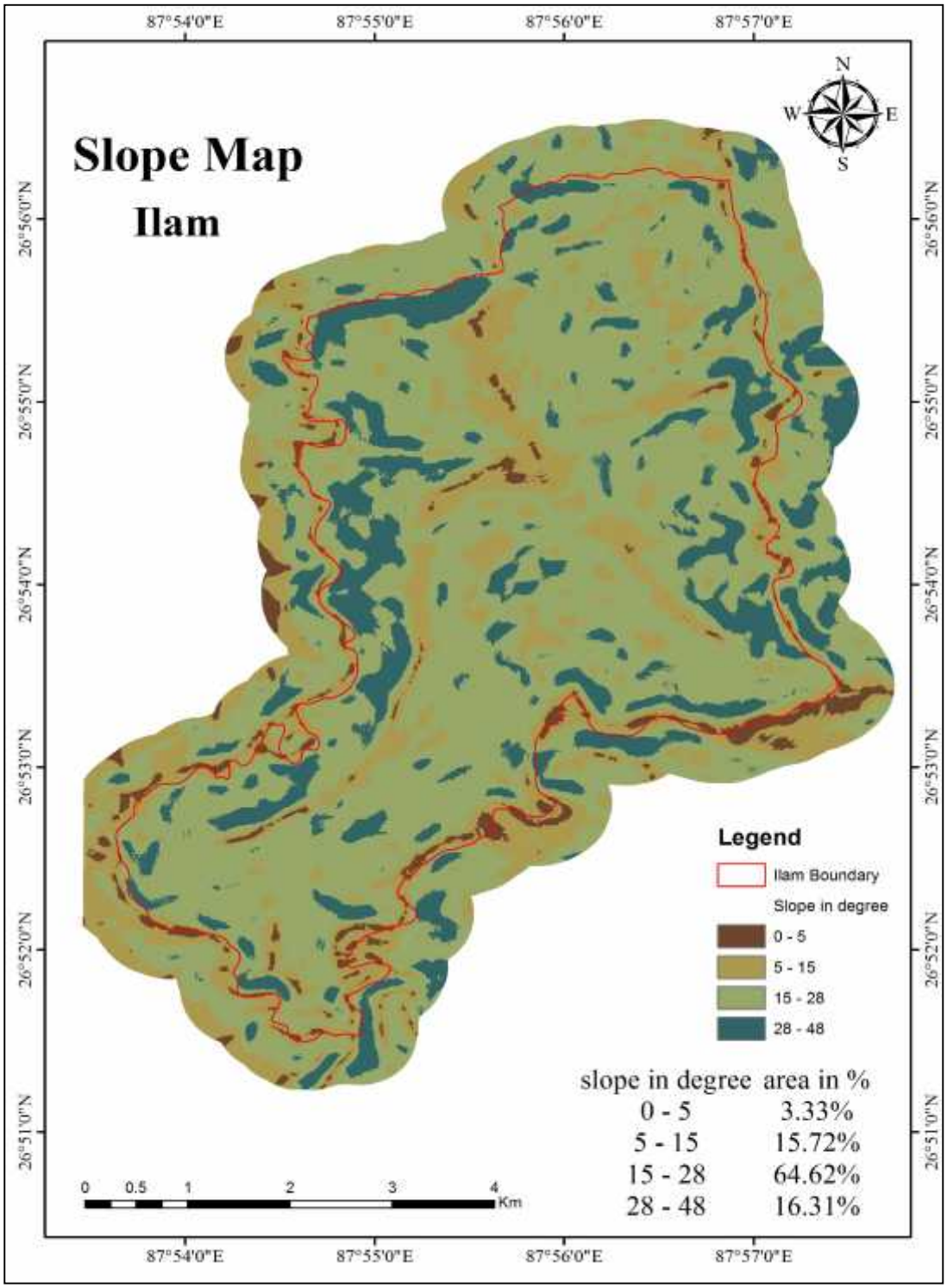

Figure 2.4: Slope Map

2.6 Climate

As is the case of whole Nepal (except those areas lying within rain shadow) four seasons with each having its own characteristic features can distinctly be seen.

- Pre-monsoon: summer season (March-May)
- Monsoon: rainy season (June-September)

- Post Monsoon: Autumn (October-November)
- Winter: (December-February)

Micro-climatic parameters like temperature, precipitation, humidity, and sunshine hours vary in each of these distinct seasons. These microclimatic conditions have direct bearing on land use and agriculture. Mostly here found the Tropical and Sub Tropical Monsoon Climate.

The following table shows the mean monthly minimum temperature of ten years period. The mean temperature of project area was calculated through recorded temperature of Ilam. Under the calculation of mean temperature of this station from 2005 to 2015, the following record was calculated.

The annual mean minimum and maximum temperature is presented in table 2.2 and 2.3 respectively. Figure 2.4 below reveal the maximum and minimum monthly average temperature (2005-2015). Very high temperature is observed in the month of April and it remains active till September. Extreme cold starts from November and last till February.

Table 2.2: MinimumTemperature in ^{0}C (Ilam Tea Estate, 2005-2015)

Months	**Years**										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**Average**
Jan	DNA	10.7	DNA	10.2	8.8	10.8	8.6	DNA	7.5	7.9	9.21
Feb	11.3	13.7	DNA	11.8	11.1	DNA	11.2	DNA	7.8	7.8	10.67
Mar	15	15.4	DNA	14	11.9	17.1	14.7	DNA	11.7	13.8	14.20
Apr	17.1	16.6	DNA	17.5	15.7	19.2	DNA	DNA	15.8	15.1	16.71
May	17.8	18.3	19.3	17.1	17.5	18.8	DNA	DNA	16	17.2	17.75
Jun	20.2	20.2	20.3	19.6	18.9	DNA	DNA	DNA	17.2	19.2	19.37
Jul	19.7	20.6	20.8	19.9	20.4	18.8	DNA	17.4	16.9	18.6	19.23
Aug	DNA	20.6	19.5	19.6	19.3	19.5	DNA	DNA	16.7	17.5	18.96
Sep	20	19.7	20.1	DNA	19.8	19.7	DNA	17.8	16.2	17.3	18.83
Oct	17.5	18	DNA	DNA	18.6	16.5	DNA	DNA	14	14	16.43
Nov	14.6	13.7	DNA	14.2	13.6	18.6	DNA	11.4	11.4	10.5	13.50
Dec	12.4	11	DNA	DNA	8.9	16.3	DNA	DNA	8.3	7.5	10.73
Mean	16.56	16.54	20.0	15.99	15.38	17.53	11.50	15.53	13.29	13.87	

Source: Department of Hydrology and Meteorology

Table 2.3: Maximum Temperature in ^{0}C (Ilam Tea Estate, 2005-2015)

Months	Years										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**Average**
Jan	DNA	18.2	DNA	14.7	17.5	17.8	15.2	DNA	19.8	19.4	17.51
Feb	18.7	21.2	DNA	17.5	20.5	DNA	16.5	DNA	18.8	20.1	19.04
Mar	22.6	23.4	DNA	22.7	24.7	26.5	22.6	DNA	22.3	23.2	23.50
Apr	25	25.5	DNA	27.2	28.3	28.8	DNA	DNA	26.7	23.3	26.40
May	25.1	26.5	26.3	27.6	28.9	28.2	DNA	DNA	26.8	26.1	26.94
Jun	26.8	26.5	27.4	27.7	28.4	DNA	DNA	DNA	26.8	25.8	27.06
Jul	25.9	26.7	26.8	26.8	28.7	28.3	DNA	27.7	26.9	26.4	27.13
Aug	DNA	27.5	27	26.8	28.2	28.1	DNA	DNA	25.9	25.7	27.03
Sep	27.1	25.6	27.3	DNA	29.8	28.4	DNA	27.5	26.5	26.1	27.29
Oct	24.5	26.1	DNA	DNA	28.6	24.9	DNA	DNA	25.3	25.7	25.85
Nov	21.8	21.6	DNA	23.9	22.7	27	DNA	24.5	23.5	23.5	23.56
Dec	19.6	18.4	DNA	DNA	17.1	DNA	DNA	DNA	20.4	19.4	18.98
Mean	23.71	23.93	26.96	23.88	25.28	26.44	18.10	26.57	24.14	23.73	

Source: Department of Hydrology and Meteorology

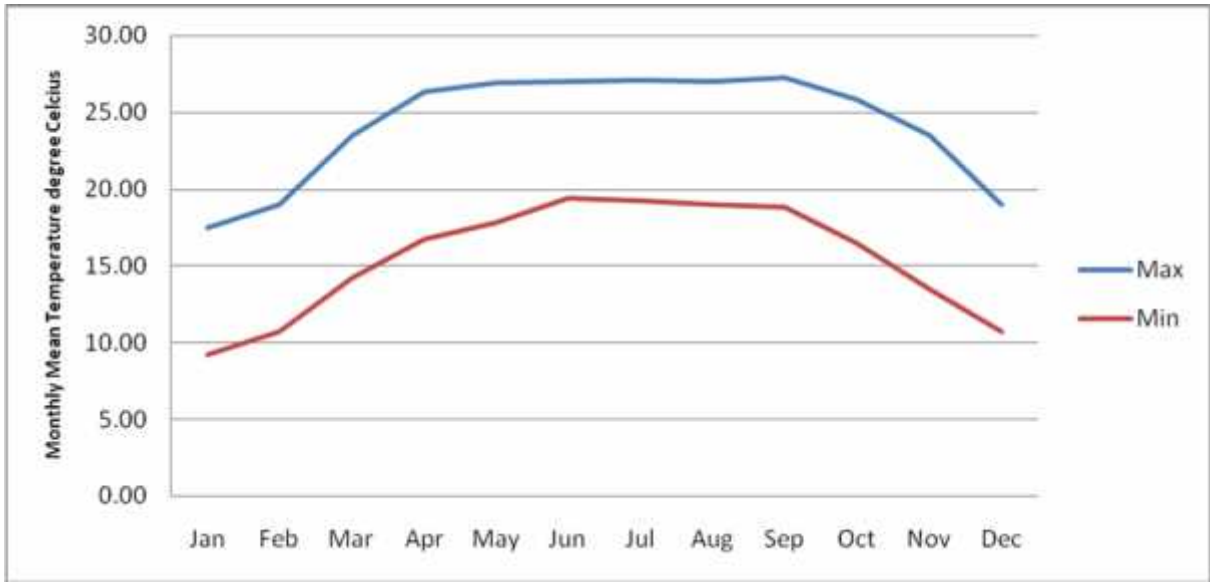

Figure 2.5 Maximum and Minimum Monthly Average Temperature (2005-2015)

The trend of monthly average rainfall from 2005-2015 vividly indicates that there is great variation in monthly rainfall. Average monthly rainfall between ten years has found greater in the month of July whereas it remained lower in the month of November. Similarly, average annual rainfall between ten years has found greater in 2015 whereas it remained lower in 2007. The details rainfall of project area shows in following table.

Table 2.4: Rainfall (in mm) (Average from Ten Years, 2005-2010)

Year	Jan	Feb	Mar	Apr	May	Jun	JUL	AUG	SEP	OCT	NOV	DEC	Monthly Mean
2005	DNA	0	30	50.4	119.9	DNA	290.6	DNA	41.9	60.2	0	0	**49.42**
2006	0	1.2	31.1	67.5	156.6	183.7	327.7	197.9	121.2	11.6	5.6	14.6	**93.23**
2007	DNA	87	8	27.3	51.4	DNA	206.6	54.6	86.5	DNA	DNA	DNA	**43.45**
2008	DNA	0	33	0	176	317.9	186.3	338.6	DNA	DNA	0	DNA	**87.65**
2009	0	0	10.2	0	271.1	96.1	297.8	439.1	8.2	120.5	0	0	**103.58**
2010	0	DNA	0	42.8	261	DNA	503.2	468.3	155.7	0	48	3	**123.50**
2011	0	0	0	0	146	301.2	237.9	326.4	268.6	41.8	11	0	**111.08**
2012	0	0	1	58	175	DNA	274	39	DNA	DNA	DNA	DNA	**45.58**
2013	DNA	DNA	86.3	81.7	175.4	199.1	135.7	252.4	158.9	DNA	DNA	DNA	**90.79**
2014	0	8	12.6	11.1	143.9	268.5	214.7	169.5	116.7	75.7	0	3.2	**85.33**
2015	0	12	41.3	96.4	140	239.8	398.4	357	298.8	33.5	0	0	**134.77**
Annual Mean	**0**	**9.84**	**23.05**	**39.56**	**165.12**	**146.03**	**279.35**	**240.25**	**114.23**	**31.21**	**5.87**	**1.89**	

Source: Department of Hydrology and Meteorology, 2016

2.7 Forest and Biodiversity

As for the public awareness, different clubs and groups has launched program for the conservation of the public land and its importance for the future. Grassland is the open spaces inside or boundary of the forest having no crown cover. Sometime it is vegetated with grasses and promptly used for the grazing cattle. In the context of bio diversity, different kinds of natural spices, and domestic animals are found here. Different kinds of birds, butterfly also found here. Ilam stretches from the Terai belt to the upper hilly belt of this Himalayan nation resulting to the large variation in climate, rainfall pattern and temperature. As the climate and temperature and the vegetation types also differ from place to place. The major types of Shorea robusta, Subtropical deciduous forest, Pinus roxburghii (pine) forest, Schima castanopsis forest, Alnus nepalensis forest, Oak-rhododendron forest, Upper slope coniferous forest, Upper slope mixed hardwood forest. But nowadays, some part of the forest is in the condition of degradation and needs proper management and conservation for its sustainability.

As biodiversity is defined as the diversity of fauna and flora in the zone, there are lots of diversities observed in Ilam districts. Some places, there are some fruit trees associated with forests like mango, banana, papaya. In some places in wilderness some medicinal trees and herbs are associated like Neem, Harro, Barro, Tejpat, Sarpaganda, Sunakhari etc.

2.8 Natural Hazards and Environment

Each year the municipality suffers from flash flood and loss of fertile land by the flood of local streams. Flash flood and bank cutting by the Maikhola and Puwakhola River is main problems faced by the local people. Most of the traditional compact wooden buildings in urban area with compact settlements have major problems of fire in this municipality. Settlements nearby forest area, thatch roof and lack of awareness are being major problems of major cause of firing.

As the environment determines the health and wealth status of its residents, it is a very important sector to be addressed properly for going green. Ilam Municipality's forests cover 27% of the total municipality area. There are 14 community forests; however their condition has been deteriorating at an alarming rate. Ilam Municipality is a sub-watershed area of the Mai river system in which many water sources are being compromised due to lack of appropriate management practices. Soil erosion

from arable land and landslides are also serious problems. Waste production and its management are both pressing issues in the city area. Over the past few years, Ilam Municipality has begun to consider and address these challenges through appropriate environment management, a crucial effort necessary to manage our overall environment in a sustainable manner.

Chapter 3
SOILS AND LAND CHARACTERISTICS

3.1 Land System and Soil Characteristics

3.1.1 Land System

The land units defined by LRMP are further subdivided based on local field variation associated with the different land use practices. Altogether nine land units identified in the project are associated with the local micro-relief variations. The spatial extent covered by the VDC area is depicted in Table 3.2 and Figure: 3.1 and 3.2.

Table 3.1: Land system type unites

Land Units	Area Ha.	Percentage
9c	105.0069	3.94
10a	281.8646	10.58
11	1636.502	61.45
12	532.6134	20.00
9a	107.0015	4.02
Total	**2662.988**	**100.00**

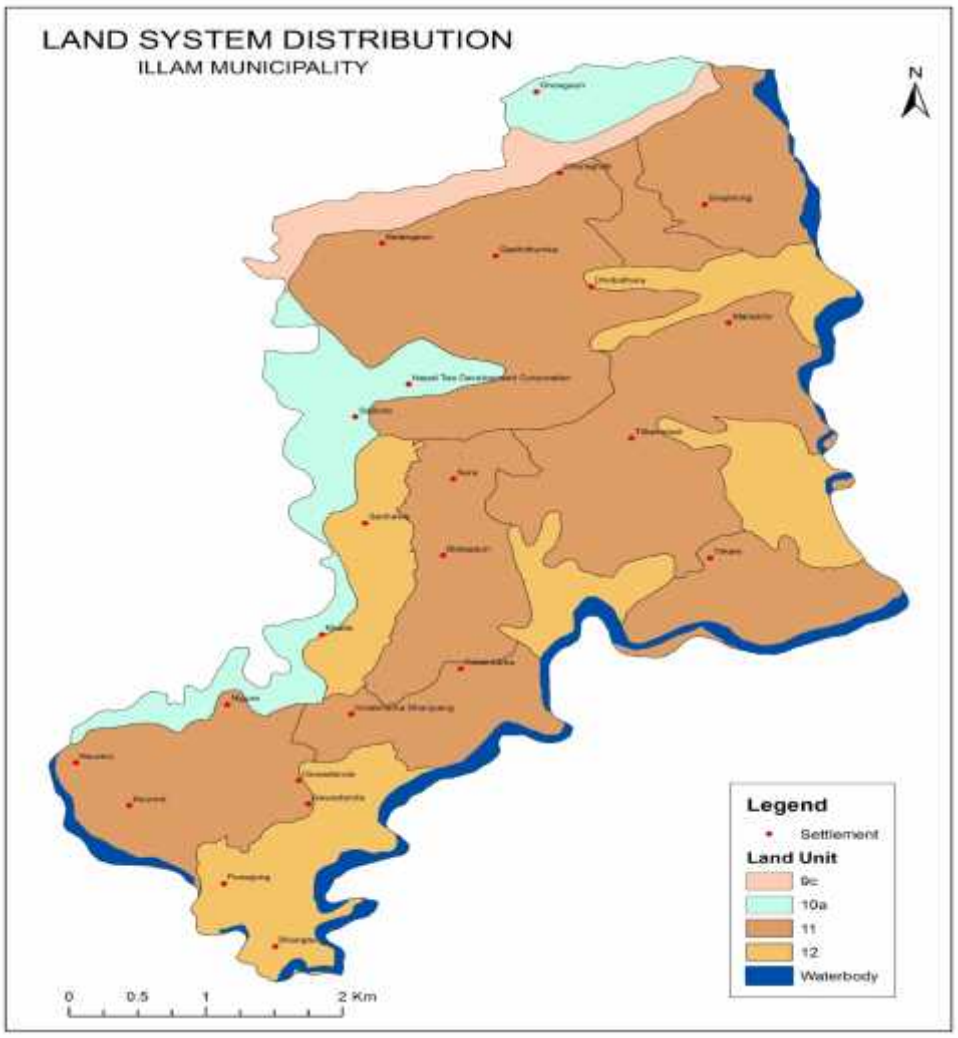

Figure 3.1: Land System Map

3.1.2 Soil Characteristics

Soils of Ilam Municipality are classified based on the information of soil derived from soil pits and soil mapping unit level. The objectives of the World Reference Base are twofold. On one hand the WRB is intended to be a reference system for users interested in a broad division of soils, at the highest level of generalization and explained in non-technical terms. On the other, the WRB must facilitate soil correlation across a wide range of national soil classification systems. This soil classification is based on the Great Soil Groups of Soil Taxonomy (USDA) because of the fact that the FAO soil classification is not a system of units grouped into higher categories, even though the system is spread worldwide. But these units relate most closely to Great Groups in the US system. In this system, the soils are grouped according to Soil Orders, Sub-Orders, Great Groups, Sub-Groups and Soil Family level. Table 3.2 and Figure 3.2 present Soil Taxonomy classification for the soils of Ilam Municipality.

In total, three orders, six sub-orders, six great soil groups and six sub-groups are found from the soil survey investigation in this municipality. The detailed description of these order of classification are characterized as below.

Table 3.2: Soil Taxonomy Classification of Ilam Municipality

SN	Order	Sub Order	Great Group	Sub Group	Area Ha	%
1	Entisols	Psamments	Ustipsamments	Aridic Lithic Ustipsamments	112.09	4.21
				Lithic Ustipsamments	360.86	13.55
		Arents	Ustarents	Lithic Ustarents	910.33	34.18
		Fluvents	Ustifluvents	Lithic Ustifluvents	105.01	3.94
		Orthents	Ustorthents	Lithic Ustorthents	262.30	9.85
2	Inceptisols	Udepts	Dystrudepts	TypicDystrudepts	420.58	15.79
		Ochrepts	Dystochrepts	UsticDystochrepts	384.81	14.45
3	Waterbody				107.00	4.02
	Total				**2662.99**	**100.00**

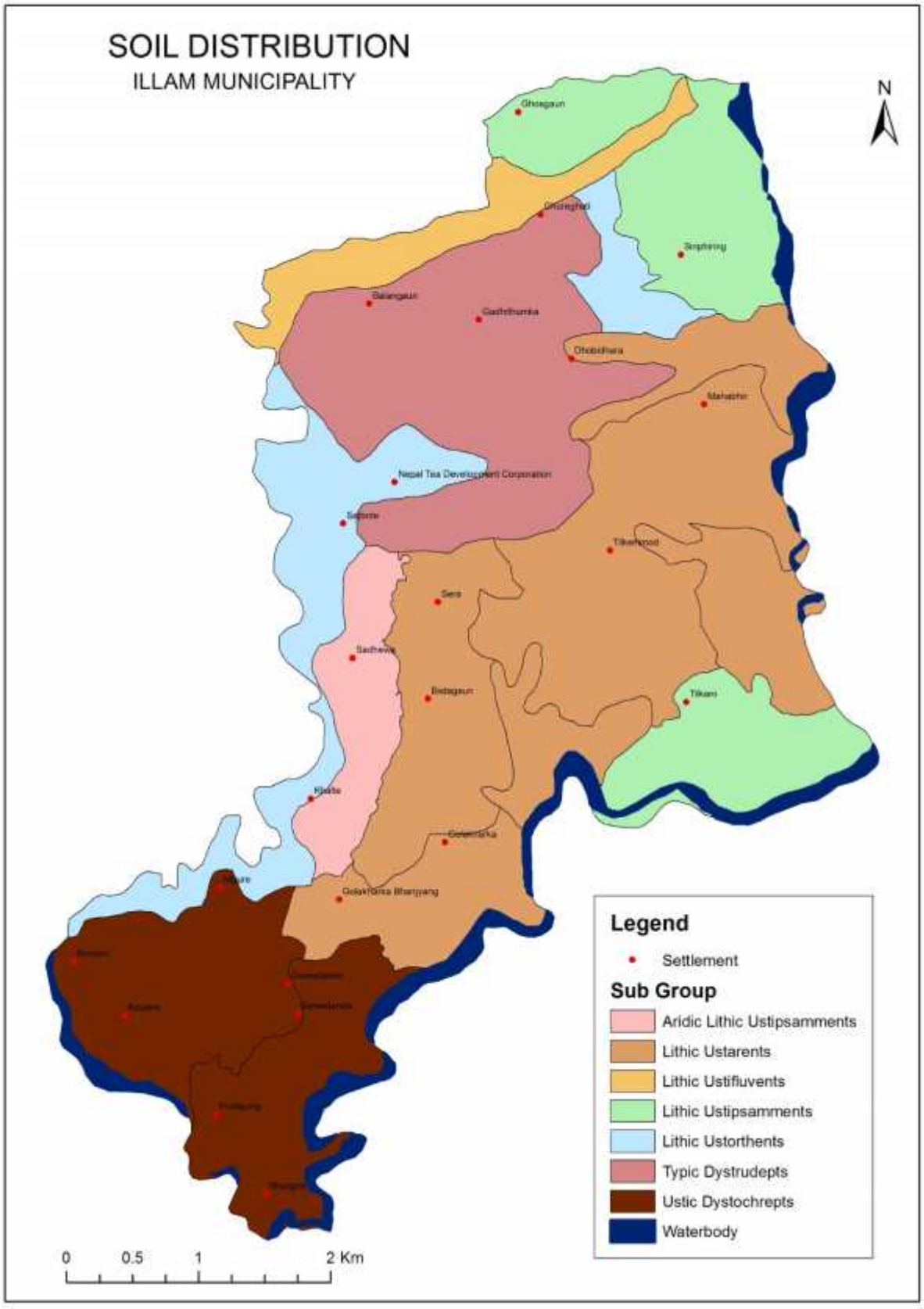

Figure 3.2: Soil Map

3.2 Land Capability of Ilam Minicipality

The Municipality was found to have nine land use classes. The present land use table and figures show that agriculture covers maximum area (50.59%) followed by forest (34.93%) and Residential (8.00%). Likewise, Riverine and Lake Area and public service area covers 3.43% and 2.29% respectively. Other coverage is not potentially significant. The spatial distribution of all the classified land capability classes in this VDC was shown in the Figure 3.5.

Table 3.3: Land Capability Classes

SN	Land Capability Class	Area Ha	Area %	Description
1	IIIAu /1	814.4	30.6	Sub-tropical, Sub-humid, Moderately to Steeply sloppy, Best for terrace cultivation, suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops.
2	IIIBh /1	433.5	16.3	Warm temperate, Humid, Moderately to Steeply sloppy, Best for terrace cultivation, suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops.
3	IIIBh/6	116.7	4.4	Warm temperate, Humid, Moderately to Steeply sloppy,Arable but sometimes Non arable due to complex topography
4	IIIBu /5	956.6	35.9	Warm temperate, Sub-humid, Moderately to Steeply sloppy, Arable but sometimes non arable due to seasonal inundation
5	IVAu	233.7	8.8	Sub-tropical, sub-humid, Too steep mostly suitable for forestry
6	IVBh	108.1	4.1	Sub-tropical, humid, Too steep mostly suitable for forestry
Total		2662.988	100.0	

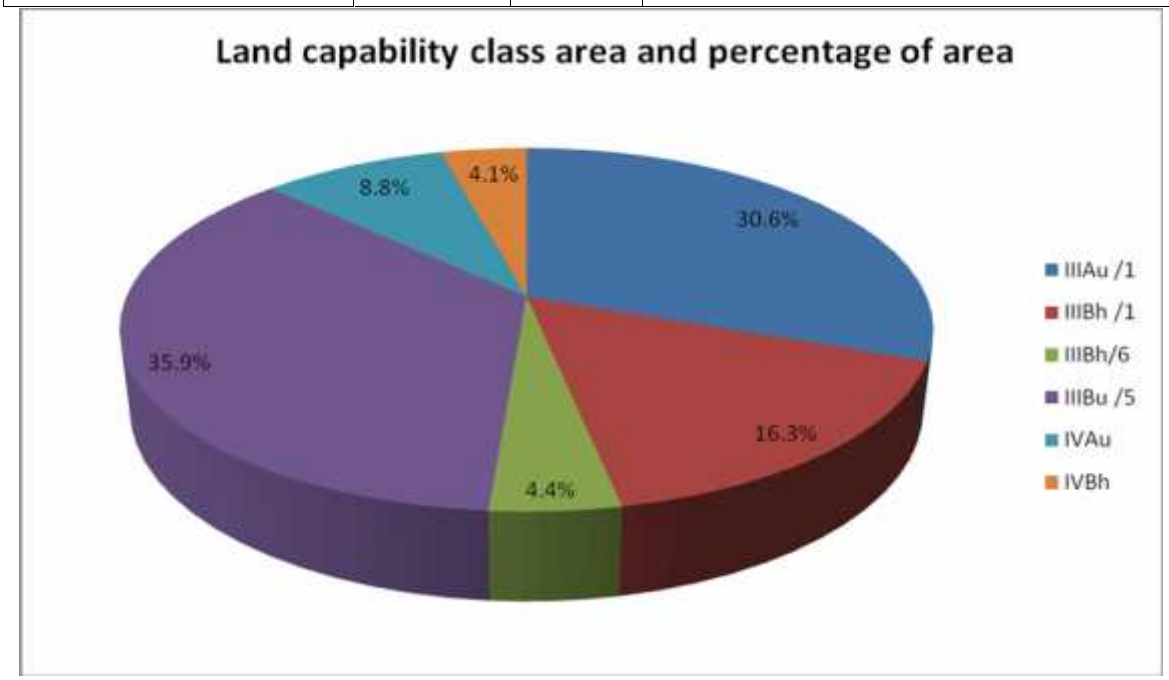

Figure 3.3: Land Capability Classes distribution

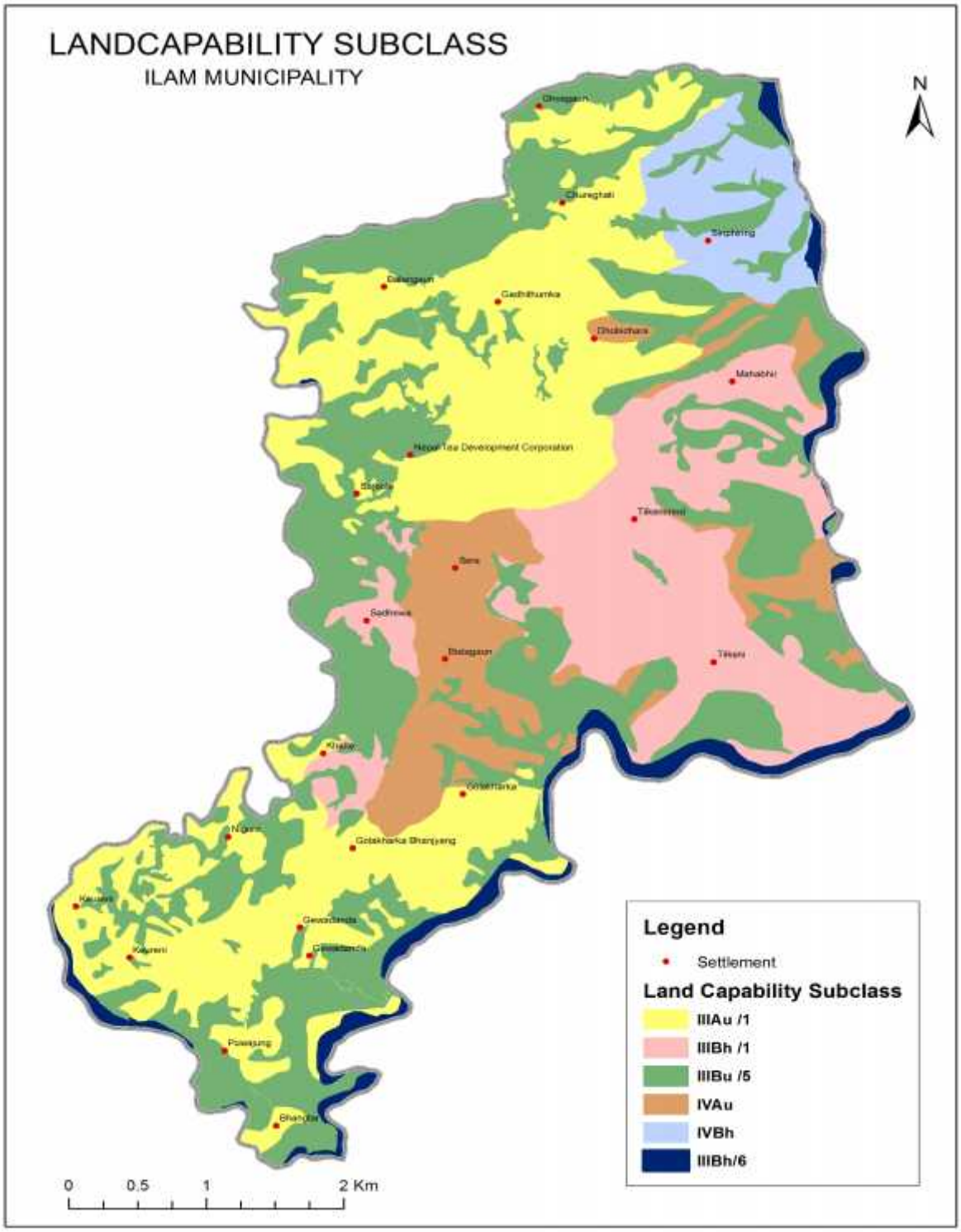

Figure 3.4 Land Capability Map, Study area

3.3 Present Land-use

The section describes the present land use pattern of the Ilam Municipality. General land cover pattern shows that agricultural land dominates land use of this area. This chapter presents land use assessed in different levels of hierarchy.

General land use of the municipality at first hierarchical level of classification is provided in Table. Out of total 2666.18 hectare land, 50.59% area is covered by agriculture followed by forest with 34.93%. The residential covers 8.00% area of the municipality. Likewise, Riverine and Lake Area and

Public service area covers 3.43% and 2.29% respectively. Other coverage is not potentially significant.

Table 3.4: General land use of Ilam Municipality

S. No.	Land Use Class	Area (Hectare)	Area (%)
1	Agriculture	1348.76	50.59
2	Commercial	5.77	0.22
3	Cultural and Archeological	0.05	0.002
4	Forest	931.21	34.93
5	Riverine and Lake Area	91.57	3.43
6	Industrial	0.39	0.01
7	Public Service	61.16	2.29
8	Residential	213.35	8.00
9	Others	13.93	0.52
Total		**2666.18**	**100.00**

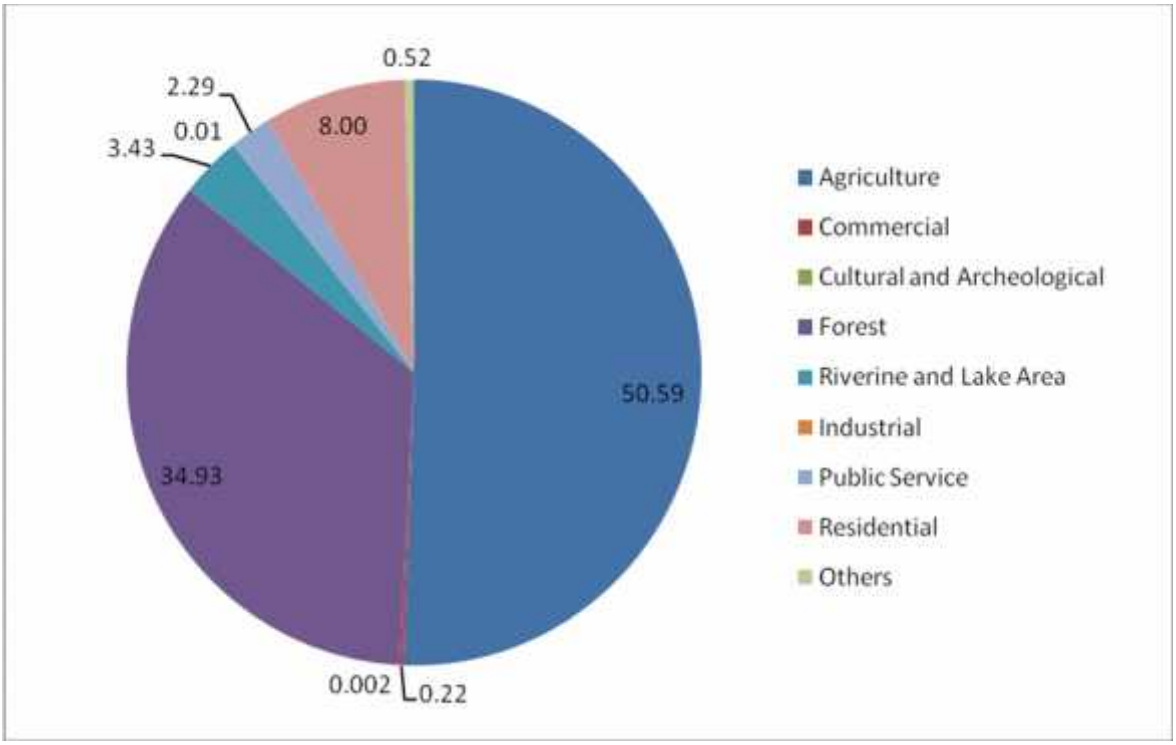

Figure 3.5: General land use of Ilam Municipality

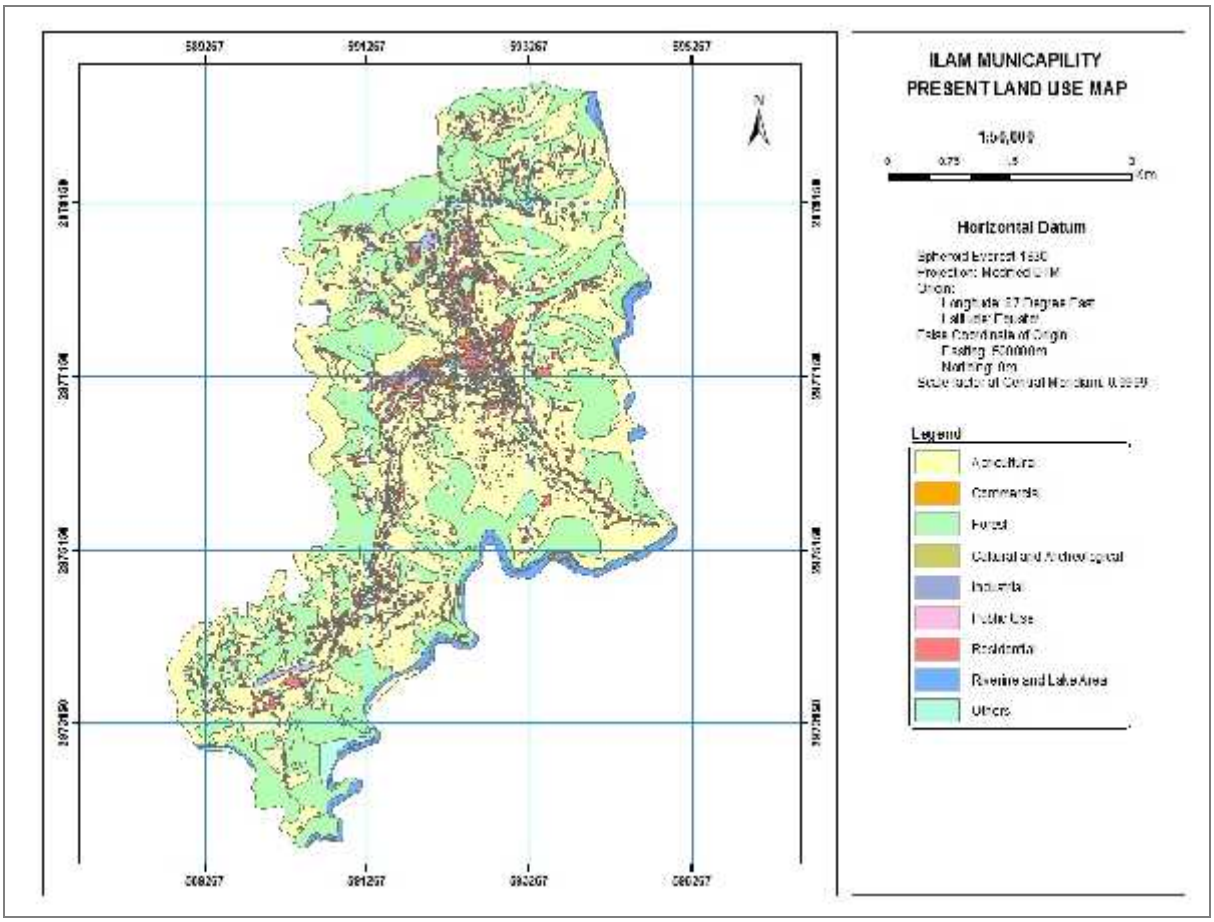

Figure 3.6: Present Land Use Map

3.4 Agriculture Pattern

Agricultural land of the Ilam Municipality is classified as Hill cultivation based on the physiographic region. This Municipality contains 84.55% of its agricultural land use as Level terraces cultivation followed by 15.45% sloping terraces cultivation. The Level terrace is further divided into lowland khet and upland pakho.

The agriculture/cropping pattern of the municipality varies according to agricultural land types, irrigation and precipitation. Hilly cultivation is the sole type of agriculture in this Municipality covering a total of 1348.76 ha of area. Analysis of cropping pattern shows that Rice-Wheat-Maize (43.39 %) is the dominant one followed by Maize-Oilseeds (16.72 %) and Maize-Others (15.95 %) as shown in the table below:

Table 3.5: Areal Coverage of Different Cropping Patterns

Cropping Pattern	Area in Hectare	Percentage
Cardamom	137.00	10.16
Fruit-Fruit	3.57	0.27
Fruit+Potato/Vegetable/Buckwheat	0.28	0.02
Maize-Rice-Fallow	4.99	0.37
Maize-Oilseeds	225.56	16.72
Maize-Pulses	13.63	1.01
Maize-Others	215.17	15.95
Rice-Maize	20.55	1.52
Rice-Others	14.81	1.10
Rice-Wheat-Maize	585.28	43.39
Wheat-Pulses	62.62	4.64
Tea	65.23	4.84
Vegetables-Vegetable	0.07	0.01
Total	1348.76	100.00

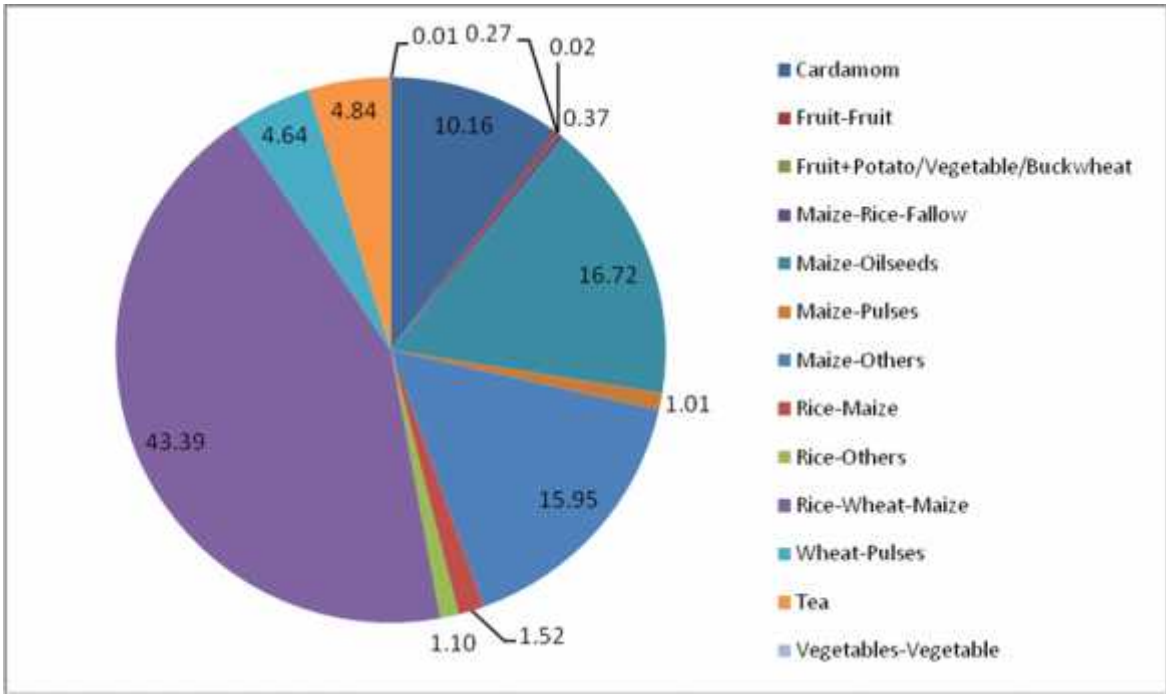

Figure 3.7: Cropping pattern of the Ilam Municipality

3.5 Land-use Zones

The existing areas used for different purposes are shown in figure. Agriculture is the dominant land use type in the study area which covers almost 46.5 percent of the total area followed by forest (33.9 percent), residential area (6.9 percent) and public use area (8.2 percent) and riverine and lake area (3.43 percent). The area used for commercial, industrial, excavation, cultural and archeological purposes are not significant in terms of area occupied by these categories in the VDC. The mines and mineral sites do not exist however, some river banks are being used to excavate sands and stones.The following land use zones are identified in this study area.

Table 3.7: Land use zoning of the Ilam Municipality

SN	Land use type	Zoning Area (Ha)	Percent
1	Agricultural Zone	1240.871	46.57
2	Forest Zone	905.6389	33.99
3	Public Use Zone	218.1958	8.19
4	Residential Zone	185.7972	6.97
5	Riverine and Lake Area	91.32368	3.43
6	Commercial Zone	12.80871	0.48
7	Industrial Zone	9.387719	0.35
8	Cultural and Archeological	0.437453	0.02
	Total	**2664.461**	**100.00**

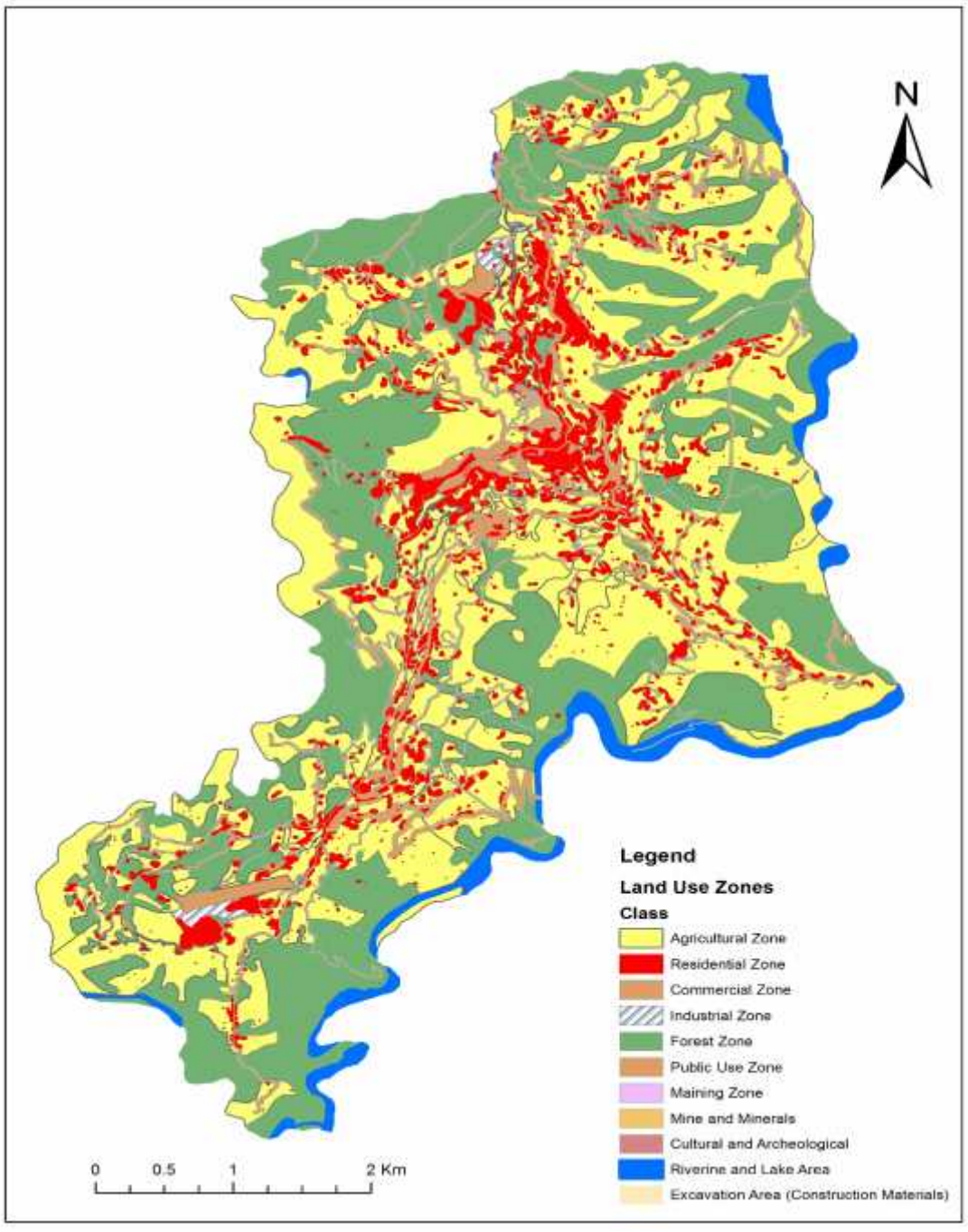

Figure 3.**8**: Land Use Zoning Map of Ilam Minicipality

3.6 Cadastral Data

3.6.1 Cadastral land parcel based on land use

Table 3.8 shows the present characteristics of cadastral parcels that falls in Ilam Municipality of Ilam District of Nepal. Out of the total 20547 parcels of the VDC, agriculture use coverss predominant with 9073 parcels (51.66 % area) followed by forest area with 3679 parcels (34.42% area), buildup area with 7630 parcels (11.84% area) and water body area with 192 parcel (2.08 % area).

Table 3.8: Parcel Characteristics of Present Land Use

Present Land Use	Parcel Count	Area	Percent
Agriculture area	9073	12436846.74	51.66
Built_up area	7630	2850302.43	11.84
Water Body area	192	500449.80	2.08
Forest area	3679	8285893.61	34.42
Total	**20547**	**24073492.58**	**100.00**

Table 3.9 shows the characteristics of cadastral parcels superimposition on Land Use Zoning for the Ilam Municipality of Ilam District of Nepal. Out of the total 22485 parcels of the VDC, agriculture area covers predominant with 9784 parcels (55.50 % area) followed by forest area with 3797 parcels (34.92% area), residential area with 4515 parcels (3.74% area) and built up area with 4218 parcel (3.66 % area). Likewise, water body covers with 2.07 % area with 187 parcels and industrial area covers an area of 0.09 % with 42 parcels.

Table 3.9: Parcel Characteristics of Land Use Zoning

Land Use Zone	Parcel Count	Area	Percent
Agriculture area	9784	13429304.89	55.50
Built_up area	4218	886346.81	3.66
Water Body area	187	501421.54	2.07
Forest area	3739	8449689.41	34.92
Industrial area	42	22111.71	0.09
Residential area	4515	903752.87	3.74
Total	**22485**	**24192627.22**	**100.00**

Chapter 4
SOCIO-ECONOMIC SETTINGS

4.1 Social Settings

The social condition portrays the different facets of a society. An effort has been made to reveal social condition of this municipality in terms of population by age and sex, population growth, caste/ethnicity, language, religion and literacy. The social setting of this municipality is found good. The major ethnic groups living here are Chhetri, Brahmin, Tamang, Newar, Tamang, Rai, and Limbu. Although there are different ethnic groups, there is we-feeling and are residing with social harmony. Major population of this area is engaged in agriculture, whereas the rest are associated with business.

4.1.1. Population Distribution and Density

The total population of this municipality is 18633 of which male population accounts for 8946 and female population is 9687. There are 4732 households in this municipality and average households size of 3.94. The population density per sq. km. is estimated 690.

Table 4.1: Population by Ward and Sex in Ilam Municipality

Ward No.	No. HHs	Population			Percentage		
		Female	Male	Total	Female	Male	Total
1	195	396	401	797	2.13	2.15	4.28
2	1240	2198	2137	4335	11.80	11.47	23.27
3	667	1266	1132	2398	6.79	6.08	12.87
4	340	830	702	1532	4.45	3.77	8.22
5	420	940	888	1828	5.04	4.77	9.81
6	574	1294	1240	2534	6.94	6.65	13.60
7	328	745	643	1388	4.00	3.45	7.45
8	438	918	809	1727	4.93	4.34	9.27
9	530	1100	994	2094	5.90	5.33	11.24
Total	**4732**	**9687**	**8946**	**18633**	**51.99**	**48.01**	**100.00**

Source: CBS, National Population and Housing Census, 2011

Similarly, the following table indicates the age structure of the population in this municipality. Age group in an important aspect of demography which shows the potential growth and economically active population. A significant feature of any population is the distribution of its members according to age, which facilitate the planner and policy makers in formulating effective socio-economic development plans for the population of different age groups. The table shows that the highest proposition of population is found in age group of 25-44 (29.82%).

Table 4.2: Population by Age Group

Age groups	Population			Percentage		
	Female	Male	Total	Female	Male	Total
Below 4 Years	635	698	1333	3.41	3.75	7.15
5–9	912	978	1890	4.89	5.25	10.14
10-14	990	1035	2025	5.31	5.55	10.87
15-24	2203	1765	3968	11.82	9.47	21.30
25-44	3071	2486	5557	16.48	13.34	29.82
45-59	1151	1225	2376	6.18	6.57	12.75
60-75	582	604	1186	3.12	3.24	6.37
Above 75 Years	143	155	298	0.77	0.83	1.60
Total	**9687**	**8946**	**18633**	**51.99**	**48.01**	**100.00**

Source: CBS, National Population and Housing Census, 2011

4.1.2. Population by Caste/Ethnicity

The basic population of this municipality comprises the different castes and ethnic groups. Caste rules were basic cultural values which influenced occupation, marriage, food habits and other social behaviors. There are 7.58% Dalit, 44.34% ethnic groups and 48.08% other caste groups including Chhetree, Brahmin, Musalman, Thakuri, Chhetri etc. The following table shows the caste wise population of Ilam municipality.

Table 4.3: Analysis of Population by Caste in Ilam Municipality

Castes	No.	Castes	No.	Castes	No.	Castes	No.
Chhetree	5036	Magar	430	Tharu	53	Teli	26
Brahaman-Hill	3419	Sarki	248	Sanyasi/Dashnami	49	Samgpang	22
Tamang	1748	Sunuwar	176	Hajam/Thakur	46	Bangali	21
Newar	1748	Gharti/Bhujal	125	Thakuri	43	Yadav	18
Rai	1522	Sherpa	118	Rajbansi	42	Hyolmo	17
Limbu	1419	Yakkha	100	Lohar	36	Thami	14
Kami	607	Kushwadiya	88	Marwadi	35	Others	215
Gurung	584	Bhote	78	Haluwai	29		
Damai/Dholi	439	Musalman	53	Yamphu	29		

Source: CBS, National Population and Housing Census, 2011

Table 4.4: Household Number by Caste/Ethnicity

Population				Percentage			
Dalit	Ethnic	Others	Total	Dalit	Ethnic	Others	Total
1412	8262	8959	18633	7.58	44.34	48.08	100.00

Source: CBS, National Population and Housing Census, 2011

4.1.3. Religion and Language

Religiously this municipality has mutual and good relationship among the different religion. Mostly population in the municipality is Hindu (84.6%). Different ethnic caste is found in this municipality. Most of the population of the municipality speaks Nepali language. Similarly, Tamang, Limbu, Newari, Rai Kirat languages are also mother tongue of many people of this municipality. Actually all the caste is used communicating common Nepali language. The following table shows the religion and language wise population of Ilam municipality.

Table 4.5: Population by Religion and Language

Religion				Language					
Hindu	**Buddhist**	**Kirat**	**Others**	**Nepali**	**Tamang**	**Limbu**	**Newari**	**Rai Kirat**	**Others**
84.6	12.8	2.0	0.6	84.5	3.7	3.3	2.9	2.7	2.9

Source: CBS, National Population and Housing Census, 2011

4.1.4. Literacy Status

Lateracy status is one of the most important social characterists of population. The literacy status of this municipality is good in comparison with the nation. Total literacy rate of this municipality is 84.66 percent. Table indicates male are 90.53 percent are literate while women are 79.32 percent. The following table shows the current literacy status of this municipality.

Table 4.6: Population aged 5 years and above by Literacy Status and sex

Sex	***Population aged 5 years & above***	**Population Who are**			**Literacy Rate**
		Can read & write	**Can read only**	**Can't read & write**	
Male	8248	7467	163	618	90.53
Female	9052	7180	192	1680	79.32
Total	**17300**	**14647**	**355**	**2298**	**84.66**

Source: CBS, National Population and Housing Census, 2011

4.2 Economic Settings

Economic development is one of the foundational pillars of balanced and sustainable development. As the income and expenditure status of people determines their quality of life, these are two major indicators for going green. Good local economy increases the access of people to basic needs, necessary services, and facilities. Local economic development should be predicated on sustainability of its local resources. Since agriculture is the mainstay of Ilam's economy, it needs to be commercialized. In addition, tourism, business, agro- and forest-based entrepreneurships, etc. are other feasible sectors to be promoted for economic development. Ilam is endowed with many natural resources, e.g., rivers, forests, and climate, which by themselves add advantage for Ilam's economic growth and development.

4.2.1 Agriculture

Agriculture makes up the most important economic sector in this municipality. Since agriculture is the major livelihood for people residing in Ilam's peri-urban area and the majority of Ilam Municipality (55.01 % of the total land) is arable, it is very important that the agriculture sector should be

addressed properly for going green. The increasing trend of agrochemical use has had a negative impact on Ilam's overall environmental and agricultural sustainability. It is necessary to introduce an agriculture system that is sustainable from environmental, economic, and social perspectives. Appropriate land use, crops of comparative advantage, and eco-friendly agro-based enterprises need to be promoted.

4.2.1.1 Food production

A variety of food crops are grown in this municipality. The major creal crops are paddy, maize, millet and wheat. Paddy, however, is the dominant crop and its area of production exceeds the area of production of other crops. Besides these crops, fruits, vegetables, cash crops, pulses and oilseeds are also grown in this municipality. The following table shows the area of land covered by different crops production in this municipality.

Table 4.7: Area of Land covered by Crops Production

Crops	***Area (hectare)***	***Percentage***
Paddy	691	29.62
Wheat	80	3.45
Maize	1008	43.20
Millet	55	2.36
Potato	133	5.70
Spices Crops	138	5.91
Vegetables	96	4.11
Fruits	60	2.57
Pulses	46	1.97
Oilseed	20	0.85
Cash Crops	6	0.26
Total	**2333**	**100.00**

Source: Agricultre Data Book, 2071/072.

4.2.1.2 Production of high value crops

Vegetable Production:

Monsoon vegetables growing are common in this municipality. Spring vegetable and winter vegetable crops are grown in irrigated condition. Vegetable is cultivated in about 4.11 percent of the total cultivated land. The municipality grown vegetables are Potato, tomato, cauliflower, cabbage, legumes, carrot, cucumbers okra, radish, broadleaf mustard (rayo), etc.

Cash Crops Production:

Main cash crops grown in this municipality are namely broom grass, ginger, potato, chili, tea. Similarly Pulses, oil seeds, vegetables and fruits are found in this municipality.

Fruit Production:

Fruit crops grown in this VDC are namely mandarin orange, pear, peach, plum, guava, banana, acid lime, etc. In this municipality, fruits mainly are produced for household consumption. Fruit is cultivated in about 2.57 percent of the total cultivated land.

4.2.1.3 Livestock farming

Livestock keeping is an integral part of agriculture. Cows and buffalos are raised for draught animal and production of manure. Cows are raised particularly for milk and buffalos are raised for milk, manure and fuel for cooking making animal dung cake. Goats and poultry also supplement the supply of animal protein. Livestock is an important component of farming system in this municipality. Livestock are regarded as one of the major assets of farm households. Livestock are primarily reared for draught power cultivation and transport, with the latter also providing milk and meat for on-farm consumption and opportunity sales. However commercial livestock farming is deployed by people for additional income sources. Some Cow, Goat and Pig/Swine and poultry farming are established in this municipality.

4.2.1.4 Poultry and fish farming

Commercially numbers of poultry farms are established in this municipality. The farmers are keeping both types of poultry birds (Hybrid and Local). The rates vary from hatchery, farm to farm according to the breed. The price of eggs and meat varies according to demand and supply. Similarly, in this municipality the occupation of fish farming is not adopted by farmers.

4.3 Employment/Occupation

Majority of people here are engaged in agriculture as it has been main source of income. According to data about 48 percent people are depend on agricultural activities. Rest population of this municipality is involved in non-agriculture activities such as labour, civil services, trade, industry etc. Main occupation of this municipality is agriculture & animal husbandry, service and business. The following table shows the economic activity of the population in this municipality.

Table 4.8: Population by Major Occupation

S.N.	***Economic activity***	***Population (Percentage)***
1	Agriculture	48.0
2	Labour	14.8
3	Civil Services	14.0
4	Trade	12.0
5	Industry	1.7
6	Others	9.5
Total		**100.0**

Source: Municipality Profile, 2073

4.4 Industry

There are many industries including different types and size in the Ilam municipality. There are numbers of service oriented, agriculture and livestock based industries. Agriculture and livestock based industries include livestocks farming, dairy industry, cheese industry, poultry farming, bee keeping, tea, cardamom and zinger processing, bag weaving etc. Similarly furniture making, bamboo

works, Nepali handmade paper production are included within the forest based industries. Bio briquett making is included within the fuel industries and metal fabrication and knife (khukuri) making is included within the mines and mineral resource based industry and the hotel management is included within the tourism industry. Due to all these some off-farm activities such as administrative and accounting job have been created as opportunities of employment in the district.

4.5 Remittances

An economic condition of the people of this municipality is good. Recently, many youth of this municipality are engaged for foreign employment mainly in India, Gulf, Malyasia, Japan and Hongkong that makes remittance high. Thus, remittance plays the vital role in the economy of the municipality.

4.6 Sources of Income

Agriculture is the main source of income for this municipality likewise animal farming, vegetable farming, commercial hotel business, market centers, technical business skills, wage labour, government and private jobs, foreign employment also contribute for income source. Some households are benifited from *byebasayamulak* skills. Similarly traditional skills (iron-smithing, tailoring, shoe-making, silver and gold ornament making etc.) are contributed for income source.

Chapter 5
ACCESS TO INFRASTRUCTURE AND SERVICES

Under this section, Infrastructure and services including road, electricity, health facility, communication, etc. have been discussed.

5.1 Road

The development of transportation is most essential in order to develop other sectors like industry, trade, communication, electricity, health, education, market, technology, drinking water projects etc. Good transport helps to enlarge the market and create more employment opportunities. It is only through the transportation we can make best use of available resources and means. Access to easy transportation is necessary for making life comfortable. Ilam Bazaar is located about 700 km east of Kathmandu. Regular buses are available from New Buspark, Koteshwar and Kalanki of Kathmandu which takes to Ilam after a bus ride of about 16hours. Daily Bus/Bolero is available from Ilam to Taplejung, Phidim, Birtamod, Chandragadhi, Kakarbhitta, Siliguri (West Bengal), Pashupatinagar, Damak, Itahari, Dharan and Biratnagar. A new buspark is being constructed at Sera. Besides these, Bus/Bolero also goes to all the municipalities/VDCs of Ilam district.

There is quite good network of road in this municipality due to the hilly terrain. All wards of this municipality are facilitated with road service with local roads and trails.

Table 5.1: Status of Road Network in this municipality

Types	***Black topped***	***Gravel***	***Others***	***Total***
Lenth (km)	36	13	145	194

Source: Municipality Profile, 2073

5.2 Health

“Health is our greatest wealth”. Government of Nepal has recognized health as the basic rights of the citizens. The interim Constitution of Nepal has guaranteed health as the fundamental rights of the citizens. It is also mentioned in the constitution that every Nepali citizens should get basic health services and facilities free of cost. As per provision of the constitution, the government has made basic health service and facilities free of cost in its health post and health centers. The ultimate goal of the green city concept is to ensure a comfortable life for its residents, an impossible task without good health. Therefore, good health of the people is crucial for going green. Even now, a majority of people in the rural areas of Ilam Municipality have unsatisfactory sanitation and personal hygiene and limited access to medical facilities. For many years, a number of health related organizations have been organizing awareness programs regarding health concerns. However, safe and healthy food and drinking water are still a major problem. Parts of the solution are increasing access to medical facilities, providing safe and healthy food and drinking water, and managing municipal waste through proper sanitation facilities.

Table 5.2: Health Facilities

Name of Health Institutions	***Numbes***	***Remarks***
Hospital (Government)	1	50 Beds
Hospital (Community)	1	7 Beds
Urban Health Centre	2	
Ayurveda Ausadhalaya	1	
Family planning clinic	1	Operated by Family Planning Association, Ilam
Monthly health services/counseling centers	13	Different wards of Ilam Municipality
Dental clinics	3	
Merry Stopes health clinic	1	

Source: Municipality Profile and Field Survey, 2073

5.3 Drinking Water and Toilet Facilities

Drinking water is one of the basic needs of human being. In the context of this municipality, Tap/Piped water is the main source of drinking water while covered and uncovered well/kuwa, spout and open source of river and stream are subsequently important sources. Out of 4732 HHs, 3478 households are used tap/piped water. Similarly, 844 households are used spout water and 166 households are still depended on river/stream. In addition, 4433 households are used toilets in which 3163 households have flush toilet while 1270 HHs have ordinary toilet system. Remaining 299 households have not access to toilet facilities.

Table 5.3: Drinking water source

Sources of Drinking Water						**HHs having Toilet Facilities**			
Tap/ Piped Water	Spout Water	River/ Stream	Well/ Kuwa	Others	Not Stated	Flush	Ordinary	No Toilet Facilities	Not Stated
3478	844	166	108	66	70	3163	1270	224	75

Source: CBS, National Population and Housing Census, 2011

5.4 Electricity

Nepal Electricity Authority's transmission line is distributed in all ward of this municipality. About 93.51% of the total household's main source of lighting is Eelectricity. Kerosene is used by 4.06% of the total households for lighting while Biogas and Solar is source of light for 0.42 % and 0.11% of the total households respectively.

Table 5.4: Households by usual source of lighting

Sources of Lighting					
Electricity	**Kerosene**	**Biogas**	**Solar**	**Others**	**Non Stated**
4425	192	20	5	15	75

Source: CBS, National Population and Housing Census, 2011

Similarly, out of the total households about 51.82% households use firewood as usual source of fuel for cooking followed by Kerosene (41.78%) and LP Gas (2.45%). Guitha and Bio-gas used for cooking by 1.92% and 0.25% of the total households respectively. Very few households (0.04%) use Electricity as usual fuel for cooking.

Table 5.5: Households by usual type of fuel used for cooking

Fuel for Cooking							
Firewood	**Kerosene**	**LP Gas**	**Guitha**	**Biogas**	**Electricity**	**Others**	**Non Stated**
2452	1977	116	91	12	2	26	73

Source: CBS, National Population and Housing Census, 2011

5.5 Educational Institutions

Education is a process of imparting knowledge, skills and among the individuals. It helps a person to change his/her outlook and the whole lifestyle. It contributes largely to make the society more civilized and forward-looking. A person cannot do his or her work effectively if he or she is not educated. Ilam municipality is well known for education institutions and plenty of opportunities have been created there. There are altogether 31 different types (Community & private) and levels (primary to campus) of educational institutions are providing education services to this municipality and others surroundings VDCs people.

The school education system in this municipality consists of primary, lower secondary, secondary, higher secondary and campus. Primary schools start from grade one to five years of education followed by three years of lower secondary, two years of secondary and two years of higher secondary education. Basically different caste and ethnic groups are settled here. The following table shows total no of educational institutions of the Ilam municipality.

Table 5.6: Educational Institutions

Type of School	**No of Institutions**
Primary School	14
Lower Secondary School	3
Secondary School	10
Higher Secondary School	2
Campus	2
Total	**31**

Source: Municipality Profile, 2073.

5.7 Communication Facility

Telecommunication facility is available in all wards of this municipality. There are out of total households, 282 HHs have internet, 4023 HHs have mobile phones, 980 HHs have landline phone, 3259 HHs have radios, 4238 HHs have television set and 724 HHs have Computers. Network reception is also quiet good in this municipality.

Table 5.7: Communication Services

Particulars	Ward no	Numbers
E-mail, Internet	1-9	282
Mobile	1-9	4023
Telephone	1-9	980
Radio	1-9	3259
Television	1-9	4238
Computer	1-9	724

Source: CBS, National Population and Housing Census, 2011

Chapter - 6
HERITAGE, CULTURE AND TOURISM

6.1 Heritage

There are a number of temples of religious importance in this municipality. During religious ceremonies and festivals people flock the temples to perform worship. Basically, this municipality is importance from cultural and touristic point of view.There are different touristic and religious places in this municipality namely Tea garden, tea Factory, Maithan Temple, Narayanthan Temple, Shankari Devi Temple, Bhimsenthan Temple, Singhabahini Devi, Temple, Setidevi Temple, Sukilumba Devithan, Gumbadanda and the gate way to Mai Pokhari.

6.2 Culture

Ilam municipality is rich in cultural diversity. There are different castes and ethnic groups living in this municipality. These different castes and ethnic groups have their own customs and traditions. Generally, people following different religions have different cultures. They have their own rites and rituals. They observe different festivals like Dashain, Tihar, Teej, Maha Shivaratri, Maghe Shankranti, Buddha, Poornima, Ubhauli, Lohasar, Chandi Naach, Chyabrung Naach, Gai Jjatra, etc. This municipality is also rich for ethnic dance like Sili of Rai, Dhol nach of of Limbu, Gaijatra of Newar, Hurra dance of Magar, Damphu dance of Tamang, Syabru dance of Sherpa, Syadar dance of Sunuwar, and Maruni and Balam of Aryan culture.

6.3 Tourism

Ilam Municipality is full of natural beauty and rich in nature. Southern Siwalik and northern high altitude area are better places for tourism development. Mai Pokhari area is rich in biodiversity and so are some other high altitude areas. Verious tea estates are full of scenic beauty and open spaces for recreational activities. Many waterfalls, view points, place of natural beauty and religious places are many parts in the municipality.

Ilam municipality has high potentiality of tourism. Different kinds of species and bio diversity can be found here. Different people from different caste, religion, ethnic groups are settle here who have their culture. There are different wildlifes like Jackal, Ban Biralo, Dumsi, Rabbit, Badel, Harin Tiger Deer, Leopard, Bear etc found in the forest area of this municipality. Similarly there are some religious and touristic places namely Tea garden, tea Factory, Maithan Temple, Narayanthan Temple, Shankari Devi Temple, Bhimsenthan Temple, Singhabahini Devi, Temple, Setidevi Temple, Sukilumba Devithan, Gumbadanda and the gate way to Mai Pokhari.

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Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

LAND CAPABILITY MAP

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

June 2017

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Chapter - 1
INTRODUCTION

1.1. Background and Rationale

Background: Nepal has remained predominantly an agricultural country and 65.6% of the total population are engaged in agriculture and allied activities (ABPSD, 2014). The agricultural growth rate is 4.72% and 34% GDP share from agriculture sector (ABPSD, 2014). The total population of the country is 2,64,94,504 and it is increasing day by day (CBS, 2012). Cultivated agricultural land of the country is 3091 thousand hectares whereas uncultivated agricultural land, forest, grassland and pasture, water body and others occupy 1030, 5828, 1766, 383 and 2620 thousand hectares respectively (ABPSD, 2014). There is always a threat of food insecurity in Nepal in spite of the effort taken by Government to reduce hunger risk and food insecurity. Probably the food insecurity problem arises due to unscientific management of land, low fertility, soil erosion, population pressure and land degradation. Land is the most valuable natural resources and it is very limited resources. This resource should be utilized judiciously and with proper care. Furthermore, the economic and social lifestyles of most of the Nepalese people are intimately related to land. There has been improper fractionation of land for housing and this business has been even flourishing in agriculturally potential areas.The food grain production in the country is not sufficient enough to feed the hungry stomach of the country and it has to import food grain from the neighbouring countries especially India. The soil and land are limited and the most valuable natural resources of the country. A country is known by the resources it has. Soil and land support a range of economic activities under different land uses. Appropriate land use and good management are essential to ensure that these resources are available for future generations. Utilization of land is determined not only the end user but also by the land capability.

Land capability is defined as the inherent capacity of land to be productive under sustained use and specific management methods. Land suitability is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for defined uses. Land capabilities are derived by combining the land systems information with climatic, agronomic, and forestry data. Land capability classes and in most cases, subclasses are assigned to each soil. They suggest the suitability of the soil for field crops or pasture and provide a general indication of the need for conservation treatment and management. There are 8 capability classes. Capability classes are designated by either Arabic or Roman numerals (I through VIII), which represent progressively greater limitations and narrower choices for practical land use. Capability subclasses are noted with an e, w, s, or c following the capability class; for example, IIe. The "e" indicates that the soil is erosive. A "w" signifies a wetness limitation. An "s" denotes a shallow, droughty, or stony soil. A "c" indicates a climatic limitation. No subclasses are shown for capability class I because these soils have few limitations.

One of the key goals of land capability classification is to know the productiveness of the land for agriculture or other uses, thereby enabling planners to plan accordingly. The major objective of land

capability classification systems is to examine and record all data relevant to finding the combination of agricultural and conservation measures which would permit the most rigorous and proper use of the land without likely danger of soil degradation. A logical classification of the land on the basis of existing soil and land forms, climate, land use patterns, irrigation, topography and other aspects of land as well as socio-economic condition of the study area is needed. Both qualitative and quantitative suitability classification is needed.A qualitative classification is one in which relative suitability is expressed in qualitative terms only, without precise calculation of costs and returns. Qualitative classifications are based mainly on the physical productive potential of the land, with economics only present as a background. They are commonly employed in reconnaissance studies, aimed at a general appraisal of large areas.

A quantitative classification is one in which the distinctions between classes are defined in common numerical terms, which permits objective comparison between classes relating to different kinds of land use. Quantitative classifications normally involve considerable use of economic criteria, i.e. costs and prices, applied both to inputs and production. Specific development projects, including pre-investment studies for these, usually require quantitative evaluation.

Qualitative evaluations allow the intuitive integration of many aspects of benefits, social and environmental as well as economic. This facility is to some extent lost in quantitative evaluations. The latter, however, provide the data on which to base calculations of net benefits, or other economic parameters, from different areas and different kinds of use. Quantitative classifications may become out of date more rapidly than qualitative ones as a result of changes in relative costs and prices.

Thelarge spatial and temporal variability in land capability can, thus, be studied only by the use of technologies that include the spatial and temporal properties. Remote Sensing (RS) and Geographic Information System (GIS) provide with new tools for analyzing the variation in space and time and help in decision making. In addition an efficient approach to management of resources can be formulated and implemented in relatively short time period.

Rationale: Nepal has recently declared its constitution. Still it is in the implementation phase of its constitution and it is hoped that within few years all the policies and laws will normally be institutionalized. Land use policy and planning are still not functional as per international standards in Nepal. This may be for several reasons: landless and jobless people are encroaching on public and state land, such as forests, setting up squatter farms and settlements, ecosystems are deteriorating, and small-scale farmers are struggling to secure stable food supplies. Land-use planning can be applied at three broad levels: national, district and local. Local level planning is about getting things done on particular areas of land – what shall be done, where and when, and who will be responsible. It requires detail basic information about the land, the people and services at local level. However, Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (LRMP, 1983/84). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the National Land Use Project (NLUP) in 2057/058 fiscal year to generate the necessary data bases on the land resources of the

country.

National Land Use Project of Nepal initiated several projects at district level and prepared Land Resource Maps and Database at 1:50,000 scale for the whole Nepal. It also prepared same kinds of maps and database for Kirtipur, Lekhnath, MadhyapurThimi and Bhaktapur municipalities at larger scales. Finally, NLUP was mandated to prepare land resource maps of Village Development Committees (VDCs) of Nepal for local level planning through outsourcing modality. Up to 2068/069 fiscal years, NLUP has completed preparation of land resource maps and database for all VDCs of Chitawan district, 21 VDCs of Nawalparasi district and one VDC each for Kavre (Panchkhal VDC) and Tanahu (AnbuKhaireni VDC) District as well. It is expected that within few years all the districts in terai region will be completed and it may take some more years to complete all VDCs of Nepal. These digital data base includes VDC level present land use, soil, land capability, land use zoning, cadastral layers and VDC profile with bio-physical and socio – economic data base.

Since the beginning of 2069 BS, the Government of Nepal has approved the National Land Use Policy, 2069. Now, this year (2072) it is amended with some modifications and generally it is known by Land Use Policy, 2072. It has intended to manage land use according to land use zoning policy of the government of Nepal and outlined six zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area. The policy has defined the respective zones as per the land characteristics, capability and requirement of the lands. Further, for the effective implementation of land use zones in the country, the National Land Use Policy, 2069 has clearly directed for an institutional set up of Land Use Council at the top to the District level and Municipality/VDC level at the bottom. It has added further importance to the NLUP projects on preparation of VDC level maps and database.

Concepts:

a) Preparation of land capability maps of the VDCs for formulating land use plan according to the quality of land in order to identify areas of Agricultural area, Residential area, Commercial area, Industrial area, Forest area, Public service area and other uses.

(b) Identification of the residential and other non-agricultural areas according to the capability of land.

(c) Promotion of agricultural productivity as per land capability in comparatively advantageous sub-areas.

(d) Conservation of natural resources including forest, shrub, rivers and rivulets and wetland in non-agricultural areas

1.2. Objectives of the Study

The main objective of this project is to prepare of Municipality level Land Resource Maps (present land use map, soil map, land capability map, land use zoning map and preparation of profile for land use zoning and cadastral layer superimpose), Database and Reports forIlam Municipality of Nepal. In order to fulfill the broad objective, the present study aims to prepare a land capability map ofIlam Municipality based on high resolution satellite image (Worldview), detailed field survey and laboratory test analysis of soil

characteristics. The specific objective of the study is toprepare Land Capability Maps, GIS database and Reports for Ilam Municipality at 1:10,000scales.

Scope

To accomplish the aforementioned objective, the following activities were carried out:

(a) Study the existing relevant maps, documents and database of the project area.

(b) Prepare Land capability maps for the selected VDCs at 1:10,000 scales by analyzing relevant data, maps, field samples and information of soil laboratory test analysis.

(c) Design appropriate GIS database logically.

(d) Discuss the accuracy, reliability and consistencies of data.

(e) Prepare reports describing methodology, existing land capability types and model of GIS data base.

1.3. Study Area

Ilam is a municipality of Ilam District, which is in the hilly region of Mechi zone, in the Eastern Development Region of Nepal. Ilam also acts as the headquarters of Ilam District and Mechi zone. Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of the important town in Mechi zone and one of the major place in Nepal for tea-production. It is famous for natural scenery and landscapes, tea production, and diverse agricultural economy. It is one of the major horticultural crop production districts of Nepal. Ilam municipality is sub-divided in 9 different wards; the major governmental and district office lies in ward number 1 and ward number 2. Ilam also is a major hub for transportation and communication for VDC that lies in the upper part of the discrict. The municipality was established in 2015 B.S.

Geographically Ilam Municipality is situated in the middle part of the district. It is extended from 87 º53’30” to 87 º57’46” Eastern Longitude and 26 º51’58” to 26º56’46”Northern Latitude have an area of 27.0 Square Kilometer.

Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municapility is surrounded by Mai Khola (River) to the east, PuwaKhola (River) to the west, Barbote VDC (Village) to the north and Mai Khola&PuwaKhola (Rivers) to the south.

The social condition portrays the different facets of a society. An effort has been made to reveal social condition of this municipality in terms of population by age and sex, population growth, caste/ethnicity, language, religion and literacy. The social setting of this municipality is found good. The major ethnic groups living here are Chhetri, Brahmin, Tamang, Newar, Tamang, Rai, and Limbu. Although there are different ethnic groups, there is we-feeling and are residing with social harmony. Major population of this area is engaged in agriculture, whereas the rest are associated with business.

The total population of this municipality is 18633 of which male population accounts for 8946 and female

population is 9687. There are 4732 households in this municipality and average households size of 3.94.The population density per sq. km. is estimated 690.

Age group in an important aspect of demography which shows the potential growth and economically active population. A significant feature of any population is the distribution of its members according to age, which facilitate the planner and policy makers in formulating effective socio-economic development plans for the population of different age groups. The table shows that the highest proposition of population is found in age group of 25-44 (29.82%).

The basic population of this municipality comprises the different castes and ethnic groups. Caste rules were basic cultural values which influenced occupation, marriage, food habits and other social behaviors. There are 7.58% Dalit, 44.34% ethnic groups and 48.08% other caste groups including Chhetree, Brahmin, Musalman, Thakuri, Chhetri etc.

Lateracy status is one of the most important social characterists of population. The literacy status of this municipality is quite satisfactory in comparison with the nation. Total literacy rate of this municipality is 84.66 percent. 90.53 percent of men are literate while women are 79.32 percent literate.

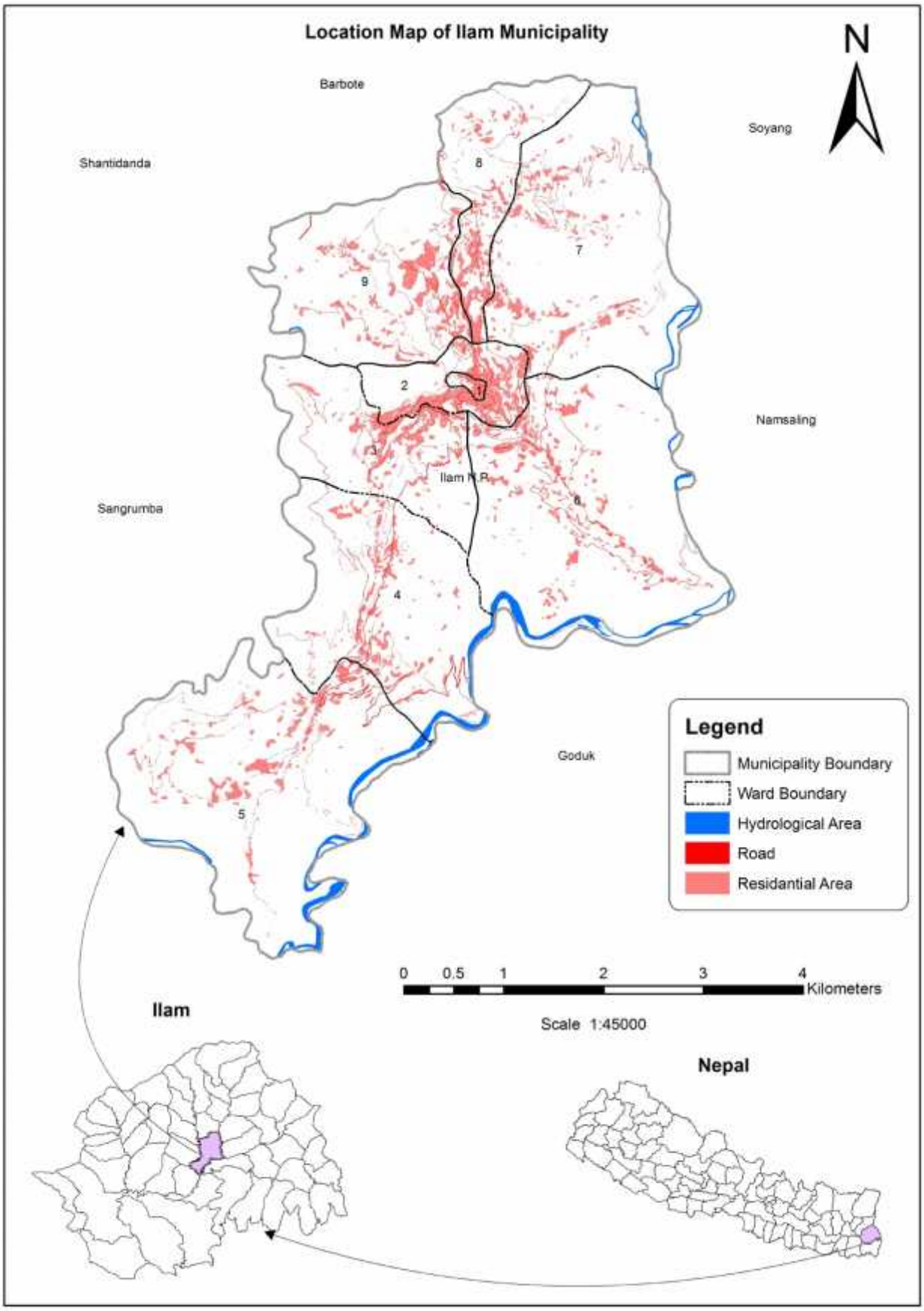

Figure 1.1: Location Map of Study Area

Chapter - 2

CONCEPTUAL BASIS OF LAND CAPABILITY CLASSIFICATION

Land is the basic natural resource and land capability is the ability of the land to sustain specific use without significant degradation or damage of land resources (US Department of Agriculture and State Planning Commission, 1989). It is the ranking of the land on the basis of its ability to sustain a range of agricultural land uses without degradation of land resources on long term in sustainable basis. It was originally developed by United States Department of Agriculture (USDA) and has been used in identifying appropriate land usages and required management practices that can sustain its productivity for long run. Land capability classification takes into account geology, soils, slope, climate, erosion hazards and land management practices. It also takes into account stoniness, flooding, salinity and drainage conditions of the land. It grades the land for broad scale agricultural uses. Land capability grading at VDC level requires assessment of land for agricultural usages considering land suitability, limiting factors for the use of that land and required management and conservation options to conserve land resources for best productivity.

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for forestland, or for engineering purposes.

In the capability system, soils are generally grouped at three levels—capability class, subclass, and unit.

Land Capability Classes and Subclasses:

Capability class is the broadest category in the land capability classification system. Class codes 1, 2, 3, 4, 5, 6, 7, and 8 are used to represent both irrigated and non-irrigated land capability classes.

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class 3 soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.

Class 4 soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

Class 5 soils have little or no hazard of erosion but have other limitations, impractical to remove, that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class 6 soils have severe limitations that make them generally unsuited to cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.

Class 7 soils have very severe limitations that make them unsuited to cultivation and that restrict their use mainly to grazing, forestland, or wildlife.

Class 8 soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for esthetic purposes.

Capability subclass is the second category in the land capability classification system. Class codes e, w, s, and c are used for land capability subclasses.

Subclass e is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass.

Subclass w is made up of soils for which excess water is the dominant hazard or limitation affecting their use. Poor soil drainage, wetness, a high water table, and overflow are the factors that affect soils in this subclass.

Subclass s is made up of soils that have soil limitations within the rooting zone, such as shallowness of the rooting zone, stones, low moisture-holding capacity, low fertility that is difficult to correct, and salinity or sodium content.

Subclass c is made up of soils for which the climate (the temperature or lack of moisture) is the major hazard or limitation affecting their use.

The subclass represents the dominant limitation that determines the capability class. Within a capability class, where the kinds of limitations are essentially equal, the subclasses have the following priority: e, w, s, and c. Subclasses are not assigned to soils or miscellaneous areas in capability classes 1 and 8.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, 2e. The letter *e* shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c,* used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class 1 there are no subclasses because the soils of this class have few limitations. Class 5 contains only the subclasses indicated by *w, s,* or *c* because the soils in class 5 are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, forestland, wildlife habitat, or recreation.

Capability units are soil groups within a subclass and are defined as follows:

Unit 1 soils have a potential or actual wind or water erosion hazard.

Unit 2 soils have drainage or overflow hazard. The soils are usually somewhat poorly or poorly drained; and are flooded or ponded.

Unit 3 soils have a slowly or very slowly permeable subsoil or substratum.

Unit 4 soils have coarse or gravelly textures.

Unit 5 soils have fine or very fine textures.

Unit 6 soils have salinity or alkali properties sufficient enough to constitute a continuing limitation or hazard.

Unit 7 soils have stones, cobbles, or rocks that are sufficient enough to interfere with tillage.

Unit 8 soils have a hardpan or hard unweathered bedrock witting the root zone.

Unit 9 soils have low inherent fertility associated with strong acidity; a low calcium-magnesium ratio; or excess calcium, boron, or molydenum.

Unit 10 soils have a high organic matter content, usually peats or mucks.

Unit 11 soils have a coarse sandy or very gravelly substratum that limits root penetration and moisture retention.

The soils in a capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, 2e-4 and 3e-6. These units are not given in all soil surveys.

Land capability assessment is based on the permanent biophysical features of the land (including climate). Land capability assessment is different to land suitability assessment which, in addition to the biophysical features, does take into account economic, social and/ or political factors in evaluating the best use of a particular area of land for various usages of land (Grose, 1999). Land capability classification gives a grading of land for broad scale agricultural uses, whereas land suitability is for landfill.

FAO Framework of Land Evaluation is most widely used for assessing the suitability of soils for various kinds of Land Utilization Types (LUTs). *Land Suitability* may be defined as "the fitness of a given type of land for a specified kind of land use" (FAO, 1983). Suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use. Suitability is assessed for each relevant use and each land unit identified in the study.

Land capability classification at VDC or Municipality level requires assessment of each individual physiographic land unit for agricultural land use as in the case of Ilam Municipality. At the level 1, land capability classification needs to be made for degree of suitability, nature of dominant limiting factors considering management and conservation requirements to tackle the limitations in order to conserve land resources for best productivity. This chapter gives a conceptual basis for the land capability assessment on which the classifications are done at VDC/Municipality level.

2.1. Review of Land Capability of LRMP

When we consider the development of human civilization, man has drawn most of his sustenance and much of his fuel, clothing and shelter from the land. Land has been men's habitat and living space. Land has been a matter of life and death, of survival or starvation. It is all in all for living being. In the beginning of eighties, Land Resource Mapping Project (LRMP) prepared 266 Land Capability Maps with entire coverage of Nepal. LRMP defines land capability classifications as "a specialized evaluation of the land resource

based on interpretative classification considering the slope stability, irrigation, flood hazards etc'' (Carson, 1986). LRMP Land Capability classification is based on observable biophysical characteristics as delineated by land system, local climatic conditions and empirically derived assessment of existing and potential land use. Lands are grouped into seven classes and five sub-divisions according to their opportunities, limitations and hazards for different sustainable usages in LRMP land capability classification system. Land suitability for arable agriculture and forestry uses are emphasized; thus the class arrangements shows the decreasing suitability/opportunities for use as well as decreasing intensity of use. There are seven classes assigned as "Class I" to "Class VII", according to the order of opportunity each class offers. For example, Class I land has no limitations for arable agriculture or forestry development usages. The categorization of classes is influenced by the land system and soil units.

The subclasses of land capability are based on distinct temperature regimes according to elevation breaks. The subclasses are categorized into five climatic regime groups' viz. sub-tropical, warm temperature, cool temperature, alpine, and arctic. These subclasses are further differentiated to represent major climatic moisture regime zones, which are arid, semiarid, sub-humid, humid, and per-humid.

Each land capability unit for Class I and Class II is further designated with irrigation suitability. By applying the United States Bureau of Reclamation (USBR) land classification framework, modified for local conditions, the irrigation suitability classification is done. Irrigation suitability classes are further sub-classified on the basis of deficiency in soil, topography or drainage conditions, which attributes to the arability of land.

Table 2.1 below shows the LRMP Land Capability classification scheme. A brief description of land capability classes are presented in subsequent subsections.

Table 2.1 LRMP Land Capability Scheme

Capability Classes						
Class I	Class II	Class III	Class IV	Class V	Class VI	Class VII

Temperature Regimes	Elevation (m)	Mean Annual Air Temperature (ºC)	Dominant Soil Temp. Regimes
Sub tropical	<1000	20 - 24	Hyperthermic
Warm Temperature	1000-2000	15 - 20	Thermic
Cool Temperature	2000-3000	10 - 15	Mesic
Alpine	3000-4000	3 - 10	Cryic-frigid
Arctic	>4500	< 3	Pergelic

Sub-Class (Temperature Regimes/ Vertical Zonation)

Sub-Division (Moisture regime)
Arid
Semiarid
Sub-humid
Humid
Per-humid

Irrigation Suitability Class
Class 1
Class 2
Class 1 R
Class 2 R
Class 5
Class 6

Deficiency Subclass
Soil
Topography
Drainage

2.1.1. Land Capability Classes

Land Capability classes are derived from Land System map units. There are seven land classes grouped on the basis of similar geophysical characteristics, reflecting management option (Maharjan& Joshi, 2007). Descriptions of each of seven classes are given below.

Class I

This land class is characterized as the nearly level (< 1 degree slope) and deep soil stratum. This type of land has very few limitations for arable agriculture or forestry land uses. River bank cutting is rampant. However, mass wasting does not pose any significant problems. Stability of the land is not considerably affected due to engineering works. Sporadic flooding occurs in the Tarai region, depositing large amount of sediment; but these depositional areas are quickly reclaimed. By using traditional, intermediate as well as modern farming practices class I lands are cultivated. To minimize the effects of flooding and subsequent mass wasting, the erosion mitigation and river embanking works are required.

Surface drainage pattern and soil moisture has the effect on land use in this capability class. Well to moderately well drained lands are suitable for a wide range of usages including annual cropping, perennial cropping, and grazing and forestry uses during the monsoon period. Poorly drained areas with high water tables included in class I lands during the monsoon, are highly suitable for rice production. In class I lands, during the dry season, where irrigation water is available, wide range of crops can be grown in various temperature regimes. Moderately well and imperfectly drained areas having sufficient subsoil moisture are producing wheat and other winter crops in dry season, where irrigation water is not available,.

The dominant land system units associated with class I are 1d, 2c, 2d, 3a, 4c, 5a, 6a, 9b, 13b. Other land system units associated are 3c, 5c, 6c, 10a, 10b and 13d and about 13.7% of total land of Nepal consists of class I type land.

Class II

Class II is characterized as gently sloping (1-5 degrees) and soil stratum is deep and well to moderately well drained. No limitations exist in this class for well managed forestry for timber, fuel wood and fodder production or pasture development. When land of this class is used for arable agriculture, terracing and contouring are required to control soil erosion and suitable provisions are required for controlling surface runoff and drainage waters. Major hazard often occurring is debris flow though lands are usually reclaimable. Due to soil characteristics and surface gradient, gully erosion is major concern. Using traditional, intermediate or modern farming techniques these lands can be successfully cultivated by considering above factors and implementing appropriate mitigation measures.

Surface and subsurface of it generally represents adequate for a wide range of uses including annual cropping, perennial cropping, pasture and forestry during monsoon season. In the areas where the climate is favorable and irrigation water is available, paddy rice may be grown even on coarser textured soil.

Class II land is dominant with land system units associated with 3b, 3c, 5b, 5c, 6c, 9c, 10a, 13c and 13d. Other land system units associated are 2d, 3b, 3d and 5d and about 3.2% of total land of the country is occupied by this land capability class.

Class III

Land in this class is characterized as moderately to steeply sloping (5-30 degrees) slopes. Soils are well drained and more than 50cm deep. These lands only occur in climatically arable regions. Soil erosion occurs constantly due to mass wasting, landslides, slumps, and debris flow and river bank failures.

There are few limitations in this class of land for the forest development for fodder, fuel wood, or timber production. Grazing is restricted due to heavy physical damage to soil by livestock overgrazing. When land is used for arable agriculture, terrace is compulsory to control erosion. Class III land cultivation is done making terraces, which is based on traditional farming practices. However, intermediate farming practices can be adopted for better crop production. Fertility of cultivated land is maintained by fodder, forest litter collection and grazing on non-cropped area in the traditional farming methods. Mostly, large area of Class III land is available for forestry usages for fodder and fuel wood collection. In terrace farming the irrigation water is extensively used wherever available. To prevent slope failure and soil erosion in terrace farming a new irrigation system should be developed.

Land system units dominantly associated with this class are 7, 11 and 14a. Significant land system units 12, 13c and 14b are also prevalent in this class and about 15.2% of the total land in the country consists of Class III land.

CLASS IV

Class IV lands are characterized by soils more than 20cm deep and well to imperfectly drained lands which are too steep (>30^{o} slopes) to be profitably terraced and cultivated, too cold to be cultivated or prone to gully erosion and flooding. These lands are best suited for all forestry related uses provided that good, permanent vegetation cover is maintained to minimize erosion. Mass wasting is a serious and constant hazard problem for any type of land use in this class.

The major area of class IV land is presently forested which can be used for fuel wood, fodder, forage, litter, medicinal plants and timber production. Degradation of forest due to overgrazing is the main problem in this land class. So grazing must be strictly controlled or prohibited altogether in sensitive areas. Sustainable forest management must be given special attention for forest usages, location and design of access roads and maintenance of ground cover.

The dominant units of land system associated to this class are 3d, 5d, 12, 14b and 15a. Other significant land system units are 1c, 1d, 43b, 6d, 7,8,11, 14a, and 15b. About 25.8 percent of the total land of Nepal is occupied by this class.

Class V

Class V lands are characterized by soils more than 20cm deep and slopes less than 30 degrees. These lands are too frequently flooded, too cold or too dry to support any vegetation cover. However, these lands are

very suitable for pasture development provided that the stocking rates are carefully controlled. Alpine regions above 3000 meters, the natural steppe country in the shadow of the Himalayas and active flooding alluvial plains are the three major Class V lands in Nepal. This land occupies about 4.1% of the total land of the country. The dominant land system units are 1c, 13a, 16a, 16b, 16c, and 16d and other significant units are 1b and 15a.

Major parts of Class V lands are flood plains which are subjected to frequent inundation throughout the country. More intensive land uses occur on flood plains and it precludes any other more intensively used land. Coarse grasses native to this land provide for fodder, wildlife habitat and construction materials. Above 3000 meters, alpine pastures are generally found, often along the crest of mountain ridges. The major limitations to production are cold and wetness in this land. The steppe country is the natural habitat of class V land which is used for tourism and recreation (mountaineering and trekking) due to scenic beauty and High Mountain peaks for climbing.

Class VI

Class VI lands are characterized by steep slope (40–50 degrees), severe gully erosion with less than 20 cm soil depth and considered to have severe limitations for food and fiber production. To minimize the risk of erosion hazard on this land vegetation cover should be maintained. The degraded areas are difficult or sometimes impossible to reclaim due to steep slope as well as low soil temperature which restricts the speed of regeneration of any type of vegetation.

Class VI lands are best suited for controlled extraction of fuel wood or timber, watershed protection and wildlife habitat conservations and tourism due to their environmental sensitivity. The dominant land system units are 6d, 8, 15b and 17a. Exactly 18.3 percent of the total land of Nepal falls in this class.

Class VII

Class VII lands are characterized by exposed rock and ice in very steeply sloping mountainous terrain. Outcrop rocks or vegetation is virtually absent in this class. The Class VII lands are best suited for the tourism and recreation (mountaineering and trekking) due to scenic beauty and High Mountain peaks for climbing. The land system units are 17b. 18.3 percent of the total land of Nepal falls in this class.

2.1.2. Irrigation Suitability Class

Irrigation suitability classes are based on systematic appraisal of soils and their designations by categories on the basis of similar physical characteristics and land use opportunities under irrigation. The classification follows the USBR land classification framework modified to suit the local conditions of Nepal. The entire Terai region, the Dun valleys and lands under Class I and Class II capability are classified according to their suitability for irrigation. A brief description of each of the irrigation classes is presented here.

Class I Diversified Crops-Arable

These lands are highly suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops as well as paddy.

Class 2 Diversified Crops –Arable

These lands are ranked lower than Class I in production capacity but these lands are moderately to fairly suitable for irrigated farming. The narrow ranges of diversified crops are adapted to these lands. There are some limitations in soil, which can be corrected and cannot be corrected. In this class the land productivity is limited compared to class I.

Class 1R Wet Land Paddy-Arable

These lands are capable to produce sustained and high yields of paddy at reasonable cost and highly suitable for paddy production under irrigated condition.

Class 2R Wet Land Paddy-Arable

These lands are ranked lower than Class 1R in productivity or more costly to farm and land is moderately to fairly suitable for paddy production under irrigation. The soil deficiencies can be corrected or cannot be corrected. These lands may possess poor drainage characteristics that affect winter crop production.

Class 5 Non-Arable

Class 5 lands are tentatively classified as non-arable and generally subjected to seasonal inundation.

Class 6 Non-Arable

Land included in this class is considered as non arable because of their failure to meet the minimum requirements for the other classes of land. Generally, soil of this class land is very shallow or impervious to root or water. The lands are characterized by extremely coarse texture surfaces, low water retaining capacity, overflow and run-off channels, permanent waste and slumps. The land is non-arable also due to complex topography.

2.1.3. Irrigation Suitability Sub-Class

The above mentioned irrigation suitability classes are further sub-divided based on the limitations or deficiency in soil, topography or drainage or the combinations of any of these two. These irrigation suitability rating sub-classes are:

- Soil deficiency
- Topography deficiency
- Drainage deficiency
- The combinations of any of the above two indicate to deficiencies of irrigation of land capability class.

2.1.4. Land Capability Sub-Class

The land capability classes described above are further classified into sub-classes on the basis of distinct climatic regimes with their altitudinal ranges. These sub-class climatic zones are as below:

Climatic Zone		Associated Farming Systems
Subtropical(altitude <1000 meters)	A	Intensive farming (multi-crops and livestock)
Warm temperate (altitude 1000-2000 meters)	B	Farming crops and livestock
Cool temperate (altitude 2000-3000 meters)	C	Livestock, fruits, limited crops farming
Alpine (altitude 3000-4000 meters)	D	Monsoon grazing, fruit farming, cattle grazing
Arctic (altitude>4500 meters)	E	None

2.1.5. Land Capability Sub-Divisions

Besides categorization of capability classes based on climatic regimes, a sub-division based on the mean annual precipitation in combination with mean annual temperature is also made. The capability sub-divisions of moisture regimes are:

- Arid (a)
- Semiarid (s)
- Sub-humid (u)
- Humid (h)
- Per-humid (p)

2.2. Framework for VDC Level Land Capability Classification

The present study at VDC level on land capability classificationfollows the basic principle of LRMP land capability. The LRMP land capability classification is further elaborated to highlight specific management limitation pertaining to the soil for sustainable agricultural uses in particular land unit. This system has been widely used in US Department of Agriculture & State Planning Commission since 1989 (Grose, 1999). This system has been adopted in the present study .

The salient features of this classifications system are as follows:

a) It follows LRMP Land capability Classifications system

b) Classifications rating is done for geo-morphological land unit i.e. land system land type unit considering soil characteristics, topography, climate, geology and geomorphology.

c) The classification system contains three tiers viz. class, subclass, and unit.

d) Unlike LRMP Land Capability, in which site specific deficiencies are assigned to the arable land units only (classes 2, 2R, and 5 for Class I and Class II), this system assigns deficiency categories to all the land capability units including (III,IV,V,VI,VII) to highlight specific management limitations in each capability classes and the associated land type units.

e) Climatic parameters viz. climatic regimes and moisture are associated with the capability class itself rather than differentiating them as sub-class and sub-division respectively as in LRMP Land

Capability. The reason for this is that the climatic and moisture regimes do not vary significantly at all within a small area/region as VDC, which is the current extent of the study.

2.3. Land Capability Classification Hierarchy

The three hierarchical levels are followed for land capability classification viz. capability class, sub-class and unit. Capability Class gives an indication of the general degree of limitations to use; sub-class identifies the dominant kind of limitation and unit differentiates between lands with similar management and conservation requirements as well as productivity characteristics. The hierarchical levels are shown in figure 2.1.

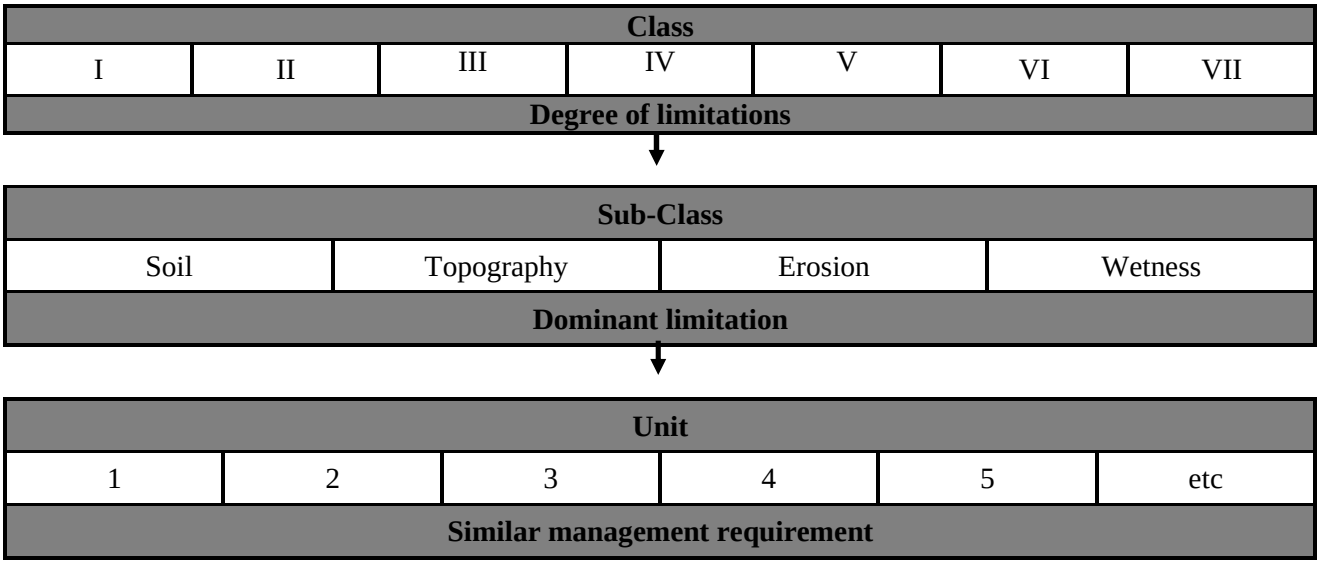

Figure 2.1: Land Capability Hierarchy (adopted from Grose, 1999)

The land capability classification system can be used and applied at various scales by mapping at the class, sub-class and unit levels.

2.3.1. Capability Class

The land capability class comprises seven classes ranked in order of increasing degree of limitation and in decreasing order of adaptability for agricultural use. Class I land is identified as the best suited land and it can produce wider range of crops and pastures at higher levels of production with lower costs and/or with less management requirements and/or less risk of damage to land compared to any other classes of land. Class II is superior to Classes 3 to 7 but inferior to Class I, and so on.

A range of land may occur in any one capability class, but it is often possible to identify good or bad quality land within the same class of land.

Class I to III, are considered as capable of supporting cropping activities on sustainable basis. Class IV is suited for forestry. Class V is suited for grazing pastures and fodder collection. Class VI has severe limitation and considered fragile and suitable for rough seasonal grazing only. Class VII land comprises of rock and snow cover with severe management limitations which cannot be corrected. The description of each capability class is presented in brief as below.

Capability classes associated with plain and terraced cultivation viz. Class I and II are further designated with the irrigation suitability as similar to LRMP irrigation suitability ratings for arability viz, Class 1, Class 2, Class 1R, Class 2R, Class 5, and Class 6 as described in Section 2.1.2 above.

Class I

Class I consists of lands with very few or no physical limitations to use of agriculture purpose. These lands are suitable for wide range of cropping, grazing or forestry. These lands are nearly level (<1^{o} slope) and soils are deep.

Class II

Class II consists of land with very few physical limitations to use. Terracing or contouring is necessary to control soil erosion when used for diversified agricultural crops and ground cover maintenance is required for forestry and grazing use. These lands are gently sloping (1^{o}–5^{o} slope) and soils are deep.

Class III

Class III consists of land with moderate limitations that limit the choice of crops or reduce productivity in comparison to Class I and Class II lands. These lands need careful management and conservation for optimum productivity and uses for agriculture. These lands are gently sloping to moderately steep (3^{o}-28^{o} slope) with soils 50-100 cm deep and moderately well to well drained. Terracing is compulsory to control erosion when used for agriculture. There are few limitations to traditional forest use provided adequate ground cover is maintained.

Class IV

Class IV consists of lands with moderately severe limitations that limit the choice of crops and/or require very careful management practices. These lands are either too steep to be terraced and cultivated (>28^{o} slope) or lie above the altitude limit of agriculture. These lands also include relatively flat to gently sloping lands with shallow soil depths (>20 cm) and well to imperfectly drained. These lands are suitable for forestry uses and require forest cover in the slopes to minimize erosion.

Class V

Class V consists of lands with severe limitations that restrict its use for agriculture and forestry. These lands have slopes (<28^{o} slope) and soils are more than 20 cm deep and in general are above tree line or are frequently flooded river plains. These lands do not support tree growth but have few limitations when used for fodder collection or grazing.

Class VI

Class VI consists of lands with very severe limitations that restrict its use to rough grazing, forestry and recreation. These lands include areas with 40^{o} to 50^{o} slope or steep slopes with soils less than 20 cm deep. These lands are considered as fragile because of extreme erosion hazard and/or poor regeneration potential.

Class VII

Class VII lands consist of rock and perpetual snow and have severe limitations that cannot be rectified.

2.3.2. Sub-Class

Within each class it may be possible to identify a number of limitations which restrict their agricultural use. Limitations may be defined as physical factors or constraints that affect the adaptability of the land and determine its capability for long-term sustainable agricultural production. Where limitations are found a class may also be assigned a subclass code indicating the nature of the dominant limitations or hazards that exists. Sub-class is equivalent to LRMP Land Capability's irrigation suitability subclasses but is assigned to all capability classes whether they are arable or not. Thus, the sub-classes can be further categorized and enabling to discriminate good and bad land within each individual capability class. In general sub-class represents management deficiency and its dominant factor. Deficiency factors may be more than one, thus indicating complex or severe management limitations. These deficiency factors are related to soil, topography, erosion and wetness.

2.3.3. Unit

Unit helps to differentiate between similar areas that have different management or conservation requirements. They may also be used to separate areas that have slightly different productivity characteristics. This is done by specifically indicating a combination of the factors. These factors pertain to one or more of the capability sub-classes related to soil, topography, erosion susceptibility and wetness. The units are represented by codes associated with each individual deficiency type as presented below:

Table 2.2 Unit code for sub-class soil deficiency

Soil Deficiency	
Soil Depth	s1
Plant Nutrient Availability	s2
Workability	s3
Drainage	s4
Permeability	s5
Acidic	s6
Alkaline	s7

Table 2.3 Unit code for sub-class topography deficiency

Terrain Deficiency	
Steep Slope	t1
Surface channel dissection	t2

Table 2.4 Unit code for sub-class erosion deficiency

Erosion Deficiency	
Sheet erosion	e1
Rill erosion	e2
Rill/Gully erosion	e3
Soil slump/mass movement	e4

Table 2.5 Unit code for sub-class wetness (drainage) deficiency

Drainage Deficiency	
Water logging	dw
Flooding	df
High water table	Dwt

Chapter - 3

METHODOLOGY

The methods appliedfor land capability classification is explained in this chapter.Based on the spatial analysis of soil, climate, and topographic parameters, to differentiate the land in arability class and deficiency type and sub-type unit by using GIS tool. A multi-criteria evaluation rule was developed to classify land units based on soil parameter, fertility, erosion susceptibility, terrain constraints and surface drainage (wetness). The details of the methodology are discussed in the following sections:

3.1. Methodology Framework

In general, the approach or methodology includes following steps:

i) Review of all the relevant maps of the project area including LRMP maps, Topographical maps and documents prepared by the Survey Department of Nepal as well as relevant products prepared by other agencies. As far as possible, the maps were made compatible to the LRMP products so that both could be used as temporal data by the concerned users for research and other uses.

ii) The VDC level land capability maps were prepared using the data sources such as high resolution satellite images, recent soil map prepared at 1: 10,000 scale, recent land system map prepared at 1: 10,000 scale, present land use map prepared at 1: 10,000 scale and management practices, soil survey data (both information gathered from the field as well as laboratory analysis), geomorphology/geology map, slope map, data on climate, soil erosion and moisture conditions.

iii) The multi-criteria evaluation rule was developed to classify land units based on soil parameters, fertility, erosion susceptibility, terrain constraints and surface drainage (wetness).

iv) The smallest mapping unit for delineation of land capability categories was of **0.25 hectare**, which is**1/4th of a square centimeter** in map scale.

v) The map layout and legends are as specified by National Level specification for the Preparation of VDC Level Land Resource Maps, Database and Reports, 2069.

vi) The VDC level out-put maps are based on Modified Universal Transverse Mercator Projection system and at 1:10,000 scales. The data base and maps are provided as per the specification provided by the NLUP office.

vii) The VDC level out-put maps are based on Modified Universal Transverse Mercator Projection system and at 1:10,000 scales. The data base and maps provided here had prepared as per the specification provided by the NLUP office.

viii) The report covers details of the methodology adopted in preparation of the soil capability maps of the selected VDCs. It covers tables, maps and charts showing the categories of the soils.

3.2. Land Capability Evaluation Criteria

Evaluation criteria for soil fertility, topography, erosion and surface drainage are derived as described in the subsequent sub-sections.

3.2.1. Soil Fertility Criteria

Soil fertility evaluation is derived from soil parameters related to top-soil rooting depth, workability (soil texture), soil drainage (permeability), alkalinity and acidity, content of organic matters, total nitrogen, available phosphorus, and available potassium. The ratings of these parameters are presented below.

Table 3.1 Topsoil Root Depth Rating

Soil Root Depth		
>200 cm	Very Deep	High Suitability
100 – 200	Deep	
50 – 100	Moderately Deep	
25 – 50	Shallow	
<25	Very Shallow	Low Suitability

Table 3.2 Workability Rating (considering non-mechanized manual farming tools)

Soil Texture (Workability)		
l (Loam)	Good	High Suitability
sil (Silt Loam)	Good	
sl (Sandy Loam)	Good	
sil+l (Silt Loam + Loam)	Good	
cl (Clay Loam)	Moderate	
cl+l/sil (Clay Laom+Loam over Silt Loam	Moderate	
sicl (Silt Clay Loam)	Moderate	
sicl+sl (Silt Clay Loam + Silt Loam)	Moderate	
sl+sicl (Silt Loam +Silty Clay Loam)	Moderate	
sic (Silty Clay)	Fair	
sl + sc (Silt Loam + Silt Clay)	Fair	
c (Clay)	Poor	Low Suitability

Table 3.3 Soil Drainage Rating

Soil Drainage	
Well drained	High Suitability
Moderately well drained	
Somewhat poorly drained	
Somewhat excessively drained	
Poorly drained	
Excessively drained	
Very poorly drained	
Very Excessively drained	Low Suitability

Table 3.4 Soil Alkalinity and Acidity Rating

Soil Alkalinity and Acidity Rating		
<5.0	Very high acidic	Low Suitability
5.1 – 5.5	High acidic	
5.6 – 6.0	Medium acidic	
6.1 – 6.5	Low acidic	High Suitability
6.6 – 7.3	Neutral	Most Suitable
7.4 – 7.8	Low alkaline	High Suitability
7.9 – 8.4	Medium alkaline	
8.5 – 9.0	High alkaline	
>=9	Very high alkaline	Low Suitability

Table 3.5 Soil Organic Matter Contain Rating

Organic Matter (%)		
>10	Very High	High Suitability
5 – 10	High	
2.5-5	Medium	
1-2.5	Low	
<1	Very Low	Low Suitability

Table 3.6 Soil Total Nitrogen Rating

>0.4	Very High	High Suitability
0.2 – 0.4	High	
0.1-0.2	Medium	
0.05-0.1	Low	
<0.05	Very Low	Low Suitability

Table 3.7 Soil Available Phosphorous Rating

Available P_2O_5 (kg/ha)		
>110	Very High	High Suitability
55 – 110	High	
30 – 55	Medium	
16 – 30	Low	
<16	Very Low	Low Suitability

Table 3.8 Soil Available Potassium Rating

Available K2O (kg/ha)	Rating	Suitability
> 504	Very High	High Suitability
280-504	High	
110 – 280	Medium	
56-110	Low	
<56	Very low	Low Suitability

Table 3.9 Soil Permeability Rating

Soil Permeability	
<0.15 (Very Slow)	Low Suitability
0.15 -0.5 (Slow)	Moderately Low Suitable
0.5 – 1.5 (Moderately Slow)	Moderate Suitability
1.5 – 5 (Moderate)	High Suitability
5 - 15 (Moderately Rapid)	Moderate Suitability
15 - 50 (Rapid)	Moderately Low Suitable
>50 (Very Rapid)	Low Suitability

3.2.2. Topography Criteria

The topography criteria pertain to management limitations in terrain topography. These limitations are related to the steepness of the terrain slopes and surface dissection, which inhibit the sustainable use of land. The land with these topographic problems requires careful management with terracing and maintaining vegetation cover to mitigate soil degradation.

Table 3.10 Topographic Deficiency Criteria due to Slope

Topographic Deficiency (Slope in degree)		
0 – 3	Flat to gently sloping	High Suitability
3 – 14	Sloping to moderately steep	
14 – 28	Steep	
>28	Very steep	Low Suitability

Irregular surface topography and surface dissection is another form for topographic limitation. The surface dissection may be due to the recent gulling or past-multi-terrace effect of surface erosion. Dissected topography increases difficulty in surface water conveyance for irrigation as well as causes severe erosion (especially gully erosion) due to concentrated run-off in this type of terrain.

3.2.3. Erosion Susceptibility Criteria

Erosion susceptibility criteria affect potential of soil loss due to erosion. The susceptibility rating of different types of erosion is given in the following table.

Table 3.11 Soil Erosion Susceptibility

Soil Erodibility (Erosion Deficiency)		
Sheet erosion	Low	High Suitability
Rill erosion	Medium	
Rill/Gully erosion	High	
Soil slumps/Mass movements	Very High	Low Suitability

3.2.4. Surface Drainage Criteria

Surface drainage (wetness) criteria pertain to the drainage condition of surface. Frequent flooding resulting in land inundation, water logging and high water table are the general problems affecting the productivity and use of land.

Table 3.12 Drainage Deficiencies

Drainage Deficiency (Wetness)	
Water Logging	dw
Flooding	df
High Water Table	dwt

3.3. Land Capability Evaluation Method

Land capability of land unit (i.e. land system land type/soil mapping unit) is evaluated based on above mentioned criteria and rating of the land unit is designated with appropriate land capability class along with its specific management limitations. Figure 3. 1 shows the general approach for classification and designation of land capability class to a land unit.

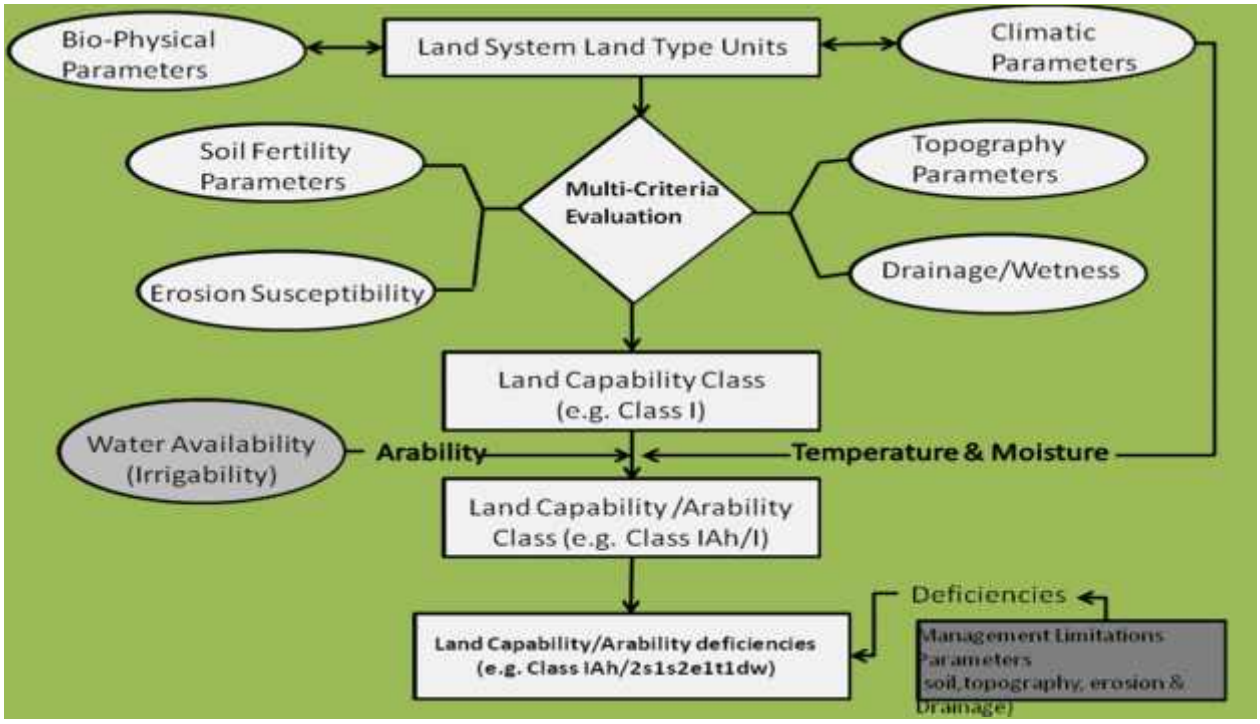

Figure 3.1: Land Capability Classification Method Flow Diagram

Chapter - 4

PRESENT LAND CAPABILITY OF ILAM MUNICIPALITY

Land capability classification of the land type units is done on the basis of different criteria of soil and other parameters. This chapter presents the result of land capability class coverage in Ilam Municipality. The chapter also presents the summary of each type of management limitations as represented by the capability sub-class and units.

4.1. Capability Classes in Ilam Municipality

The capability classification in Ilam Municipality is done mostly on the basis of the soil properties, terrain slope,drainage and erosion characters of the land, which is presented in (Table 4.2 and Figure 4.1). Land capability symbol is indicated by Class I, its arable Symbol is denoted by A. Most of the land area in this Municipalityis slopy.Ilam municipality has large ranges of slope. It is mostly sloppy and most of the area has 15-28% slope. However, the municipality contains slope ranging from less than 0% to 48%.Having little fair soil properties including soil depth(shallow and moderate depth) this land is classified as Class IlI and class iv as shown in table below. The total land of Ilam Municipality is2666 ha and out of which Agricultural land occupy 50.59% (1348 ha) and forest occupy 35% of the total area. Area under public serviceis about 61 ha that consist of only 2.29% of the total area. Land which is not used for agriculture is not assigned the capability class (Table 4.1).

The Municipality was found to have nine land use classes. The present land use table and figures show that agriculture covers maximum area (50.59%) followed by forest (34.93%) and Residential (8.00%). Likewise, Riverine and Lake Area and public service area covers 3.43% and 2.29% respectively. Other coverage is not potentially significant.

Table 4.1 Land use and Land Capability Classes

S. No.	Land Use Class	Area (Hectare)	Area (%)
1	Agriculture	1348.76	50.59
2	Commercial	5.77	0.22
3	Cultural and Archeological	0.05	0.002
4	Forest	931.21	34.93
5	Riverine and Lake Area	91.57	3.43
6	Industrial	0.39	0.01
7	Public Service	61.16	2.29
8	Residential	213.35	8.00
9	Others	13.93	0.52
Total		**2666.18**	**100.00**

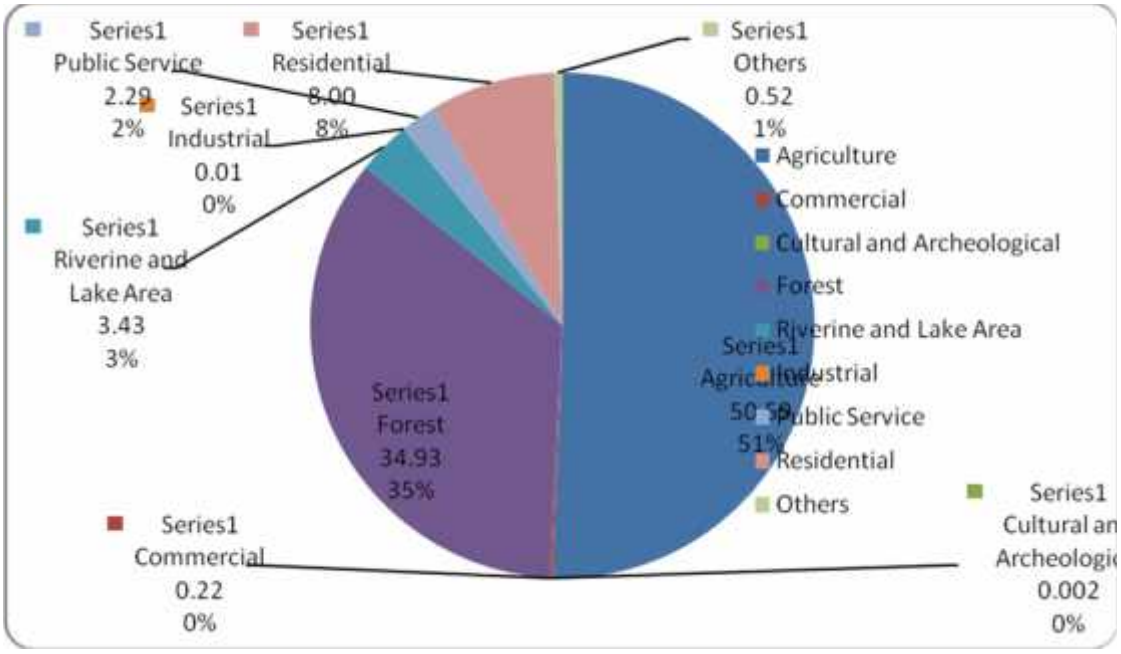

Figure 4.1: General land use of Ilam Municipality

The total land of Ilam Municipality is 2662 ha. This VDC has six different land capability classes. Class IIIAu/1 covers 814.4 ha of the total land of Ilam Municipality and it extensively covers most of the area comprising of 30.6%. This type of land is moderately to steeply sloppy. Cultivation with terraces will be more beneficial and such type of land ishighly suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops. Ilam Municipality has class IllBh/1 covering only 433.5 ha of the total area of the VDC. It consists of only 16% of the area and this area is also suitable forirrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops.Class IIIBh/6 covers 116.7 ha with 4.4% of the total area and this type of land is moderately to steeply sloppy, arable but sometimes non arable due to complex topography. Class IIIBu/5 covers 956.6 ha with 35.9% of the total area and this type of land is moderately to steeply sloppy, arable but sometimes non arable due to seasonal inundation.Class IVAu covers 233.7 ha with 8.8% of the total area and this type of land is toosteep and is suitable for forestry.Class IVBh covers 108.1 ha with 4.1% of the total area and this type of land is toosteep and is suitable for forestry.In a nutshell, Ilam Municipality possesses six different land capability classes with the following properties as described in Table 4.2.

Table 4.2 Land Capability Classes

SN	Land Capability Class	Area Ha	Area %	Description
1	IIIAu /1	814.4	30.6	Sub-tropical, Sub-humid, Moderately to Steeply sloppy, Best for terrace cultivation, suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops.
2	IIIBh /1	433.5	16.3	Warm temperate, Humid, Moderately to Steeply sloppy, Best for terrace cultivation, suitable for irrigated farming and are capable of producing sustained and relatively high yields of climatically suited upland crops.
3	IIIBh/6	116.7	4.4	Warm temperate, Humid, Moderately to Steeply sloppy, Arable but sometimes Non arable due to complex topography
4	IIIBu /5	956.6	35.9	Warm temperate, Sub-humid, Moderately to Steeply sloppy, Arable but sometimes non arable due to seasonal inundation
5	IVAu	233.7	8.8	Sub-tropical, sub-humid, Too steep mostly suitable for forestry
6	IVBh	108.1	4.1	Sub-tropical, humid, Too steep mostly suitable for forestry
	Total	2662.988	100	

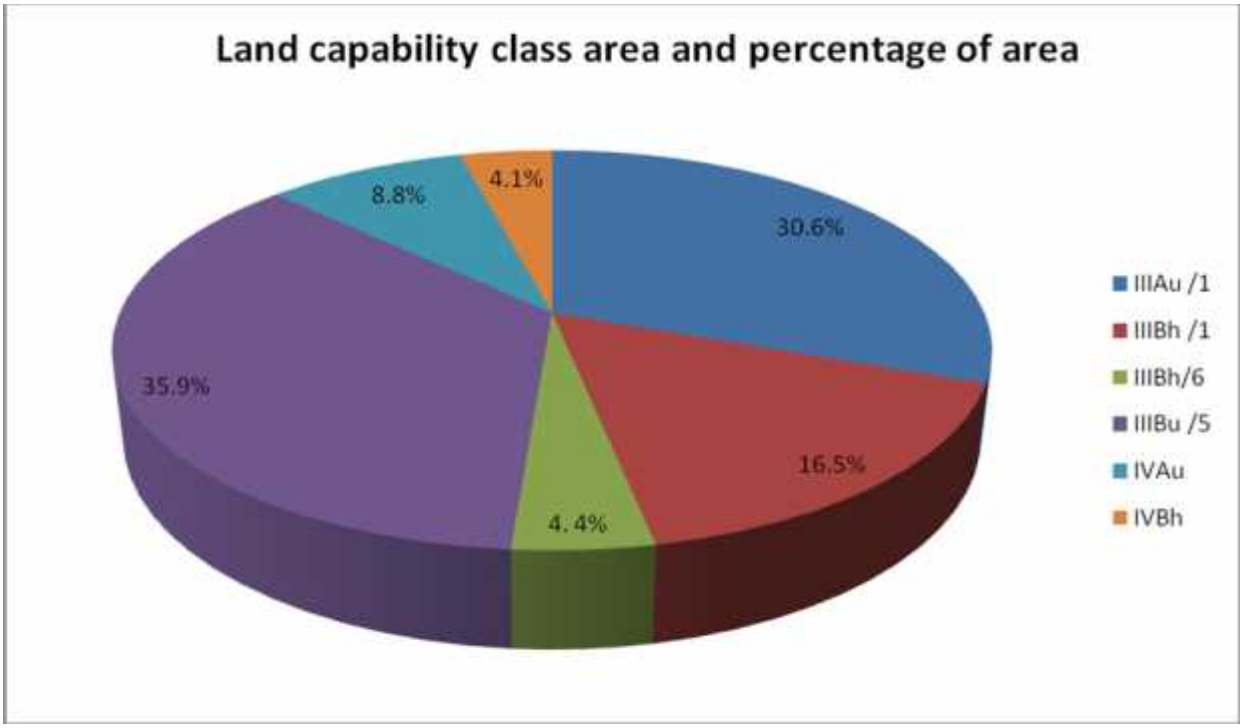

Figure 4.2: Land Capability Classes distribution of Ilam Municipality

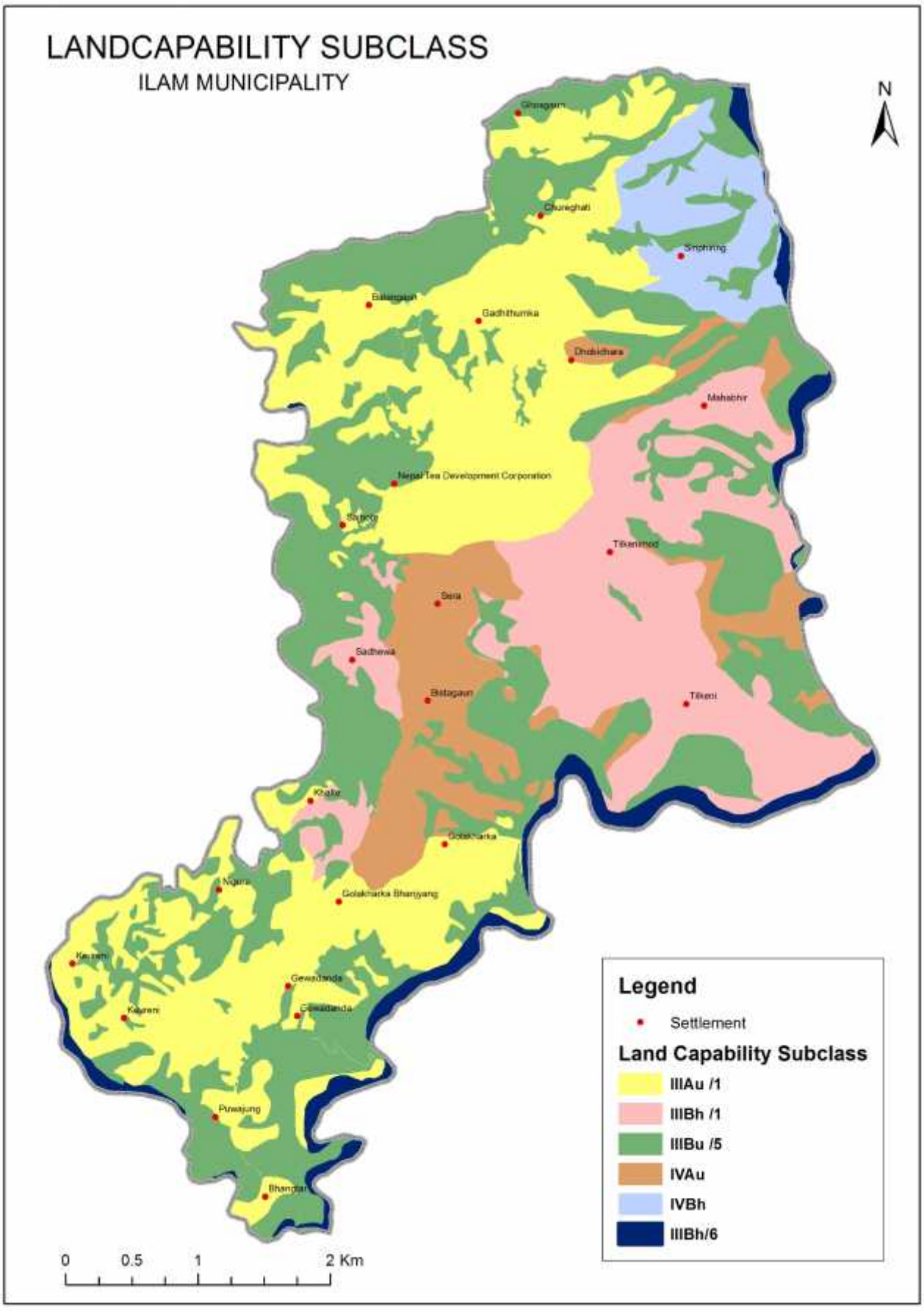

Figure 4.3: Land Capability Map of Ilam Municipality

4.2. Land Capability GIS Database

The land capability GIS data is stored in vector geo-database and “shape” file formats as a single land unit class which contains a hierarchy of sub-classes that are defined in various attribute fields of vector GIS database. Table 4.3 represents the data model of GIS database.

Table 4.3 Land Capability GIS Attribute Data

S. No.	Attribute	Data Type	Description	Remarks
1	FID	Feature Id	Feature	
2	SHAPE	Geometry	Geometric Object type	
3	OBJECTID	Long	Unique Object ID	
4	CAPABILITY	String	Land Capability Class	
5	ARABILITY	String	Arability Class	
6	AREA	Double	Area in m^2	
7	AREA_HA	Double	Area covered by land capability land unit in ha	
8	SYMB_NUME	Integer	Land Capability mapping symbol	
9	SYMB_DINO	String	Land Capability deficiency mapping symbol	
10	DEFICIENCY	String	Deficiency in land unit (soil, topography,)	
11	CLIMATE	String	Climate Regime	
12	MOISTURE	String	Moisture Regime	
13	ASSO_LS	String	Associated land system	
14	SLOPE_CLS	String	Associated slope class of terrain	
15	SLOPE_DEG	String	Slope description	
16	SOIL_TXT	String	Associated soil texture class	
17	DRAINAGE	String	Associated soil drainage pattern	
18	PH	Integer	Associated soil pH value	
19	PH_RATE	String	Associated soil pH rating	
20	OM_PER	String	Associated soil organic matter percentage	
21	OM_RATE	String	Associated soil organic matter rating	
22	TN_PER	String	Associated soil total nitrogen percentage	
23	TN_RATE	String	Associated soil total nitrogen rating	

S. No.	Attribute	Data Type	Description	Remarks
24	P_2O_5_ KGHA	String	Associated soil available P_2O_5 in kg/ha	
25	P_2O_5_ RATE	String	Associated soil available P_2O_5 rating	
26	K_2O_ KGHA	String	Associated soil available K_2Oin kg/ha	
27	K_2O_ RATE	String	Associated soil available K_2Orating	
28	FERTILITY	String	Associated soil fertility value (based on different soil parameters)	
29	FER_RATING	String	Associated soil fertility rating	
30	EROSION	String	Erosion susceptibility rating	
31	SOLUM_DPTH	String	Top soil depth in cm	
32	TOPO_DEF	String	Terrain slope type	
33	DRAIN_DEF	String	Surface drainage problem	
34	PERMIABILI	String	Associated soil permeability	
35	SOIL_DEF	String	Associated soil deficiency symbol	
36	ERO_DEF	String	Associated erosion deficiency symbol	
37	TERRA_DEF	String	Associated terrain deficiency symbol	
38	DRAINAGE_D	String	Associated surface drainage deficiency symbol	
39	Class	Short	Subtype for Top Level of Land Capability	
40	LandCap_Subclass	String	Land Capability Sub Class	
41	LandCap_Subdiv	String	Land Capability Sub division	
42	LandcapabilityClass	String	Land Capability of each mapping unit	

Chapter - 5
CONCLUSIONS

5.1 Conclusions

Land capability classification of Ilam Municipality is done on the basis of topography (slope), soil parameters (depth, texture, drainage, physicochemical properties like pH, organic matter content, total N, available P, available K, available Zn and B) climatic factors, erosion hazard and land management. The classified lands are ranked suited for agricultural uses without degrading the soil for long term sustainable basis in class III. The class III land is the most suitable for the agriculture under terrace system, forestry and grazing with limitations of soil and erosion parameters. The increase in class number of land capability indicates that there are increasing limitations (e.g. stoniness, poor drainage, salinity/acidity, flooding, erosion, soil depth) for the use of land in sustainable manner. Thus, land capability assessment is therefore based on the permanent biophysical features of the land with existing climate.

The total land of Ilam Municipality is 2662 ha. This VDC has six different land capability classes. Class IIIAu/1 covers 814.4 ha of the total land of Ilam Municipality and it extensively covers most of the area comprising of 30.6%. This type of land is moderately to steeply sloppy. Cultivation with terraces will be more beneficial and such type of land ishighly suitable for irrigated farming and is capable of producing sustained and relatively high yields of climatically suited upland crops. Ilam Municipality has class IllBh/1 covering only 433.5 ha of the total area of the VDC. It consists of only 16% of the area and this area is also suitable for irrigated farming and is capable of producing sustained and relatively high yields of climatically suited upland crops. Class IIIBh/6 covers 116.7 ha with 4.4% of the total area and this type of land is moderately to steeply sloppy, arable but sometimes non arable due to complex topography. Class IIIBu/5 covers 956.6 ha with 35.9% of the total area and this type of land is moderately to steeply sloppy, arable but sometimes non arable due to seasonal inundation. Class IVAu covers 233.7 ha with 8.8% of the total area and this type of land is toosteep and is suitable for forestry.Class IVBh covers 108.1 ha with 4.1% of the total area and this type of land is toosteep and is suitable for forestry.

Classifying land according to its capability or suitability helps to land users and planners to direct their resources to particular type of production in the most suitable area and protect the highly suitable land for crop production from encroachment by non-agricultural practices. Depending on the socio-economic and environmental consequences that can result from the introduction of new practices, suitability classes can provide policy makers with information to make best choice among alternatives.

5.2 Recommendations

For a country like Nepal, where the natural resources are limited, a strategy of land evaluation, land capability mapping and their database preparation play the vital role for sustainable use of available resources. Therefore, this type of study should be extended to other areas of the country. The implementation of the result of this report is highly recommended for proper land management of Ilam Municipality. The changes due to implementation of this recommendation should be studied and replicated in wider scale for sustainable land management.

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Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

SOIL REPORT

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

June 2017

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Chapter - 1

INTRODUCTION

1.1 Background and Rationale

Soil is the precious gift of nature and it is the fundamental to life on Earth. Nepalese culture has intrinsic cultural values with regards to soil. It is believed that even human body is compost of 5 elements, of which one is soil. It is considered holy and there are instances that people use soil as cultural components. The values of soil can be multidimensional- cultural, economical, social, political, environmental, etc. Soils constitute the foundation of agricultural development and ecological sustainability and constitute the basis for food, feed, fuel and fibre production. Soils also provide many critical ecological services such as clean water, nutrient cycle regulation and hydrological cycle moderation. They are the greatest pool of terrestrial organic carbon, contain one quarter of global biodiversity and provide a habitat for seed dispersion and dissemination of the gene pool. Soils also provide construction materials and are the foundation for construction.

Soil is the basis of agriculture and soil is where food begins.There is interdependent relationship between soil and society. As aptly mentioned by American president, Roosevelt, " A nation that destroys its soil destroy itself". The importance of soil can none better be explained than his statement. Better the condition of soil, happier will be the society and vice versa. Fertility of the soil corresponds to prosperity and healthiness of the people. Higher the fertility of the soil, healthier will be the society. That is why; soil classification in earlier days was done based on the fertility status of the soil. There is always increasing demands for arable land, grazing, forestry, wild-life, tourism and urban development than the land resources available. In the developing countries, these demands become more pressing every year and the population dependent on the land for food, fuel and employment will double within the next 25 to 50 years (FAO, 1993). Nepal is not an exception to this case.

Nepal has remained predominantly an agricultural country and 65.6% of the total population are engaged in agriculture and allied activities (ABPSD, 2014). The agricultural growth rate is 4.72% and 34% GDP share from agriculture sector (ABPSD, 2014). The total population of the country is 2,64,94,504 and it is increasing day by day (CBS, 2012). Cultivated agricultural land of the country is 3091 thousand hectares whereas uncultivated agricultural land, forest, grassland and pasture, water body and others occupy 1030, 5828, 1766, 383 and 2620 thousand hectares respectively (ABPSD, 2014). There is always a threat of food insecurity in Nepal in spite of the effort taken by Government to reduce hunger risk and food insecurity. Probably the food insecurity problem arises due to unscientific management of land, low fertility, soil erosion, population pressure and land degradation. Land is the most valuable natural resources and it is very limited resources. This resource should be utilized judiciously and with proper care. Furthermore, the economic and social lifestyles of most of the Nepalese people are intimately related to land. There has been improper fractionation of land for housing and this business has been even

flourishing in agriculturally potential areas. Therefore, land–use planning for making the best use of the limited land resources is inevitable.

The Government of Nepal has also felt necessity of the Land use planning in recent years. Land-use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land–use options (FAO, 1993). Except sporadic attempts for the urban areas (GoN, 2002), Nepal has not practiced land-use planning for the country as a whole, although attempts were made for balanced use of Country's existing natural resources in the past through different policies and national planning efforts. Land-use planning can be applied at three broad levels: national, district and local. Local level planning is about getting things done on particular areas of land – what shall be done, where and when, and who will be responsible. It requires detail basic information about the land, the people and services at local level. Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (LRMP, 1983/84).

In connection to this line, the Ministry of Land Reform and Management, has taken the initiative by formulating National Land Use Policy, 2069 which has been adopted by the Government of Nepal. This policy is to be implemented through the preparation of land use zoning maps and the necessary regulatory framework to enforce the land use strategy.Remote sensing and GIS technology can play vital role in acquiring spatial/temporal data, and preparing digital data base. These spatial databases together with data on different land characteristics that could be collected from the field survey certainly will be helpful in decision making support systems for an efficient management of resources in relatively short time period at local level. Preparation of soil maps by classifying the soil samples from order to family level of the project area and appropriate soil GIS database from detailed field survey and laboratory analysis is vital for formulating land use plan that consists of Agricultural area, Residential area, Commercial area, Industrial area, Forest area, Public service area and other use area.

There is great variation of soil characteristics in Nepal. There is no homogeneity in distribution and properties of soil. Even, there is heterogeneity in soil within a field.The soil variability within a VDC/Municipality, district or zone influences the use of soils for different purposes. In order to make optimum use of our limited soil resources, we need detailed information about their characteristics, types, and distribution on landscape. Soil survey and soil mapping is the process of classifying soil based on their soil properties in a given area and geo-encoding such information by applying the principles of soil classification which draws heavily from geomorphology, theories of soil formation, physical geography and analysis of vegetation and land use patterns. Now-a-days, remote sensing using high spatial resolution and digital techniques is gaining popularity. Today, a growing number of soil scientists are using a computer aided program and GPS into the field with them to map the soil properties. Soil surveys are of great importance to any nation as they provide necessary inventory of soil resources. Soil survey provide information for the development of land use plans, help predicting adaptability of identified soils

to various uses and help in recognizing the areas having constraints. In short, soil surveys provide information about the soils of a country and form the basis for land use planning.

Basically, soil survey plays important role in gathering information about the properties, genesis, classification and nomenclature of soils. The applied aspect in a soil survey includes interpretation of soil data for use in agriculture, forestry, recreational purposes, urban, industrial and pastures development etc. Therefore a detail soil survey and mapping is an essential step for land use planning of an area. Nepal has been doing land-use planning at VDC level from past few years through NLUP but has not completed for the country as a whole. It requires detail basic information about the land, the people and services at local level. Realizing this fact, Ilam Municiality also has initiated land use classification this year to generate the necessary data bases on the land resources of the municipality for the future planning.

As per the RFP and the ToR, the proposed project work is concerned with the Preparation of municipality level Land Resource Maps (Present Land Use Maps, Soil Maps, Land Capability Maps, Land Use Zoning Maps and Cadastral Layer Superimpose and Municipality Profile), Database and Reports of Ilam municipality.

1.2 Objectives of the Study

The general objective of the present study is to prepare soil maps by classifying the soil samples from order to family level of the project area and generate appropriate soil GIS database from detailed field survey and laboratory analysis for formulating land use plan that consists of Agricultural area, Residential area, Commercial area, Industrial area, Forest area, Public service area and other use area. The area covered under the municipality is nine wards of Ilam municipality.

However, the specific objective of the study is:

- To prepare Soil maps, GIS database and reports for the selected Municipality at 1:10,000 scales.

Scopes of work

In order to attain the above objective as per the TOR, the scopes of service for the study are:

(a) Prepare Geological Maps of the selected Municipality

(b) Prepare Land System Maps for the selected Municipality at 1:10000 scales.

(c) Prepare maps of sample pits covering each land unit/land type of the Municipality with coordinate points to be identified in the field.

(d) Carry out extensive field survey for field verification of land system maps and to collect soil samples from the pits and fill up of the soil profile description form.

(e) Analyse the physio-chemical characteristics of soils including nutrients based on the field survey as well as detailed Laboratory test of the soil samples

(f) Prepare Soil Maps from order to family level following United States Department of Agriculture & Soil Conservation (USDA) system for the selected Municipality at 1:10000 scales.

(g) Design appropriate GIS database logically for detailed field survey and Lab test analysis data.

(h) Discuss the accuracy, reliability and consistencies of data.

(i) Prepare reports describing methodology, distribution of different soil types and model of GIS data base.

(j) Prepare A4 size Maps of N, P, K, Boron, Zinc, OM, Texture, and pH to attach in the soil reports of the Municipality.

1.3 Study Area

Ilam is a municipality of Ilam District, which is in the hilly region of Mechi zone, in the Eastern Development Region of Nepal. Ilam also acts as the headquarters of Ilam District and Mechi zone. Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of the important town in Mechi zone and one of the major place in Nepal for tea-production. It is famous for natural scenery and landscapes, tea production, and diverse agricultural economy. It is one of the major horticultural crop production districts of Nepal. Ilam municipality is sub-divided in 9 different wards; the major governmental and district office lies in ward number 1 and ward number 2. Ilam also is a major hub for transportation and communication for VDC that lies in the upper part of the discrict. The municipality was established in 2015 B.S.

Geographically Ilam Municipality is situatedin the middle part of the district. It is extended from 87 º53'30" to 87 º57'46" Eastern Longitude and 26 º51'58" to 26º56'46"Northern Latitude have an area of 27.0 Square Kilometer.

Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municapility is surrounded by Mai Khola (River) to the east, PuwaKhola (River) to the west, Barbote VDC (Village) to the north and Mai Khola&PuwaKhola (Rivers) to the south.

The social condition portrays the different facets of a society. An effort has been made to reveal social condition of this municipality in terms of population by age and sex, population growth, caste/ethnicity, language, religion and literacy. The social setting of this municipality is found good. The major ethnic groups living here are Chhetri, Brahmin, Tamang, Newar, Tamang, Rai, and Limbu. Although there are different ethnic groups, there is we-feeling and are residing with social harmony. Major population of this area is engaged in agriculture, whereas the rest are associated with business.

The total population of this municipality is 18633 of which male population accounts for 8946 and female population is 9687. There are 4732 households in this municipality and average households size of 3.94. The population density per sq. km. is estimated 690.

Age group in an important aspect of demography which shows the potential growth and economically active population. A significant feature of any population is the distribution of its members according to age, which facilitate the planner and policy makers in formulating effective socio-economic development plans for the population of different age groups. The table shows that the highest proposition of population is found in age group of 25-44 (29.82%).

The basic population of this municipality comprises the different castes and ethnic groups. Caste rules were basic cultural values which influenced occupation, marriage, food habits and other social behaviors. There are 7.58% Dalit, 44.34% ethnic groups and 48.08% other caste groups including Chhetree, Brahmin, Musalman, Thakuri, Chhetri etc.

Lateracy status is one of the most important social characterists of population. The literacy status of this municipality is quite satisfactory in comparison with the nation. Total literacy rate of this municipality is 84.66 percent. 90.53 percent of men are literate while women are 79.32 percent literate.

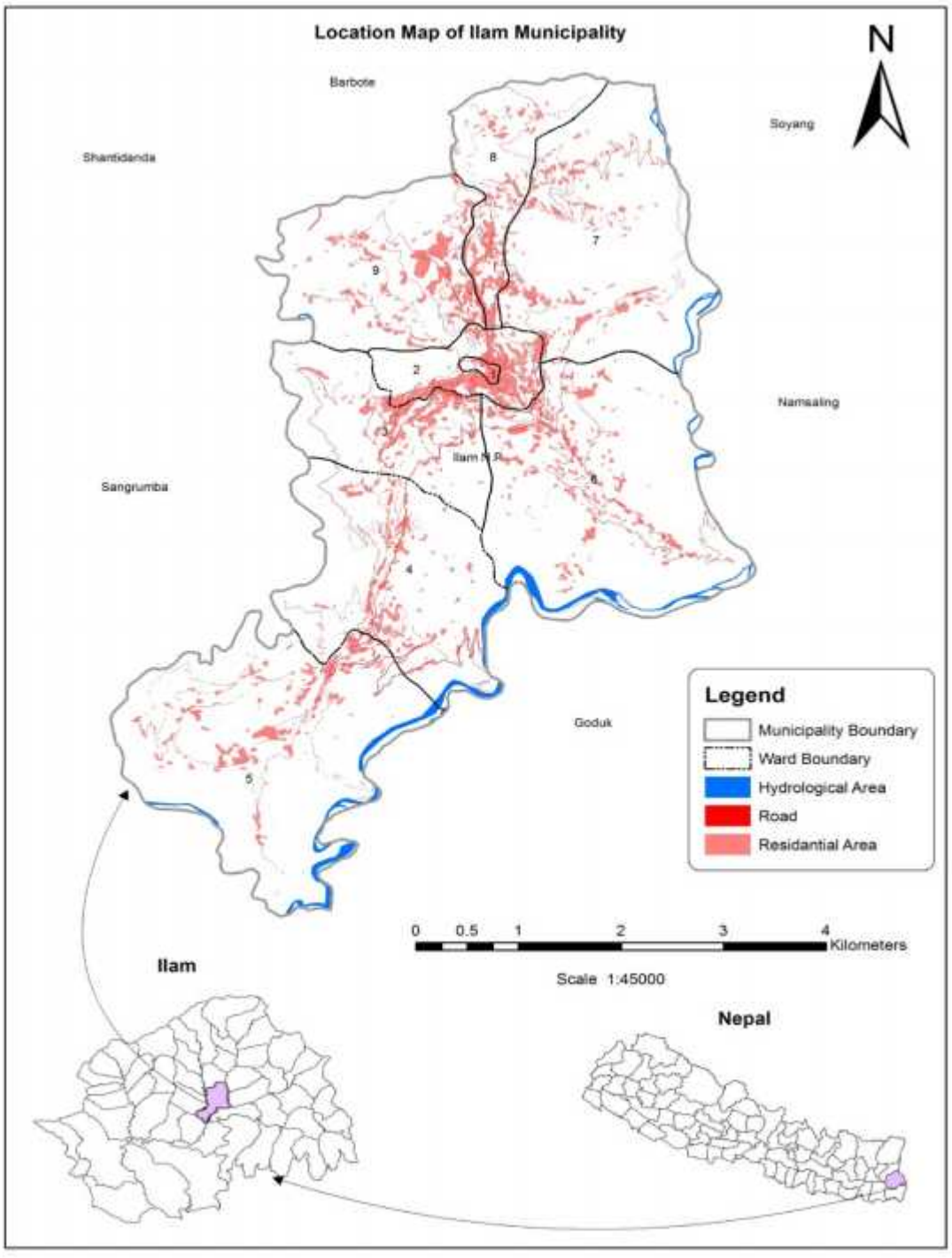

Figure 1.1: Location Map of the Study Area

Chapter - 2

BIO-PHYSICAL CONDITION OF THE STUDY AREA

Soil is Life. Without soil, it is difficult to imagine life on this beautiful earth.The importance of soil has been aptly described by UN by declaring 2015 to 2025 as International decade of Soils. Even the prime minister of India, NarendraModi, in his first visit to Nepal pointed out the importance of soil. He raised the issues of soil health card for farmers. Soil is the foundation of all living entities. Soil is a natural resource and a country is known by its resources. The ultimate user of all natural resources is the human being. Soil entities will dictate what society can do from it. Soil is a living factory where millions of lives are ceaselessly working day and night. Soil is made favourable by living organisms. That is why without life, there is no soil and without soil, there is no life in this planet earth. Therefore, soil is basis of food and nutritional security, employment generation and much more.

Soil is a natural resource but non-renewable and its loss is not recoverable in the context of a human lifespan. It takes hundred years to form an inch of soil. The maintenance or enhancement of global soil resources is essential for humanity's overarching need for food security and nutrition, climate change adaptation and mitigation and overall sustainable development.Soil needs to be managed in a sustainable way. This will be achieved when the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity.

Human pressures on soil resources are reaching critical limits, inherently reducing or eliminating soil functions critical to human well-being. Soil degradation is a pervasive process that in its various forms affects all regions. One third of all global soils are already degraded, affecting mainly smallholders and family farmers, who are responsible for 80% of the food production in value terms.

There is an urgent need for concerted efforts to ensure the sustainable management of soils to ensure sustainability and food security and nutrition for all.

Nepal has various agro ecologies and depending upon the agroecological zones, the soil of Nepal vary. Therefore, Nepal can be a museum of world soils with different characteristics.This chapter describes the bio-physical condition of the study area in terms of physiography geology and environment and their relationship with soil formation factors and pedological development. It includes physiography, elevation, slope, geology, streams and canals and climatic condition.

2.1 Physiography

Physiography refers to the study of surface landform characteristics. Physiography of Nepal has been mainly divided on the basis of river, relief, structure altitude and geographical distribution. Because of such variations it has resulted in distinct landform and topography. For the sake of convenience, the physiography of Nepal is divided as high himal, high Mountain, middle mountain, siwalik and terai from north to south. The terai is the flat land below 300m elevation formed by alluvial deposition. The siwalik,

churiya, lies just above terai. It ranges from 300-900 meter elevation in general. It is formed with conglomerates.

The middle mountain or the mahabharat extends widely just immediately after the siwalik. It lies between 900 to 3000 meters elevation. It has sprus, hills, river basins and valley, the arunvallley, Kathmandu valley, pokhara valley, tumlingtar, rumjatar, and salyantar lie in this belt. The high mountain also has steep and dissected landforms. The high himals is in the northernmost part where hundreds of mountain peaks are founds.

In a nutshell, Physiography as the study of surface form, geology, climate, soils, water and vegetation and their inter-relationship, is essential to point out the broad general pattern of soil development. The study of physiography in relation to soils is based on following three basic assumptions: the factors involved in physiographic processes more or less correspond to the factors of soil formation. Soil as a three dimensional body cannot be characterized by surface features alone. But surface features can provide sufficient clues for delineation of soil boundaries as changing expression in vegetation, topography, relief, slope, soil colour are determined by physiographic processes. Various landforms or surface features of the earth can be easily recognized and interpreted with the help of the remote sensing data products.

Physiographically, Ilammunicpality is in the mid hill area of Nepal. Topographically Ilam is mostly a hill district with altitude ranging from 140 meter to 3636 meter from the mean sea level. It extends from the low land of the Bhabar in the south to the higher mountain of Mahabharat range to the north. This district has a very small area of Bhabar zone to the southwest which covers only 2.35% of total area of the district. Its altitude is up to 250 meter. Most of the southern part is occupied by the Siwalik hill covering 29.53% area of the district. The altitudinal range of Siwalik is 250 to 600 meter. Siwalik region of Ilam is lower than its western counterpart of Nepal. Remaining 68.12% is lower and higher hills of Nepal. It covers whole of the central and northern part of this district. This area has the altitudinal range from 600 meter to 3636 meter. This area is known as Mahabharat range. This mountain range is rugged in form and has steep face toward the south. Since its elevation is lower than that of the mountains of the higher Himalayas, it is free from permanent snow cover. It has several spurs extending towards south with deep and narrow valleys in between them forming the major features of the mountain ranges. Many rivers and streams originate from the springs at and various sections they have carved out fairly deep valleys. Mai river valley extends from east to west direction just north of Siwalik region with the similar characteristics of major river valley of Nepal. Some small river valleys have been formed by the Mai River and its tributaries. Wider valleys lie at the southern Siwalik regions. The physiography of the municipality is basically hilly terrain of this municipality. The micro topographic variations are depicted in the terms of Shaded Relief Map, Slope Map and Digital Elevation Map.

2.2 Elevation

The shape of the land surface, its slope and position on the landscape, greatly influence the kinds of soils formed. Elevation is an important element of soil forming factors. Soils that are formed in similar parent

materials with the same climatic conditions exhibit differences as a result of their position on the landscape. These differences are largely a result of varying drainage conditions due to surface runoff or depth to water table.

Soils that developed on higher elevations and sloping areas are generally excessively drained or well drained. Soils that occur at lower elevations generally receive surface runoff from higher elevations and often have a seasonal high water table at a shallow depth. Permeability of the soil material; as well as the length, steepness, and configuration of the slopes, influence the kind of soil that is formed in an area. The local differences in the soils mapped in an area are largely the results of differences in parent material and topography.The elevation of this municipality ranges from 381 to 1387 meters above from the sea level. Southern part of the municipality has lower elevation. Northern part of the municipality has higher elevation as shown in the map below.

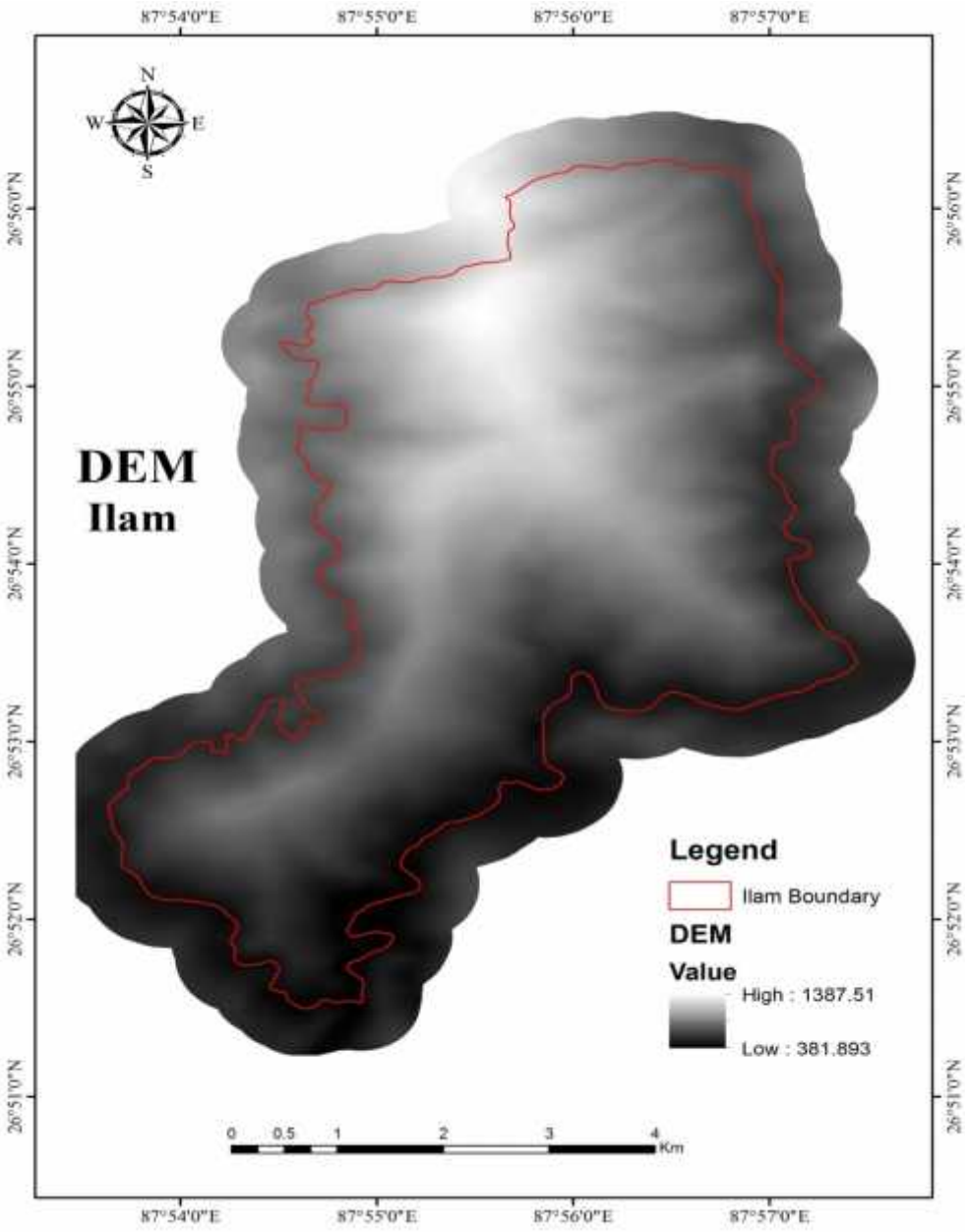

Figure 2.2: DEM of Ilam Municipality

2.3 Slope

Slope angle and length affects runoff generated when rain falls to the surface. Hill slope orientation affects the microclimate of a place. As the slope of the surface increases, so does the local sun angle up to a point. As the local sun angle increases, the intensity of heating increases, causing warmer surface temperatures and, likely, increased evaporation. Orientation of the hill slope is certainly important too. Those slopes which face into the sun receive more radiation than those facing away. Thus inclined surfaces facing into the sun tend to be warmer and drier, than flatter surfaces facing way from the sun. The microclimate also impact vegetation type.Slope has a major influence on the distribution of water on and within the soil, as well as on the rate at which water moves during and after rainfall; gradient also influences the processes and rates of soil movement down the slope (Selby, 1991). Areas with steeper slopes are less stable, all other factors being constant. The steeper the slope, the shallower the unconsolidated material on the slope, which is likely to be removed by erosion processes. Conversely on the gentler slopes landscape is stable, the soil forming processes is relatively less hindered.

From the slope map it could be revealed that Ilam municipality has large ranges of slope. It is mostly sloppy and most of the area has 15-28% slope. However, the municipality contains slope ranging from less than 0% to 48% as depicted in the map below.

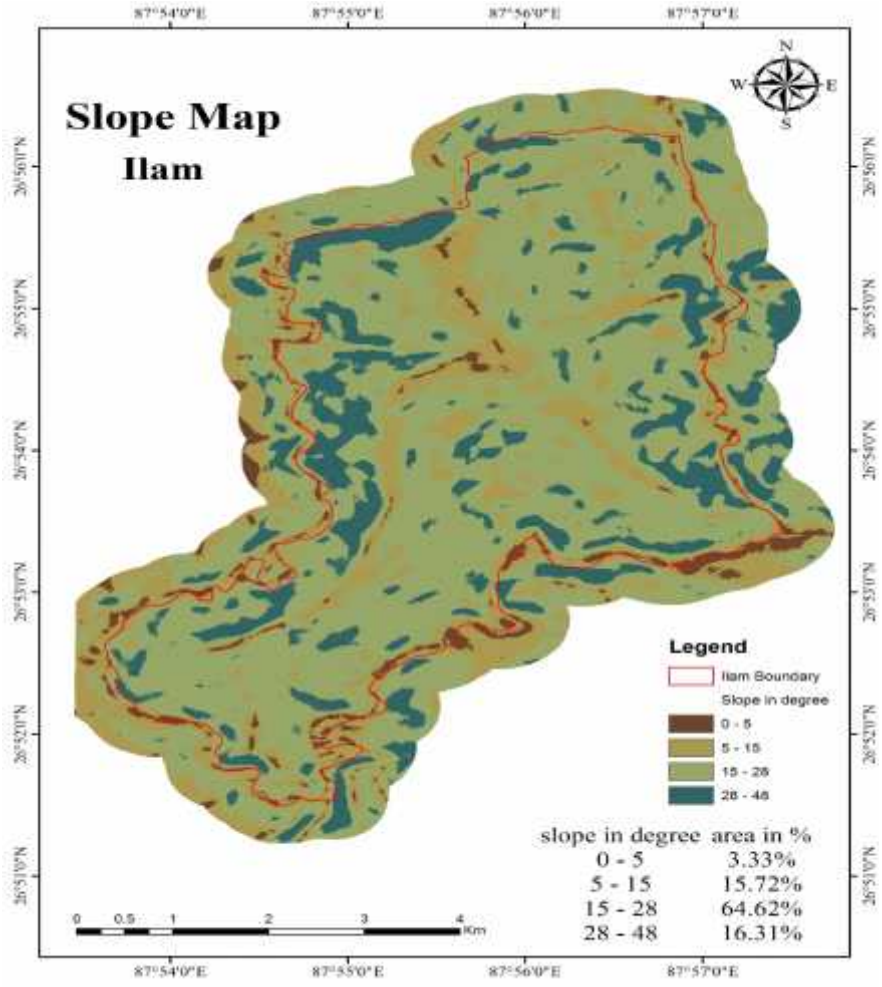

Figure 2.3: Slope Map of the Ilam Municipality

2.4 Geology

Most of the northern part of Ilam district is in the Mahabharat Range which is also known as the Lesser Himalayan Zone. The geology in the Mahabharat Range is complicated. Stoecklin (1979) explains, "Stratigraphic work in the thick, slightly metamorphosed argillo-arenaceous and calcareous deposits is hampered by the almost total lack of palaeontological control." A series of geomorphic processes including metamorphism and migmatization (partial melting of rock through extreme metamorphism) has caused folding, faulting, and thrusting; as well as interesting features such as nappes, klippes and windows (Skoecklin, 1979). This geological structure causes thick landslides and rockslides creating a colluvial cover on crystalline rock sequences common in the Lesser Himalayan zone (Schramm &Uhlir, 1998). Extreme precipitation from monsoon season and weathering processes hinder the stability of these soils causing massive gully erosion and landslides. Southern Siwalik region has deposit of huge quantity of calcium carbonate and sub-economic grade of important minerals such as iron, sulfur, copper etc. The tectonically active zone of the Himalaya, Siwalik Hills are considered as the most dynamic formation where they annually rise up by 3 to 4mm. Being very young in geological formation and tectonically active, the hills exhibit a very conspicuous fragile terrain. They stretch east west forming the north

boundary of plains of Terai and southern boundary of Middle-hill Mountains. The Bhabar zone with an altitude ranging from 140 to 250 meters is an area of sediment deposits transported from the Siwalik and is tectonically active zone which is considered as the most dynamic formation. This area is geologically very young and tectonically an active and exhibits a very conspicuous fragile terrain. This area is the prime source of sediments. A number of steep torrents transport them downstream to the Bhabar and plain of Tarai leading to the rise of streambed level further aggravating the flooding and inundation problems in the plains. The weak geological formation, intense rainfall and tectonically uplifted phenomenon have contributed to the geo-morphological development of these instabilities. To the north of the Main Boundary Thrust (MBT) Mahabharat ranges are however composed of mainly limestone, sandstone, shale, marble, granite, slate and other metamorphic rocks of varied geological ages.

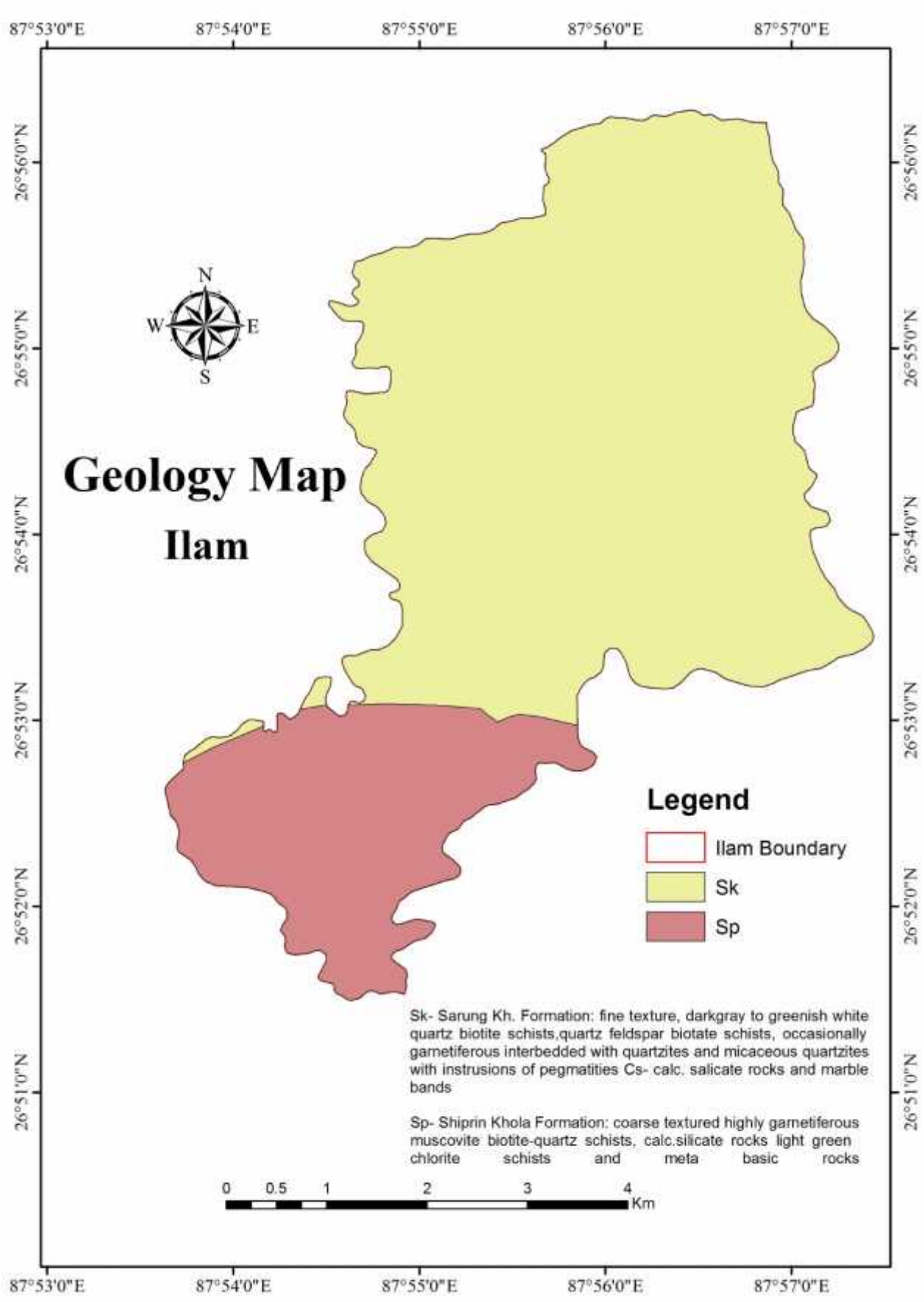

Figure2.4: Geology map of Ilam

2.5 Streams and Canals

Mai khola and Puwakhola are the two major rivers flowing in the municipality. As mentioned above, the municapility is surrounded by Mai Khola (River) to the east, PuwaKhola (River) to the west, Barbote VDC (Village) to the north and Mai Khola&PuwaKhola (Rivers) to the south.Besides, there are small streams that flow through the hills.

2.6 Climatic Condition

Soils tend to show a strong geographical correlation with climate, especially at the global scale. Energy and precipitation strongly influence physical and chemical reactions on parent material. Climate also determines vegetation cover which in turn influences soil development. Precipitation also affects horizon development factors like the translocation of dissolved ions through the soil. As time passes, climate tends to be a prime influence on soil properties while the influence of parent material is less. Climate affects both vegetative production and the activity of organisms. Hot, dry desert regions have sparse vegetation and hence limited organic material available for the soil. The lack of precipitation inhibits chemical weathering leading to coarse textured soil in arid regions. Bacterial activity is limited by the cold temperatures in the tundra causing organic matter to build up. In the warm and wet tropics, bacterial activity proceeds at a rapid rate, thoroughly decomposing leaf litter. Under the lush tropical forest vegetation, available nutrients are rapidly taken back up by the trees. The high annual precipitation also flushes some organic material from the soil. These factors combine to create soils lacking much organic matter in their upper horizons.

Climate, interacting with vegetation, also affects soil chemistry. Pine forests tend to dominate cool, humid climates. Decomposing pine needles in the presence of water creates a weak acid that strips soluble bases from the soil leaving it in an acidic state. Additionally, pine trees have low nutrient demands so few soil nutrients are taken back up by the trees to be later recycled by decaying needle litter. Broadleaf deciduous trees like oak and maple have higher nutrient demand and thus continually recycle soil nutrients keeping soils high in soluble bases.

Climate and vegetation are considered as active soil forming factors. Climate is one of the major soil forming factors affecting the soil formation directly and indirectly. Directly it affects by supplying water and heat to react with parent material whereas indirectly it determines flora and fauna activities which furnish a source of energy in the formation of organic matter.

The climate of this municipality is humid sub-tropical monsoon type. Generally, rainfall starts in the month of February but there is hardly little rainfall in April. Then the rainfall again goes up from the month of May and last till the last of September. In December and January, there is no rainfall and it remains dry. The minimum temperature is also found to be lowest in the month of January (9.21 degree celcius). The minimum temperature tend to increase from April and reached upto 19.37 degree celcius in the month of June (Table 2.1) and mean maximum temperature is nearly 27.29 (Table 2.2) in September. Summer season starts by April with mean maximum temperature of 26.40 degree celcius reaching

highest in September and again drop down in December. The lowest maximum temperature was recorded in January. The amount of rainfall that occurred in this season is more than 1077.9 mm in 2015 (Table 2.3). Roughly speaking winter season begins in the month of October and lasts till February as the sun moves southward from the equator.

2.6.1 Temperature

Temperature is an important parameter for soil forming process and development as well. With the increase in temperature, the chemical and biological processes also fasten. There is great influence of temperature in oxidation and reduction process in soil. The annual mean minimum and maximum temperature is presented in table 2.1 and 2.2 respectively. Figure 2.4 below reveal the maximum and minimum monthly average temperature (2005-2015). Very high temperature is observed in the month of April and it remains active till September. Extreme cold starts from November and last till February.

Table 2.1: Minimum Temperature in ^{0}C (Ilam Tea Estate, 2005-2015)

Months	Years										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**Average**
Jan	DNA	10.7	DNA	10.2	8.8	10.8	8.6	DNA	7.5	7.9	9.21
Feb	11.3	13.7	DNA	11.8	11.1	DNA	11.2	DNA	7.8	7.8	10.67
Mar	15	15.4	DNA	14	11.9	17.1	14.7	DNA	11.7	13.8	14.20
Apr	17.1	16.6	DNA	17.5	15.7	19.2	DNA	DNA	15.8	15.1	16.71
May	17.8	18.3	19.3	17.1	17.5	18.8	DNA	DNA	16	17.2	17.75
Jun	20.2	20.2	20.3	19.6	18.9	DNA	DNA	DNA	17.2	19.2	19.37
Jul	19.7	20.6	20.8	19.9	20.4	18.8	DNA	17.4	16.9	18.6	19.23
Aug	DNA	20.6	19.5	19.6	19.3	19.5	DNA	DNA	16.7	17.5	18.96
Sep	20	19.7	20.1	DNA	19.8	19.7	DNA	17.8	16.2	17.3	18.83
Oct	17.5	18	DNA	DNA	18.6	16.5	DNA	DNA	14	14	16.43
Nov	14.6	13.7	DNA	14.2	13.6	18.6	DNA	11.4	11.4	10.5	13.50
Dec	12.4	11	DNA	DNA	8.9	16.3	DNA	DNA	8.3	7.5	10.73
Mean	16.56	16.54	20.0	15.99	15.38	17.53	11.50	15.53	13.29	13.87	

Source: Department of Hydrology and Meteorology

Table 2.2: Maximum Temperature in ^{0}C (Ilam Tea Estate, 2005-2015)

Months	Years										
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2014**	**2015**	**Average**
Jan	DNA	18.2	DNA	14.7	17.5	17.8	15.2	DNA	19.8	19.4	17.51
Feb	18.7	21.2	DNA	17.5	20.5	DNA	16.5	DNA	18.8	20.1	19.04
Mar	22.6	23.4	DNA	22.7	24.7	26.5	22.6	DNA	22.3	23.2	23.50
Apr	25	25.5	DNA	27.2	28.3	28.8	DNA	DNA	26.7	23.3	26.40
May	25.1	26.5	26.3	27.6	28.9	28.2	DNA	DNA	26.8	26.1	26.94
Jun	26.8	26.5	27.4	27.7	28.4	DNA	DNA	DNA	26.8	25.8	27.06
Jul	25.9	26.7	26.8	26.8	28.7	28.3	DNA	27.7	26.9	26.4	27.13
Aug	DNA	27.5	27	26.8	28.2	28.1	DNA	DNA	25.9	25.7	27.03
Sep	27.1	25.6	27.3	DNA	29.8	28.4	DNA	27.5	26.5	26.1	27.29
Oct	24.5	26.1	DNA	DNA	28.6	24.9	DNA	DNA	25.3	25.7	25.85
Nov	21.8	21.6	DNA	23.9	22.7	27	DNA	24.5	23.5	23.5	23.56
Dec	19.6	18.4	DNA	DNA	17.1	DNA	DNA	DNA	20.4	19.4	18.98
Mean	23.71	23.93	26.96	23.88	25.28	26.44	18.10	26.57	24.14	23.73	

Source: Department of Hydrology and Meteorology

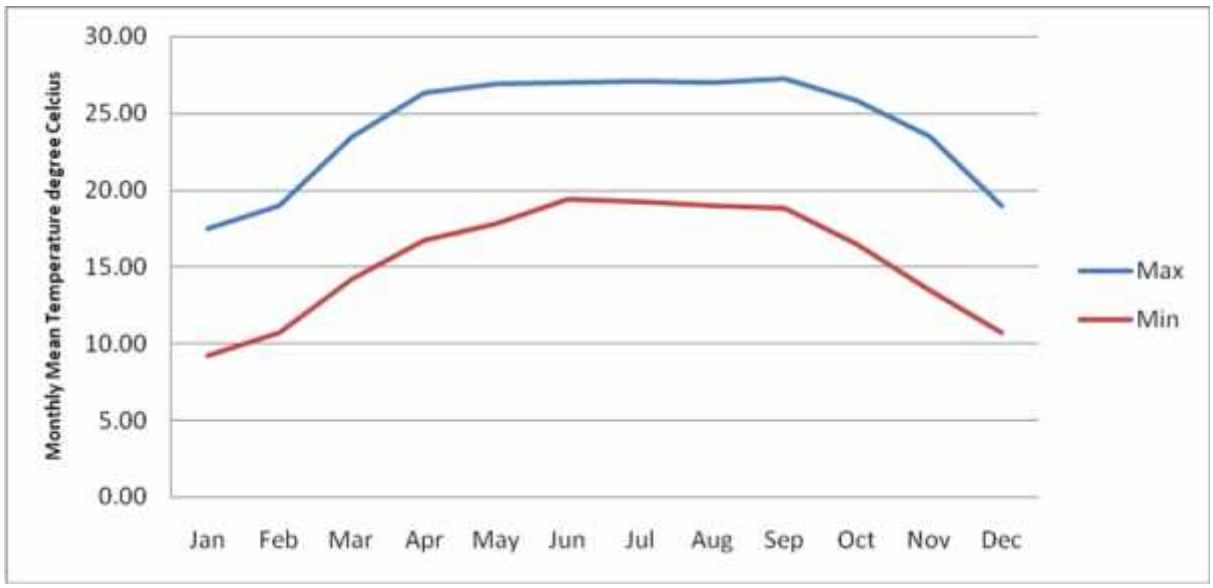

Figure 2.5 Maximum and Minimum Monthly Average Temperature (2005-2015)

2.6.2 Rainfall

Rainfall is another factor that influences soil forming processes. Rainfall buffers the soil temperature. Soil moisture prevents soil from sudden fluctuation in temperature. It makes the soil cool after it gets heated during summer season. Rainfall starts from February and last till the month of December. Maximum raining is recorded in the month of July reaching more than 279 mm in average. Due to the effect of climate change, these days there is erratic and torrential rainfall. The number of rainy days has been decreased in recent years. The detail of rainfall of each year and trend of rainfall for each month is presented in table 2.3 and figure 2.6 below.

Table 2.3:Rainfall (in mm) (Ilam Tea Estate, 2005-2015)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Av
2005	DNA	0	30	50.4	119.9	DNA	290.6	DNA	41.9	60.2	0	0	59.30
2006	0	1.2	31.1	67.5	156.6	183.7	327.7	197.9	121.2	11.6	5.6	14.6	93.23
2007	DNA	87	8	27.3	51.4	DNA	206.6	54.6	86.5	DNA	DNA	DNA	65.18
2008	DNA	0	33	0	176	317.9	186.3	338.6	DNA	DNA	0	DNA	350.60
2009	0	0	10.2	0	271.1	96.1	297.8	439.1	8.2	120.5	0	0	103.58
2010	0	DNA	0	42.8	261	DNA	503.2	468.3	155.7	0	48	3	148.20
2011	0	0	0	0	146	301.2	237.9	326.4	268.6	41.8	11	0	111.08
2012	0	0	1	58	175	DNA	274	39	DNA	DNA	DNA	DNA	78.14
2013	DNA	DNA	86.3	81.7	175.4	199.1	135.7	252.4	158.9	DNA	DNA	DNA	155.64
2014	0	8	12.6	11.1	143.9	268.5	214.7	169.5	116.7	75.7	0	3.2	85.33
2015	0	12	41.3	96.4	140	239.8	398.4	357	298.8	33.5	0	0	134.77
Mean	0.0	12.0	253.5	39.6	165.1	229.5	279.4	264.3	139.6	49.0	8.1	3.0	

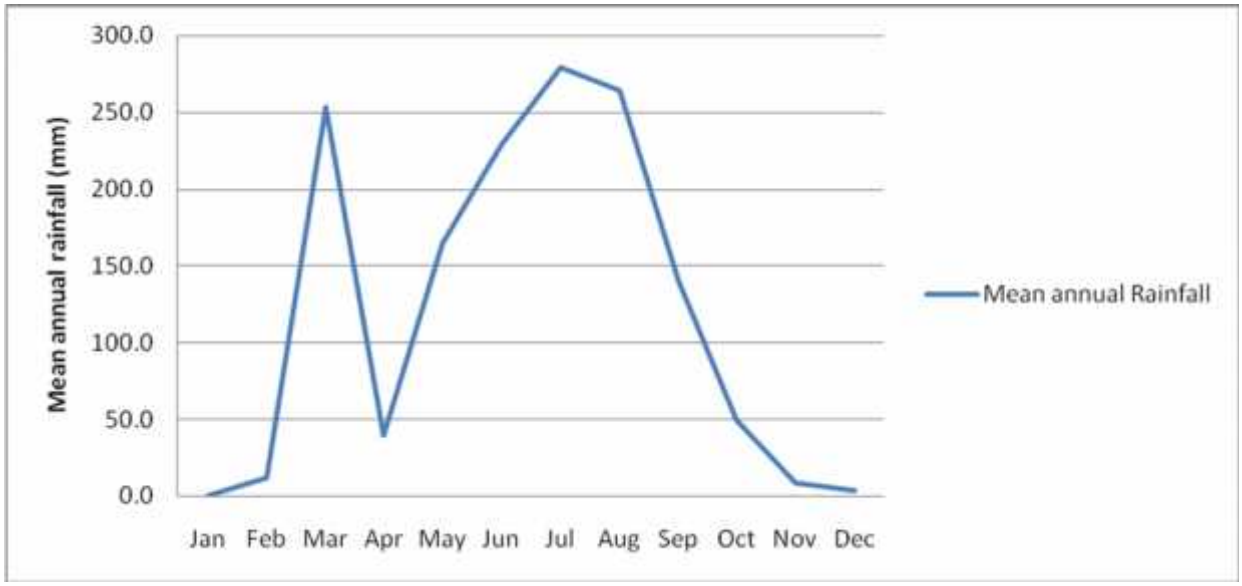

Figure 2.6: Mean monthly rainfall (2005-2015)

2.7 Vegetation/Land use /Landcover

Vegetation is another important active soil forming factors which greatly influences soil evolution and formation. This is evident from the fact that desert soils are markedly different from forest soils, grassland soils, and tropical soils depending upon nature of vegetative cover. The greatest contribution of the vegetation is through the addition of organic matter or leaf litter to the surface. If we see the vegetation of the area, there is mostly agricultural and forest land. Most of the land is used for farming.

Agriculture is the one of the sources of livelihoods in the district. A total of six land use classes are recorded in the Municipality. The present land use show that agriculture covers maximum area (54.81 %) followed by forest (32.11 %). Next significant land use coverage is public use (8.18 %). Other coverage is not potentially significant. Hill cultivation is the sole type of agriculture in this Municipality covering a total of 639.53 ha of area. Analysis of cropping pattern shows that Rice-Wheat-Maize (34.73 %) is the dominant one followed by Rice-Maize (31.67 %). Farmers are growing crops combined with livestock such as cows, goats, poultry, etc. Major crops are rice, wheat, maize, millet, pulses, mustard, potato and vegetables.Almost every household is raising few heads of cows/buffalos/goats. Most of the farmers are growing improved varieties of crops and raising improved breeds of cows and buffalos. Chemical fertilizers, pesticides and fungicides are used for crop production and plant protection. Major cropping patterns are Rice-Wheat-Maize Rice-Wheat-Vegetables, Rice-Maize-Vegetables, Rice-Rice-Potato, Rice-Wheat, Rice-Pulses and Rice-Oilseeds. Details of the hierarchy of agricultural land use, cropping patterns and Cropping Intensity are shown in Table-1.

Table-1: Hierarchy of Agricultural Land Use of Ilam Municipality

Level 2	Level 3	Level 4	Level 5 - Cropping pattern (Monsoon-Winter-Dry Season)	Level 6 – Cropping intensity
Terai Cultivation	Wet land cultivation	Low khet land cultivation	Maize-Oilseeds-m2; Maize-Pulses-m4; Maize-Wheat-m5; Maize - Vegetable-m6; Maize-Millet-m7; Maize-Potato-m8; Maize-Others-m9; Pulses-Fallow-p1; Pulses-Others-p2; Rice-Fallow-r0; Rice-Rice-r1; Rice-Wheat-r2; Rice-Wheat-Pulses-r3; Rice-Oilseed-r4; Rice-Pulses-r5; Rice-Rice- Vegetable-r6; Rice-Vegetable-r7; Rice-Potato-r8; Rice-Potato-Vegetable-r9; Rice-Maize-r10;	Intense (75%-100% cultivated)
		Upper khet land cultivation –TariKhet		
	Dry land cultivation	*Unclassified*		medium(50 %-75% cultivated)
	Mixed land cultivation	*Unclassified*		
Hill Cultivation	Level terraces	Level terraces Khet land cultivation		Light (25%-50% cultivated)
		Level terraces upland / Pakho land cultivation		
	Sloping	Sloping upland / Pakho		

	terraces	land cultivation	Rice-Vegetable-Vegetable-r11; Rice-Maize-Vegetable-r12; Garlic-Vegetable-v2; Vegetables-Vegetable-v3; Fruit+Potato/Vegetable/Buckwheat-f2; Banana-b2; Tea-t1; Coffee-c1; Cardamom-c2; Amriso-a1; Ginger-g1; Livestock/Cattle/buffalo Farm-l1; Turmeric-t2; Fruits-f4; Rice-Buckwheat-r14; Rice-Wheat-Maize-r15; Bamboo-b3; Pond for Fish farming-p3; Beekeepig-b4; Cotton-c3; Floriculture-f5; Barren Cultivable land-b5; Livestock Grazing area-g2; Maize-Rice-Cereal-m3; Rice-Others-r13; Sugarcane-Sugarcane-s1; Potato-Vegetable Crops-v1; Others-o1; Shrub from non-forest area-s3; Vegetables-Others-v4; Sugarcane-Others-s2; Barley-Buck Wheat-b1; Fruit-Fruit-f1; Fruit-Others-f3; Others-Others-o2; Others-Others-others-o3; Maize-Rice-Fallow-m1	
Mountain cultivation	Level terraces upland cultivation	*Unclassified*		
	Slopy upland	*Unclassified*		
Valley cultivation	Level terraces Khet land cultivation	*Unclassified*		
	Level terraces upland / Pakho cultivation	*Unclassified*		
	Valley slope upland / pakho cultivation	*Unclassified*		
	Valley riverbeds (lower footslope) Alluvial fans cultivation	*Unclassified*		

Average yields of crops are as follows:

Rice 3600 kg/ha

Wheat 3000 kg/ha

Maize 3000 kg/ha

Potato 10500 kg/ha

Oilseeds 650 kg/ha

Pulses 7500 kg/ha

Fishery3800 kg/ha

Suggestion:

The following cropping patterns are suggested to be followed in irrigated and unirrigated area of the MUNICIPALITY:

Low land irrigated area

- Spring Rice- Rice- Pulses
- Spring Rice- Rice- Potato
- Spring Rice- Rice- Vegetables
- Rice-Maize-Pulses
- Rice-Vegetables-Vegetables
- Rice-Wheat-Spring maize
- Rice-Wheat-Vegetables
- Rice-Wheat-Green gram
- Rice-Wheat-Cluster bean
- Rice-Potato- Vegetables

a. Upland unirrigated area

- Rice- Pulses
- Rice- Oilseeds
- Rice- Vegetables
- Maize-Pulses

Chapter - 3
METHODOLOGY OF SOIL SURVEY AND MAPPING

3.1 Review of Soil Survey Methods

Soil surveys provide information needed for land use management and land use planning. The selection of good land for farming is as old as agricultural land use. The fact that during early Holocene, some 8000 years ago the first farmers in Europe were cultivating the relatively rich loss soils and alluvial plains shows that these people were aware of major differences in fertility between major land units, and that they were able to judge which soil was more productive than others. Gong (1994) stated that the oldest historical record of soil survey and land classification is most likely the Chinese book "Yugong" in which soils of China were classified into three categories and nine classes, based on soil color, texture and hydrological features. Also now, farmers have a vast knowledge on soil and land resources which ought to be taken into account during soil surveys. However, one of the limitations is that this information is rather location-specific and not transferable as such. Unless brought together under a common denominator, indigenous knowledge will seldom lead to a synthesis of land resources for land planning and management.

Soil surveys are meant to investigate the geographical distribution of soils that occur in a given area; to determine the most important characteristics of the soils; to delineate map units and describe them in a logical legend in terms of dominant, associated and inclusion soil units, including classification of soils.

With the advancement of science and technology, methods of survey have been changing with time and situation. Soil survey methods have undergone large changes during the recent past with the availability of satellite imagery, apart from topographical maps and aerial photographs. In earlier days aerial photographs were used as base map for demarcating physiographic-photomorphic units using photo-interpretation technique. More recently, medium to high resolution satellite data are common in mapping of soil resources. The current project has used high resolution satellite imagery for the soil survey and mapping purpose. Usually, there are two approaches in soil mapping using satellite data.

A) Computer aided digital analysis approach: Digital analysis of remote sensing data utilizing the computers has been developed to meet the requirement of faster analysis and extract information from the large quantities of data based on the utilization of the spectral variations for classification.

B) Visual image interpretation: Visual interpretation is based on shape, size, tone, shadow, texture, pattern, site and association. This has advantage of being relatively simple and inexpensive. Soil mapping needs identification of a number of elements, which are of major importance for soil survey. They are land type, drainage pattern and drainage condition, vegetation, land use, slope and relief.

The current project has used visual image interpretation for soil survey and it is discussed below:

3.1.1 General Traversing for Mapping

The surveyor with the interpretation of physiographic-soil relationship on aerial photo or imagery walks briskly along the field by digging a hole at interval depending upon the intensity of mapping and studying soil morphological properties by the field method and put these observations on the map.

3.1.2 Grid Survey

The grid survey method is adopted in the pre-selected sample strips to establish correlation between soil and aerial photo/imagery units in the small area. In this method, traverse lines are located along the grid pattern of geo-referenced image and four-five observations are recommended at per hectare of area.

3.1.3 Free Survey

The free survey method is adopted for checking and confirming of established soil-physiographic relationship mapping units and inferred soil boundaries demarcated are to be matched with the actual soil properties depending upon indicators and associated features.

3.1.4 Geo-Statistical Sampling

In geo-statistical sampling method, systematic sampling of accurate interpolation by krigging producing spatial pattern maps and for accurate estimation of semi-variogram are two primary concerns. A regular grid with square, triangular or hexagonal elements is most often used and placement of sample locations is in the center of each grid cell. Sample spacing for these grid cells should be less than 1/2 of the range for the semi-variogram as a useful tool for modeling spatial structure in a measured soil property.

The methodology adopted for the present soil survey was based on integrated use of visual interpretation and computer aided technology and integrated use of GIS and Remote Sensing techniques. The entire methodology comprises three- tier approach furnished below in detail.

3.2 Desk Study

The digital LRMP maps, land system, land capability and land use at the scale of 1:50,000 and geological Map scale at 1:125000 together with MUNICIPALITY map and Topographic - thematic layers at 1: 25,000 and Geo-Eye image at 2 m spatial resolution of MSS provided by National Land Use Project and available reports were reviewed in connection with preparation of soil map prior to the field survey. All these layers and satellite images were made compatible for overlay analysis by geo-referencing them in same projection system prescribed by NLUP. These imageries /sheets are visually interpreted for lithological (parent material) units which are initially delineated based on available geological maps. It is followed by delineation of broad physiographic units based on relief information available in topographical maps. Topographic information, such as relief and slope can also be deduced by interpreting drainage features, drainage density exhibited on imageries. GIS based digital elevation model, relief and hill shade map were produced for the visualization of virtual 3D terrain surface for delineating the land system units that was used for detailed soil survey. The soil mapping units were interpreted and delineated on the imagery with the aid of physiographic-soil relationship such as topography, geology, drainage and land use. The image depicts clearly land system units and upland, lowland and wetland were

clearly delineated on the imagery. The physiographic units are further sub-divided based on land use/land cover as revealed in the image.

The land units required for demarcating of soil polygon/mapping were determined with the integration of physiography, land system, landform, geology, slope and land use of Ilam Municipality.

a. Soil Mapping Unit

The soil mapping units were demarcated based on the land units that also identified capturing the local topography variation. The description of soil mapping unit and the symbol was formed with the integration of land system, landform, land type and geological map and land use/land cover that is shown in Table 3.1. The whole project area is divided into three land system units, seven land units, two local land types and five major land use/land cover types. The major land use/land cover is further subdivided into eleven categories based on minor description of cropping pattern.

Table 3.1: Soil Mapping Unit Description

<table>
<tr><th>Geology</th><th>Land System</th><th>Land Unit / Form</th><th>Land Type</th><th>Land Use/ Cover</th><th>Soil Mapping Symbol</th></tr>
<tr><td rowspan="12">1a:Alluvial deposit or reworked by water</td><td rowspan="9">2: Recent Alluvial Plain “Lower piedmont (Depositional and Erosional)</td><td rowspan="2">2a: Depressional</td><td></td><td rowspan="2">Agriculture(Ag)</td><td>G1a2aLlAg</td></tr>
<tr><td>Lowland (L)</td><td>G1a2aUpAg</td></tr>
<tr><td rowspan="3">2b: Intermediate,position level</td><td rowspan="2">Upland(U)</td><td rowspan="3">Built up(Ba)</td><td>G1a2aUpBu</td></tr>
<tr><td rowspan="2">G1a2bLlOr</td></tr>
<tr><td>Lowland (L)</td></tr>
<tr><td rowspan="5">2c: Intermediate,position undulating</td><td rowspan="2">Upland (U)</td><td rowspan="5">Bush(Bu)</td><td>G1a2bLlBa</td></tr>
<tr><td>G1a2bLlBu</td></tr>
<tr><td rowspan="2">Lowland (L)</td><td rowspan="2">G1a2bLlSa</td></tr>
<tr><td>G1a2bLlFl</td></tr>
<tr><td>G1a2bLlBu</td></tr>
<tr><td rowspan="6">1b:Alluvial Fan,tallus, colluvial</td><td rowspan="6">3: AlluvialApprian Complex “ Upper piedmont erosional)</td><td rowspan="6">3c: Undulating</td><td rowspan="3">Upland (U)</td><td>Sandy area(Sa)</td><td>G1a2bUpAg</td></tr>
<tr><td>Swampy area(Sw)</td><td rowspan="3">G1a2bUpBa</td></tr>
<tr><td rowspan="3">Lowland (L)</td><td rowspan="3">Depressed area(Dp)</td></tr>
<tr><td>G1a2bUpBo</td></tr>
<tr><td>G1a2bUpBu</td></tr>
</table>

		3d: Highly dissected	Upland (U)	Forest(Fl)	G1a2bUpFl
					G1a2bUpOr
					G1a2bUpPo
				Nursery(Nu)	G1a2cUpAg
					G1a2cUpBu
					G1a2cUpFl
					G1a3cLlAg
			Lowland (L)		G1a3cUpAg
					G1b3cLlAg
				Orchard(Or)	G1b3cUpAg
					G1b3cUpBa
					G1b3cUpSw
					G1b3cUpFl
	5 Fans Aprans and ancient river Terrace(Tar)	5a: very gentle slopes		Swamp Depressed area	G1a2bLlAg
					G1a2bLlBa

SN	**Land System**	**Land Unit**	**Description**	**Area Ha**	**%**
1	9	9c	Alluvial plains and fans (depositional)	105.01	3.94
2	10	10a	Ancient lakes and river terraces (tars) (erosional)	281.86	10.58
3	11	11	Moderately to steeply sloping mountainous terrain	1636.50	61.45
4	12	12	Steeply to very steeply sloping mountainous terrain	532.61	20.00
5	9	9a	Present River Channel	107.00	4.02
	Total			**2662.99**	**100.00**

b. Sample Pit Design

Soil mapping units derived from Land units were formed and overlaid on Standard False Color Composite (RGB: 432) of the project area at the scale of 1:10000. Altogether 14 soil pits and their location were obtained for the soil pits collection where detailed soil profile was dug for this Municipality. The spatial distribution of those soil pits are shown in Fig 3.1. Soil pits are characterized by geology, land system, slope and land use as mentioned in GIS Database and Municipality name was coded as IM and their numerical numbers are used which is presented in Fig 3.1.

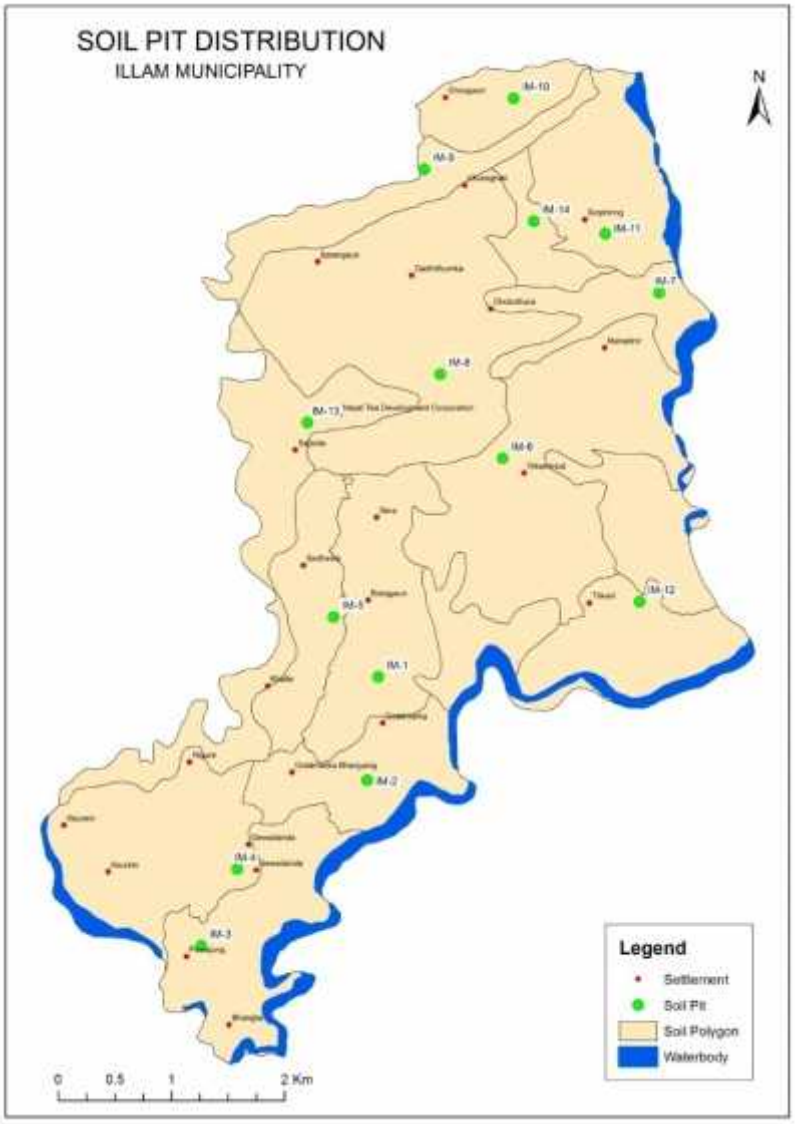

Figure 3.1: Sample soil pit location map

3.3 Field Survey

A preliminary reconnaissance survey was carried out during the pre –field activities to get the insight of ground situation of project area regarding the association of landform and soil. It helped in identification of soil mapping units and designing the soil sample pit collection. Field work was carried out to study the physiography, landform and their associated soils based on the soil pit shown in Fig 3.1. Soil Sample pits covering all the units were dug based on the interpreted soil map, topographical map, GEO-EYE Satellite

imagery for determination of soil profile. The digging of soil pits was carried out from 2073/4/30 to 2073/5/5at the concerned area by employing trained soil sample collectors. These sample pits were studied in the field for soil mapping and soil profile observation. Each soil profile (pedon) description were carried out as per the Standard Soil Profile Description Form provided by NLUP Specification, 2013. This form consists of the information on site sampled, general information on the soil, general information of the profile and information on individual soil horizon. Soil of each horizon was described following FAO soil description as a guidelines and sample from surface horizon collected to determine the soil primary nutrients and chemicals for analyzing fertility status. Besides the topographical map, standard false color composite (FCC), land system maps as the basic information, the following equipment were used during the profile digging in the field:

a. Soil sample airtight plastic bag with Tag
b. Measuring Tape and Scale
c. Standard Soil description form
d. GPS(1m accuracy) instrument
e. Digital Camera
f. Abney Level
g. Marker pen (Permanent)
h. Spade or Shovel
i. Knife
j. pH (Field Kit)
k. MunsellSoil Color Chart

The soil information observed and recorded in form includes the following morphological and physical characteristics of each soil pit at different horizon. These characteristics include the information as below:

1. Information on the site sampled

a. Soil Pit Number
b. Higher category classification (Order)
c. Date of examination
d. Name of soil of field supervisor
e. GPS Location: Easting and Northing
f. Elevation (in meters amsl.)
g. Land –form at the pit
h. Physiographic position of the site
i. Land-form of surrounding area
j. Slope on which profile studied(direction and degree)
k. Land use /land cover or Vegetation
l. Climate

m. Cropping pattern
n. Irrigation water availability
2. General Information on the soil
a. Parent Material
b. Drainage class
c. Moisture conditions in the Soil
d. Depth of Ground Water Table (in meters/feet)
e. Presence of Surface Stones or Rock outcrops
f. Evidence of Erosion Class
g. Presence of Salt or Alkaline.
h. Human Influence
i. LandUse Classification
j. Local name of soil
k. Series name if known
l. Pans (hard pan) if any

3. Description of Individual Soil Horizon
a. Horizon symbol
b. Depth of top and bottom of horizon (in centimeters)
c. Color (Munsell soil color chart Moist/ Dry)
d. Color of mottling
e. Texture
f. Coarse fragments
g. Structure
h. Consistency
i. Cutans (Clay Skin)
j. Cementation
k. Pores (visual only)
l. Features of Biological Origin
m. Content of roots
n. Nature of Boundary with Horizon below
o. pH Value
p. Number of Sample taken for Analysis

The standard soil profile description form was attached in Appendix. Surface horizon soil samples are collected from profiles with auger bores for analysis in the soil laboratory. Based on morphological and chemical analysis data soils are classified according to Soil Taxonomy (USDA, 2010).

3.4 Laboratory Soil Analysis

Post Field Interpretation

After field work, soil information on soil pits was compiled. Modification in the soil mapping units associated with physiographic units, delineated earlier is made. Soil mapping units with the land type are subsequently translated into soil scape units by incorporating information on soils. Soil scape units are subsequently transferred onto base map of the same scale generated from topographical maps. Beside this, the following major activities were carried out for preparation of soil map.

Spatial Data Analysis: After completing the field study, different thematic layers such as contour, spot height, drainage and municipality and ward, land system and land use were made compatible by transforming into the same projection system (MUTM) adopted by Survey Department. The soil pits location were transferred into base map and vector to raster conversion of line segment were made for preparation of digital surface model required for Digital Terrain Model and Hill shade.

Attribute Data Analysis: The attribute data analysis includes the physical and morphological attributes of soil. The information containing in standard soil description form regarding physical and morphological attributes of each soil pit at different horizon level were converted into digital tabular format in order to join with the spatial location of soil pits. All spatial locations of each soil pit were transferred into the base map of same scale geo-referenced base map projected on MUTM parameters.

*Laboratory Soil Analysis:*Composite soil samples were collected from area around each pit and the samples were sent to Soil Testing Laboratory to examine the chemical properties of soil including soil texture. Top layer or epi-pedon particularly first horizon was examined in the laboratory for the purpose of plant growth fertility assessment whereas sub-surface or endopedon was assessed for the classification purpose. The soil samples collected were preserved in airtight plastic bags, dried in shade and powdered to pass through 2 mm size sieve that are used for examination of physical and chemical analysisin the laboratory using the specific methods (Table 3.2).

Table 3.2: Methods adopted in Soil sample tests in laboratory

Soil Sample Tests	Analysis Method
Texture	Hydrometer & Texture Classification
pH	1:2 water suspension(soil water paste)
Organic Matter content	Walkley and Black
Available Phosphorous(P_2O_5)	On the basis of pH,Olsen sodium bicarbonate extraction and detected in spectrophotometer in 560 nm and Bray method was employed
Available Potassium(K_2O)	1 N neutral ammonium acetate 5 min shaking and filtered through Whatman No 42 filter paper and detected through flame ignition
Total Nitrogen(N)	Kjeldahl method

A good correlation was found between routine test in the laboratory and in the field. Thus field determined pH and texture were found considerably reliable.

Soil Mapping: Based on shape, size, tonal variation and color variation and relative height, the landform and land types of the project area were identified on aerial photograph, satellite imagery and Digital Terrain Model. The color variation ranging from light to dark represents the soil difference identifying dry soil differentiated from wet soil. Soil association as the universally accepted for soil mapping was adopted in order to correlate the soil pit and soil mapping units because these two spatial entities are geometrically different. One soil pit is enclosed by one of more soil mapping unit. Thus classifications were made based on soil association. Based on morphological and chemical analysis data soils are classified according to Soil Taxonomy (USDA, 2010)

Chapter - 4

LAND SYSTEM, LANDFORM AND LAND TYPES

Land systems are defined as areas or regions with recurring patterns of component parts, in geographical, geological, and ecological terms.Land systems are generally seen in terms of landform, underlying geology,vegetationand can also have other components that may be recurrent across regional landscapes.They are used extensively in surveys of land use planning and land management.

The soil properties varies based on the dynamic inter-relationship between physiography and soils resulting in the pattern of soil development by allowing prediction of soil attributes from landform position. Physiography includes relief and topography representing geomorphologically distinct units and difference in elevation of the land surface respectively. Even though, topography is considered as passive factor of soil formation, it significantly influences climate, vegetation and organism of an area as a genesis factor. It affects soil formation, the thickness of soil profile determining the nature of its position on landscape. The soil profile on flat topography tends to be thick, but as the slope increases, erosion hazard increases resulting in thin, stony soils. It influences soil formation through slope and exposure of valley sides (Sehgal, 1990). The topography of the land can hasten or delay the work of climate forces. Rolling to hilly topography encourages natural erosion of the surface layer, which reduces the depth of soil. There is a definite interaction among topography, vegetation, and soil formation. The length of time that materials have been subjected to weathering influences soil formation. Such interactive relationship between soil and landform is utilized while deriving information on soils from multi-temporal aerial photographs with stereo-capability.

The guiding principle has been that soils are the product of same natural processes and condition that affect the land they dwell in. However, this does not imply that any given physiographic unit will contain a single class of soils; but the soils within the same physiographic unit normally vary within a certain range. Black & white aerial photographs were extensively used by various Pedologists for soil mapping. Soil surveyors consider the topographic variation as a basis for depicting the soil variability. Even with the aerial photographs, only the physiographic variation in terms of slope and aspects along with surface cover are considered for delineating the soil boundary. Multi-spectral satellite data provide better information about the earth resources in the discrete wavelength bands of electro-magnetic spectrum, than photographs taken in single band. Satellite data provide synoptic coverage of the large area that enable surveyor to study various landforms, geomorphic processes and its association with natural vegetation.

The present investigation is based on the physiographic-soil relationship approach assuming the physiographic controlled landform as the basic spatial and structural entities of forming soil mapping units (Table 4.1). Physiography in study area is further divided into land system according to recurrent pattern of landforms, altitude, geology and slope and arable agriculture limits and then land units based on mapable land surface significantly from some user oriented point of view for delineation (LRMP, 1986).

Within the land units, land types were delineated based on position, slope, direction, drainage of landscape features which is especially important for local level project design (Carson, 1985). The soil properties within the land types further subdivided based on the cropping pattern determined by detailed field soil survey.

4.1 Land System

Physiographically, the project area falls in the range of Mid hill region. It includes land system units of 2 basically differentiated based on geology and geomorphology. Physiography is further subdivided into landforms basically defined by the position of land surface in landscape and it is characterized by slope and its direction, elevation, rock exposure and soil type. The landforms in the study area can be found evolution in period of Recent and Pleistocene age. Alluvial deposit spatially concentrated in the southern and alluvial fans located in northern part of the municipality are the landforms of Recent and Pleistocene.The sediments of Middle Terai zone covers 100% area of the municipality and the zone is characterized by presence of unconsolidated sediments contents of cobbles as well as pebbles and sands. Lithologically, it consists of sub rounded to rounded, well sorted cobble and pebble interbed with sands and silty clay layers. The sediments either fine or coarse sediments are derived from the Lesser Himalaya rocks. The boulders, cobble and pebble are composed of quartzite, sandstone, gneiss. The loose beds of sands and gravel are roughly horizontal and show fining upward succession with cobble pebble with loose sands and silty sands at base and silty clay and clayey silt and clay as the residual soil on top. Some planar bedding structures are observed in sandy layers. The top layers are covered by thick residual soils contents of silty sands and clayey sands. There is fine sediments in almost all part of the municipality.

4.2 Land Form

Land Units/Land Type

Landform is further subdivided into land units basically defined by the mapable size of land surface for demarcation in landscape by the user.

Among the land units defined by LRMP Land System, land types are demarcated considering the local situation of land units representing micro-relief differences based on the local slope and elevation and its orientation. The classified/demarcated land types are as follows:

Table 4.1: Landtype units

Land Units	Descriptions
1a	Active Alluvial Plain(Depositional), present river channels
1b	Active Alluvial Plain(Depositional), Sand and Gravel bars.
1c	Active Alluvial Plain(Depositional), Lower terrace with less than 1% slope
1d	Active Alluvial Plain(Depositional), Higher Terrace
2a	Recent Alluvial Plain lower piedmont(depositional and erosional), depressional
2b	Recent Alluvial Plain lower piedmont(depositional and erosional), intermediate position,

	level
2c	Recent Alluvial Plain lower piedmont(depositional and erosional), intermediate position, undulating
2d	Recent Alluvial Plain lower piedmont(depositional and erosional), high position
9c	Alluvial plains and fans (depositional)
10a	Ancient lakes and river terraces (tars) (erosional)
11	Moderately to steeply sloping mountainous terrain
12	Steeply to very steeply sloping mountainous terrain
9a	Present River Channel

Landform affects soil formation and its profile development in association with the steepness of land and slope direction. The slope classes are required for land type classification. The slope of project area is classified in table 4.2.

Table 4.2: Slope classes and symbol

Slope description	Slope (in degrees)	Symbol
Flat or nearly flat	<1.0	S1
Gentle Slope	>1.0 up to 5.0	S2
Moderately sloping	5-20	S3
Steep	<30	S4

The main classes of soil according to their texture are sands, clay and loams with intermediate classes such as sandy clay loams and so on. The texture depends upon the relative proportion of soil particles of different size such as sand, silt and clay. The top layer of soil texture is used for land system classification, soil suitability and classification of soil at family level. The soil textures found in project area are given with symbol in table 4.3. Sandy loam and silty loam soils were found dominating in the study area

Table 4.3: Soil texture and symbol

Textural classes	Symbol
Loam	L
Silty Loam	SiL
Sandy Loam	SL

4.3 Description of Individual Land Type Units

The land units defined by LRMP are further subdivided based on local field variation associated with the different land use practices. Altogether five land units are identified in the project area associated with the local micro-relief variations. The spatial extent covered by the project area is depicted in table 4.4.

Table 4.4: Land type units

Land Units	Area Ha.	Percentage
9c	105.0069	3.94
10a	281.8646	10.58
11	1636.502	61.45
12	532.6134	20.00
9a	107.0015	4.02
Total	**2662.988**	**100.00**

The area is mostly covered by agricultural land and majority of the area of this Municipality isslopy as mentioned earlier. Moderately to steeply sloping mountainous terrrain area is dominating which occupies 1636.5 ha consisting of almost 62% of the total area. Most of the area of the Municipality is covered by 11 land unit that accounts for 61.45% of the Municipality, followed by 12 i.e, steeply to very steeply sloping mountainous terrain. Ancient lakes and river terraces (tars), erosional (10a) covers around 281 ha of the Municipality that covers 10.58% of the area. Alluvial plains and fans depositional occupy very small area (3.94%) of the Municipality.

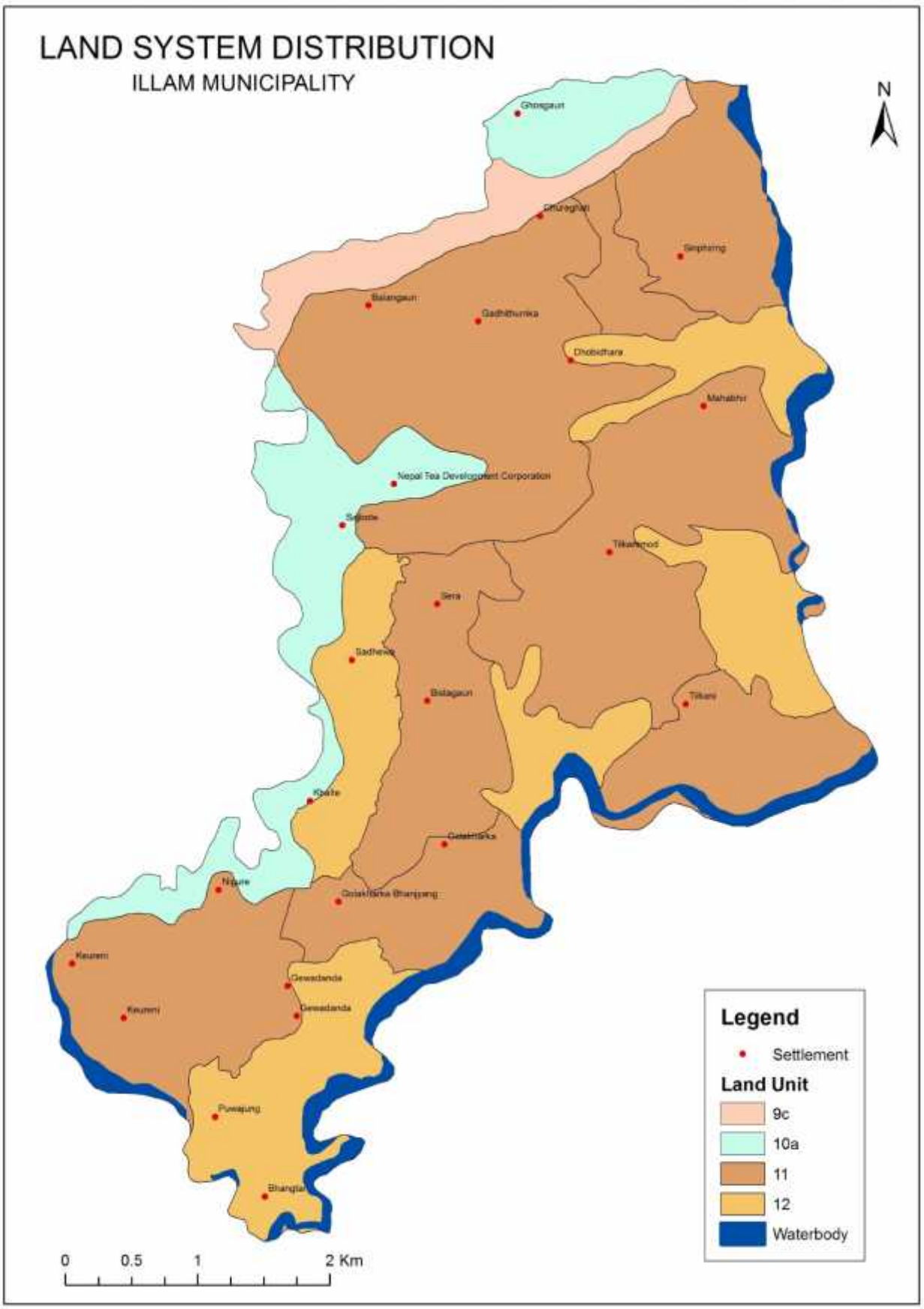

Figure 4.1: Land System Map of Ilam Municipality

Chapter - 5

SOIL CLASSIFICATION AND FERTILITY RATING SCHEME

Humans tend to classify and categorize almost everything we encounter in our natural world. From rocks to soils, from landscapes to living things on the land and in the water, we have systems of classification to describe these things in uniform terms. These systems then enable us to communicate with each other about these subjects in terms that are understandable and consistent. Classification systems and taxonomic conventions allow us to describe a thing or phenomenon in a way that can then be understood by those in remote locations and without direct experience of the subject.

The nature and properties of soils can vary widely from one location to the next, even within distances of a few meters. These same soil properties can also be found to exhibit similar characteristics over broad regional areas of like climate and vegetation. The soil forming factors of parent material, climate, vegetation (biota), topography, and time tend to produce a soil that describes the environment in which it is formed. By surveying properties of soil color, texture, and structure; thickness of horizons; parent materials; drainage characteristics; and landscape position, soil scientists can prepare map and classify soils in each category.

Classification is the grouping of objects in some orderly and logical manner. Based on the properties of objects, they are classified for the purpose of their identification and study. Soil classification is grouping of soils into categories based on each soil's morphology (appearance and form). The comprehensive soil classification, called Soil Taxonomy (USDA, 2010), maintains the natural body concept and has two other major features that make it most useful. First, the system is based on soil properties that are easily verified by others. This lessens the likelihood of controversy over the classification of a given soil, which can occur when scientists deal with systems based on soil genesis or presumed genesis. Soils are classified in a systematic manner to remember their properties and understand their relationships.

The Comprehensive System is a morphogenetic system in which morphology of soil serves as a guide. It is based on the properties of the soil as they exist today. Although one of the objectives of the system is to group soils similar in genesis, the specific criteria used to place soils in these groups are those of soil properties. It considers all properties of soil which affect soil genesis or are the outcome of soil genesis. It is an orderly scheme without prejudices, but facilitates easy recognition of the objects.

The chemical, physical, and biological properties are used as criteria for Soil Taxonomy. A few examples are the moisture, temperature, colour, texture, and structure of the soil. Chemical and mineral properties such as the contents of organic matter, clay, iron and aluminum oxides, silicate clays, salt, the pH, the percentage base saturation, and soil depth are the other important criteria for soil classification.

Differences between horizons generally reflect the type and intensity of processes that have caused changes in the soil. Ideally, we should always be striving in our descriptions to maintain a link between process and morphology. In many soils, these differences are expressed by horizonation that lies

approximately parallel to the land surface, which in turn reflects vertical partitioning in the type and intensity of the various processes that influence soil development.

5.1 Soils Diagnostic Horizons

Diagnostics horizons are understood to reflect genetic horizons widely occurring in soils, which fairly well describe and define soil classes. A diagnostic horizon is formed through pedogenic processes having distinct properties or features that can be described in terms of measurable soil properties. Diagnostic horizons are used not only for identifying soils but also in classifying them at various categorical levels. A number of diagnostic horizons are identified in Soil Taxonomy.

Horizonation is described in term of soil horizon characterized as three components:

a. Master Horizons

Master horizons (major horizons) are designated by capital letters, such as O, A, E, B, C, and R. The description of master horizons is given in table 5.1.

Table 5.1: Master horizons

Oi / Oe	Loose leaves and organic debris, largely not decomposed
Oa /Oe	Organic debris, partially decomposed
AC	Transition to C
A	A dark colored horizon of mixed mineral and organic matter
E	A light colored horizon of maximum eluviations
EB	Transitional to C but more like E than B
BE	Transitional to B but more like B than E
B	Maximum accumulation of silicate clay mineral or of sesquioxides and organic matter
BC	Transitional to C but more like B than C
AC	Transition to C, more like C with A horizon properties such as organic matter/humus.
C	Weathered parent material
R	Rock beneath the soil

b. Transitional Horizons

Transitional horizons are layers of the soil between two master horizons. There are two types of transitional horizons as the first letter indicating the dominant master horizon and the second letter indicating subordinate characteristics.

Separate components of two master horizons are recognizable in the horizon and at least one of the component materials is surrounded by the others. The designation is by two capital letters with a slash in between. The first letter designates the material of greatest volume in the transitional horizon such as A/B, B/A, E/B or B/E. For example, an AB horizon indicates a transitional horizon between the A and B horizon, but one that is more like the A horizon than the B horizon. An AB or BA designation can be used as a surface horizon if the master A horizon is believed to have been removed by erosion.

c. Subordinate Distinctions within Master Horizons

Lower case letters are used to designate specific features within master horizons. Highly decomposed organic material, as 'a' is used only with the O master horizon. The rubbed fiber contents < 17 % of the volume.

The following information is collected for assembling standard profile descriptions:

(i) Horizon boundary characteristics

(ii) Color

(iii) Texture

(iv) Rock Fragments

(v) Structure

(vi) Consistency

(vii) Roots

(viii) pH, $CaCO_3$effervescence

(ix) Special features such as coatings, nodules, and concretions

d. Diagnostic Horizons of Soils

Diagnostic soil horizons are found in the surface or the subsurface (Table 5.2). The diagnostic surface horizons are called epi-pedons (from the Greek words epi means over and pedon means soil). The epipedons are simply the uppermost soil horizons and include the upper part of the soil darkened by organic matter. They are not synonymous with A-horizon. It may include part of the B horizon if the latter is significantly darkened by organic matter. Nine epi-pedons are recognized and they are described as follows:

Table 5.2: Major Features of Diagnostic Horizons of Soil Taxonomy

Surface Horizon (Epipedons)	
Mollic	Thick, dark colored, high base saturation, strong structure overlaid on $CaCO_3$ materials
Umbric	Same as Mollic except low base saturation no $CaCO_3$ materials
Ochric	Light colored, low organic content, may be hard and massive when dry
Histic	Very high in organic content, wet during some part of year
Anthropic	Man-modified Mollic-like horizon, high in available P
Plaggen	Man-made sod-like horizon created by years of manuring and cultivated
Melanic	Thick black horizon rich in organic matter usually associated with aluminum-humus complex
Folistic	Never saturated with water for more than 30 days in a year, consist of more than 75% organic soil material, has b.d. of $<0.1 Mg/m^3$or is 15 cm or more thick.
Grossarenic	A sandy (loamy fine sand or coarser) horizon, 100 cm or more thickover an argillic horizon

Subsurface Horizons (Endopedon)	
Argillic	Silicate clay accumulation
Natric	Argillic, high in sodium, columnar or prismatic structure
Spodic	Organic matter, Fe and Al oxides accumulation
Cambic	Changed or altered by physical movement or by chemical reactions
Agric	Organic and clay accumulation just below plough layer resulting from cultivation
Oxic‘	Highly weathered, primarily mixture of Fe, Al oxides and non-sticky-type silicate
Duripan	Hard pan, strongly cemented by silica
Fragipan	Brittle pan, usually loamy textured, weakly cemented
Albic	Light colored, clay and Fe and Al oxides mostly removed
Calcic	Accumulation of $CaCO_3$ or $CaCO_3.MgCO_3$
Gypsic	Accumulation of gypsum
Salic	Accumulation of salts
Kandic	Accumulation of low activity clays
Petrocalcic	Cemented calcic horizon
Petrogypsic	Cemented gypsic horizon
Placic	Thin pan cemented with iron alone or with manganese or organic matter
Sombric	Organic matter accumulation
Sulfuric	Highly oxidized and the production of jarosite and sulfuric acids
Glossic	shows albic horizon characteristics gradually intruding into and argillic, a kandic or a nitric horizon; 5 cm or more thick and consist of eluvial part 15-85% of glossic horizon and an illuvial part

5.2 Local Classification System

Generally, local farmers are considered as best engineers because of the fact that they know many thing and they have local knowledge derived from their ancestors and historical practices. Local classification helps the farmers to know the soil properties benefited to agriculture. Ethnopedology is another branch of soil science dealing with the indigenous knowledge of local people regarding soil naming and management in Nepalese society, local farmers use to naming the soil base on color, texture and fertility of top soil.

Table 5.3: Local name of soil texture given by the local communities.

Sand	Baluwa
Loam	Domat
Silt	Pango
Clay	Chimtyailo
Sandy soil	Balaute
Loamy soil	Domat
Silt clay loam	Pangochimtyailodomat

5.3 USDA Soil Taxonomy Systems

The system of soil classification used by the National Cooperative Soil Survey has six categories. Beginning with the broadest, these categories are the Order, Suborder, Great Group, Subgroup, family, and Series. These categories are defined in the following paragraphs.

Order – Twelve soil orders are recognized. The differences among orders reflect the dominant soil forming processes and the degree of soil formation. Each order is identified by a word ending in 'sol.' An example is Alfisols. The order category is based largely on soil-forming processes as indicated by the presence or absence of major diagnostic horizons. A given order includes soil whose properties suggest that they are not dissimilar in their genesis. As an example, many soils that developed under grassland vegetation have the same general sequence of horizons and are characterized by a thick, dark epipedon (surface horizon) high in metallic cations. Soils with these properties are thought to have been formed by the same general genetic process and are included in the same order. There are twelve soil orders in Soil Taxonomy (Table 5.4) are presented below with their characteristics.

Table 5.4: Soil orders and their major characteristics

Name	Major characteristics
Entisols	Little profile development, ochricepipedoncommon
Inceptisols	Embryonic soils with few diagnostic features, ochric or umbricepipedon; cambic horizon
Mollisols	Mollicepipedon, high base saturation, dark soils, some with argillic, calcic or natric horizons
Alfisols	Argillic or natric horizon; high to medium saturation, Argillic horizon, low base saturation
Ultisols	Argillic horizon, low base saturation
Oxisols	Oxic horizon, no argillic horizon, highly weathered
Vertisols	High in swelling clays; deep cracks when soil dry
Aridisols	Dry soil, ochricepipedon, sometimes argillic or natric horizon
Spodosols	Spodic horizon commonly with Fe, Al, and humus accumulation

Histosols	Peat or bog; >30% organic matter
Andisols	From volcanic ejecta, dominated by allophane or Al-humic complexes
Gelisols	Permafrost within 100 cm

Suborder - Each order is divided into suborders primarily on the basis of properties that influence soil formation and/or are important to plant growth. The suborders are subdivisions of orders that emphasize properties that suggest genetic homogeneity. Thus, wetness, climate environment, and vegetation, which help determine the nature of the genetic process, help determine the suborder in which a given soil is found.

Great Group – Each suborder is divided into great groups on the basis of similarities in horizons present, soil moisture or temperature regimes, or other significant soil properties. Diagnostic horizons are the primary bases for differentiating the great groups in a given suborder. Soils in a given great group have the same kind and arrangement of these horizons.

Subgroup – Each great group has a 'typic' (typical) subgroup which is basically defined by the Great Group. Other Subgroups are transitions to other orders, suborders, or great groups due to properties that distinguish it from the great group. The subgroups are subdivisions of the great groups. The central concept of a great group makes up one subgroup (Type). Other subgroups may have characteristics that are integrates between those of the central concept and soils of other orders, suborders, or great groups.

Family – Families are established within a subgroup on the basis of physical and chemical properties along with other characteristics that affect management. In the family category are found soils with a subgroup having similar physical and chemical properties affecting their response to management and especially to the penetration of plant roots (e.g., soil-water-air relationships). Differences in texture, mineralogy, temperature, and soil depth are primary bases for family differentiation.

Series – The series consists of soils within a family that have horizons similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The series category is the most specific unit of the classification system. It is a subdivision of the family, and its differentiating characteristics are based primarily on the kind and arrangement of horizons. Conceptually, it includes only one polypedon; however, in the field, aggregates of polypedons and associated inclusions are included in the soil series mapping units.

5.4 World Reference Base for Soil Resource (FAO)

There are many soil classification systems - French, South African, Australian, Canadian, Russian, and still others. Some of these are limited mostly to soils of that country and do not attempt a comprehensive coverage of world soils. None of them are equated simply to terms in any other classification. The Food and Agricultural Organization (FAO) of the United Nations has prepared a world map with described classification units. The FAO world soils are given in Table 5.5 with approximate comparisons to the

1975 US system. This comparison provides an acquaintance with taxonomic names and approximate relationships of the systems.

The FAO soil classification system is worldwide, but it is not a system of units grouped into higher categories. The units are designed as the legend of a soil map of the world. The soil map has about 5000 units. These units relate most closely to great groups in the US system. The FAO system uses the US system of diagnostic horizons, although they are sometimes more simplified in definition.

Comparisons of the United States and FAO Classification System

A tabulation of the FAO system is given as the basis for comparing the systems: FAO and the 1975 US system (Table 5.5). These comparisons are only approximate because the systems are very different. The great group of the USDA 1975 system is most accurately related to the first sub-unit level of the FAO system. The meanings of most of the FAO sub-unit names and adjectives are identifiable from the formative elements given in the Table 5.5. A few terms not given in the table are as follows:

Table 5.5: A comparison of the FAO and the U.S. Systems of Soil Classification

FAO System and Name Meanings	US Systems (1975)
ACRISOLS Latin acris = very acidic, low base status. Subunits: Orthic, Ferric, Humic, Plinthic	ULTISOLS Hapl-ults Pale-ults Hum-ults Plinth-ults
ANDOSOLS Japanese an = black, do = soil. Subunits: Ochric, Mollic, Humic, Vitric	ANDISOLS Several suborders and great groups
ARENOSOLS Latin arena = sand. Subunits: Cambic, Luvic, Ferralic, Albic	Psamments. Several subgroups
CAMBISOLS Latin cambiare = change Subunits: Eutric, Dystric, Humic, Gleyic, Golic, Calcic, Chromic, Vertic, Ferralic	INCEPTISOLS Many Ochrepts
CHERNOZEMS Russian chern = black, zemlja = earth. Subunits: Haplic, Calcic, Luvic, Glossic	MOLLISOLS Several Borolls OXISOLS Most suborders
FERRALSOLS Latin ferrum = iron and aluminum. Subunits: Orthic, Xanthic, Rhodic, Hemic, Acric, Plinthic	Fluvents
GELOSOLS Greek gelid = very cold, permafrost in part	Gelisols

FAO System and Name Meanings	US Systems (1975)
GLEYSOLSRussiangJey = mucky soil mass. Subunits: Eutric, Calcaric, Dystric, Mollic, Humic, Plinthic, Gelic	Aquents, Aquepts, Aquolls
GREYZEMS English grey and Russian zemlja = earth. Subunits: Orthic, Gleyic	MOLLISOLS Borolls, Aquolla
HISTOSOLS Greek histos = tissue. Subunits: Eutric, Dystric, Gelic	HISTOSOLS
KASTANOZEMS Latin castanea = Chestnut, Russian zemlja = earth. Subunits: Haplic, Calcic, Luvic	MOLLISOLS Ustolls, Borolls
LlTHOSOLSGreeklithos = stone shallow to rock. Subunits: none	Lithic subgroups
LUVISOLS Latin Juo = to wash, Iliuvial clay layer. Subunits: Orthic, Chromic, Calcic, Vertic, Ferric, Albic, Plinthic, GleyicBrawn Wooded, Acid Brawn Forest soils	ALFISOLS Many suborders
NITOSOLS Latin nitidus = shiny, shiny ped surfaces. Sub-units: Eutric, Dystric, Humic	Paleudalfs, manyUdults, Tropohumults
PHAEOZEMS Greek phaios = dusky, Russian zemlja = earth. Subunits: Haplic, Calcaric, Luvic, Gleyic	Udolls and Aquolls
PLANOSOLS Latin planus = flat, level, poorly drained. Sub-units: Eutric, Dystric, Mollic, Humic, Solodic, Gelic	Pale-alfs, Albaquults, Aqualfs, Albolls
PODZOLS Russian pod = under, zola = ash, white layer. Sub-units: Orthic, Leptic, Ferric, Humic, Placic, Gleyic	SPODOSOLS Orthods, Humods, Aquods
PODZOLUVISOLS FromPodzol and Luvisol. Sub-units: Eutric, Dystric, Gleyic	MOLLISOLS Udalfs, Boralfs, Aqualfs
RANKERS Austrian rank = steep slope, shallow	Lithic Haplumbrepts

FAO System and Name Meanings	US Systems (1975)
soils. No Sub-units	
REGOSOLS Greek rhegos = blanket, thin soil. Sub-units: Eutric, Calcaric, Dystric, Gelic	Orthents, Psamments
RENDZINAS Polish rzedzic = noise, stoney soil. No Sub-units	Rendolls
SOLONETZ Russian sol = salt, affected by salt. Sub-units: Orthic, Mollic, Gleyic	Salids
SOLONETZ Russian sol = salt, affected by salt. Sub-units: Orthic, Mollic, Gleyic	Natr-alfsNadurargids
VERTISOLS Latin verto = turn, self mixing. Sub-units: Pellic, Chromic	VERTISOLS Pell-erts Chrom—erts
XEROSOLS Greek xeros = dry areas. Sub-units: Haplic, Calcic. Gypsic, Luvic	ARIDISOLS CalcidsGypsids –argids
YERMOSOLS Spanish yermo = desert areas. Sub-units: Haplic, Calcic	ARIDISOLS Cambids Argids

5.5 Rating of Soil Fertility Status and Crop Suitability

Crop suitability has been defined as specific cultivate of crop types based on the requirement of different crops for agriculture and soil attribute pertaining in soil mapping units defined. It has been done for various crops considering for a single clearly defined, reasonably homogenous purpose or practice and suitable appraisal for a list of crops or other activities. The soil suitability has been performed in following two stages:

The requirements (natural, social and economic and technology etc.) of the particular crop/activity need to be known or alternatively what soil/site attributes adversely influence the crop .To identify and to delineate land with the desirable attributes but without the undesirable ones. Numbers of classes are determined according to degrees of suitability as below:

Highly suitable (S1) – land having no limitation to sustainable application of a given use or only minor limitations will not significantly reduce benefits

Moderately suitable (S2) – land having limitations in which aggregate are moderately to severe for sustained application of a given use or increase inputs to the extent that overall benefit to be gained

Marginally suitable (S3) – land having limitations to sustained application of a given use or increase required inputs, marginally justified; costly rice in Mustang; sub divisions, if this is differences in moderately suitable, marginally suitable s2 & s3 should be mutually exclusive.

Currently not Suitable (N1) – refers to the suitability for a defined use of land in its present condition, without major improvements. A current suitability classification may refer to the present use of the land either with existing or improved management practices, or to a different use.

Permanently not suitable (N2) – refers to the suitability, for a defined use, of land units in their condition at some future date, after specified major improvements have been completed where necessary.

Suitability Analysis based on Soil nutrient

The soil suitability analysis in the present case has the result of performed based on the soil nutrients derived from chemical properties of soil pits based on soil lab test. Soil fertility status analysis has been performed based on the soil test results.

5.5.1 Crop Requirement

The soil suitability analysis is done based on the major soil nutrient available on the ground investigated from soil survey and requirement criteria of the different on the optimum condition. In general the range of pH required for the cultivation of crops, fruits, and vegetables is taken as 5.5 to 7.5 with optimum at 6.5

5.5.2 Rating of Soil Nutrients

Soil fertility status assessment is derived from soil parameters related to top-soil rooting depth, workability (soil texture), soil drainage (permeability), alkalinity and acidity, content of organic matters, nitrogen, available phosphorus and, available potassium. These fertility ratings are developed by Soil Science Division of then DoA/MoAD of the Government of Nepal which is based on their own research crop response and are presented In Tables 5.6-5.15 and Figures in the appendix.

Table 5.6: Soil Depth Rating

Soil depth	Category	Suitability
>100 cm	Deep	High Suitability
50 – 100	Moderately Deep	↓
25 – 50	Shallow	
		Low suitability

Table 5.7: Workability Rating

Soil Texture (Workability)	Rating	Suitability
Loam	Good	High Suitability
Silt Loam	Good	
Sandy Loam	Good	
Silt Loam + Loam	Good	
Clay Loam	Moderate	
Clay Laom+Loam over Silt Loam	Moderate	
Silt Clay Loam	Moderate	
Silt Clay Loam + Silt Loam	Moderate	
Silt Loam +Silty Clay Loam	Moderate	
Silty Clay	Fair	
Silt Loam + Silt Clay	Fair	
Clay	Poor	Low Suitability

Table 5.8: Soil Alkalinity and Acidity Rating

Soil Alkalinity and Acidity	Rating	Suitability
<5.0	Very highly acidic	Low Suitability
5.1 – 5.5	Strongly acidic	
5.6 – 6.0	Medium acidic	
6.0 – 6.5	Low (slightly) acidic	High Suitability
6.6 – 7.3	Neutral	Most Suitable
7.4 – 7.8	Low (slightly) alkaline	High Suitability
7.9 – 8.4	Medium alkaline	Marginal
> 9.0	Highly alkaline	Low Suitability

Table 5.9: Soil Organic Matter Content Rating

Organic Matter (%)	Rating	Suitability
>10	Very High	High Suitability
5–10	High	
2.5-5	Medium	
1-2.5	Low	
<1	Very low	Low Suitability

Table 5.10: Soil Total Nitrogen Rating

Soil Total Nitrogen Rating	Rating	Suitability
>0.4	Very High	High Suitability
0.2 – 0.4	High	
0.1-0.2	Medium	
0.05-0.1	Low	
<0.05	Very Low	Low Suitability

Table 5.11: Soil Available Phosphorous Rating

Available P2O5 (kg/ha)	Rating	Suitability
>110	Very High	High Suitability
55-110	High	
30 – 55	Medium	
10-30	Low	
<10	Very Low	Low Suitability

Table 5.12: Soil Available Potassium Rating

Available K2O (kg/ha)	Rating	Suitability
> 504	Very High	High Suitability
280-504	High	
110 – 280	Medium	
56-110	Low	
<56	Very low	Low Suitability

Table 5.13: Soil Drainage Rating

Soil Drainage	
Well drained	High Suitability
Moderately well drained	
Somewhat poorly drained	
Some what excessively drained	
Poorly drained	
Excessively drained	
Very poorly drained	
Very excessively drained	Low Suitability

Table 5.14: Soil Available Zinc Rating

Zinc (ppm)		
>1.0	High	High Suitability
0.5 – 1.0	Medium	Moderate
0.0 – 0.5	Low	Low suitability

Table 5.15: Soil Available Boron Rating

Boron (ppm)		
>1.0	Very High	Low suitability (Could be toxic)
0. 80-1.00	High	High Suitability
0.41 – 0.80	Medium	
0.21-0.40	Low	
<0.20	Very Low	Low suitability

Chapter – 6
SOIL TYPES AND GIS DATABASE

6.1 Soil Types

Texturally, soil type refers to the proportion of sand, silt and clay in the (sampled) soil. Generally, the soil is formed from rocks and minerals, therefore the composition of soil reflect the parent materials. Soils made up in part of finely ground rock particles, grouped according to size as sand and silt in addition to clay. Organic material such as decomposed plant matter and animal matter also is a basic component of soil.

Each component, and their size, plays an important role. For example, the largest particles, sand, determine aeration and drainage characteristics, while the tiniest, sub-microscopic clay particles, are chemically active, binding with water and plant nutrients. The ratio of these sizes determines soil type: clay, loam, clay-loam, silt-loam, and so on.

In addition to the mineral composition of soil, humus (organic material) also plays an important role in soil characteristics and fertility for plant life. Soil may be mixed with larger aggregate, such as pebbles or gravel. Not all types of soil are permeable, such as pure clay.

There are many recognized soil classification, both international and national. USDA classifies soil based on the order, sub order, great groups, subgroup, family and series.Soil types can be delineated based on order, sub order, great group and great sub group as well as based on soil family and series. The present study has incorporated both classification systems to devise the soil type of the area.

6.1.1 Soil Types from Order to Sub-group Level

Soils of IlamMunicipality are classified based on the information of soil derived from soil pits and soil mapping unit level (Figure 5.1). The objectives of the World Reference Base are twofold. On one hand the WRB is intended to be a reference system for users interested in a broad division of soils, at the highest level of generalization and explained in non-technical terms. On the other, the WRB must facilitate soil correlation across a wide range of national soil classification systems. This soil classification is based on the Great Soil Groups of Soil Taxonomy (USDA) because of the fact that the FAO soil classification is not a system of units grouped into higher categories, even though the system is spread worldwide. But these units relate most closely to Great Groups in the US system. In this system, the soils are grouped according to Soil Orders, Sub-Orders, Great Groups, Sub-Groups and Soil Family level. Table 6.1 and Figure 6.1 present Soil Taxonomy classification for the soils of Ilam Municipality.

Table 6.1: Soil Taxonomy Classification of IlamMunicipality

SN	Order	Sub Order	Great Group	Sub Group	Area Ha	%
1	Entisols	Psamments	Ustipsamments	Aridic Lithic Ustipsamments	112.09	4.21
				Lithic Ustipsamments	360.86	13.55
		Arents	Ustarents	Lithic Ustarents	910.33	34.18
		Fluvents	Ustifluvents	Lithic Ustifluvents	105.01	3.94
		Orthents	Ustorthents	Lithic Ustorthents	262.30	9.85
2	Inceptisols	Udepts	Dystrudepts	TypicDystrudepts	420.58	15.79
		Ochrepts	Dystochrepts	UsticDystochrepts	384.81	14.45
3	Waterbody				107.00	4.02
	Total				**2662.99**	**100.00**

In general, only Entisols and Inceptisols were found in the Municipality. Order Entisols was found along with foursub-orders, four great soil groups and five sub-groups from the soil survey investigation in Ilam Municipality. Entisolsis the most extensively available soil found in Ilam Municipality. These types of soils are found in the entire country and covers extensive areas of land. Entisols are recently formed soils. OrderInceptisols are comparatively older and used for cultivation quite for some time. Inceptisols was found in about 30% of the Municipality area. It was found along with two sub orders, two great groups and two sub groups.

Psamments, Arents, Fluvents and Orthents are the major sub order of Entisols that are found in the area. Majority of the area is covered by Lithic Ustarents comprising of 34.18% of the total area. Fluvents covered the least.

Udepts and Ochrepts are the major sub orders found within Inceptisols. Among the greatgroups of Inceptisol, this Municipality has Dystrudepts and Dystochrepts. Typicdystrudepts and usticdystochrepts are the subgroups of Inceptisols found in the area.

In general, order Entisols covers 65.73% of the total area and Inceptisols covers 30.25% of the total area. Waterbody covers only 4.02% of the Ilam Municipality.

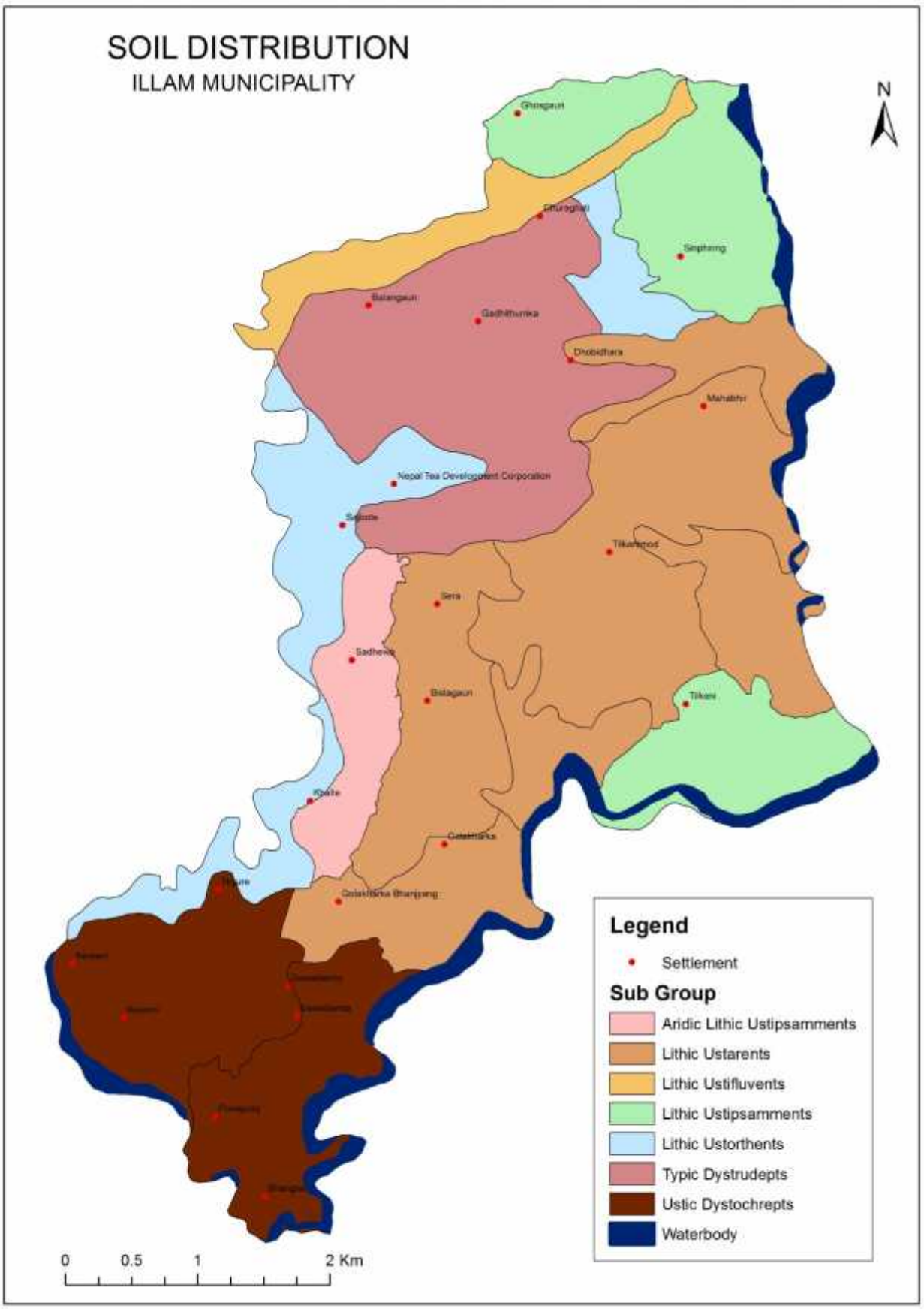

Figure 6.1: Soil map of Ilam Municipality

Soil Profile Information

Soil Profile Description:

The detail of soil profile description is presented in the appendix. Altogether 14 soil profiles were studied for the purpose.

Among the total area of this Municipality, almost 96%is covered by soil landmasses and only 4.02% is covered by waterbodies. Most of the area of this Municipality is covered by Entisols. Our study has found only two soils order in this Municipality.

Soil Order Entisolsare dominantly found in Ilam Municipality. In this order there is little profile development. It is the recently formed soil mostly dominated by ochricepipedon. This order is very common in Nepal and occupies most of the areas in Nepal. These types of soils are generally shallow with mere developed soil properties. In our study area, psamments, arents, fluvents and orthents were found.

Soil Order Inceptisols are also extensively found in the IlamMunicipality. This order of soil is major soil order found in the entire country and covers extensive areas of land. Inceptisols are comparatively older and used for cultivation quite for some time. These soils are generally deep, with well-developed properties of A and B horizons. Due to presence of illuvial horizons, the clay content in the epipedon is higher. Therefore, these soils are considered medium to heavy soil which is hard to plough when dry. Since illuviation of clay materials the B horizon is well developed to Bt horizon due to higher clay accumulation. In this orderDystrudepts and DystochreptsGreat Groups are available in our study area of IlamMunicipality.

6.1.2 Soil Types Based on Soil Series

The soil series is the lowest category. It is a grouping of soil individuals on the basis of narrowly defined properties, relating to kind and arrangement of horizons; colour, texture, structure, consistence and reaction of horizons; chemical and mineralogical properties of the horizons. The soil series are given local place names following the earlier practice in the old systems in naming soil series.

6.1.3 Physical and Chemical properties of the soil

Altogether 14 pits were dug and soil samples were collected from periphery area of pits and the data of laboratory analysis for different parameters are presented in the table below.

Pit No.	pH (1:2.5% H_2O)	Total Nitrogen (N %)	Av. Phosphorous (P_2O_5) kg/ha	Av. Potassium (K_2O) kg/ha	Organic Matter (OM) %	Sand %	Silt %	Clay %	Av Zinc (ppm)	Av Boron (ppm)	Soil Texture
1	7.94	0.238	97	15	8.13	13.91	58.55	5.87	Trace	0.73	Siltloam
2	5.27	0.196	58	8	7.734	24.93	66.05	6.02	Trace	1.01	Siltloam
3	5.28	0.154	52	5.6	6.98	32.2	55.7	8.03	Trace	1.68	Siltloam
4	5.4	0.14	13.1	2.89	4.58				Trace	1.12	Siltloam
5	5.72	0.196	25.06	4.88	6.32	12.66	66.92	17.02	Trace	0.76	Siltloam
6	5.6	0.084	36.1	6.12	4.12	21.7	66.38	9.22	Trace	0.6	Siltloam
7	5.53	0.21	63	10.72	6.1	13.18	72.78	12.58	Trace	1.53	Siltloam
8	5.52	0.14	31	3.9	5.22	28.1	54.36	14.64	Trace	1.37	Siltloam
9	5.45	0.196	42.1	3.12	6.11	23.48	58.04	16.04	Trace	0.71	Siltloam
10	5.44	0.182	40	3	6	28.37	61.35	8.47	3.64	1.04	Siltloam
11	5.49	0.098	19	2.82	4.2	25.76	65.6	6.78	Trace	1.45	Siltloam
12	5.44	0.084	10.41	2.5	4	22.58	62.58	11.88	Trace	0.99	Siltloam
13	5.49	0.14	31	3.9	5.22	33.88	56.57	8.29	Trace	0.78	Siltloam
14	5.45	0.07	18.5	2.7	4.8	24.78	60.52	11.34	Trace	0.47	Siltloam

Summary Statistics of the Soil analysis results:

Achieving and maintaining appropriate levels of soil fertility, especially plant nutrient availability, is of paramount importance if agricultural land is to remain capable of sustaining crop production at an acceptable level. Soil sampling and analysis is the first of three equally important steps in managing the nutrients required by plants. The second is the interpretation of the analytical data leading to the third step, recommendations for nutrient additions, as fertilisers or manures, to optimise crop yields while minimising any adverse environmental impact from their application.

The productive capacity of a soil depends on often complex and sometimes little understood interactions between the biological, chemical and physical properties of soil. Good farm practice aims to manage the various factors that make up each of these three properties to optimise the yields of crops in environmentally friendly ways. Although the focus is on plant nutrients, managing these properly is only one part of best soil management practice which also involves consideration of soil organic matter, soil structure, and the maintenance of a thriving soil microbial population. Soil analysis is an aid to managing soil nutrients efficiently to maintain soil fertility for those nutrients like phosphorus (P), potassium (K) and magnesium (Mg) that are retained in soil in plant available forms. If the amount of any of these

nutrients in such forms in soil is too less then yield is jeopardised, but increasing reserves in agricultural soils to very high levels is an unnecessary expense.

By using Excel program, summary statistics of the results of soil analysis of Ilam Municipality were prepared for better understanding of the soil parameters that were investigated in the laboratory. Brief tables of each parameter are presented below.

Variable	Mean	SE Mean	StDev	Minimum	Median	Maximum
pH	5.644	0.179	0.671	5.27	5.47	7.94
Ec (dsm^{-1})	23.76	5.09	19.03	5.7	18.45	66.1
OM (%)	5.68	0.353	1.32	4	5.61	8.13
Carbon (%)	9.698	0.6	2.245	6.88	9.532	13.98
Phosphorus	38.31	6.25	23.39	10.41	33.55	97
Potassium	5.368	0.973	3.639	2.5	3.9	15
Sand %	23.5	1.89	6.81	12.66	24.78	33.88
Silt %	61.95	1.49	5.38	54.36	61.35	72.78
Clay %	10.48	1.04	3.76	5.87	9.22	17.02
Nitrogen %	0.152	0.0142	0.0532	0.07	0.147	0.238
B	1.0171	0.0994	0.372	0.47	1	1.68

General analysis of the soils of IlamMunicipality:

There are different types of soil in Nepal. Various factors such as geology, climate and vegetation types have resulted in variations in soil properties. There is limited research about soils in Nepal. So far, soils of Nepal can be divided into six broad types such as alluvial soil, sandy gravel soil, lacustrine soil, rocky soil and mountain soil. Alluvial soil are generally found in terai and in river basins. It is formed by the materials deposited by rivers and it's very fertile. The sandy gravel and gravel soil are found in churiya where gravel and conglomerate are predominately found. This is not fertile soil. There are various types of soil in the middle hill. But rocky soil is predominant. The lacustrine soil is found in the Kathmandu valley. It is formed by the deposited materials in the lake hence, it is fertile. The mountain soil is formed by where boulders, sands and stone brought by glacier are found. It is also not fertile soil.

The soil reaction of Ilam Municipality varies from 5.40 to 7.94 ranging from strongly acidic to strongly alkaline. Mean soil reaction of the area is 5.64, which is moderately acidic in nature and is almost suitable for most of the crops. Almost all soils of IlamMunicipality were within the slightly to moderately acidic range. The soil pH being slightly low, almost all micronutrients will not be in available form. Vegetables and most food crops can be grown in such type of soil. However, crucifers must be applied with sufficient amount of Mo and B.

The organic carbon or organic matter content of the soil ranged from 4.0 to 8.13% OM. Mean organic matter content of the sampled soil is 5.68% which falls under the category of Medium. Most of the soils of IlamMunicipality are under the category of low to medium organic matter content. Organic matter is the heart of the soil and it plays vital role in crop performance and maintaining soil health. Arresting the fall of soil organic matter in the area will be one of the key to maintain better soil status. Total nitrogen in the soils of the Municipality ranged from 0.07 to 0.23% which falls under the category of low to medium. Mean N content of the soil is 0.152%, which is medium as per our fertility ratings. Presence of Organic matter in the soil is closely related with the amount of total N in the soil. Both parameters in the soils are within low to medium. Care should be taken to grow crops with ample incorporation of organic manure in this area. Available phosphorus of the soils, in general falls within wide range and depending upon the soil types. It ranges from 19 to 97 $kgha^{-1}$ that falls in the category of very low to medium. Mean Phosphorus content of the soil is only 38 kg per hectare which falls in medium fertility rating. But the amount of available potassium in the soils of Ilam Municipality is very low to low which ranged from 2 to 15 $kgha^{-1}$. The mean value of the available potassium in the soil is 5 kg per hectare which falls under the category of very low. All of the soils contain very low amount of available K and there may be problem of K in the soils of the study area in near future. Micronutrients level specially Zn content of the soil were found in trace amount and B content was found to be heterogenous ranging from medium to very high. In general, micronutrient content in soils of Ilam was satisfactory when B is considered. But Zn is criticial because it was found in trace amount. However, management efforts should be carried out in soils where critical situation appears.

Majority of the soils of study area is silty loam. The irrigation water in the area might have deposited silt in the soil. Based on the soil analysis report, it could be concluded that the soils of Ilam Municipality is fair enough for cultivating food and vegetable crops at the moment but may have severe problem of major nutrients like potassium in the soil in near future. The inherent soil nutrients are readily available because of suitable soil pH but in long run the soil will be exhausted and replenishment of the soil nutrients is necessary at the moment.

Chapter - 7

CONCLUSIONS

7.1 Conclusions

Based on the laboratory analysis of the soil of the area, soil fertility map is prepared. Soil map of Ilam municipality is prepared by integrated use of Geo-science technology consisting of RS, GIS and GPS and soil mapping unit identified with landform and land type units.

Soil classification of the area was done based on the USDA soil taxonomy and only two soil orders were found in the Municipality (Entisols and Inceptisols). A total of 14 soil pits were taken in the field representing varied micro topography. Soil analysis report of all the 14 pits showed that the soil of Ilam Municipality is very suitable for all types of crops to be grown based on the soil reaction. All individual soil pits are grouped and aggregated into soil mapping units together under different USDA Soil Taxonomy hierarchy as sub-order, great group, sub-group, and family. In the context of soil available nutrients, Organic matter content in the soil was found to be within the range of low to medium and Nitrogen were found to be within the range of low to medium but available Phosphorus was found to be in very low to medium range and Potassium content in the soil were also found to be in very low range, which is very critical. Unless potassium is added from external sources, the crop production and productivity will paralyse in near future. Available Zn is also another limiting factor for the crop production, which is at the present found in trace amount. However, Boron content is found to be satisfactory. Care should be taken to incorporate Zn and Potassium at the earliest possible.

7.2 Recommendations

The integration of 3S (RS, GIS & GPS) technology in soil survey is found satisfactory. The use of methodology adopted for this study is essential for digital soil mapping required for sustainable land use planning. The present study strongly felt the need of the soil survey and mapping of all the VDCs and Municipalities of Nepal for optimum land use planning and sustainable development of VDCs and Municipalities in future. Since the taxonomical classification is entirely based on some chemical and morphological properties of endopedon (subsoils) some additional analysis such as Texture, organic matter, CEC and pH of the endopedon and CEC of Epipedonalso needs to be analyzed. Based on the analysis of nutrient status it can be recommended to supply organic manure, potassium and Zinc immediately in adequate quantity as well as appropriate crops as per the suitability of the soil. The soils of Ilam Municipality were found to be very much suitable for most of the crops. But continuous and adequate application of organic matter as well as major nutrients is mandatory in order to prevent soil from extreme nutrient mining. The amount of Zn and Potassium is at an alarming stage, it is highly recommended to add Zn and Potassium immediately to prevent soil from extreme mining of these nutrients and for secured crop production.

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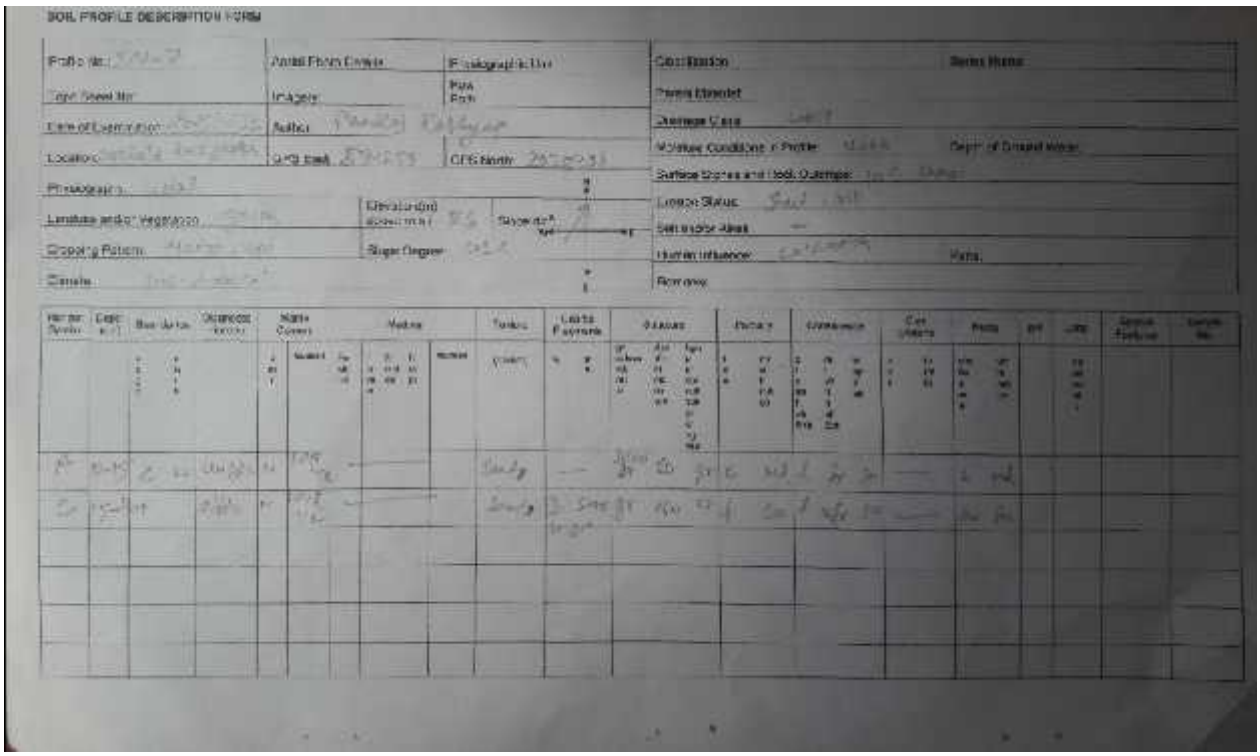
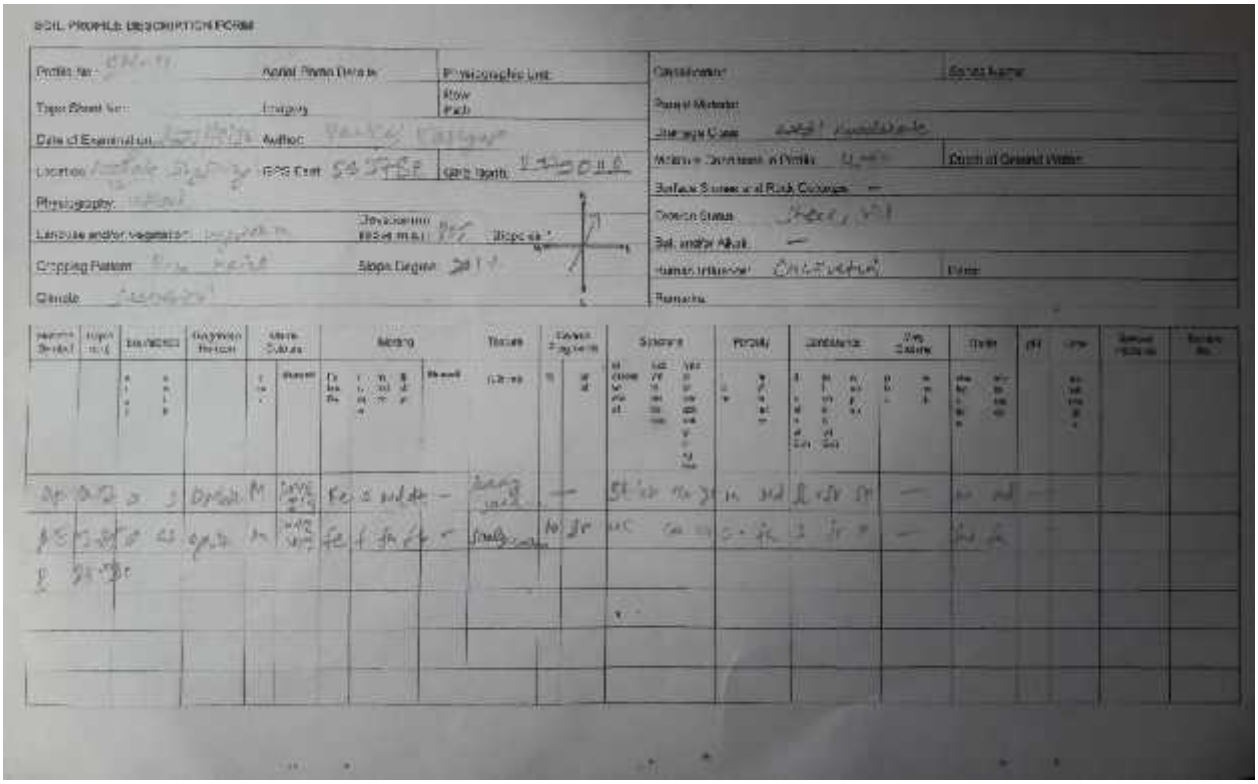
APPENDIX

Soil Profile Description

Classification:



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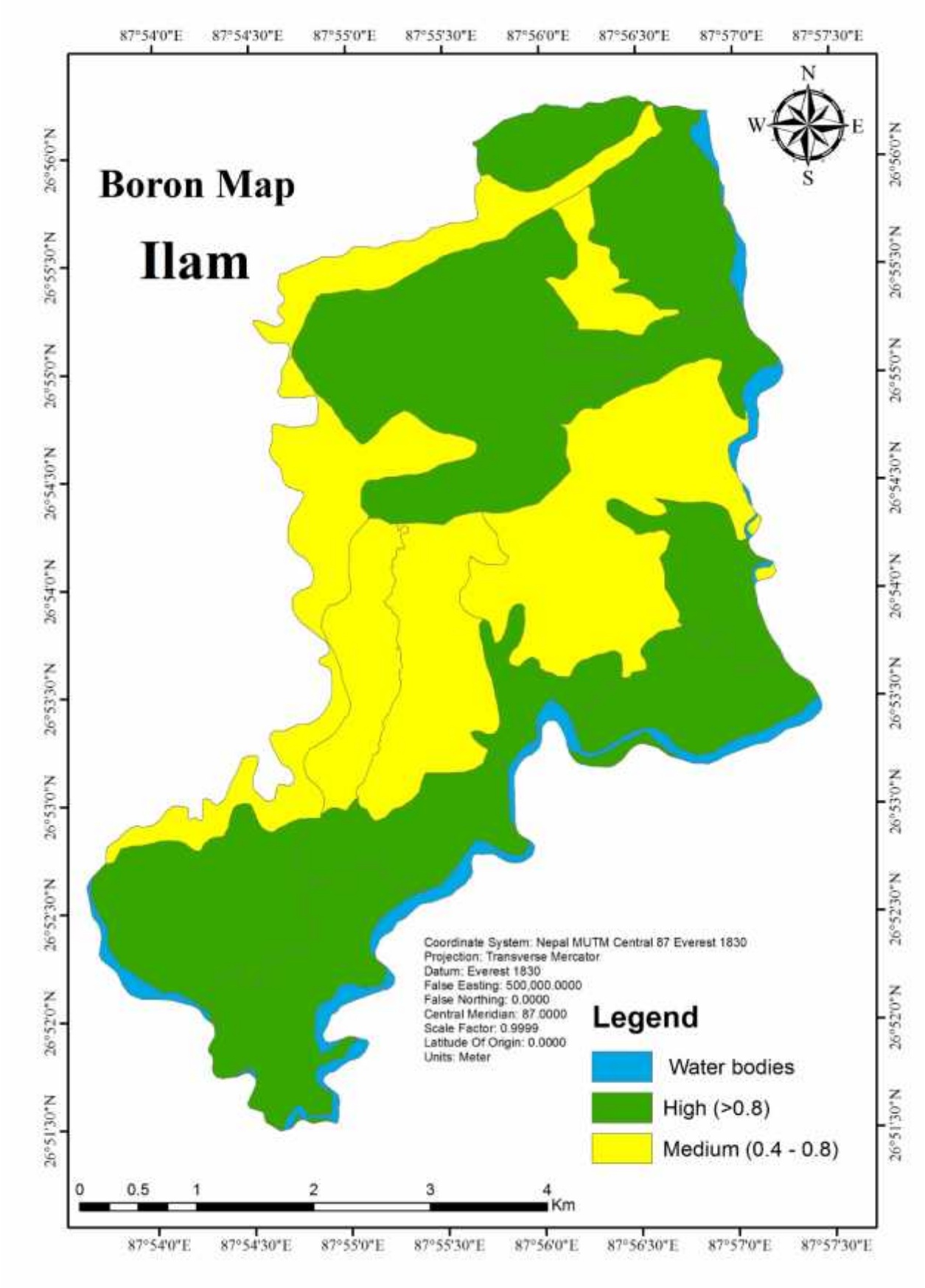
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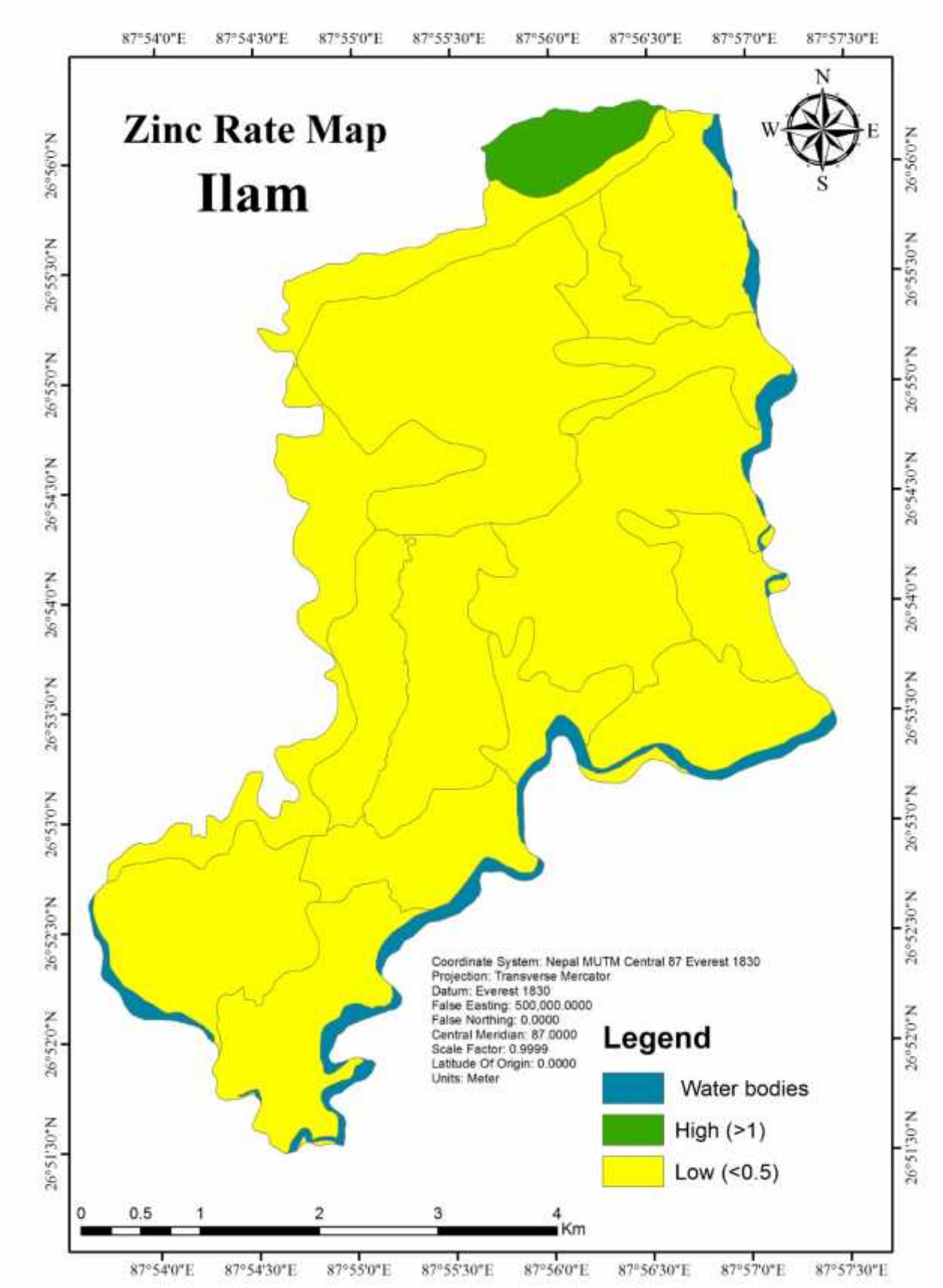
Zinc Rate Map
Ilam
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Latitude Of Origin: 0.0000
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Legend
Water bodies
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Low (<0.5)
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Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

Present Land Use Map

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

June 2017

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Chapter -1
INTRODUCTION

1.1. Background and Rationale

Land is definitely one of the most important natural resources, since life and developmental activities are based on it. Land use refers to the type of utilization to which man has put the land. It also refers to evaluation of the land with respect to various natural characteristics. But land cover describes the vegetal attributes of land. Land use and land cover data are essential for planners, decision makers and those concerned with land resources management (Ndukwe, 1997).

Land cover is an observable image of the many processes taking place on the land surface. It reflects land occupation by various natural, modified or artificial systems, and to some extent the way land is used in such systems. Land cover cartographical and statistical information plays accordingly a central role in the description and quantification of economy-nature interaction. Land is the only natural resource that is at the centre of all economic activities. An inventory of land, skillfully classified according to various economic uses, has been an important database for governments, planners and policy makers for a long time. Generally government has produced the databases through using available resources to address the local needs.

Land is one of the important and precious natural resources of the earth surface. The demands for arable land, grazing, forestry, wild-life, tourism and urban development are greater than the land resources available. Hence, land-use planning for making the best use of the limited land resources is ineable. Land-use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options (FAO, 1993). Except sporadic attempts for the urban areas (GoN, 2002), Nepal has not practiced land-use planning for the country as a whole, although attempts were made for balanced use of country's existing natural resources in the past through different policies and national planning efforts.

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world’s forest, grassland, and agricultural resources has become an important priority. Land-use planning can be applied at three broad levels: national, district and local. Local level planning is about getting things done on particular areas of land - what shall be done, where and when, and who will be responsible. It requires detail basic information about the land, the people and services at local level. However, Nepal has only regional level data base on land use, land system and land capability which were' produced by Land Resource Mapping Project (LRMP, 1983/84). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the National Land Use Project (NLUP) in 2057/058 fiscal year to generate the necessary data bases on the land resources of the country.

In the first phase, the National Land Use Project of Nepal had initiated several projects at district level and prepared Land Resource Maps and Database at 1 :50,000 scale for the whole Nepal. It had also prepared same kinds of maps and database for Kirtipur, Lekhnath, Madhyapur Thimi and Bhaktpur municipalities at larger scales. Finally, NLUP was mandated to prepare land resource maps of Village Development Committees (VDCs) and Municipalities of Nepal for local level planning through outsourcing modality. Up to fiscal year 2070/071, N LUP had completed preparation of land resource

maps and database for 28 VDCs of Chitwan district, 51 VDCs of Nawalparasi district, 96 VDCs of Bara district. 12 VDCs of Jhapa district, 7 VDCs of Banke district, 24 VDCs of Kailali district, 12 VDCs of Kathmandu district, 22 VDCs of Lalitpur district and one VDC each for Kavre (Panchkhal VDC) and Tanahu (Anbu Khaireni VDC) District as well. The work progress was furthered by carrying out land use mapping of more 143 VDC/Municipalities in the fiscal year 2071/072 from around the country. This digital database includes VDC level present land use, soil, land capability, land use zoning , cadastral layers and VDC profile with bio-physical and socioeconomic information.

It is well known that the Government of Nepal has approved the National Land Use Policy, 2069 on the 4th Baishakh of 2069,. It has intended to manage land use according to land use policy of the government of Nepal and had outlined six zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area. The policy has defined the respective zones as per the land characteristics, capability and requirement of the lands. Further, for the effective implementation of land use zones in the country, the National Land Use Policy, 2069 had clearly directed for an institutional set up of Land Use Council at the top to the District level and Municipality 1VDC level at the bottom . It has added further importance to the NLUP projects on preparation of VDC level maps and database. However, . based on the scenario developed after the major earthquake of 12th of Baishakh 2072, Government of Nepal has re-directed for possible amendment on the existing Land Use Policy, 2069 which possibly may also emphasize the safe and secure settlement along with the environmental protection and ensuring of food security. Moreover, the Land Act 2021 (Sixth amendment) have mandated for designation of more than six land use classes, some of which obviously differs from what exist in the National land use policy, 2069. NLUP at present endeavors on the same to maintain the essence of the proposed amendment on the National Land Use Policy and as mandated by the Land act 2021 (Sixth Amendment) at the same time with the strategy of completion of land use mapping within 5 years to come as directed by the parliamentary committee in 2071 .

In the context stated above, Government of Nepal, Ministry of Urban Development, Department of Urban Development and Building Construction (DUDBC) has also initiated to support the municipality for preparation of Land Use Plan of concerned municipalities by this fiscal year. In this regards, the DUDBC has awarded to conduct the project entitled: Preparation of GIS based Digital Base Urban Map upgrade of Ilam Municipality, Ilam District.

1.2 Objective of the Study

The present study aims to provide a comprehensive municipality level land use maps in order to formulate and implement sustainable land use planning. The gathered information acts as land resource inventory of the specified area that includes the study of existing cropping pattern, forestry information, hydrography etc. that are useful parameters for various functional purposes such as land use zoning. The main objectives of the present study, in connection with the land use mapping are:

- To prepare present Land use maps, GIS database and Reports for the selected Municipality in different hierarchical levels at 1:10,000 scales

1.3 Study Area

The study area lies in middle part of Ilam district. Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municipality is surrounded by Mai Khola (River) to the east, Puwa Khola (River) to the west, Barbote

VDC (Village) to the north and Mai Khola & Puwa Khola (Rivers) to the south. A detail of this VDC is given in municipality profile later in this report. The location map of the study area has been shown in Figure.

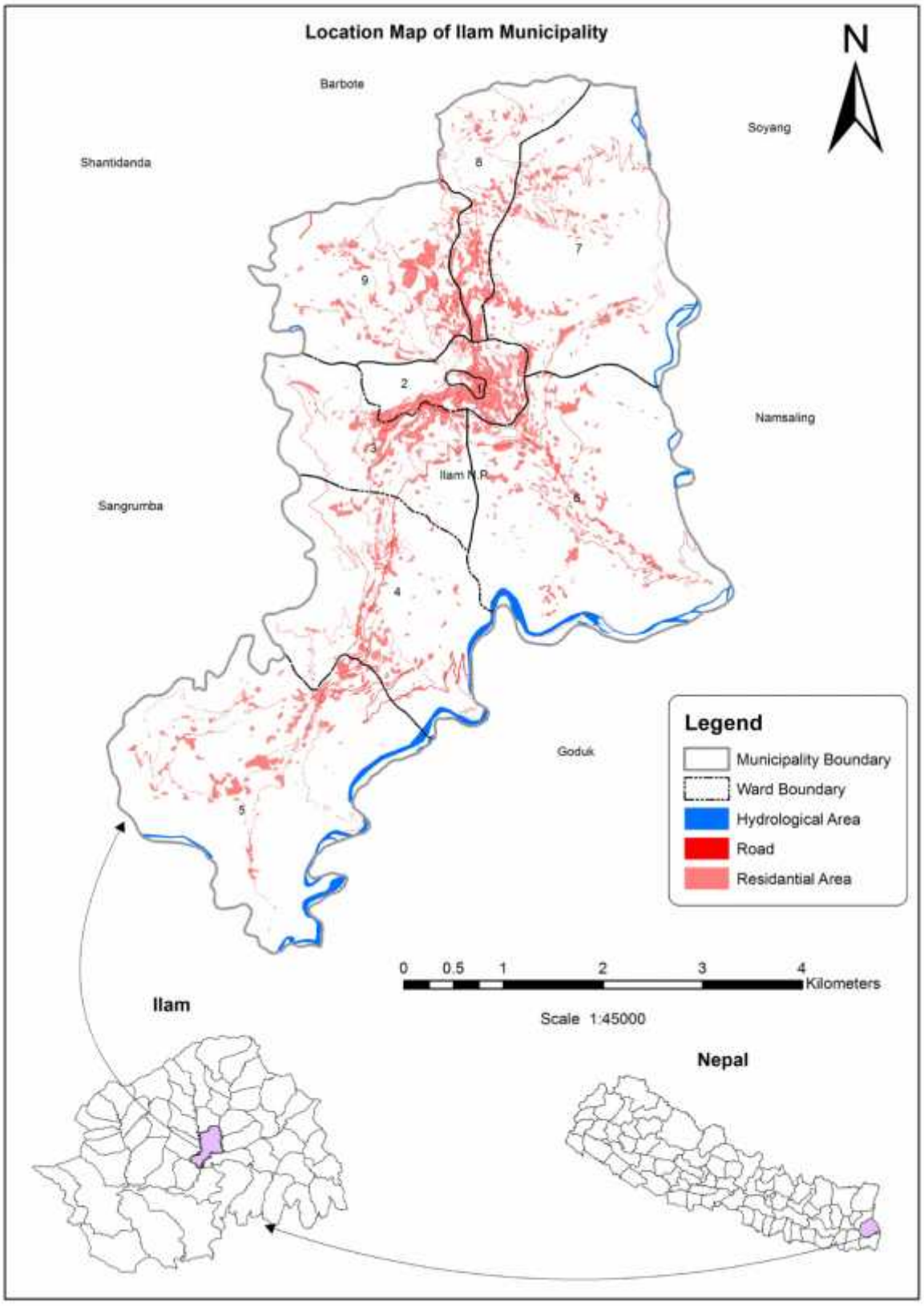


Figure1.1: Location Map of Ilam Municipality

Chapter – 2
CONCEPTUAL BASIS OF LAND USE CLASSIFICATION

2.1 Classification System and Criteria

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population.

Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria: the classifiers defined it as: "the ordering or arrangement of objects into groups or sets on the basis of their relationships". A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relation between classes. Classification thus necessarily involves definition of class boundaries that should be clear, precise, possibly quantitative, and based upon objective criteria. A classification should therefore be:

- Scale independent, meaning that the classes at all levels of the system should be applicable at any scale or level of detail; and
- Source independent, implying that it is independent of the means used to collect information, whether satellite imagery, aerial photography, field survey or some combination of them is used.

Classification systems come in two basic formats, hierarchical and non-hierarchical. Most systems are hierarchically structured because such a classification offers more consistency owing to its ability to accommodate different levels of information, starting with structured broad-level classes, which allow further systematic subdivision into more detailed sub-classes. At each level the defined classes are mutually exclusive. At the higher levels of the classification system few diagnostic criteria are used, whereas at the lower levels the number of diagnostic criteria increases. Criteria used at one level of the classification should not be repeated at another lower level (Gregorio & Jansen, 2005).

A land use and land cover classification system which can effectively employ orbital and high-resolution remote sensing image should meet the following criteria (Anderson et al., 1971):

- The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensing image should be at least 85 percent.
- The accuracy of interpretation for the several categories should be about equal.
- Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.
- The classification system should be applicable over extensive areas.
- The categorization should permit vegetation and other types of land cover to be used as surrogates for activity.
- The classification system should be suitable for use with remote sensing image obtained at different times of the year.
- Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensing image should be possible.
- Aggregation of categories must be possible.
- Comparison with future land use data should be possible.
- Multiple uses of land should be recognized when possible.

Some of these criteria are applicable to land use and land cover classification in general, but some of the criteria apply primarily to land use and land cover data interpreted from remote sensing image.

2.2 Land Use Hierarchy and Description

Land use practice in any region of the country is governed by physiography, lithology/soil, settlement pattern, cultural practices, climatic conditions and socio economic factors. To incorporate diverse land use at the VDC/Municipality level, comprehensive model should be adopted while making land use inventory.

Priori classification system with land use categories as specified in the specification provided by NLUP should be adopted. This will ensure the standardization among the classification result. National Land Use Policy 2069 provides the nomenclature of the Land Use classes. The level 1 categories of the land use are such as **Agricultural area**, **Residential area**, **Commercial area**, **Industrial area**, **Forest area**, **Public services, Mine and Minerals, Cultural and Archaeological, Riverine and Lake Area, Excavation Area and other lands.**

2.2.1 Agricultural Land Use

Agricultural land is defined broadly as land used primarily for production of food and fiber. The areas those have been used for agricultural production such as cereals, cash crops, orchards, and so on. Use of land for different agricultural production differs due to physical (e.g. climatic condition, topography, soil) and social/cultural believes of the particular region. LRMP has broadly categorized cultivated land based on physiograpy of Nepal, namely Tarai, Hill, Mountain and Valley cultivation. The Tarai cultivation is further sub divided into Wet land, Dry land and Mix land and Sloping terraces. The Mountain cultivation is further divided into Level terraces, Upland cultivation and Sloppy upland. Similarly, Valley cultivation is divided into Level terraces, Khet land cultivation, Level terraces, Upland/pakho cultivation, Valley slope upland cultivation and Valley riverbeds lower footslope alluvial fans cultivation (alluvial riverbed fans). The Wetland cultivation is further divided into Low khet land cultivation and Upper khet land cultivation-tari khet. Different cropping patter is presented in level five, whereas cropping intensity is also presented in subsequent chapter. Based on above information, NLUP has provided hierarchy of agricultural land for this study.

Table 2.1: Hierarchy of Agricultural Land Use

Level 2	Level 3	Level 4	Level 5 - Cropping pattern (Monsoon-Winter-Dry Season)	Level 6 – Cropping intensity
Terai Cultivation	Wet land cultivation	Low khet land cultivation	Maize-Oilseeds-m2; Maize-Pulses-m4; Maize-Wheat-m5; Maize - Vegetable-m6; Maize-Millet-m7; Maize-Potato-m8; Maize-Others-m9; Pulses-Fallow-p1; Pulses-Others-p2; Rice-Fallow-r0; Rice-Rice-r1; Rice-Wheat-r2; Rice-Wheat-Pulses-r3; Rice-Oilseed-r4; Rice-Pulses-r5; Rice-Rice- Vegetable-r6; Rice-Vegetable-r7; Rice-Potato-r8; Rice-Potato-Vegetable-r9; Rice-Maize-r10; Rice-Vegetable-Vegetable-r11; Rice-Maize-Vegetable-r12; Garlic-Vegetable-v2; Vegetables-Vegetable-v3; Fruit+Potato/Vegetable/Buckwheat-f2; Banana-b2; Tea-t1; Coffee-c1; Cardamom-c2; Amriso-a1; Ginger-g1; Livestock/Cattle/buffalo Farm-l1; Turmeric-t2; Fruits-f4; Rice-Buckwheat-r14; Rice-Wheat-Maize-r15; Bamboo-b3; Pond for Fish farming-p3; Beekeepig-b4; Cotton-c3; Floriculture-f5; Barren Cultivable land-b5; Livestock Grazing area-g2; Maize-Rice-Cereal-m3; Rice-Others-r13; Sugarcane-Sugarcane-s1; Potato-Vegetable Crops-v1; Others-o1; Shrub from non-forest area-s3; Vegetables-Others-v4; Sugarcane-Others-s2; Barley-Buck Wheat-b1; Fruit-Fruit-f1; Fruit-Others-f3; Others-Others-o2; Others-Others-others-o3; Maize-Rice-Fallow-m1	Intense (75%-100% cultivated) medium(50%-75% cultivated) Light (25%-50% cultivated)
		Upper khet land cultivation –Tari Khet		
	Dry land cultivation	*Unclassified*		
	Mixed land cultivation	*Unclassified*		
Hill Cultivation	Level terraces	Level terraces Khet land cultivation		
		Level terraces upland / Pakho land cultivation		
	Sloping terraces	Sloping upland / Pakho land cultivation		
Mountain cultivation	Level terraces upland cultivation	*Unclassified*		
	Slopy upland	*Unclassified*		
Valley cultivation	Level terraces Khet land cultivation	*Unclassified*		
	Level terraces upland / Pakho cultivation	*Unclassified*		
	Valley slope upland / pakho cultivation	*Unclassified*		
	Valley riverbeds (lower footslope) Alluvial fans cultivation	*Unclassified*		

2.2.2 Residential Land Use

Residential areas are the built up areas used for housing purposes. Area of sparse residential land use such as farmstead will also be included in this category. This includes annex buildings like cow sheds, garage and farm house etc. This also includes features such as lawn area, well, private path, vegetable farm close to the house etc. The area delineated as residential area by government should also be categorized in this class. Based on density of houses, the residential area is further divided into three categories; dense (> 70%), moderate (40-70%) and sparse (<40%). Similarly, it is also divided in terms of origin of the settlement; old area, newly developed area (unplanned) and planned area such as colony type, parcels plotting area and housing complex etc.

Table 2.2: Hierarchy of Residential Land Use

Level1	Level2	Level3	Level4
Residential	Densely Populated Medium Populated Scarcely Populated (The category were devised based on the local condition; based on the density of houses, dense, moderate and or sparse residential unit areas may be used for > 70 %, 40-70% and < 40% categories respectively)	Old Area, Newly Developed Area (Unplanned) Planned Area (Colony Type, Parcels Plotting Area and Housing Complex, etc.)	Residential cluster, Apartment/Multi-storeys, Oldage care place, Hostel, Dharashram, Quarters, Infrastructure developed area, Other

2.2.3 Commercial Land Use

Commercial areas are those used predominantly for the sale of goods and services. It consists of the main building, supporting structure and area that serve for commercial purpose. They are often abutted by, residential, agricultural, or other contrasting uses which help define them. It includes shopping centers, hotels, guest houses, shops, private schools, health centers, radio station, petrol pumps etc. Commercial areas are further classified into service areas and business areas. The service areas include public services whereas Business area includes market area where exchange of goods and services occur. Commercial strip are situated along the highway and access route to the highway in this municipality.

Table 2.3: Hierarchy of Commercial Land Use

Level 2	Level 3	Level 4
Service Areas	Government service Area (G)	Agriculture Office – ag; CBS - b5; Civil Aviation – ca; Communication – cm; Court – co; Cultural Office – cu; District Administration office - a1; Doildar – do; Education – en; Electricity office – eo; Forestry office - f2; Health office - h5; Irrigation office - i1; Land Transaction Office –lt; Local Development office - l2; Mining and Geology – mg; Other - o5; Petroleum – pm; Post Office – po; Road Office - r4; Soil Conservation – sc
Business Areas	Market Area with specific categories, like:	
	Market (M)	Shop - s1; Boutique - b2; Departmental Store - d1; Retail Business - r2; Supermarket - m1
	Hotel (H)	Hotel - h1; Guest House -g1; Fast-food -f1; Restaurant - r1; Bar - b1; Travel Agency - t1; Other hotel - o1
	Recreation (R)	Cyber cafe - y1; Cinema Hall - c2; Concert Hall - h2; Theatre - t2; Dance Hall - d2; Night Club - n1; Gaming Hall - g2; Gambling Hall - l1; Exhibition Centre - e1; Gym House - m2; Other Entertaining area - x2
	Utility (U)	Water Reservoir - w1; Hydropower Area - h4; Cable Car - c5; Gas Plant - g3; Oil Storage - o4; Other storage - x3
	Storage (T)	Storage house/ area - s3; Consultancy service area - c4; Business house - b4
	Service (S)	Bank/Money Exchange - b3; Private Post office - p1; Private Communication Area - c3; Broadcast Studio - d3; Private School Area - e2; Private Health Service Area - h3; Petrol Pump - m3; Radio Station - r3; Service centre - s2; TV Station - t3; Other Service - o3

2.2.4 Industrial Land Use

Industrial areas are the areas where production of goods occurs. It includes a wide array of land uses from light manufacturing to heavy manufacturing plants. It includes area covered by land, house and shed that are used as workshop or processing and manufacturing industry. It consists of factories such as textile, food, brick, timber, vehicle, brewery etc. It is further sub-divided into small scale industry including cottage industry, medium scale industry and large scale industry.

Table 2.4: Hierarchy of Public Land Use

Level1	**Level2**	**Level3**	**Level4**
Industrial	Small Scale including Cottage Industry Medium Scale Industry Large Scale Industry		Designated Name

2.2.5 Forest Land Use

Area covered by vegetation completely or partially and which does not fall under above mentioned category is forest. It consists of area covered by forest, shrub and grazing land/grassland. It is an area with natural or planted trees along with shrubs and grass where the dominant species are trees of various kinds. The forest land are subdivided into level 2 sub types as per the climatic vegetation zone such as tropical (<1000 m), subtropical (1000-2000/2100m), temperate (2000/2100-3000/3100), sub-alpine (3000/3100-4000/4100) and alpine (4000/4100-4500). Similarly the forest land is further subdivided into level 3 categories by cover type as hardwood, coniferous and mixed. On the basis of crown density, forest is classified as dense, sparse, degraded types. Similarly, according to the forest ownership category or use right, it is classified as private, protected, government managed, community, leasehold, collaborative and religious.

Bushes/Shrubs are classified as a category of forest. These are different from trees due to their multiple stems and lower height. Bushes generally have dense foliage and many small leafy branches growing close together. Shrubs are generally found in the gardens, narrow gullies, along the river bank as well as on bare unattended land during rainy season. Bushes are not categorized into lower levels. The hierarchy of forest land use is shown in Table.

Table 2.5: Hierarchy of Forest Land Use

Level 1	**Level 2 (*Climatic Vegetation Zone)***	**Level 3 *(Cover Type)***	**Level 4 *(Species Type)***	**Level 5 (*Crown Density)***	**Level 6 (*Maturity Class)***	**Level 7 (*Forest Ownership Category or Use Rights)***
Forest	**Tropical Forest** (<1000m) **Sub-tropical** (1000-2000/2100 m) **Temperate** (2000/2100-3000/3100 m) **Sub-alpine** (3000/3100-4000/4100 m) **Alpine** (4000/4100-4500m)	**Hardwood** **Coniferous** **Mixed** **Other**	Sal: Shorea R7obusta Or Dalbergla Sissoo etc Pr: Pinus Rosburghii Quercus (Oak) all species Pinus wallchiana) Blue Pine etc	**Dense** (>70% Crown Density) **Sparse** (40-70% Crown Density) **Degraded** (<40% Crown Density) followed by name of Dominant species (Crown Density/Tree density and Maturity of the forest should be adopted to categorize dense, sparse and degraded forest)	***Mature*** To over mature-trees have reached at least estimated rotation age of saw timber size **Immature** or small timber size materials **Reproduction** New generation to pole size	Private Protected Government Managed Community Leasehold Collaborative Religious Others
		Shrub				

2.2.6 Public Services Area Land Use

Public services are those services which cannot exclude someone to use it under certain terms of condition. Public land used by School, College, Hostel, Well, Parks, Airport, Road, Stadium, Picnic spot, and other public service activities are categorized in this class. Public service is further classified on the basis of their functional use into Educational, Security Services, Transportation Infrastructure, Health Service, Recreational facility, Institution and other. School, Colleges and Universities are placed in Educational class. Police station and Fire station are categorized in Security services. Transportation Infrastructure includes Road, Trail, Airport, Bus park, Railway, Ropeway, etc. Hospital, Health Post, Polyclinic etc are included under Health services. Recreational facility includes Park, Picnic spot, Open Spaces, Stadium, Playground etc. Institutional service includes Government and Public institutions. The hierarchy of public services is given below:

Table 2.6: Hierarchy of Public Service Land use

Level 1	**Level 2**	**Level 3**	**Level 4**
Public Services	Educational	School, College and Universities	Designated Name
	Security Services	Police, Armed Police, Military	
	Transportation Infrastructure	Road, trail, airport, bus park, Railway, Ropeway, etc.	
	Utility Places	Telephone booth, Crematory, Electricity office, Fire station, Landfill site, Water tank, Electric pole etc.	
	Health Service	Hospital, Health Post, Polyclinic	
	Recreational Facility	Park, picnic spot, open spaces, stadium, playground, etc)	
	Institution	Government,Public, Private, NGOs, INGOs etc.	
	Other	Other public use - o4.	

2.2.7 Mine and Minerals

Mines and minerals in their original position are part and parcel of the land. The common law presumption is that a landowner owns everything below the surface down to the centre of the earth. Unworked mines and minerals are the property of the surface owner.

This class includes areas being mine reserve and extraction area; house, hut and the land which is occupied by mining project.

Table 2.7: Hierarchy of Mine and Minerals Area

LEVEL1	LEVEL2	LEVEL3	LEVEL4	LEVEL5
Mine and Minerals Area	Metallic Minerals	**Mine, Minerals, Construction (Materials) Subcategory (CNSM)**	Licensed	Not Operated So Far
	Nonmetallic Minerals	Sands	Not-Licensed	Currently under Operation
	Gemstones	Cobbles	Reserved	Closed
	Construction Minerals (Materials)	Flaggy quartzite	Banned	Other Operation Status
	Fuel Minerals	Limestone		
	Decorative and Dimension Stones	Pebbles		
	Other Minerals	Quartzite, River boulders, Schist, Slates, Other Construction Minerals		
		Mine minerals_ Decorative and Dimension _Subcategory (DCDEM)		
		Basalt , Colored sandstone, Granites, Marble, Quartzite, Other Decorative and Dimension Minerals		
		Mine_minerals_Fuel_Sub_category(FUEL)		
		Coal, Hot springs, Methane, Petroleum, Other Fuel Minerals, Natural Gas		
		Mine, minerals, GEM Subcategory (GM)		
		Aquamarine, Beryl, Garnets, Gem, Kyanites, Quartz crystals, Ruby, Sapphire, Tourmaline, Other Gemstone Minerals		
		Mine, minerals, non-metallic category(NM)		
		Clay, Dolomite, Limestone, Magnesite, Mica, Phosphorite, Quartz, Silica sand, Talc, Other Non-Metallic, Phyllite		

LEVEL1	LEVEL2	LEVEL3	LEVEL4	LEVEL5
		Mine_minerals_Metallic_Sub _category (MTL)		
		Iron, Copper, Zinc, Lead, Cobalt, Nickel, Gold, Silver, Tin, Tungsten, Molybdenum, Uranium, Lithium, Lepidolite (Mica), Tantalum, Bismuth, Arsenic, Cadmium, Chromium, Mercury, Titanium, Other Metallic Minerals		

2.2.8 Cultural and Archaeological

These are institutions or establishments related to religious, culture and history. This class includes areas of Temple, palace, buildings, Mosque, Stupa, Mane and other cultural buildings and areas.

Table 2.8: Hierarchy of Cultural and Archaeological Area

LEVEL1	LEVEL 2
Historical and Archeological	**Historical, Archeological and Religious Sub category**
	Heritage Site (h)
	Durbar Square (d)
	Gadh (g)
	Archeological Site (a)
	Cultural Site (c)
	Fort (f)
	Temple(t)
	Stupa/Monastary(s)
	Mosque(m)
	Church(c)
	Bahal(b)
	Patis(p)
	Bihar(v)
	Other(o)

2.2.9 Riverine and Lake Area

All water related natural and man-made features are categorized as hydrography. This class includes pond, lake, canal, glacier, snow area, wetland, river, spout, Kulo, sand and other hydrography.

Table 2.9: Hierarchy of Riverine and Lake Area

LEVEL1	LEVEL2
Riverine and Lake Area	Pond (p)
	Lake (l)
	Canal (c)
	Glacier (g)
	Snow Area (s)
	Wetland (w)
	River (r)
	Spout (t)
	Well (e)
	Kulo (k)
	Other (o)
	Sand (d)

2.2.10 Excavation Area

This class includes areas of aggregate material such as gravels, sand, clay and occupied area.

Table 2.10: Hierarchy of Excavation Area

LEVEL1	LEVEL2	LEVEL3
Excavation (Construction Materials) Area	Cobbles	Licensed
	Flaggy quartzite	Not-Licensed
	Limestone	Reserved
	Pebbles	Banned
	Phyllite	
	Quartzite	
	River boulders	
	Sands	
	Schist	
	Slates	
	Other Excavation Materials	

2.2.11 Other Land Use

Others land use includes a type of land that does not belong to the above mentioned categories. Grass land is further divided into tropical (<1000m), sub-tropical (1000-2000/2100m), temperate (2000/2100-3000/3100 m), sub-alpine (3000/3100-4000/4100m) and alpine (4000/4100-4500m).

Table 2.11: Hierarchy of Others Land Use

Level 2	Level 3 (Climatic vegetation zone)
Grazing land (G)	Tropical (<1000 m), Sub-tropical (1000-2000/2100 m), Temperate (2000/2100 m-3000/3100 m), Sub-alpine (3000/3100-4000/4100 m), Alpine (4000/4100 m-4500 m)
Others(X)	

Chapter – 3
METHODOLOGY

3.1 Data Sources

Primary data has been collected from various sources in the central level as well as in the field from various sources and agencies. The collected data from primary source include the followings:

World View Satellite Imageries: World View satellite system is one of the best ground resolution commercial color imaging satellite of the present time. The satellite has extraordinary detail, high accuracy and enhanced stereo imagery for DEM generation. High resolution satellite imagery not exceeding 1m ground resolution has been acquired along with their metadata, satellite orbital model file (rational polynomial coefficient file) and tile information files.

Table 3.1: Specification of World View Satellite Image

Sensor	World View 2
Acquisition date for RGB color imagery from Archive	2014-02-01
Spatial Resolution	0.5m
Image Bands	4 bands
Image Format	TIFF image
Pixel Type/Depth Exterior orientation	signed integer/ 16 bit /DGPS Ground Control Points
Photogrammetric workstation/software	ERDAS
Processing	Orthorectification using Rational Polynomial Coefficient (RPC)

The World View images used in the study area are shown in Figure.

Figure 3.1: World View 0.5 m Image

Topographical Map: Data collection process was initiated by making visit to the different departments and ministries. Digital GIS data from 1:25,000 scale Topographical maps prepared by Survey Department, 1996 were used as base data for GIS analysis. Topographical Maps were used for planning process of GCPs collection with DGPS survey and also used for feature extraction of dataset such as drainage network, Municipality boundary, location name, etc and additional data for GIS based analysis.

Digital Elevation Model: Digital Elevation Model was prepared from the spot height and contour data of Topographic map of study area prepared by Department of Survey. The DEM was used for the orthorectification of the image and to derive information such as slope, aspect, relief intensity surface etc for performing different terrain analysis. The DEM prepared from contours of topographical map is overlaid with Municipality boundary.

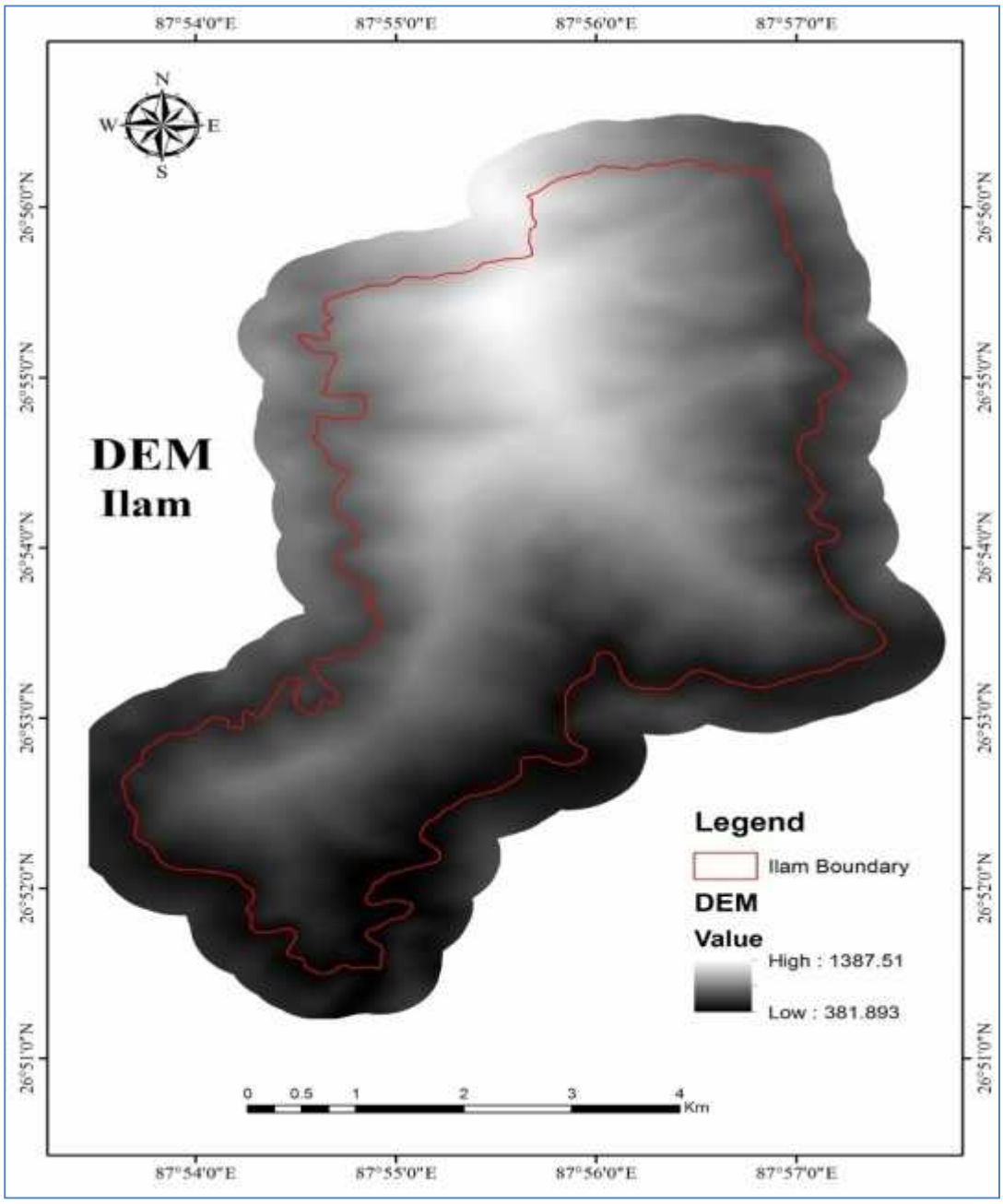


Figure 3.2: DEM of Ilam Municipality

LRMP Maps/Reports: Land Utilization, Land System and Land Capability maps and reports prepared by Land Resource Mapping Project (LRMP), 1986 were used as references for getting insights into existing land use classification and zonation system of Nepal. These maps are used to aid the classification process and as reference for symbology as well.

Land Use Policy 2069: Land Use Policy (2069) was the main basis for the classification of the land use categories. The policy was reviewed. The major land use categories ascribed by the policy were adopted in classifying the existing land use of the study area.

Ground Control Point: Differential global positioning system (DGPS) survey was carried out for the collection of ground control points (GCPs) including check points. The control points that are distinct in the map as well as can be easily identified in the field has been marked to carry out DGPS survey work described in the consequent point. The control points has been marked assuring well distribution per scene. The distribution of the identify nine GCPs is shown in following figure.

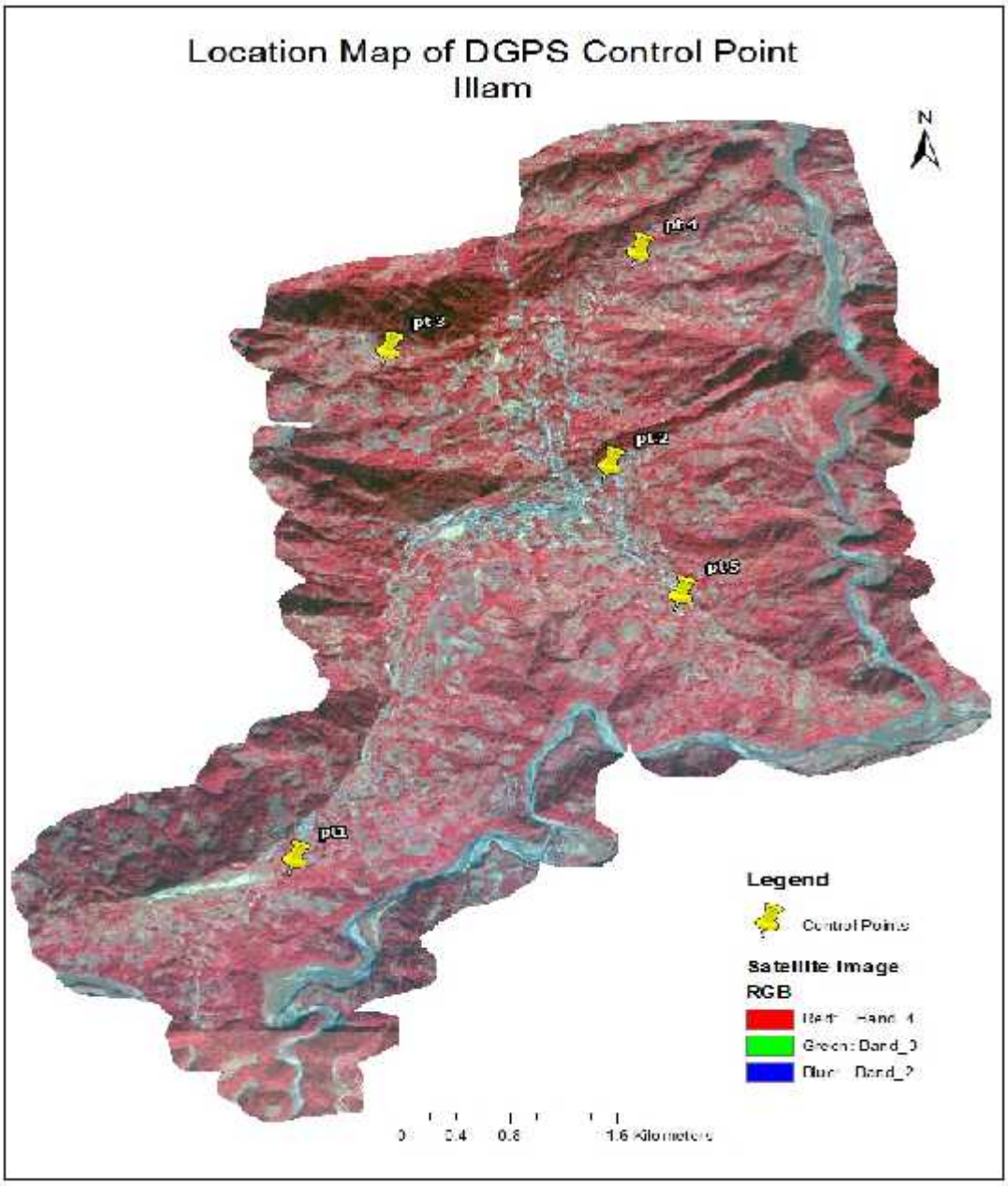


Figure 3.3 Distribution of Ground control points (GCP) identification for DGPS survey

Differential Global Positioning System (DGPS) is an enhancement to Global Positioning System that uses a network of fixed ground based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. It is a means of correcting for some system errors by using the errors observed at a known location to correct the readings of a roving receiver. The basic concept is that the reference station "knows" its position, and determines the difference between that known position and the position as determined by a GPS receiver. This error measurement is then passed to the roving receiver which can adjust its indicated position to compensate.

DGPS survey has been undertaken to establish Ground Control Points (GCPs) to geometrically correct the high resolution satellite imagery. DGPS Survey has been done using high precision Geomax Zenith25 GPS receivers to identify numbers of GPS Points. Among numbers of GPS points some points are GCPs and some numbers of GPS points are check points. Check points have been used to check the accuracy of the Satellite Ortho photo generated using collected GCPs. These GCP Points has been linked with National Geodetic control point, which is established by Department of Survey. Another National Geodetic control points were taken for accuracy assessment. The observation has been made for 1-1.5 hours in each station to receive signals from the minimum of four satellites to identify the GPS location. Each GPS stations have been observed with reference to the National Geodetic Control Point and three other adjacent points so as to form GPS triangulation network.

Base Station	National Geodetic control point
DGPS Station	7 GCPs
DGPS Equipment	Geomax Zenith25
Method	Triangulation and Post-Processing

3.2 Methods Adopted

The specific approaches and methods adopted to generate the municipality level land use map of the project municipality area is explained briefly in the below.

The stepwise procedure adopted to generate the land use map of the area is following:

- Geometric Correction and Ortho-rectification
- Pan-sharpening (Image Fusion)
- Visual Image Interpretation and classification
- Detail Field Verification
- Mapping and Accuracy Assessment
- Land Use Geo-database Creation

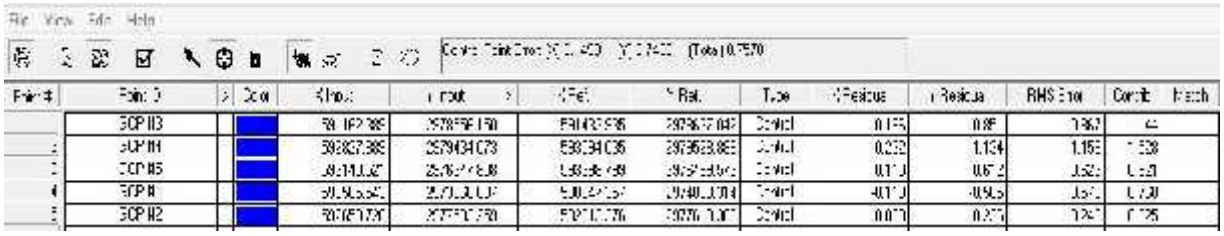
3.2.1 Geometric Correction

For an image taken with very high resolution satellite (VHRS) with push broom sensor in which each image line is taken at a different instance of time, i.e. each scan line has its own perspective projection model. On satellite board, there is GPS receivers which are used for determining satellite ephemeris, i.e. camera position with respect to time. Star trackers and gyros on board measure the camera attitude angle (roll, pitch and yaw) as a function of time (Grodecki and Gene, 2003). The sensor camera position and attitude angle most essential to geo-rectification of VHRS optical images. Geometric

corrections include correcting for geometric distortions due to sensor-earth geometry variations, and conversion of the data to real world (Tempfli, Bakker, & Kar, 2001). Geometric correction was done to compensate for errors caused by variation in altitude, velocity of sensor platform, rotation of the earth and earth curvature etc.

The Ground Control Points (GCPs) were collected from the field visit using global positioning system (GPS). The GCPs were used to geometrically correct the image. Sufficient numbers of GCPs were used to improve the RMS error. The observed data has been post-processed using DGPS processing software to calculate the co-ordinates of the GCPs. For Orthorectification of World View-2 satellite imagery, Rational Polynomial Coefficient (RPQ has been used. Orthorectification process has been carried out in projection UTM 84-44 North and the imagery has been later re-projected into Everest 1830 Central Meridian 87. The extent of the image as followed. The following table presented the Orthorectification process data.

Table 3.2: GCPs used and RMS error obtained during geo-referencing the image



Similarly the contour at 5m interval has been generated using specialized DTM software in AutoCAD environment. Contour at 5m have been generated for the core city area only. For rest of the fringe area, 10m contours from 1:25,000 scale topographic maps have been used. The contours from both the sources has been matched and merged to generate a seamless terrain contour. This has been used in generating the Digital Elevation Model (DEM) of the entire municipality. This DEM has been used for ortho-rectification and generative other derivative terrain maps (slope, aspect etc.).

3.2.2 Visual Interpretation

The common visual interpretation technique was used that includes the parameters like tone, texture, colour, pattern, form, shadow, association etc. This technique is preferred while classifying the high resolution satellite images by experienced user so that they have more control on the classification process. It includes assigning the pixels in a multispectral image to classes and sub-classes, extracting thematic information from the image using visual interpretation keys. Visual interpretation takes advantage of the human skills to recognize data "content" by combining several elements of image interpretation. It relies on experience, a prior knowledge and skilled analysts qualities to produce excellent results. Availability of high resolution remote sensing data and sufficient a prior knowledge of a small area to be mapped, with adequate ground trotting allows the analysts to extract information about cover (physical dimension) and the use (functional dimensional) of the land.

Interpretation keys such as tone, colour, shape, size, pattern, texture, shape, association were applied for predicting land use and land cover types in using both true and infrared colour composite images.

Common image enhancement techniques such as contrast enhancement, intensity-Hue-Saturation processing, decorrelation stretching and color composites were applied. The spectral bands of World View, which are useful for detecting various land features land was reviewed from the reports and previous studies. Accordingly the spectral bands were included in producing various color composite imageries to be used for visually interpreting land use and land cover types.

3.2.3 Accuracy Assessment

Accuracy assessment was done to evaluate classification performance and usefulness of the image classification. It shows the degree of correctness of a map or classification in comparison to the actual ground features. Accuracy assessment in terms of class specific producer's and user's accuracy, overall accuracy and Kappa coefficient are subsequently computed after generating confusion matrix. The producer's accuracy relates to the probability that a reference sample is correctly mapped and measures the errors of omission. In contrast, the user's accuracy indicates the probability that a sample from land cover map actually matches what it is from the reference data and measures the error of commission. This method is applicable when the digital classification is carried out, which is recommended for the coarser resolution of image. However, at present case, the visual classification method was adopted with the aid of high resolution satellite image and hence no such matrix could be developed. However, the classification made at the present study is more realistic as the image interpretation was followed by the intensive field verification.

Chapter – 4
PRESENT LAND USE PATTERN IN THE ILAM MUNICIPALITY

The chapter describes the present land use pattern of the Ilam Municipality. General land cover pattern shows that agricultural land dominates land use of this area. This chapter presents land use assessed in different levels of hierarchy.

4.1 Land Use Pattern

Recent high-resolution satellite image was interpreted along with detailed field visits and also taking references from other existing maps and publications. The Municipality was found to have nine land use classes. The present land use table and figures show that agriculture covers maximum area (50.59%) followed by forest (34.93%) and Residential (8.00%). Likewise, Riverine and Lake Area and public service area covers 3.43% and 2.29% respectively. Other coverage is not potentially significant.

Table 4.1: General land use of Ilam Municipality

S. No.	Land Use Class	Area (Hectare)	Area (%)
1	Agriculture	1348.76	50.59
2	Commercial	5.77	0.22
3	Cultural and Archeological	0.05	0.002
4	Forest	931.21	34.93
5	Riverine and Lake Area	91.57	3.43
6	Industrial	0.39	0.01
7	Public Service	61.16	2.29
8	Residential	213.35	8.00
9	Others	13.93	0.52
Total		**2666.18**	**100.00**

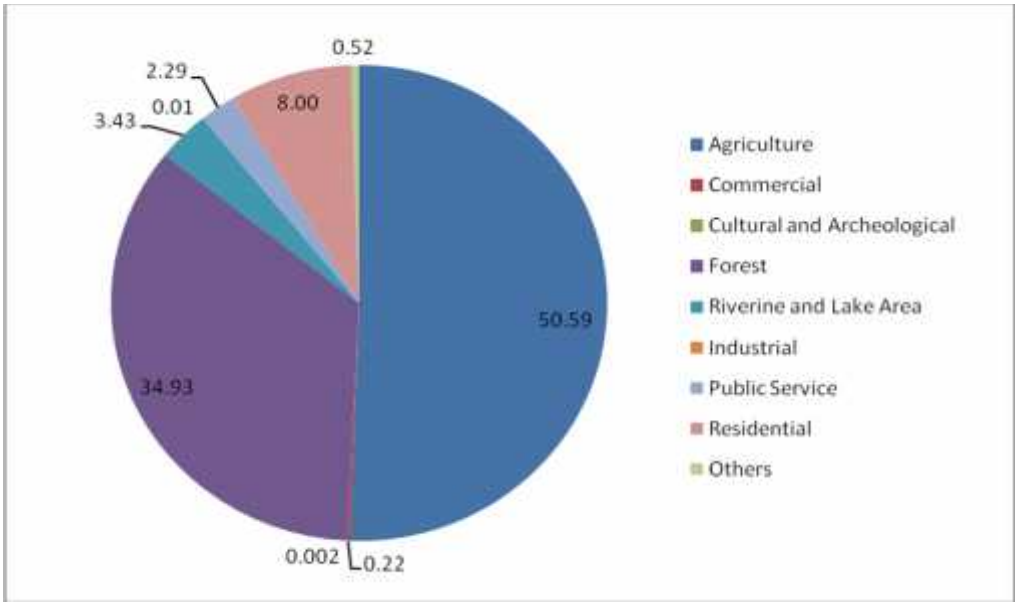


Figure 4.1: General land use of Ilam Municipality

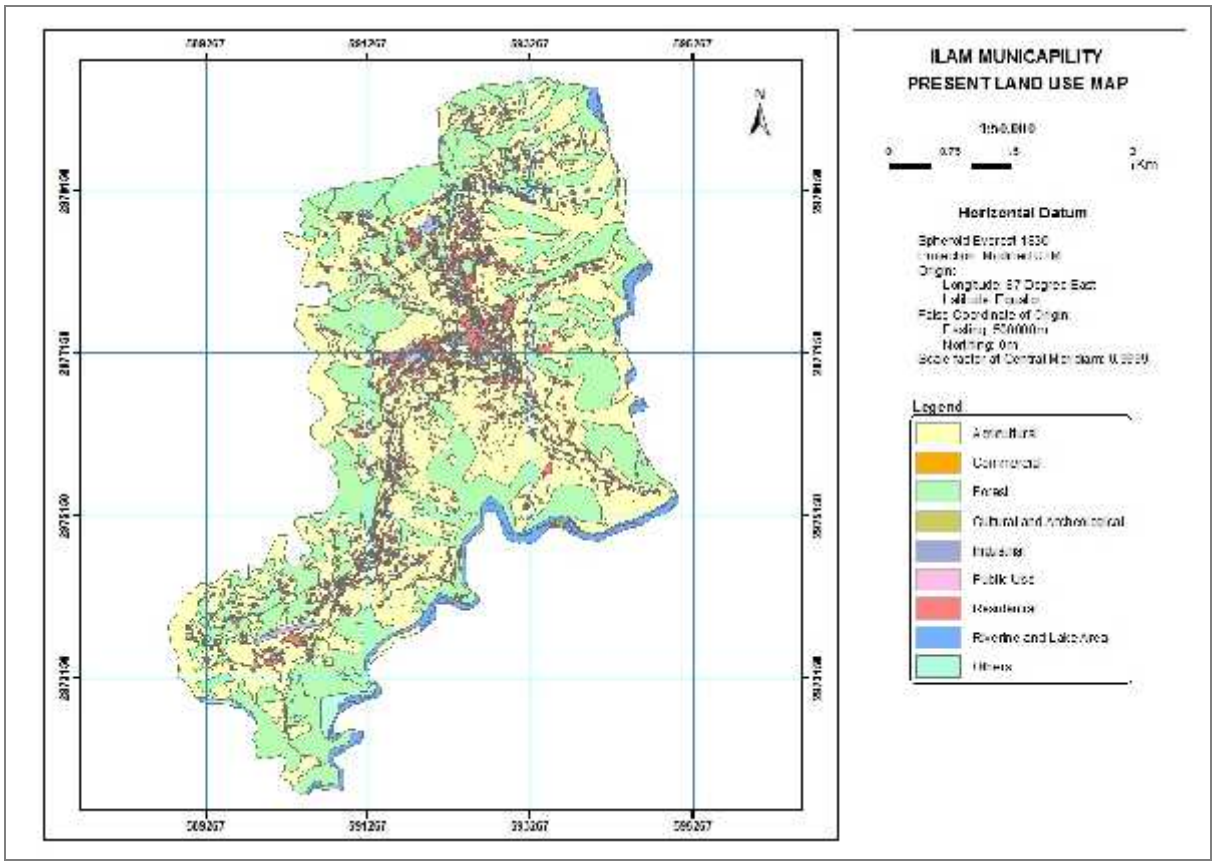


Figure 4.2: Present Land Use Map

Agricultural Land Use: Agricultural land of the Ilam Municipality is classified as Hill cultivation based on the physiographic region. The cropping pattern of the Municipality varies according to agricultural land types, irrigation and precipitation. Hilly cultivation is the sole type of agriculture in this Municipality covering a total of 1348.76 ha of area. Analysis of cropping pattern shows that Rice-Wheat-Maize (43.39 %) is the dominant one followed by Maize-Oilseeds (16.72 %) and Maize-Others (15.95 %) as shown in the table below:

Table 4.2: Areal Coverage of Different Cropping Patterns

Cropping Pattern	Area in Hectare	Percentage
Cardamom	137.00	10.16
Fruit-Fruit	3.57	0.27
Fruit+Potato/Vegetable/Buckwheat	0.28	0.02
Maize-Rice-Fallow	4.99	0.37
Maize-Oilseeds	225.56	16.72
Maize-Pulses	13.63	1.01
Maize-Others	215.17	15.95
Rice-Maize	20.55	1.52
Rice-Others	14.81	1.10
Rice-Wheat-Maize	585.28	43.39
Wheat-Pulses	62.62	4.64
Tea	65.23	4.84
Vegetables-Vegetable	0.07	0.01
Total	1348.76	100.00

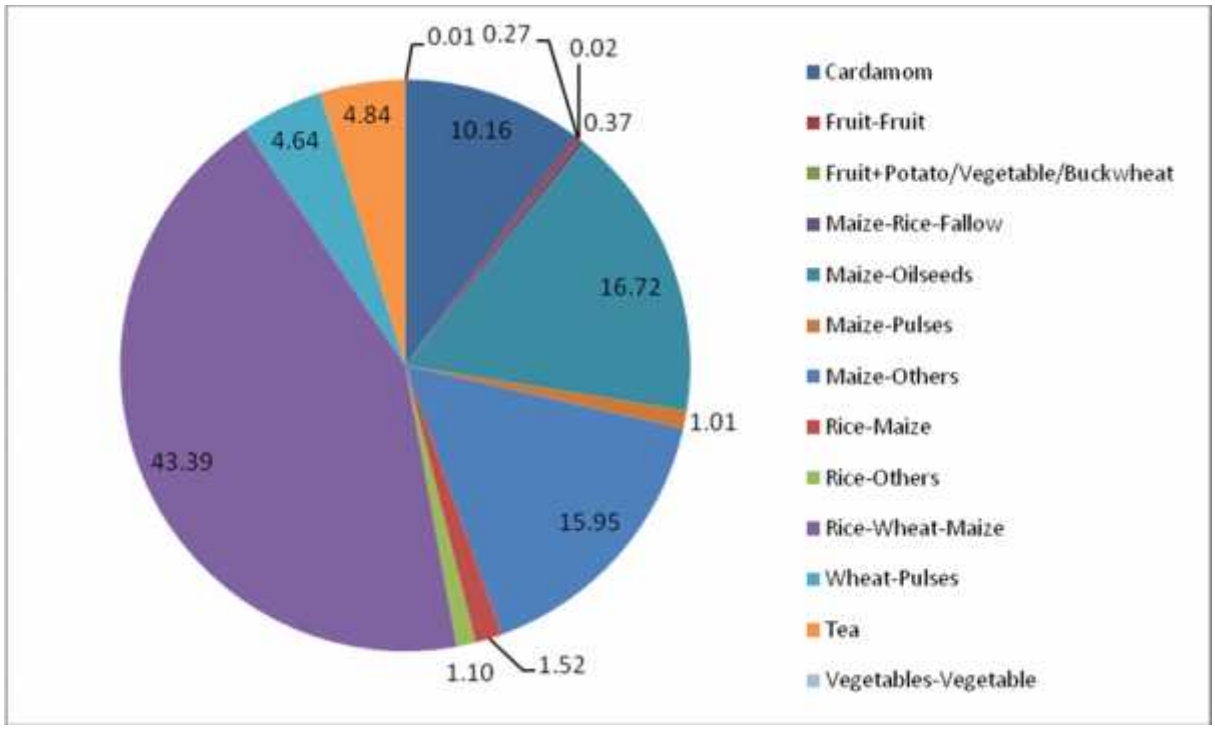


Figure 4.3: Cropping Pattern in Agricultural land

Forest Cover: Ilam Municipality has forest cover of 34.93%. All the forest species are of regeneration type in terms of immature in maturity class. As the Municipality is in the hill, all the forest is sub-tropical evergreen forest type. Analysis of crown density shows that Sparse (61.98 %) is the dominant one followed by Dense (37.38 %) as shown in the table below:

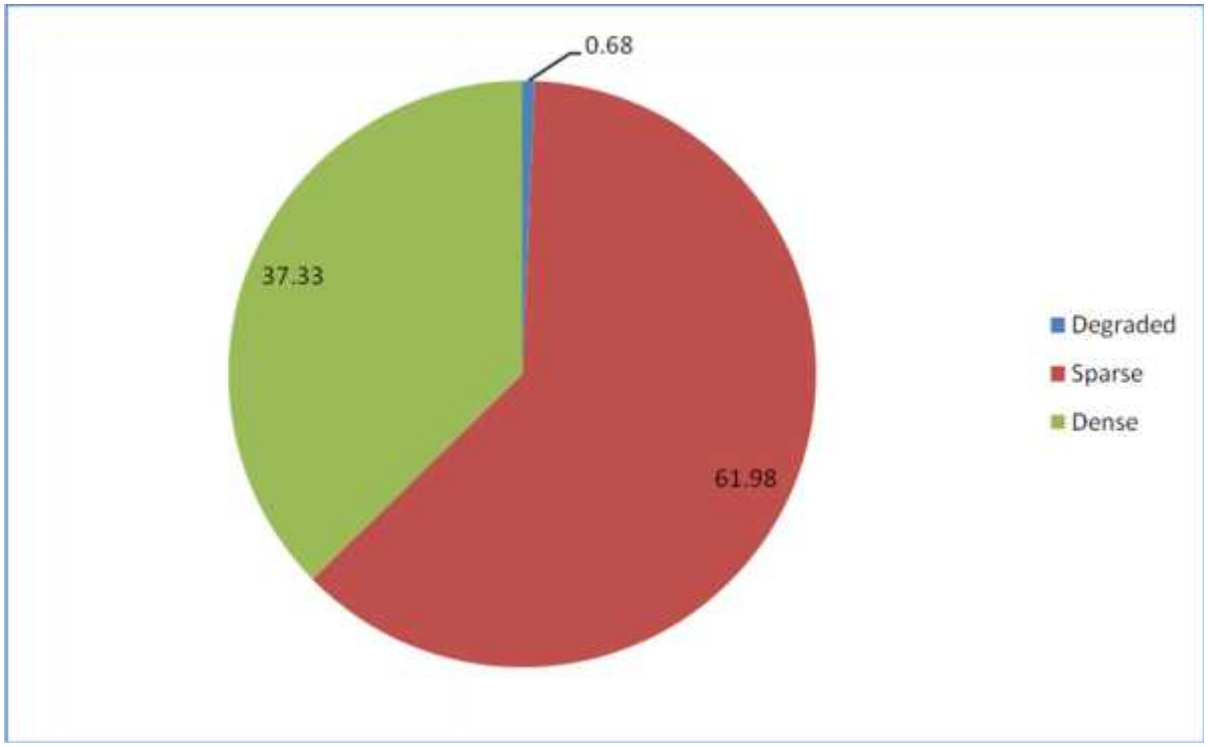


Figure 4.4: Forest Cover distribution

Residential Land Use: Ilam Municipality has 8.00% residential area. Most of the residential areas of the Municipality are Sparse type (98.05%) followed by Sparse residential unit (4.15). Most of the residential unit of Ilam Municipality are old residential areas (92.00). Similarly, 8.00% residential area of the Municipality is found under planned area category. No planned area is found in the Municipality.

Public Services: Public services which include Educational services such as school, college, recreational facility includes playground, open space, Park etc; temple is religious facility, road and trail in transportation infrastructure etc. About 71.41 percent public services areas are of transportation infrastructure followed by 11.72% Security Service. The Educational service consists of 10.06% of the public services. Detail of the public services is presented in table and figure below.

Table 4.3: Public services of Ilam Municipality

Public Services	Area in Hectare	Percentage
Educational	6.15	10.06
Recreational Area	1.57	2.57
Health Service	1.72	2.82
Instructional Area	0.83	1.35
Security Service	7.17	11.72
Temple	0.02	0.04
Transportation Infrastructure	43.67	71.41
Utility Service Area	0.00	0.01
Other Public Use Area	0.01	0.02
Total	61.16	100.00

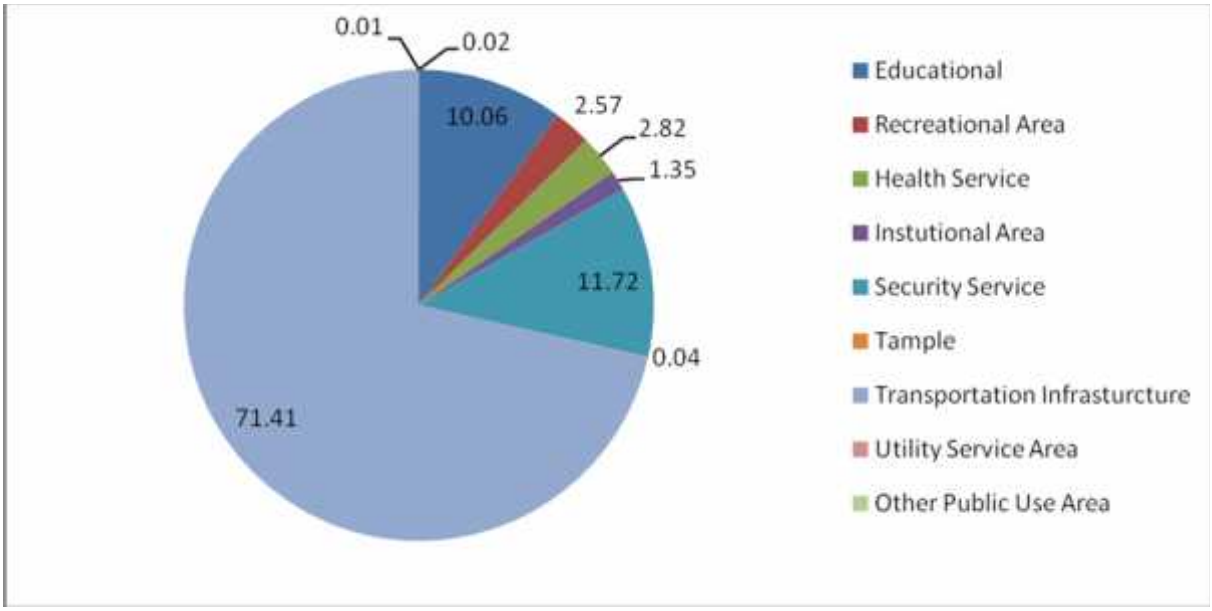


Figure 4.5: Public services land use distribution

Industrial Area: Industrial area covers only 0.39 hectare which covers 0.01 percent of total area in the municipality.

Cultural and Archeological: This municipality has very small proportion of Cultural and Archeological area covers 0.05 hectare which covers 0.002 percent of total area.

Riverine and Lake Area: Ilam municipality has 91.57 hectare land in Riverine and Lake Area, which is 3.43% of the total area of the municipality. Most of the Riverine and Lake Area of the Municipality are found River (99.78%) followed by Canal (0.19%) and Pond (0.04%).

Table 4.4: Riverine and Lake Area

Category	Area in Hectare	Percentage
Canal	0.17	0.19
Pond	0.03	0.04
River	91.37	99.78
Total	**91.57**	**100.00**

Others Land Use: Ilam municipality has 13.93 hectare land in others use, which is 0.52% of the total area of the municipality. Most of the lands (84.66%) under others category are others land and only 15.34 % others land is under grass land.

Table 4.5: Other Land use

Category	Area in Hectare	Percentage
Grazing land	2.14	15.34
Others	11.79	84.66
Total	**13.93**	**100.00**

4.2 Land Use GIS Database

Present Land Used database prepared for this study is strictly followed as Geo-database of NLUP for this project as specification. All data related to land use prepared for this study have been submitted in digital format with this report to DUDBC office.

Table 4.6: Database for present land use

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	FID
SHAPE	Geometry	Geometric Object type	SHAPE
ID	Long	Unique Object ID	ID
LEVEL 1	String	Land Use Class	LEVEL 1
LEVEL 2	String	Land Use Class	LEVEL 2
LEVEL 3	String	Land Use Class	LEVEL 3
LEVEL 4	String	Land Use Class	LEVEL 4
LEVEL 5	String	Land Use Class	LEVEL 5
LEVEL 6	String	Land Use Class	LEVEL 6
LEVEL 7	String	Land Use Class	LEVEL 7
AREA	Double	Area in Square meter	AREA
AREA_HA	Double	Area in Hectare	AREA_HA

Chapter – 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The present land use mapping was carried out through interpretation of satellite imagery, visual observation/interpretation and extensive field verification. During the visual image interpretation, the knowledge of experienced image interpreter along with ancillary data such as LRMP maps/data, DEM, DEM derivative, different ratio and indices, and field verified data were used. Land use map at the scale of 1:10,000 has been generated with the combination of road networks in order to fulfill the requirement as mentioned in the specification of this project.

The municipality showed variability in land use pattern in which much of the land is used for agricultural land. Analysis of cropping pattern shows that Rice-Wheat-Maize is the dominant crops pattern of the municipality. Similarly, all the forest is sub-tropical evergreen forest type. Analysis of crown density shows that Sparse is the dominant. Somewhere, nearby areas of settlements, small patches of land are used for vegetable farming and also recently introduced cash crop like cardamom, Tea, , menthol. Besides this, few lands is found being used for commercial and industrial uses.

5.2 Recommendation

Based on the present experience of the project, the following recommendation could be made for developing the similar projects in future. The following recommendations are made to the concerned authorities:

- High resolution panchromatic images if combined with multispectral images can enhance the preparation of land use map.
- The land use maps should be easily accessible to the stakeholders so that they can use it for sustainable resource management.
- It is necessary to update the land use map within certain interval of time.
- Public should be made aware of sustainable use o f land resources.
- There is need to raise public awareness towards sustainable utilization of land resources. It can be achieved through displaying the land use maps of various time interval and explaining the changes (positive and/or negative) so that the local people visualize the scenario, accept the causes and effects thereby easing for implementation of the plans.

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Appendix 1: Photographs

Photo 1: Photo of Study Area

Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

LAND USE ZONING

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

June 2017

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale

1.1.1 Background

Land is a basic resource and livelihood base for almost tree-fourth of the population in Nepal. Lack of physical infrastructure like irrigation facilities, scattered small sized land parcels and subsistence farming practices have resulted in low agricultural productivity. Increasing demand of agricultural production as caused by population growth cannot be fulfilled due to low rate of agricultural production resulted in food deficit and insecurity in the future. High rate of migration from hilly region to fertile land of Terai has created unplanned settlement and increasing loss in agricultural area and production. At the same time, encroachments on public and government lands (like forests) for squatter farming and settlement have been alarming.

Nepal being a developing nation, massive urban land has been encroached as slums and real estate markets. This activity has been flourished in Nepal since last two decades specifically in large municipalities and fringe areas. As land is the pivotal for economic development, almost all economic activities in these areas depend on lands. There has also been rising unsystematic and unhealthy real estate business in the absence of effective land use planning and zoning. The provisions of utility services are very poor in the developmental areas due to lack of updated planning and monitoring. All these facts have resulted in serious problems on settlement pattern and have resulted in environmental deterioration. The state being the guardian of development, it needs to pay serious attention to face, overcome and tackle the ever growing problems.

The Government of Nepal is trying to cope with various land related issues in national and local level. The highly fertile agricultural land is getting urbanized haphazardly in many urban and semi urban areas. In many places, agricultural lands have been left unused and abandoned. The available land is not being used on its optimum level. Crop production is not according as the suitability and capability of the land. Improper use of lands in many places have been causing varieties of disasters such as landslides and flooding. If situation continues, Nepal has a serious threat to face varieties of problems including food insecurity and hunger in future. To cope with these challenges, available land should be managed appropriately. Land use planning is one of the tools for getting optimum benefit from scarce land resource. Sustainable development of a country is highly dependent on the proper use and utilization of resources available. Land is one of these resources. Therefore, a comprehensive land use plan is highly essential for the national development.

1.1.2 Rationale

Government of Nepal has identified land use zoning as an important device to design a detailed land use plan and devise its policy. This policy is expected to be implemented with the help of land

use zoning maps. In this context, the Ministry of Land Reform and Management, National Land Use Project has taken an initiative to prepare land use zoning maps of Nepal in different level such as district and VDC level. Like this Department of Urban Development and Building Construction (BUDBC) also initiated to support the municipality for preparation of Land Use Plan of concerned municipalities by this fiscal year. The rationales of the program are as follows:

- Minimize the ratio amongst the different land use sectors for maintaining the balanced land use from the point of view of population, environment and sustainable development; and classify the land for agriculture, forest, settlement, industrial and commercial areas, etc.
- Identify and classify the sectors based on geographical characteristic, land capability and soil quality which are comparatively more beneficial for arable land for agricultural crop production and the areas for income generation such as fruits, cash crops and herbs production areas.
- Identify and zoning the land for housing, urbanizing, industrialization and other non-agricultural purposes in the existing municipalities areas as well as to balance the environment and sustain the system by preserving and developing water, forest and living treasure.
- Identify the main settlements which are in transition zone and develop such areas in a planned and environmentally justifiable way.

The Government of Nepal has approved the National Land Use Policy, 2069 on the Baisakh of 2069. It has intended to manage land use according to land use policy of the Government of Nepal and had outlined 11 zones such as *Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area*. However, based on the scenario developed after the major earthquake of 12th of Baisakh 2072, the Government of Nepal has re-directed for possible amendment on the existing Land Use Policy, 2069 which possibly may also emphasize the safe and secure settlement along with the environmental protection and ensuring of food security. Moreover, the Land Act 2021 (Sixth amendment) have mandated for designation of more than six land use classes, some of which obviously differs from what exist in the National land use policy, 2069. DUDBC at present endeavors on the same to maintain the essence of the proposed amendment on the National Land Use Policy and as mandated by the Land act 2021 (Sixth Amendment) at the same time with the strategy of completion of land use mapping within 5 years to come as directed by the parliamentary committee in 2071.

The different land use zones as per the Land Use Policy, 2072 are made in appropriate hierarchy as per the requirement of the data model provided by the DUDBC Office. As per the Land Use Policy - 2072, the hierarchy of 11 types of fundamental land use zones are such as ***Agricultural Zone, Residential Zone, Commercial Zone, Industrial Zone, Mining and Mineral Zone, Cultural and Archaeological Zone, Riverine and Lake Area, Forest Zone, Public Service Zone and Others***.
In the context stated above, the municipality land use zoning has been commissioned to pursue the project entitled *Preparation of municipality level land resource maps, databases and reports for Ilam Municipality* of Ilam District by DUDBC Office, Kathmandu.

1.2 Observes and Scope of the Study

1.2.1 Objectives

The main objective of the study is to carryout land use zoning; prepare land use zoning maps, GIS database and reports of Ilam Minicipality of Ilam district of Nepal. The specific objectives of this study are:

- To perform land use zoning of Ilam Minicipality by using different available data sources using multi-criteria analysis in GIS.
- To produce land use zoning map at 1:10,000 scale showing different zones and sub-zones as per the Government's National Land Use Policy 2072 BS.
- To prepare appropriate GIS database of proposed land use zoning.
- To prepare detailed report containing conceptual basis and methodology, criteria of land use zoning, distribution of different land use zones and data models of GIS database.

1.2.2 Scope

The scope of this project is limited to:

- Studying the existing relevant maps, documents, and database of the project area
- Preparing land use zoning maps of the Ilam Minicipality at 1:10000 scale portraying different zones and sub-zones as per the Government's Land Use Policy 2072 BS
- Designing appropriate GIS database logically on land use zoning for the Ilam Minicipality
- Discussing accuracy, reliability and consistency of data
- Preparing detailed reports, describing methodology, criteria and distribution of different land use zones and sub zones with GIS data models and databases.

1.3 Study Area

Ilam is a municipality of Ilam District, which is in the hilly region of Mechi zone, in the Eastern Development Region of Nepal. Ilam also acts as the headquarters of Ilam District and Mechi zone. Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of the important town in Mechi zone and one of the major place in Nepal for tea-production. It is famous for natural scenery and landscapes, tea production, and diverse agricultural economy. It is one of the major horticultural crop production districts of Nepal. Ilam municipality is sub-divided in 9 different wards; the major governmental and district office lies in ward number 1 and ward number 2. Ilam also is a major hub for transportation and communication for VDC that lies in the upper part of the discrict. The municipality was established in 2015 B.S.

Geographically Ilam Municipality is situated in the middle part of the district. It is extended from 87 ^{o}53’30” to 87 ^{o}57’46” Eastern Longitude and 26 ^{o}51’58” to 26^{o}56’46”Northern Latitude have an area of 27.0 Square Kilometer.

Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municapility is surrounded by Mai Khola (River) to the east, PuwaKhola (River) to the west, Barbote VDC (Village) to the north and Mai Khola&PuwaKhola (Rivers) to the south.

The social condition portrays the different facets of a society. An effort has been made to reveal social condition of this municipality in terms of population by age and sex, population growth, caste/ethnicity, language, religion and literacy. The social setting of this municipality is found good. The major ethnic groups living here are Chhetri, Brahmin, Tamang, Newar, Tamang, Rai, and Limbu. Although there are different ethnic groups, there is we-feeling and are residing with social harmony. Major population of this area is engaged in agriculture, whereas the rest are associated with business.

The total population of this municipality is 18633 of which male population accounts for 8946 and female population is 9687. There are 4732 households in this municipality and average households size of 3.94.The population density per sq. km. is estimated 690.

Age group in an important aspect of demography which shows the potential growth and economically active population. A significant feature of any population is the distribution of its members according to age, which facilitate the planner and policy makers in formulating effective socio-economic development plans for the population of different age groups. The table shows that the highest proposition of population is found in age group of 25-44 (29.82%).

The basic population of this municipality comprises the different castes and ethnic groups. Caste rules were basic cultural values which influenced occupation, marriage, food habits and other social behaviors. There are 7.58% Dalit, 44.34% ethnic groups and 48.08% other caste groups including Chhetree, Brahmin, Musalman, Thakuri, Chhetri etc.

Lateracy status is one of the most important social characterists of population. The literacy status of this municipality is quite satisfactory in comparison with the nation. Total literacy rate of this municipality is 84.66 percent. 90.53 percent of men are literate while women are 79.32 percent literate.

CHAPTER 2: CONCEPTUAL BASIS OF LAND USE ZONING

This chapter presents the conceptual basis and principles of land use zoning. It explains the land use zones and their detailed description as mentioned in the National Land Use Policy 2072 and also highlights on the general criteria used for land use zoning.

2.1 Land Use Zoning, Principles and Criteria

2.1.1 Land Use Zoning

Zoning is a technique of land use planning used mainly by the local governments in most of the developed countries. It is the practice of assigning permitted uses of land based on official zoning record which separate one set of land uses from another. Land zoning is how local institution, such as Village/ Municipal/ District Councils restrict the physical development and use of specific parcels of land.

Land use zoning determines the types of activities (such as agricultural, residential, commercial or industrial) that can occur on the land. Theoretically, the primary purpose of zoning is to separate land uses that are thought to be incompatible to each other. A detailed map or plan may be prepared showing different allocated use on the particular land or territory. As such, the zoning map portrays and reflects both current conditions and anticipated conditions.

A Zoning Map is a graphic depiction of the boundaries for which a certain set of standards or regulations have been adopted by a government entity. The zoning map typically provides predictability for the residents and development community as to what type of land uses may be expected and allowed within each Municipality/VDC/ district. Land is divided into zones on the basis of land capability and suitability analysis. The zonation of land is further supported and regulated by specific regulations which ensure designated use of each particular zone category.
Land use zoning is assessed based on the suitability of sustainable use for a specific purpose. Land use zoning differs from land capability classification in a sense that land capability is general classification of land based on arability and productivity of soil without degradation or offsite effects of farming whereas land use zoning is suitability classification of land for various land use purposes.
Zoning is commonly controlled by local governments such as municipalities or villages, though the nature of the zoning regime may be determined or limited by state or national planning authorities or through enabling specific legislation.

2.1.2 Land use Zoning Principles

The main principles adopted for land use zoning are as follows:

- Promotion of complementary land use
- Maintain competitive land use
- Avoid conflicting land use

Moreover, land use zoning process specifically adopts the following spirit and follows these principles:

- Identification and protection of prime land areas for suitable agricultural crop production.
- Development of stable, attractive, safe and secured residential neighborhoods which contain a range of supportive commercial, institutional, and public facilities
- Development of stable and functional commercial centers based on site suitability and compatibility with adjacent land uses.
- Identification, development and protection of prime land areas for future quality industrial growth based on site suitability and compatibility with adjacent land uses.
- Protection of natural resources and environment for green and eco-friendly society
- Protection and conservation of cultural, religious and archeological heritages for future generations
- Appropriate management of river, water bodies, wetlands and watersheds for sustainable future use
- Provision of appropriate location and distribution of public facilities such as transportation, parks and schools throughout the community.
- Promotion of rehabilitation and improvement of the living environment in older neighborhoods and areas characterized by conflicting patterns of land use.
- Promotion of land use activities appropriate to the features and characteristics of the natural landscape.
- Appropriate management of mines, minerals and other land based resources for optimum use and support sustainable development
- Support and promote consistency between the Land Use Plan and current land use pattern.
- Provision of adequate transitioning and buffering between residential/ commercial uses and industrial uses.
- Promote growth in areas adjacent to existing urban development so that public services and facilities may be provided efficiently and economically.

2.1.3 Land use Zoning Criteria

Based on the above mentioned objectives, principles and description of land use zones, zoning is carried out adopting the following broad guidelines:

- The zoning of the Municipality should not contradict with the essence of the National Land Use Policy, 2072.
- In identifying potential residential zone a model based on the growth of built-up area in last ten years and infrastructure development within the area should be used.
- The existing forest land should be kept intact in the zoning.
- Based on the soil suitability analysis the prime agricultural lands should be preserved for future food reserve.
- Emphasis should be made to allocate less or unproductive barren lands and areas of marginal productivity for future residential, industrial, commercial and public service zone.
- Analysis of hazard risk must be done before working on zoning. Mainly the flood, landslide, erosion, seismic, fire and industrial hazard should be taken into account. Zoning

should be done in such a way that the land use zones with human activities should be restricted to the areas with low hazardous or hazard free area as much as possible.

- Sufficient land should be zoned at appropriate locations throughout the study area to accommodate the expected growth in population and other growth needs of the study area within the lifetime of the Plan.
- Zoning should be designed to promote particular uses in appropriate locations, to reduce conflict of uses and to protect resources. Where appropriate, zonings should be used as a tool for shaping the area and not solely reflect existing land uses.
- Development should be encouraged in established centers and the development of underutilized land in these areas should be promoted with a view to consolidating and adding vitality to existing centers, and ensuring the efficient use of the lands thereby, according with the principles set out in the National Land Use Policy.

Based on the above guidelines, the general criteria for zoning are as following:

1. Agricultural Area

a. Most of the agricultural areas are kept intact but it is almost impossible to retain all agricultural areas as some of the newly proposed residential, commercial, industrial and public use areas are proposed on the agricultural land. It is essential to address the needs of housing, marketing, employments, public utility development and other economic activities besides agriculture for the growing population. Therefore, the agricultural areas may be slightly decreased. However, we need to retain the most arable agricultural land and marginally capable lands should be used for infrastructure development.

b. Within the agricultural land, the area of comparative advantage can be identified on the basis of land capability, land system, temperature, irrigation and drainage system, and other physical, chemical parameters of soil. Extensive discussions are done with agriculture experts and their opinion is taken to do further sub classification of agricultural land.

2. **Residential Area**:

a. The existing residential area is kept intact if they are risk free or at low risk. Generally, the settlements in the local area or villages are established on the basis of inherent indigenous knowledge, they are generally safe and the infrastructures are already available in many of the areas. Therefore, these settlements are kept intact.

b. Keeping the local population growth and flow of internal migration to the area in mind and looking at the rate of built-up development in the area during last 10 years, some new settlements are proposed. Some of the criteria to identify appropriate land for new settlements are:

i. The land should be free from or at low hazard risk as much as possible
ii. The area should be in the neighborhood of the existing settlement, if possible
iii. Availability of Road and infrastructures if possible
iv. The area should not in the flood plain of any river
v. The area should be geologically stable

vi. The area should not be in the vicinity of dense forests and Industrial areas as much as possible
vii. The land should be of marginal utilization, i.e. the land should be less capable for agricultural crop production

3. Commercial Area

a. The existing commercial area is kept intact as they are already establishes according to the necessity of the local people in or near residential areas.
b. For the future planning, the land is allocated for the new commercial and business areas including government institution on the basis of the following criteria:
i. The land should be free from or at low hazard risk as much as possible
ii. The areas should be in the neighborhood of residential area, number of household and population should be considered
iii. Availability of road and infrastructures if possible
iv. The area should not in the flood plain of any river
v. The area should be geologically stable
vi. The area should not be in the vicinity of dense forests and Industrial areas as much as possible
vii. The land should be of marginal utilization, i.e. the land should be less capable for agricultural crop production

4. Industrial Area

a. Most of the existing industries in the rural area are small and are agriculture based. The impacts of these industries on human activities are not much prominent. Therefore, the existing small industries are kept intact. Most of the heavy industries are already either far from settlement or they are managed in such a way that the impact should be less on the human activities. Such kind of industries, if found affecting human life, will be recommended to relocate.
b. For the proposed industrial areas, the following criteria are chosen:
i. The land should be free from or at low hazard risk as much as possible
ii. It should be in the neighborhood of existing industrial area (if it is already suitable)
iii. It should not be in the vicinity of residential and commercial area but within the approachable distance from market and settlements with infrastructures
iv. The area should have accessibility to roads if possible
v. The area should not be in the vicinity of rivers, ponds or any other water sources and dense forest
vi. The land should be of marginal utilization, i.e. the land should be less capable for agricultural crop production
vii. Geologically stable
viii. The proposed industrial area should not be in the international boundary but can be in the bordering area of two or more administrative units (Municipality/VDC/Districts) so that there would be opportunity to share benefits of the resources of both administrative units

5. Forest Area

a. Existing forests are kept intact
b. New forests or plantation are proposed mainly on the basis of the following criteria:

i. Barren lands, Wetlands, Abandoned lands
ii. Slopping land, watershed, high mountains
iii. Flood and erosion prone river banks
iv. Other lands of marginal utilization
v. Sides of roads, canals etc., if possible
vi. Near or around Industrial areas to make natural protection from pollution
vii. On the land under high or medium hazard risk
viii. Other suitable areas for agro-forestry or timber product etc

6. Public Use zone

a. Existing public use areas are kept intact
b. Some of the new public use areas such as Health, Education, open area etc are proposed on the vicinity of existing and proposed residential/commercial/industrial areas wherever appropriate.
c. Mostly, these types of service areas are located on the basis of the necessity and requirement of the local people. Therefore, this category is suggested to be planned after discussion with local community using participatory approach.

7. Mining and Minerals Zone

a. Existing Mining and Minerals areas as defined and described by National Land use Policy 2072
b. Identified and prescribed areas as potential Mining and Minerals area in future

8. Cultural and Archaeological Zone

a. Existing religious, cultural, archeological areas as defined and described by National Land use Policy 2072
b. Area defined as cultural heritage and their master plans

9. Riverine and Lake Area Zone

a. Existing Riverine and Lake Area as defined and described by National Land use Policy, 2072

10. Excavation (Construction Material) Zone

a. Existing areas as defined by National Land Use Policy, 2072
b. Areas prescribed and allocated by the national/local government for such use
c. Areas found appropriate from expert's study for such use in future

11. Other Zone prescribed as required

a. As per the prescription of experts and decision of the government
b. If any land use cant not be fit in any class mentioned above

2.1.4 Land Use Zones and their Descriptions

According to the National Land Use Policy 2072 BS, there must be following eleven land use zones:

1. **Agricultural Zone**

The agricultural zone means the area where there is a presence of agro products (food grains, cash crops, horticulture, etc.), animal husbandry, fisheries, agro and forest products or orchards in a private land. This word also indicates a region prescribed by the government as an agricultural zone.

2. **Residential Zone**

Residential zone means the land used by people for shelter or housing and the word also includes animal shed, food container, garage, stable, well, tap, orchard, backyard, courtyard or land with any other use whether joined with the house or separate. This word also denotes a collective housing or apartment built by a business company or institution, and also to a specific land declared by the government for housing purposes.

3. **Commercial Zone**

Commercial zone means the land occupied by or allocated for shops, hotels, exhibition stalls, petrol pumps, warehouses, health and information facilities, commodities trade centre, an organization providing any literary, scientific or technical service or advice, fair venues, discos, clubs, swimming pools, cinema halls opened for business purposes, entertainment joints or any other building meant for commercial use. This word shall also include a commercial building built in a trade zone by a business company or institution and the land occupied by the same. Moreover, this word shall also indicate an area declared by the government to develop a city for market expansion and commercial use in a definite geographical region.

4. **Industrial Zone**

Industrial zone means the land occupied by or allocated for any workshop, goods manufacturing industry, the associated buildings and sheds. This word also denotes an industrial corridor, industrial village, cluster, special export zone and special economic zone declared by the government for industrial promotion in a definite geographical region.

5. **Mining and Minerals Zone**

Mining and minerals zone means a land being used for mining, production or processing of minerals or area declared by the government as a mining and quarrying zone definite geographical region. This word also includes any area where mineral deposit is discovered or a mine is operational, where industries for mining, production, processing and purification of minerals are being located as well as the associated buildings, sheds as the land being used for the operation of such industries as well.

6. **Cultural and Archaeological Zone**

Cultural and archaeological zone means the forts, palaces, buildings, temples, shrines, mosques, monasteries, Manes, with a historical and archaeological significance as well as other pilgrimage

sites and places of worship. This word also implies an area declared by the government as a historical, cultural, religious and archaeological place in a definite geographical region.

7. Riverine and Lake Area Zone

Riverine and Lake Area zone means an area where rivers, rivulets, streams, canals, lakes, ponds, long-holding swamps or wetlands are existent.

8. Forest Zone

Forest zone means an areas being covered with public, community, leasehold forests in part or entirety, national parks, wildlife reserves, conservation areas, bushes, shrubs, plains, all types of jungles and places designated by the government as a forest regardless of whether there are trees or not. This term also infers an area nominated by the government for the expansion of forests or green areas, in a definite geographical region.

9. Public use Zone

Public utilities and open zone means land occupied by schools, colleges, vocational educational centres, academic institutions including the universities, security agencies, health centres, health posts, private or community hospitals, telecom, drinking water, government agencies involved in providing electricity or other energy, community buildings, libraries, old age homes, child protection homes, other buildings, sheds, platforms erected for public use. This term also includes the hills, meadows, cliffs, mountains, snow covered areas, pastures. The word also denotes playgrounds, parks, stadiums, grounds, platforms, picnic spots, open places having no special use, district roads, rural roads, bus parks, airports, cargo areas, dry ports, railways, ropeways, waterways, cable cars, electricity transmission lines, ports and the places designated as public utilities zone by the government or prevailing laws.

10. Excavation (Construction Material) Zone

Excavation (Construction Material) zone means the area designated for quarrying, production or processing of stones, pebbles and sand as per the determined standards, or any other place designated by the government as an aggregate quarrying zone (stones, pebbles and sand) in a definite geographical region.

11. Other Zone prescribed as required

Other Zones prescribed as required mean the areas that do not fall under any of the above land use zones but which need to be mentioned as an exclusive land use zone. This term also implies an area with mixed characteristics. Mixed zone means the areas where the residential and business zones have merged so seamlessly that they cannot be bifurcated as is seen now in various cities, towns, highway areas. This zone shall be applied only for regulating settlements and market areas that have been since the past.

In this study, the instructions of National Land Use Policy 2072 are followed and categorized the study area on the following zones and sub-zones as shown in the table 2.1.

Table 2.1 Land use zoning scheme of the study area

Class	Zone	Zone Type	Code	Sub zone	Description	Remarks
1	Zone 1	Agricultural Zone	AGR	Zone 1A	Cereal crop production area	
				Zone 1B	Cash crop area	
				Zone 1C	Horticultural area	
				Zone 1D	Animal husbandry area	
				Zone 1E	Fish farming area	
				Zone 1F	Agro forestry area	
2	Zone 2	Residential Zone	RES	Zone 2A	Existing residential zone	
				Zone 2B	Potential area for residential zone	
3	Zone 3	Commercial Zone	COM	Zone3A	Governmental institutions and service areas	
				Zone 3B	Business area	
4	Zone 4	Industrial Zone	IND	Zone 4A	Areas under industrial use	
				Zone 4B	Potential area for Industrial zone	
5	Zone 5	Forest Zone	FOR	Zone 5A	Existing forest	
				Zone 5B	Potential area for forest including barren lands, wet lands etc.	
6	Zone 6	Public use Zone	PUB	Zone 6A	Areas under roads, railways, bus parks, airport and land fill site etc.	
				Zone 6C	Open spaces, picnic spots, playing grounds and stadiums etc.	
				Zone 6E	health/education/library, police station, fire station, telephone /electricity areas etc.	
				Zone 6F	Grazing Land	
7	Zone 7	Other area	OTH	Zone 7	as per requirement	if necessary
8	Zone 8	Mining and Minerals Zone	MIN	Zone 8A	Existing Mines and mineral area	
				Zone 8B	Potential areas for Mines and mineral	
9	Zone 9	Cultural and Archeological Zone	CULARCH	Zone 9A	Existing cultural and archeological area	
				Zone 8B	Potential cultural and archeological areas	
10	Zone 10	Riverine and Lake Area zone	HYD	Zone 10A	Existing rivers and riverine area	
				Zone 10B	Potential hydrographic areas	
11	Zone 11	Excavation (Construction Materials Zone	EXC	Zone 11A	Existing quarrying and excavation area	
				Zone 11B	Potential areas for quarrying and excavation	

CHAPTER 3: METHODOLOGY

This chapter deals with the data used and method adopted for land use zoning and preparing land use zoning maps.

3.1 Data

Various data sources are used in this land use zoning exercise. The major data sources include:

- Ortho rectified very high resolution satellite image World View-2 of the study area,
- GIS vector data (shape file) of mainly land capability, land system, present land use, and administrative boundary (VDC, Ward),
- Various maps (Land system, Capability) data, and reports from LRMP, and
- Socio economic data and village profile

3.2 General Approach and Methodology Framework

Government of Nepal has enacted the National Land Use Policy 2072. According to the policy the overall land mass of nation shall be divided into 11 land use zones as mentioned above. These zones shall be further sub-divided into sub-zones as required.

Since earthquakes, landslides of devastating nature and other natural calamities negatively affect more than one land use zones, the risk prone areas shall be identified through geological review and such risk spots shall be marked in the land use maps so as to sustainably secure the development of settlements, townships and infrastructure in an earthquake and other risk resistant manner.

The primary bases of land use zoning are as follows:

a) The basis of land composition, capability and appropriateness

The indicator of geographical and geological land composition, capability and appropriateness shall be the primary basis for determining land use zoning.

b) The basis of present land use

The land use zone for a particular area shall be determined on the basis of present land use of that area, if it is in accordance with its land composition, capacity and appropriateness.

c) The basis of necessity

In case the state has to use any particular land for a use other than it is directed for public good and development of physical infrastructure, then the land use zone shall be assigned in a manner so as to facilitate its utilization as per the need.

The zoning map is prepared keeping the objective of the policy in mind. Therefore, the following main principles are adopted:

- Agricultural land should be kept intact as much as possible

- Forest cover should not be decreased, but can be increased. Wetlands should be preserved.
- Natural disasters such as flood risks should be minimized
- Appropriate housing and residential areas should be identified for planned settlement
- Appropriate land should be allocated to commercial, business and industrial areas for economic activities
- Area of comparative advantage should be identified within agricultural crop production

To achieve the aforementioned objectives, the following basis is taken for land use zoning:

- Existing land use
- Capability and suitability of the land
- Socio economic data
- Expert's opinion
- Subjective analysis

3.3 Methods

Mainly two methods are applied for land use zoning in this study

a. Multi-criteria Analysis

Land use zoning is carried out by considering various criteria as mentioned in the previous section. These criteria are translated in GIS software and analysis is done. This is a scientific process and individual judgments cannot be made while applying the process. The suitability of certain use is judged by the software based on the provided criteria. An example of such criteria is the potential residential area should not lie in a flood prone-risky land, highly productive agricultural land and in a slopping terrace of more than 30°. These kinds of multiple criteria are evaluated and suitable land for particular use is identified with the help of GIS software.

b. Subjective Analysis

Subjective analysis on the basis of requirement and expert's opinion is carried out. As an example, if a small piece of land is found suitable for agricultural use, it is surrounded by residential area, then it is placed in the residential area. Similarly, if the land is found suitable for agricultural purpose but it is in the flood plain of the river and high risk of flooding, then it can be used for forest and plantation to control the flood.

General approach and methodology used for the land use zoning is shown on the following schematic diagram (Figure 3.1).

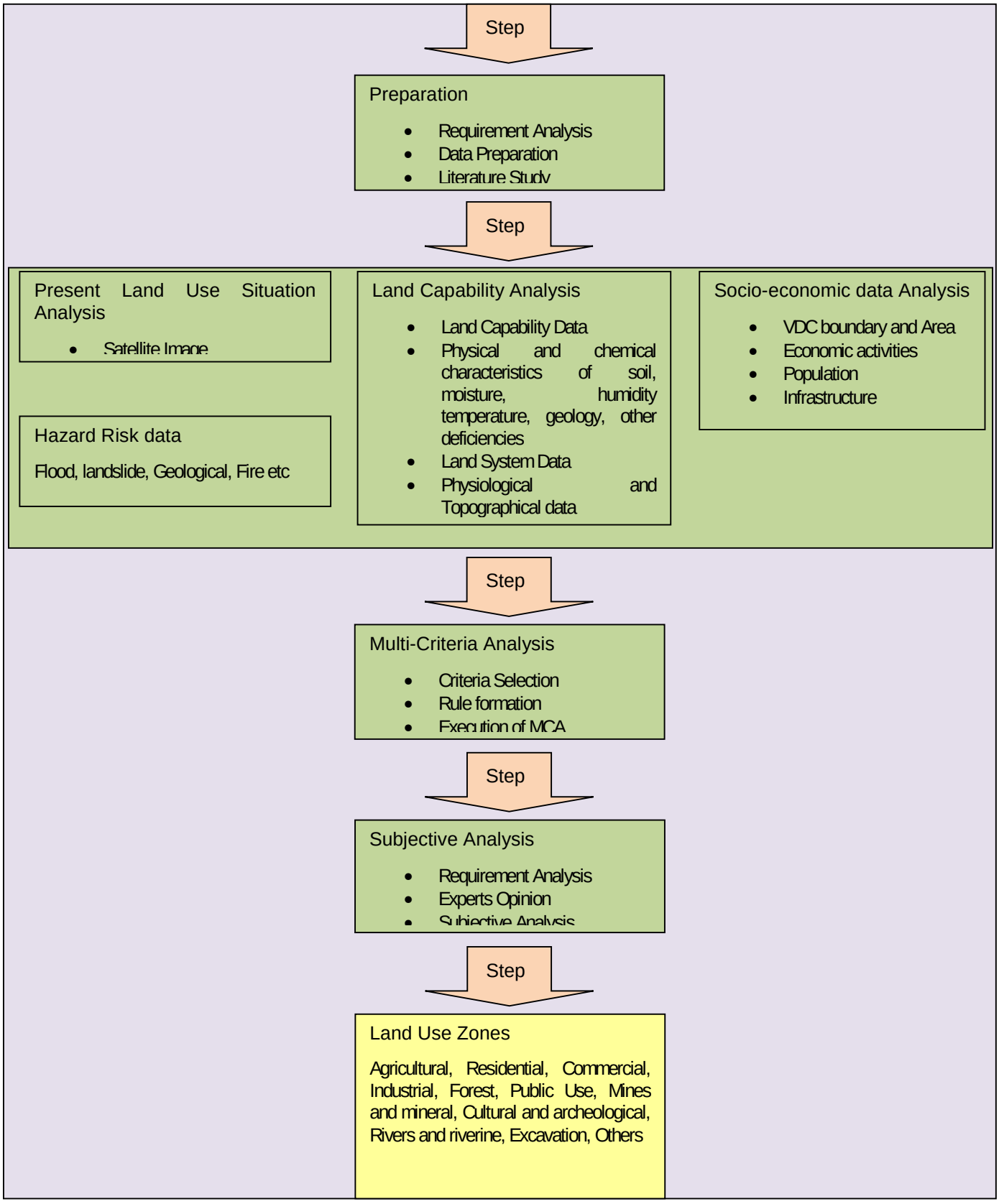

Figure 3.1 Methodology used for land use zoning

3.4 Result

The methods described in the previous chapter are applied and GIS analysis is performed on the various steps for land use zoning. The land use zones identified in this VDC are summarized on the Table 3.1.

Table 3.1 Land use zones of the study area

Class	**Zone**	**Zone Type**	**Code**	**Sub zone**	Description	Area of sub zone type (Ha)	% of individual zone	**Area of zone type (Ha)**	**% of total area**
1	Zone 1	Agricultural	AGR	Zone 1A	Cereal crop production area	976.5	78.7	1240.87	46.57
				Zone 1B	Cash crop area	194.0	15.6		
				Zone 1C	Horticulture	1.1	0.1		
				Zone 1D	Animal Husbandry	0.00	0.00		
				Zone 1E	Fish farming area	0.00	0.00		
				Zone 1F	Agro-forestry	69.3	5.6		
2	Zone 2	Residential	RES	Zone 2A	Existing residential zone	177.4	95.5	185.80	6.97
				Zone 2B	Potential area for residential zone	8.4	4.5		
3	Zone 3	Commercial	COM	Zone3A	Government institutions and service areas	5.6	43.9	12.81	0.48
				Zone 3B	Business area	7.2	56.1		
4	Zone 4	Industrial	IND	Zone 4A	Areas under industrial use	0.00	0.00	9.39	0.35
				Zone 4B	Potential area for Industrial zone	9.4	100.0		
5	Zone 5	Forest	FOR	Zone 5A	Existing forest	891.8	98.5	905.64	33.99
				Zone 5B	Potential area for forest including barren lands, wet lands etc.	13.9	1.5		
6	Zone 6	Public use	PUB	Zone 6A	Areas under roads, railways, bus parks, airport and land fill site etc.	201.2	92.2	218.20	8.19

				Zone 6C	Recreation, picnic spot	1.1	0.5		
				Zone 6E	Health, education etc. institutions	10.9	5.0		
				Zone 6F	Grazing land	0.00	0.00		
				Zone 6G	Government Institutional Area	2.9	1.3		
				Zone 6H	Open spaces	2.1	0.9		
7	Zone 7	Other area	OTH	Zone 7	as per requirement	0.00	0.00	0.00	0.00
8	Zone 8	Mining and Minerals Zone	MIN	Zone 8A	Existing Mines and mineral area	0.00	0.00		
				Zone 8B	Potential areas for Mines and mineral	0.00	0.00	0.00	0.00
9	Zone 9	Cultural and Archeological	CUL ARCH	Zone 9A	Existing cultural and archeological area	0.3	67.2		
				Zone 9B	Potential cultural and archeological areas	0.1	32.8	0.44	0.02
10	Zone 10	Riverine and Lake Area	HYD	Zone 10A	Existing rivers and riverine area	91.32	100.00		
				Zone 10B	Potential hydrographic areas	91.3	100.0	91.32	3.43
11	Zone 11	Excavation (Construction Materials)	EXC	Zone 11A	Existing quarrying and excavation area	0.00	0.00		
				Zone 11B	Potential areas for quarrying and excavation	0.00	0.00	0.00	0.00
Total								2664.46	100.00

The existing areas used for different purposes are shown in Figure 3.2. Agriculture is the dominant land use type in the study area which covers almost 46.5 percent of the total area followed by forest (33.9 percent), residential area (6.9 percent) and public use area (8.2 percent) and riverine and lake area (3.43 percent). The area used for commercial, industrial, excavation, cultural and archeological purposes are not significant in terms of area occupied by these categories in the VDC. The mines and mineral sites do not exist however, some river banks are being used to excavate sands and stones.

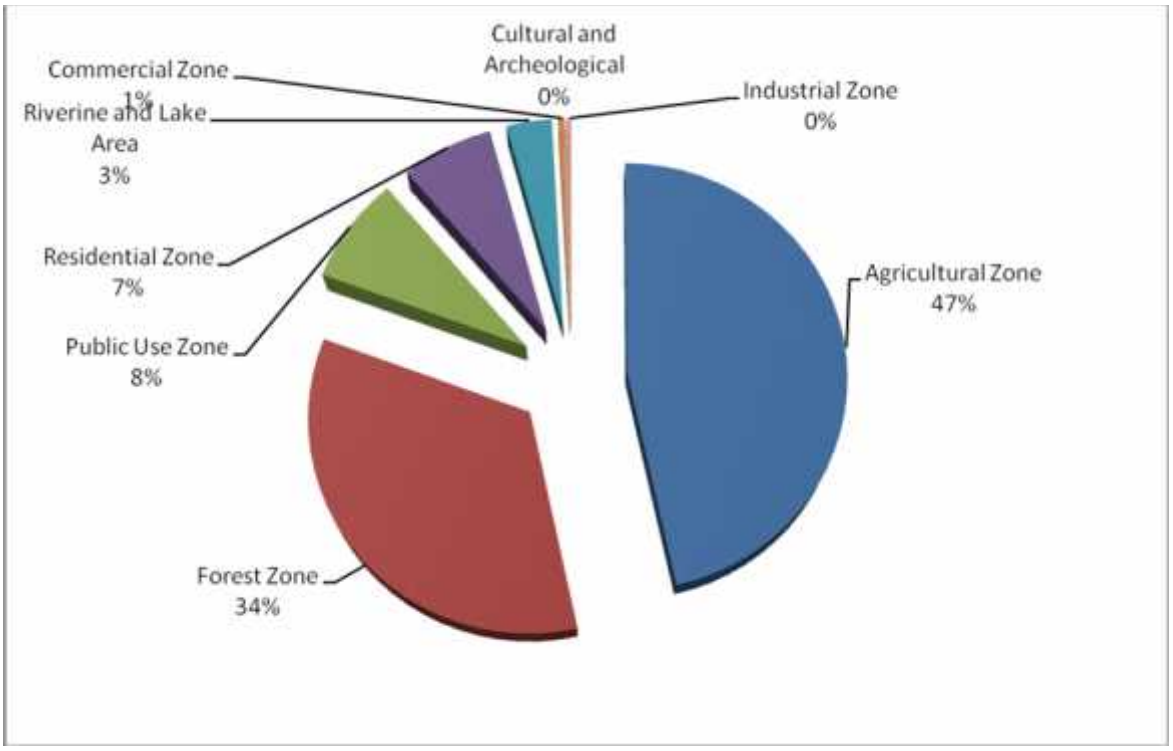

Figure 3.2 Status of existing land use in Ilam Minicipality

More than 80 percent of agricultural land is occupied by cereal crop production (Figure, 3.3) and cash crops occupy only 16 percent of the total agricultural lands. About five percent of agricultural land is occupied by agro forestry..

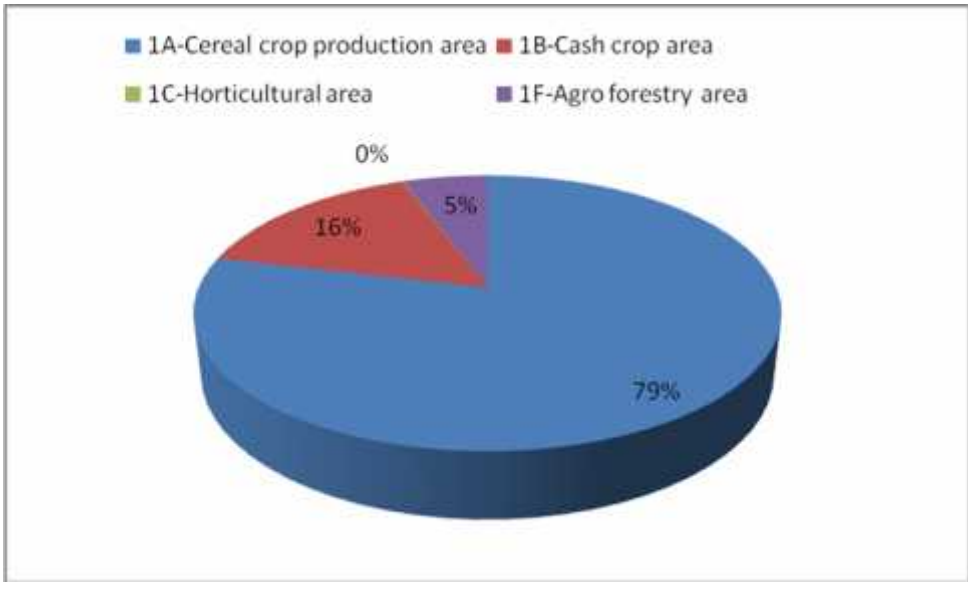

Figure 3.3 : Distribution of agricultural sub-zones, Ilam Minicipality

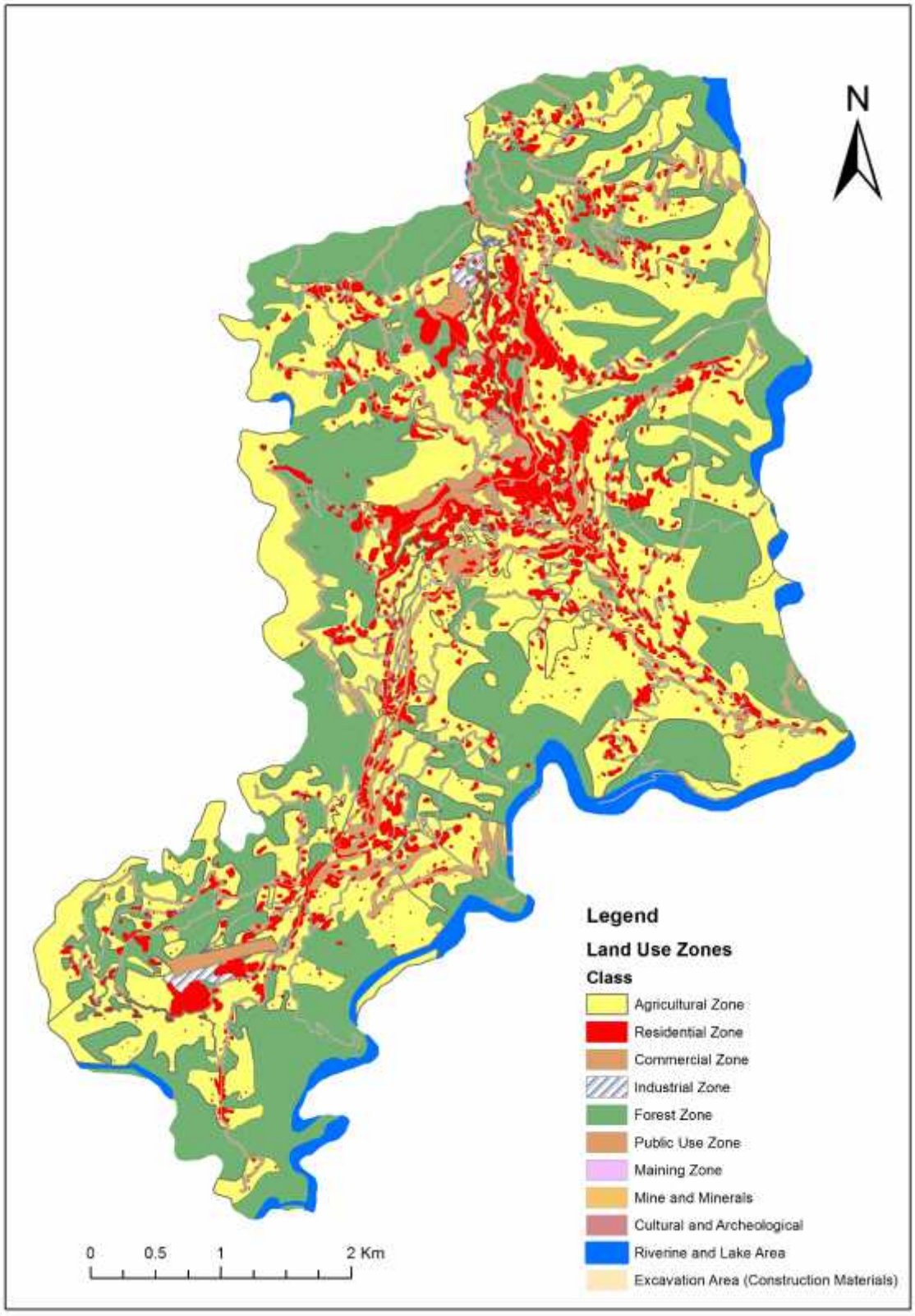

Figure 3.4 Land Use Zoning Map of Ilam Minicipality

3.5 Discussion

As noted above, almost 46 percent of the total area is occupied by agricultural lands, the existing agricultural area declines with the new zonation of the lands. Some lands are proposed for residential, commercial, industrial and public uses (roads) considering the increasing demand of such lands and some for forest area. Obviously, this needs extra lands and proposed in agricultural lands. For this allocation, land suitability analysis was done using land capability data. Lands of marginal utilization with low capability of agricultural production as well as areas with poor drainage are allocated for residential, industrial and commercial areas as far as possible. Likewise, the land areas having high risk of bank cutting, erosion and flood prone are proposed for forest area.

According to the CBS data, the rate of population growth is almost 1.46 percent during the decades 2001 to 2011. It has been observed that the present settlement has been developed gradually in last 50 years. But in last 10 years, the rate of urbanization is very high. The main reasons behind this include internal migration from the hills as well as rural area, increasing investment of remittance earned from foreign employment on housing lands in urban areas, increasing social trend of unitary small family. population growth is expected to rise further due to inflow of migrants from rural VDCs in search of better education and employment. Therefore, significant growth can be seen in the residential zoning. Buildings in this area are used for mixed purposes i.e. residential and commercial purposes. This is the reason why the commercial area is shown very low in proportion. However, some new commercial and business areas are proposed considering the future demand of increasing size of population in this area. The population in this has been rising tremendously in recent years.

The land used for industrial purpose is limited. There are only two industrial areas purposes to establishments industry. These include agro-processing industries, bag factory, crusher industry and Petrol pump.

Although most of the land is used for agricultural purposes, the optimum utilization of land is not observed in the study area. Most of the fertile land has been left uncultivated and barren. The main reason behind this as pointed are lack of irrigation facility, working labor, and high production cost (high cost of fertilizers, seeds and other production requirements). The benefit as compared to investment is very low. Considering the situations the Government should identify appropriate solutions to address the problem.

Regarding crops, cereal and cash crops are mostly produced in this area. Maize and wheat are the main cereal crops whereas tea, vegetable and oilseeds are the major cash crops grown in this area. Few people have shown their interest to horticulture, specially, fruits. Soils are moderately fertile so they are more suitable for cash crops. Animal husbandry is most suitable in this area. The area is mostly safe for human settlement as it is located in the flat plain because of igh value of land, the risk of landslide is shown in the hill slope. The risk of bank cutting and flooding is limited and liable especially in dame area. However, the situation is not much severe. Nonetheless, many houses are made of woods and other inflammable material, thus, risk of fire outburst exists in some areas.

CHAPTER 4: LAND USE ZONES OF THE STUDY AREA

4.1 Risk Areas within the study area

There is no much risk for human activities in this area. The most prominent risk observed in the area is because of flood in rainy season. Mai khola and other streams which may cause destruction of human life and livelihood base of the local people when they flood. As the study area lies in the hill area, so the risk of landslide is liable in steep slope. However, bank cutting and erosion of fertile land has been observed.

To identify such flood prone area and the extent of flood, flood modeling has been carried out. The flood prone area has been classified as high, medium and low risk areas for flooding. The high and medium risky area has not been allocated to those land use zones which may have higher human interactions such as residential, commercial and industrial areas. These areas are proposed for forest and plantation areas to reduce the impact of potential floods in the future. The area with low flood risk is allocated for agricultural activity.
No major industrial area exists in this municipality. However, the consultant proposed not to build any residential or commercial structures within a periphery of 500m from the existing industrial area.

The other risk in the area is because of fire spreading in summer. In rural settlement, some houses are made of wood and other combustible materials. These houses are in cluster and attached to each other in the main market area. Further, many of the households used to store fuel woods, straw and other inflammable material inside or adjoining to houses for daily use. In this situation, if one of the house or surrounding catches fire accidently, there is a huge risk of spreading fire all over the settlement.

4.2 Analysis of Present Land Use and Potential Land use Zone

The detailed description of risk and risk prone area in the study site is separately described and delineated in risk study.
Figure 3.4 clearly shows that agricultural area is the single dominant land use type followed by residential area, forest, public use area, and riverine and lake Area. The lands occupied for commercial, Industrial, and cultural and archeological purposes are not significant in terms of area occupied. The Mines and mineral sites do not exist in the municipality except for excavation some construction materials like stone and sand.

The agricultural area is decreased by 2.5 ha while zoning. The proposed allocation of new sites for residential, Industrial and commercial use needs extra land. The proposed lands were allocated after suitability analysis was done using land capability data. Land of marginal utilization with low capability of agricultural production and poor drainage facility is allocated for residential, industrial and commercial use as far as possible.

4.3 Analysis of Safe settlement Areas and Open Areas

Existing settlement in the area are mostly safe. However, some settlements or individual houses lies in the landslide prone area

According to the CBS data, the rate of population growth is almost 1.46 in this area during 2001 and 2011. It has been observed that the present settlement has been developed gradually in last 50 years. But in last 10 years, the rate of urbanization is increasing rapidly because of district headquarter. The main reason behind this is internal migration, foreign employment, increasing social trend to small family. Therefore, significant growth can be seen in the residential zoning.
These areas have a mixed type of use of residential and commercial purpose. This is the reason why the commercial area is shown very low in proportion. However, some new commercial and business area are proposed for future use which is required for serving the need of high population growth in the area.
The potential residential areas for future settlement are proposed after thorough study of possible hazards in the area. New settlements are not proposed in around under industrial area and other risks area. Therefore, the residential and commercial areas are almost at minimum risk. Because of the limitation of available techniques, the seismic hazard and its occurrences cannot be studied and couldn't be considered for proposing new residential, commercial as well as industrial zones. However, geological stability is studied and considered during the process.

Regarding open area, the study site is rural area which means most of the land is periphery of forest and agriculture area. The residential and other construction areas are very less. So, most of the areas are open in nature. However, open area left for recreation purpose, parks and playgrounds are negligible except some open area used for grazing and unused /uncultivated lands.

4.4 Land Use Zone in the Study Area

The following land use zones are identified in this study area. The Mine and Mineral area are not identified in this municipality. The detailed description of land use zone in the study area has been provided in section 3.4.

Table 4.1 Land use zoning of Ilam Minicipality

SN	Land use type	Zoning Area (Ha)	Percent
1	Agricultural Zone	1240.871	46.57
2	Forest Zone	905.6389	33.99
3	Public Use Zone	218.1958	8.19
4	Residential Zone	185.7972	6.97
5	Riverine and Lake Area	91.32368	3.43
6	Commercial Zone	12.80871	0.48
7	Industrial Zone	9.387719	0.35
8	Cultural and Archeological	0.437453	0.02
	Total	**2664.461**	**100.00**

4.5 Land Use Zoning GIS Database

The following database schema is used for preparation of GIS database of land use zoning. The GIS database of land use zoning includes data field, data types, feature descriptions and remarks.

Table 4.2 Database schema used for land use zoning

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	
SHAPE	Geometry	Geometric Object type	
ID	Integer	Unique Object ID	
ZONE NO	String	Zone No	
ZONE TYPE	String	Zone type	
SUB ZONE TYPE	String	Subzone Type	
VDC	String	VDC/Municipality Name	
DISTRICT	String	District Name	

CHAPTER 5: CONCLUSIONS

5.1 Conclusions

Ilam Minicipality has covered significantly by agricultural land suitable for both cereal and cash crop production. Urbanization is getting increased and hence the agricultural land is being rapidly converted into residential and commercial purposes. Industrial and commercial activities in the municipality are not significant. Since, there is predominance of agricultural lands; most of the fertile land has should be utilized as per its capacity for food security as well. Most of the areas are safe for residential purpose.

5.2 Recommendation

- The zoning categories are too many which are overlapping and confusing. It is recommended to review and make them clearer.
- Zoning criteria are subjective, which may lead to ambiguous zoning and inconsistency amongst different consultants. Therefore, it is recommended to have a discussion and develop scientific guideline as much as possible.
- The land use in this area is still not deteriorated so far. Therefore, land use planning should be started on the basis of this study as soon as possible.
- The implementation should be initiated through local government to address the local needs. Some of the local needs and aspiration could not be judged by this study as it lacks wide participation of the local people. This study has suggested a potential place based on spatial analysis. But actual location should be ultimately finalized by the local people on the basis of available land and other circumstances.
- It is suggested to develop a micro zoning by the local government on the basis of this report/maps/database/document for further implementation.
- Land use act is the most important tool to take this policy in action. So it is recommended to formulate land use act and enact it as soon as possible.

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Government of Nepal
Ministry of Federal Affairs and Local Development
Ilam Municipality
Ilam

Preparation of GIS based Digital Base Urban Map Upgrade of Ilam Municipality, Ilam

Final Report

CADESTRAL SUPERIMPOSE

Submitted By:
JV Grid Consultant Pvt. Ltd, Galaxy Pvt. Ltd and ECN Consultancy Pvt. Ltd

June 2017

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Chapter 1

INTRODUCTION

The present chapter deals with the background, rationale and objectives of the cadastral layer superimpose on the land use zoning map in Illam Municipality of Illam District.

1.1 Background

Cadastral map is defined as "the outlines of the property and the parcel identifier normally are shown on large scale maps which, together with registers, may show for each separate property the nature, size, value and legal rights associated with the parcel" (Dooley). The cadastral map should be defined as the outline of parcels or pieces of land which constitute the units of the land recorded whatever the purpose of the land may be. Generally, cadastral maps are prepared based on the ground survey either with plane table or total station, and/or interpretation of ortho-photo prepared from stereo pairs of aerial photograph or high resolution satellite imageries. The cadastral map at all times should show the real situation, shape and size of each and every individual land parcel within the area with complete accuracy and adequacy. Cadastral maps are dynamic; they must reflect the changes in the cadastral framework arising from land development and land fragmentation.

The history of cadastral survey is not new in Nepal and it shows the system has existed in the country since *Lichchhav*i period (Singh, 1985). In around 1300 AD, during the *Lichchhav*i period the cadastral survey was initiated for assessing particular land with the objective of taxation. However, the land registration process was introduced only in 1923 AD in order to give the assurance of the transacted amount of money during land transaction (Bhumichitra). After the World War First, in 1923 analogue cadastral survey was introduced in Bhaktapur using plane table survey by a military named as Campase (Singh, 1985). With the introduction of Land (Survey & Measurement) Act, 1963 and Land Reform Program, 1964 in Nepal a nationwide systematic cadastral survey was carried to impose ceiling on land holding and implementation of land reform program. These steps made the cadastral map as the legal document defining the boundaries of land properties and provided the basic data for land administration together with land taxation. It has made cadastral maps as an integral part of the land registration process.

Recognising the importance of separate digital cadastral databases particularly after 9th five year plan in 2000, the government of Nepal has established office of the Department of Land Information Archive (DOLIA). It has the objective of creating digital cadastral database based on analogue cadastral survey data. DOLIA has been performing the management of digital cadastral database through the concerned district offices and the projects of preparing digital cadastral database simultaneously. In the DOLIA system, the attributes of the cadastral parcel feature (spatial data) contains the following fields (table 1.1).

Table 1.1: Schema of cadastral parcel feature class in the database of DOLIA

Field	Data Type	Description
OBJECT_ID	Object ID	Unique geometric object ID
SHAPE	Geometry	Geometric object type
SHAPE_LENGTH	Double	Parcel boundary length in meter
SHAPE_AREA	Double	Parcel geometric object area in sq. meter
PARCEL_NO	Integer	Parcel number as in cadastral map
DIST_ID	Integer	District ID
DISTRICT	Integer	District name
VDC_CODE	Integer	VDC Code
VDC_NAME	Integer	Name of the Municipality
WARD_NO	String	Ward number
GRID_SHEET	Integer	Grid sheet number
GRID_NO	Integer	Grid number of parcel map
GRIDSHEET_NO	String	Grid sheet number (Both sheet & grid no.)
LAND_TYPE	String	Parcel type (e.g. river, track, ravine, pine etc.)
PARCEL_KEY	String	Unique parcel key
PARCEL_TYPE	String	Parcel type (i.e. government, private, etc.)
SHEET_NO	String	Sheet number (Sheet1Ka)

Cadastral database are essential and useful in visualizing and implementing land use zoning regulations in an area. Land use zoning is the classification of land use as per the development of real state of that area. It is defined as “the segregation of land use into different areas for each type of use such as agricultural, vegetation (forest), industrial, residential and recreational” (Dictionary of Geography, 1990). In practice, generally, as per the policy of the central government, land use zoning regulation and restriction are implemented by the local government bodies to control and direct the development of property within their boundaries.

Land use zoning regulation is necessary to control the conversion of the food producing areas into other non-agricultural uses, to optimize the food security, improvement of environment and

sustainable development of land. Land use zones separate one set of land uses from another based on the optimum and sustainable use of resources. For this purpose, it is necessary to identify the proper zone of an individual parcel. Zoning of a parcel of land where all surrounding parcels are zoned for a different use in particular creates a use that is compatible with surrounding land uses.

1.2 Rationale of the Study

It is not an exaggeration to state that Nepalese economy and social lifestyle are intimately related to land and thus proper management of land resources is an important issue. Due to the finite nature of land resources, increase in population, industrialization and increasing number of disasters in the wake of climate change always pose threat to the land resources and its management. As such, proper management policies and strategies for land use zoning are inevitable for the sustainable development of the country (Chapagain, 1993). In order to attain the sustainability through proper management practices, comprehensive and extensive database on available land types, land use type and zoning are unavoidable. A systematic approach to sustainable land resource management through land utilization planning, land use zonation and assessment of land could be the appropriate measure for this purpose.

However, the superimpose of cadastral layers within the land use zoning map could be the vital step to observe the realities and propose considerations of the zoning of parcel of lands of an area. The use of recent technologies such as Remote Sensing (RS) and Geographic Information System (GIS) could be helpful to devise digital cadastral data base, land use zoning and analysis.

With the support of field-data (soil and other socio-economic data), RS and GIS could provide scope for analyzing the variation in space and time and help in decision making support systems. As such, an efficient approach to management of resources can be formulated and implemented in relatively short time period

Understanding the needs, the Illam Municipality has undertaken initiative to prepare land use zoning maps and superimpose it on cadastral layer at village development committee (VDC) level in Nepal. It was very much helpful due to other components of the same project as the preparation of current land use maps, soil, land capability and suitability maps and databases as well. The rational for the superimpose of cadastral layer on the land use zoning maps at Illam Municipality is to identify zones of agricultural land, forest area, pasture, built-up, water body, industrial and public service area, cultural and heritage area and other categories within Municipality. The Illam Municipality viewed it as necessary for various other reasons as following:

- Classification of land parcels on the basis of its types for the purpose of non-agricultural land uses.

- Delineation of land parcels according to land use zoning areas viz. agriculture, forest, grazing, built-up/residential, industrial area, water body, public services area, culture and heritage area and others according to optimum land characteristics.
- Delineation of the areas for conservation of forest, shrubs/herbs, river, wetlands and other natural resources for achieving environmental balance.
- Sub-classification of agricultural land parcels into optimum production sub-areas based on soil characteristics, land capability, irrigated and potential irrigable areas to increase the productivity of the land.
- Preparation of Land Use Plan of Ilam Municipality data base and maps using GIS for the implementation of land use plan.
- Management of land resources on the basis of land characteristics as well as the conceived policy.

1.3 Objectives of the Study

The broad objective of Preparation of Land Use Plan of Ilam Municipality, land use maps, soil maps, land capability maps, land use zoning maps and preparation of profile for land use zoning and cadastral layer superimposing for Illam Municipality of Illam District of Nepal.

In order to fulfill the broad objective, the present study aims to prepare report, map and database of the superimposing of cadastral layers with land use zoning map of Sibanagar VDC of the project area. However, the specific objectives of the study are to:

i) classify the cadastral parcels of Illam Municipality according to existing land use and potential land use zoning;

ii) prepare a superimpose map of cadastral parcels on land use zoning map of the Illam Municipality at 1:10000 scale;

iii) prepare GIS inventory on cadastral parcels together with current land use and zoning characteristics as well; and

iv) Assist the government by providing actual database to regulate land use zoning and publish notice on "*RAJPATRA*" for implementation of it.

1.4 Study Area

Ilam is a municipality of Ilam District, which is in the hilly region of Mechi zone, in the Eastern Development Region of Nepal. Ilam also acts as the headquarters of Ilam District and Mechi zone. Geographically it lies in the hill region which is mostly known as Mahabharata range. It is also one of

the important town in Mechi zone and one of the major place in Nepal for tea-production. It is famous for natural scenery and landscapes, tea production, and diverse agricultural economy. It is one of the major horticultural crop production districts of Nepal. Ilam municipality is sub-divided in 9 different wards; the major governmental and district office lies in ward number 1 and ward number 2. Ilam also is a major hub for transportation and communication for VDC that lies in the upper part of the discrict. The municipality was established in 2015 B.S.

Geographically Ilam Municipality is situated in the middle part of the district. It is extended from 87 °53'30" to 87 °57'46" Eastern Longitude and 26 °51'58" to 26°56'46"Northern Latitude have an area of 27.0 Square Kilometer.

Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municapility is surrounded by Mai Khola (River) to the east, PuwaKhola (River) to the west, Barbote VDC (Village) to the north and Mai Khola&PuwaKhola (Rivers) to the south.

The social condition portrays the different facets of a society. An effort has been made to reveal social condition of this municipality in terms of population by age and sex, population growth, caste/ethnicity, language, religion and literacy. The social setting of this municipality is found good. The major ethnic groups living here are Chhetri, Brahmin, Tamang, Newar, Tamang, Rai, and Limbu. Although there are different ethnic groups, there is we-feeling and are residing with social harmony. Major population of this area is engaged in agriculture, whereas the rest are associated with business.

The total population of this municipality is 18633 of which male population accounts for 8946 and female population is 9687. There are 4732 households in this municipality and average households size of 3.94.The population density per sq. km. is estimated 690.

Age group in an important aspect of demography which shows the potential growth and economically active population. A significant feature of any population is the distribution of its members according to age, which facilitate the planner and policy makers in formulating effective socio-economic development plans for the population of different age groups. The table shows that the highest proposition of population is found in age group of 25-44 (29.82%).

The basic population of this municipality comprises the different castes and ethnic groups. Caste rules were basic cultural values which influenced occupation, marriage, food habits and other social behaviors. There are 7.58% Dalit, 44.34% ethnic groups and 48.08% other caste groups including Chhetree, Brahmin, Musalman, Thakuri, Chhetri etc.

Lateracy status is one of the most important social characterists of population. The literacy status of this municipality is quite satisfactory in comparison with the nation. Total literacy rate of this municipality is 84.66 percent. 90.53 percent of men are literate while women are 79.32 percent literate.

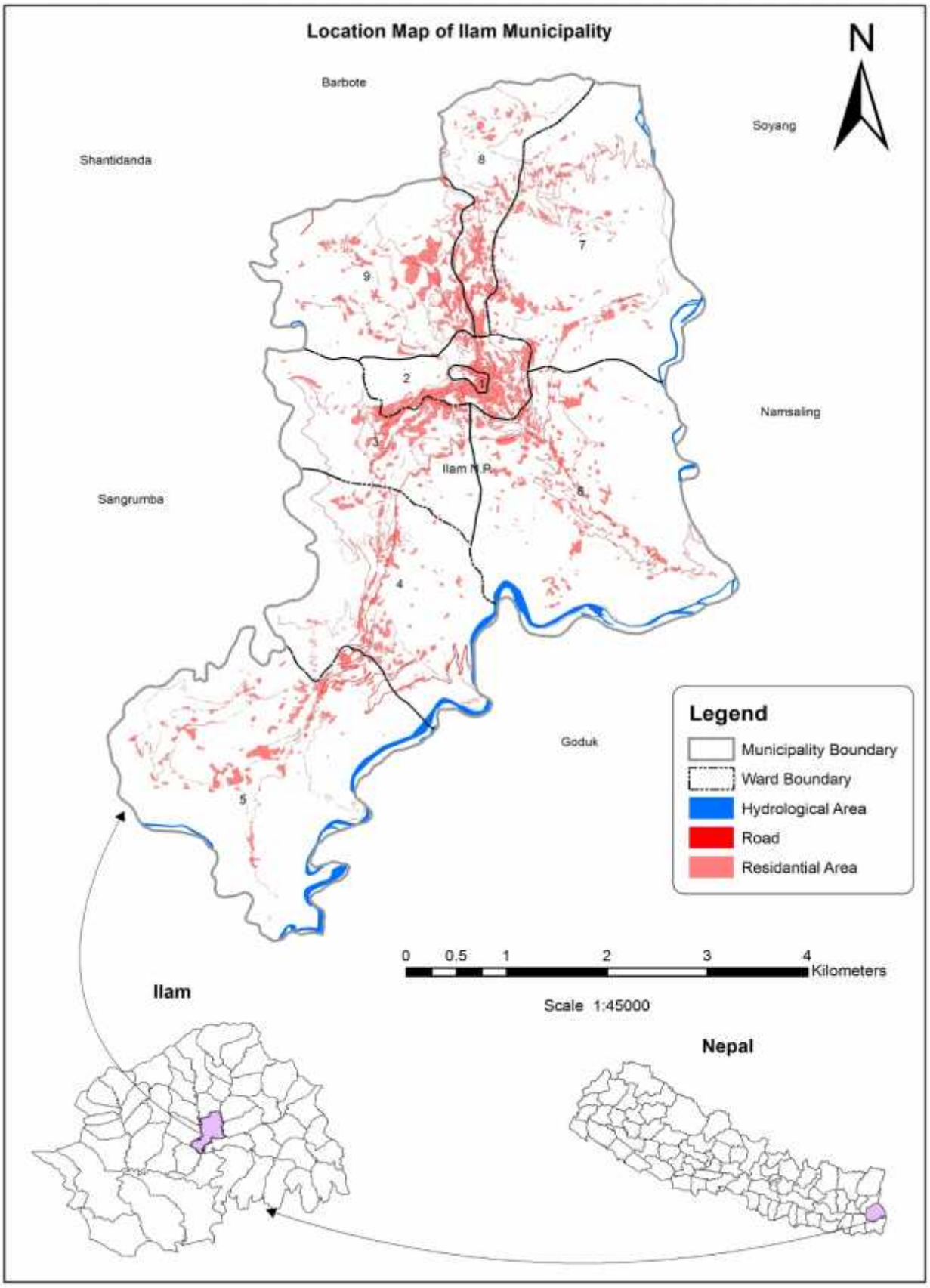


Figure 1.1: Location map of the study area

Chapter 2

CONCEPTUAL BASIS OF SUPERIMPOSE CADASTRAL LAYER ON ZONING MAP

The present chapter describes the conceptual basis behind the superimposing of cadastral layer on landuse zoning map.

2.1 Conceptual Basis of Superimposing Cadastral Layer on Land Use Zoning Map

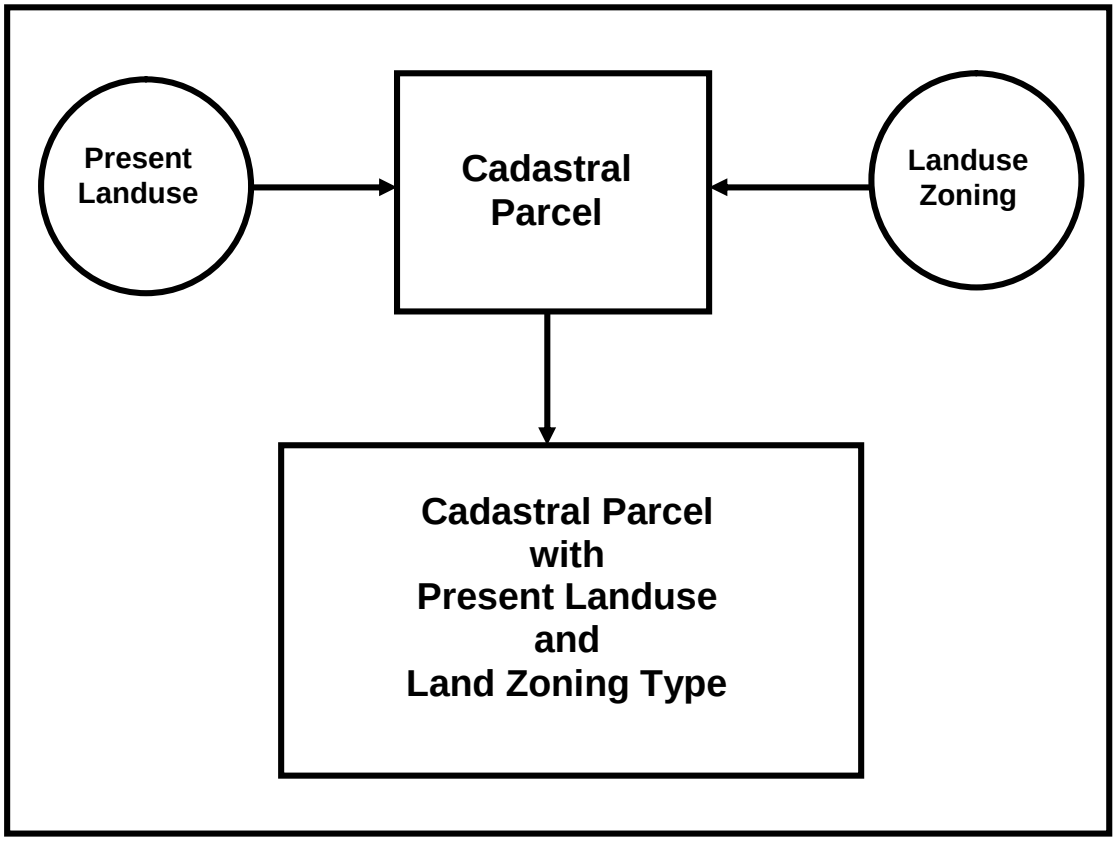
The groundwork of superimposing the land use zoning in cadastral layer is useful for implementation of goals of land use policy. The goals express the government policies on land use, citizen's right, housing, natural resources, and local comprehensive planning. These national policies and law help local level bodies like municipality of the county to develop a comprehensive plan and implementation of the plan. Local governments can do the planning and administer most of the land use regulations that as per the standards for planning set by national government.

A local comprehensive plan of cadastral layer guides a community's land use, conservation of natural resources, economic development, and related public services. For this, it needs two components: a cadastral layer as base and a land use zoning layer for implementation of land use policy. The cadastral layer data and related land information show the spatial location of the land parcel and legal rights of land owners including the land fragmentation process within existing land-laws. Land use zoning determines the types of land use activities that occur on that land, such as agriculture, forest, residential, commercial, industrial and public activities. Land use zoning visualizes both the current situation of land and proper planning for future.

2.2 Spatial Function Related to Spatial Databases

The overlay process of two digital spatial data layers such as cadastral and zoning map having same reference system would lead to the preparation of composite map and data bases (figure 2.1). .It leads to the generation of a new set of polygons (and attributes) that explain the relations existing between the two inputs of spatial data (i.e. Land use zone class and parcel id).

Figure 2.1: Spatial Function Related to Spatial Databases



2.3 Attribute Database Management

Attribute database management is accomplishment of graphic/alphanumerical connections between graphical and alphanumerical databases. This connection is based on the use of a GIS internal table as a linkage with other tables in external databases. The set or collection of data that describes the characteristics of real world entities or conditions is too large to be stored in a single table associated with the graphic elements. This data are usually managed by a relational database management system (RDBMS).The usual procedures are based in the connection of each graphical element to a line of a column of the alphanumerical table containing its attributes (record). This action can be performed automatically or not depending on the use of GIS software.

Chapter 3

METHODOLOGY

This chapter describes the materials and methods adopted to superimpose cadastral parcel on land use zoning map within the study area as per the TOR.

3.1 Data Sources

The cadastral data for the seven Municipality of Illam district are obtained from Department of Land Information Archive (DOLIA) has provided digital copies of island cadastral maps in digitized vector format with the attribute database as presented in table 1.1. The digital cadastral maps are not in national co-ordinate system.

Similarly, the land use zoning maps for the study area is prepared under the separate components of the project as per the TOR (refer land use zoning report for detail). The land use zoning map of the Municipality contains a detailed categories of zones.

3.2 Methods Adopted

The following steps are adopted to superimpose cadastral parcel on land use zoning map within the study area (Figure 3.1).

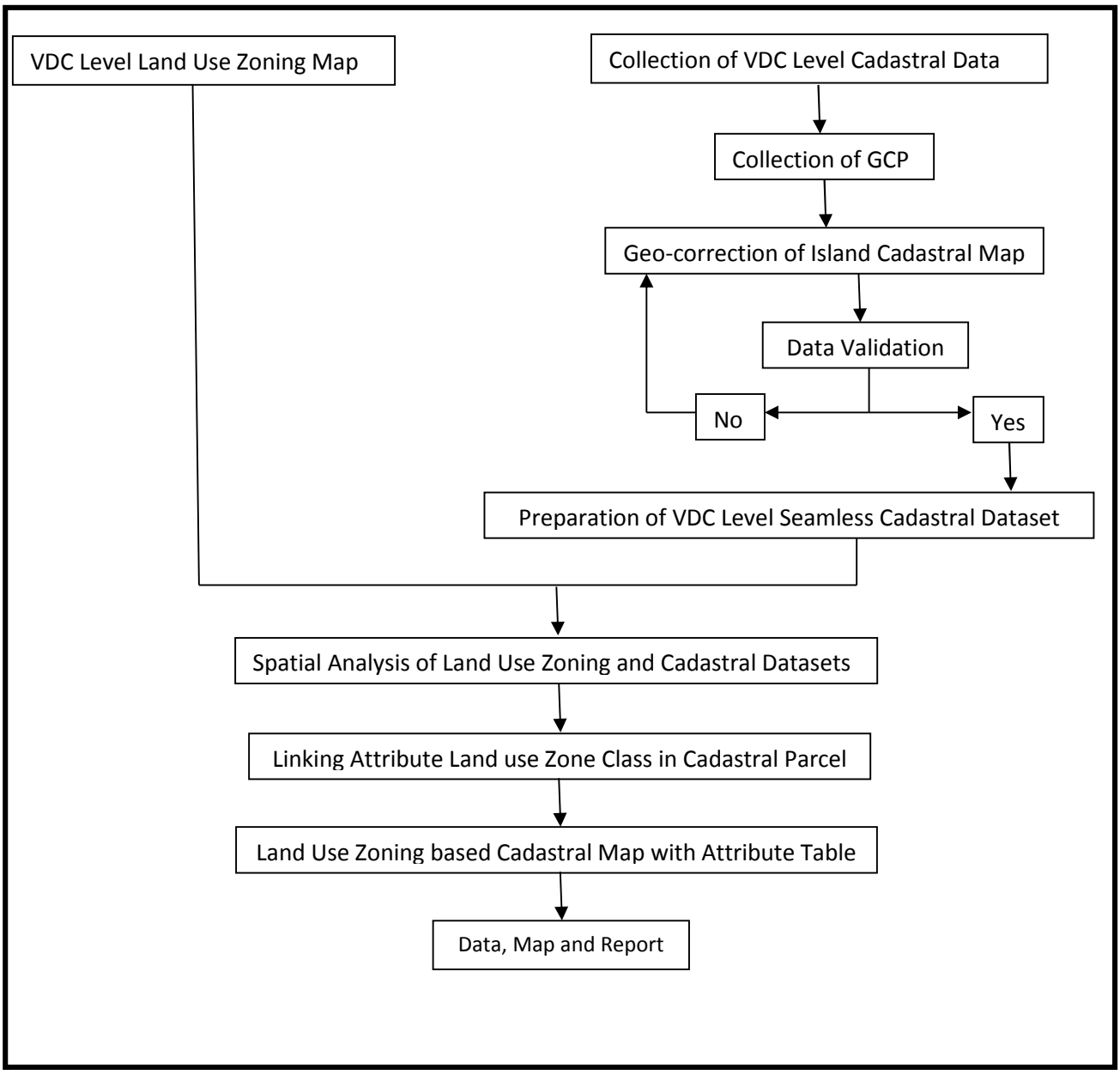
3.2.1 Collection of Municipality level land use zoning and cadastral data

The details are discussed in sub section 3.1.

3.2.2 Collection of Ground Control Points (GCPs)

As the digital cadastral maps are not in national co-ordinate system, the first step was to collect GCPs for reference of the cadastral parcels. some hard copies of the cadastral maps and collected necessary GCPs with GPS receivers by differential GPS technique with the accuracy of 1m. Each island cadastral map has 16 to 20 tic points that are measured for geo-correction of the digital vector layer (digitized island cadastral map). The same process was followed to collect the GCPs for all island cadastral maps of Illam Municipality.

Figure 3.1: Schematic Diagram of Methods Adopted



3.2.3 *Geo- correction of island cadastral maps*

The third step was geo-correction of vector layer of island cadastral map using GCPs. Usually, four GCPs of four corners of a rectangle are sufficient to geo-correct island cadastral map. However, to maintain required accuracy in a map of 1:500 scale 16 to 20 GCPs are needed. After assigning required GCPs a 3rd degree polynomial transformation was used for rectification of the vector layer of cadastral maps. However, due to the larger errors in source some of the cadastral maps still have error of overlapping and gap even after the rectifications. The rectification and adjustment process was helpful to the digital cadastral maps with less than five meters of gaps. Accuracy of each individual cadastral map sheet transformation has been assessed and error report has been generated. The details of the coordinate system used are presented in Table 3.1.

Table 3.1: Parameters used for geo-reference of cadastral layers

Projection	**Modified Universal Transverse Mercator**
Spheroid	**Everest 1830 (Adjustment 1937)**
Semi-Major axis	**a=6377276.345m**
Semi-Minor axis	**b= 6356075.413**
1/f	**300.8017**
Central Meridian	**87º E, 0º N**
False Coordinate	**500,000 m E, 0 m N**
Scale Factor at Central Meridian	**0.9999**

3.2.4 Data validation

It is used for checking and cleaning up the vector layer cadastral data so that the clean up data should always be valid. Examination of it can be used to give a measure of the overall data quality in vector layer of the cadastral data. Thresholds for data quality may be set for acceptance criteria and it may state the type for particular object in cadastral dataset. Examination of it can be applied to various aspects of the data held in GIS; be that topology, connectivity, position or attribute information. If the data validation is acceptable then these data are used for preparing seamless dataset of Municipality, otherwise there is need for repeating the process.

3.2.5 Preparation of Illam Municipality seamless cadastral dataset

A ward level seamless cadastral dataset of vector cadastral layer is prepared by spatial analysis process of merging in GIS environment. Municipality seamless cadastral dataset is prepared with

ward wise seamless cadastral datasets. Overlapping and gap between the individual cadastral island maps have occurred in the spatial merging. However these errors are eliminated with the building topology within the permissible limit of threshold.

3.2.6 Spatial analysis of land use zoning map and cadastral dataset

Municipality land use zoning map of the study area and seamless cadastral datasets are overlaid using the overlay spatial analysis function in GIS environment. At the time of overlay process, caution is taken to maintain three different topology functions. These are:

- Must not be overlapped
- Must not intersect
- Must not be contained

3.2.7 Linking attribute of land use zoning class in cadastral parcel

Land use zoning class map is linked with the level seamless dataset by the process of querying in the attribute table, cadastral dataset and land use zoning class data. It is possible to link the geographic objects in a vector map to one or more tables. A link defines driver database to be used. Each parcel category number in a geometry file corresponds to a row in the attribute table. The practical benefit of this system is that it allows placement of thematically distinct but topologically related objects on a single map. Further, the tables can be linked to subsequent layers. The attribute of table joining cadastral parcel with the proposed land use zoning class is shown in Table 3.2:

3.2.8 Production of data, map and report

The whole process described in this section has resulted in a composite data base and maps (see chapter four for detail) and the elaboration is documented in the form of report.

Chapter 4

CHARACTERISTICS OF THE SUPERIMPOSE OF CADASTRAL PARCEL

This chapter describes the characteristics of superimpose of cadastral parcel on existing land use and land use zoning map within the study area as per the TOR.

The cadastral survey in Illam district took place. The following subsection discusses other characteristics of the databases of superimpose cadastral layers on land use zoning map:

4.1 Parcel Characteristics on present land use map and land zoning map

The table 4.1 shows the characteristics of cadastral parcels occurring in Illam Municipality of Illam district of Nepal. Out of the total 22485 cadastral parcels of the Municipality, 9073 parcels covering almost two-third areas are under agricultural landuse in 2015. Similarly, the zoning map suggested 4010 parcels covering 58 percent areas are suitable for agricultural use and must be preserved maintain food security of the area. Areas under present settlement (*built up category*) cover almost similar trends; however, there is a potentiality of about 4515 present parcels suitable to convert into future settlements.

Table 4.1: Characteristics of cadastral parcels in relation to landuse and zoning maps

Parcel characteristics on present landuse map				**Parcel characteristics on landuse zoning map**			
Present Land Use	**Parcel Count**	**Area**	**Percent**	**Land Using Zoning**	**Parcel Count**	**Area**	**Percent**
Agriculture	9073	12436846.74	51.66	Agriculture	9784	13429304.89	55.50
Built_up	7630	2850302.43	11.84	Built_up	4218	886346.81	3.66
Water Body	192	500449.80	2.078	Water Body	187	501421.51	2.072
Forest	3679	8285893.62	34.419	Forest	3739	8449689.41	34.92
				Industrial	42	22111.71	0.091
				Residential	4515	903752.87	3.735
Total	**20547**	**24073492.58**	**100**	**Total**	**22485**	**24192627.22**	**100.00**

There are very few parcels under forest cover in present land use category. Similarly the multi criteria evaluation of the different thematic layers and human consciousness show no potential areas to be kept under forest cover; the voluntary decision is up to the land owners. In the same way, a very low percent of the parcels are under wet land which could be conserved and protected for wetland biodiversities.

4.2 Parcel characteristics on superimposed map

The table 4.2 shows the status of cadastral parcels within the superimpose map of Illam Municipality (figure 4.1). It shows almost fifty percent of the total parcels are in use of agriculture in present land use map and the same are also best suitable for the same in land use zoning types (figure 4.2).

Similarly, almost one-fourth of the cadastral parcels of the Municipality are under residential and these parcels are kept in the same categories because there are almost impossible chances of these being converted to other types. However, almost 9785 parcels of present agriculture categories, and some minor other parcels are suitable to be develop for future residential areas. Likewise almost 8 percent of the wet lands have potentiality for conversion into agriculture areas including fisheries.

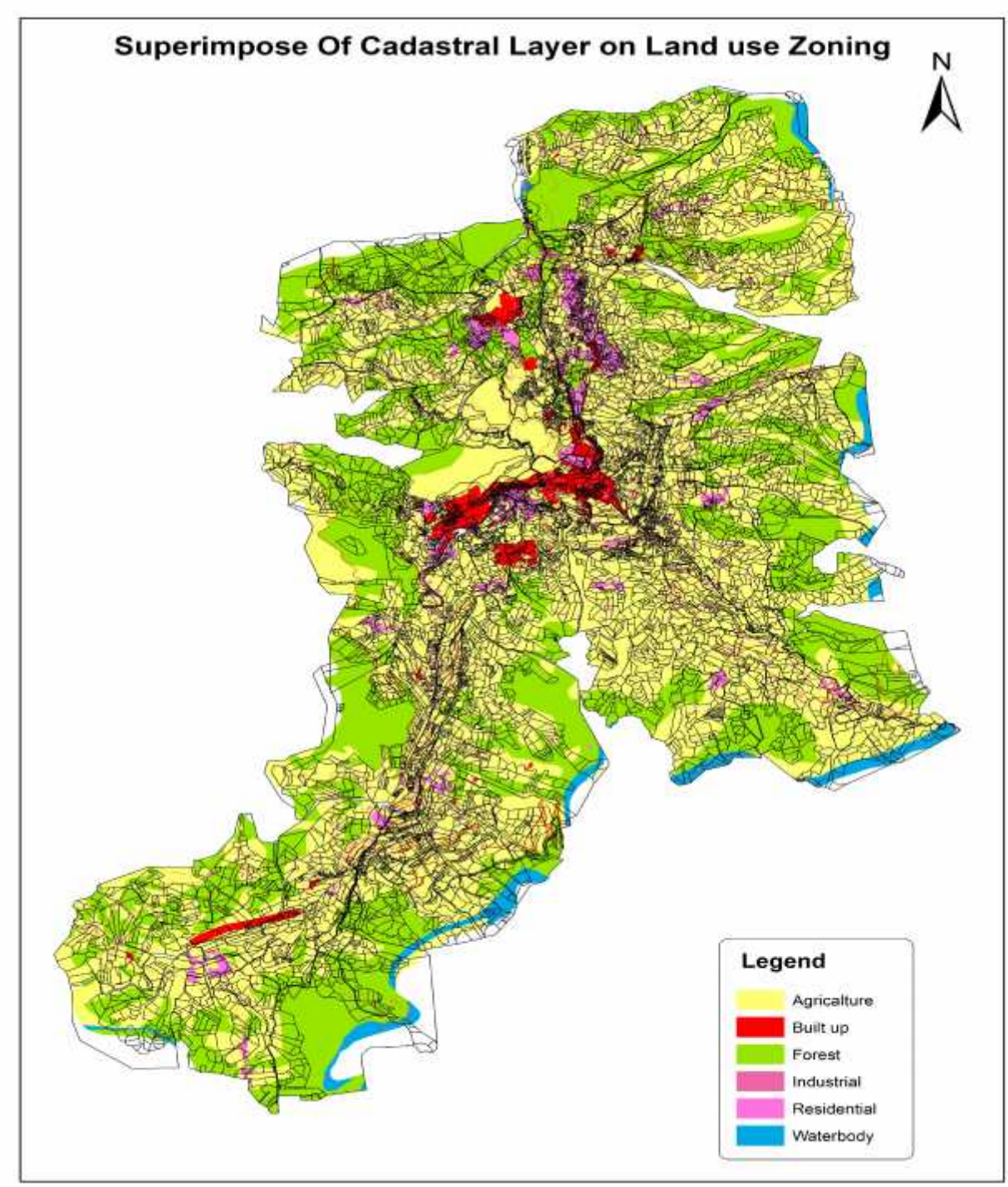


Figure 4.1: Parcel characteristics on superimposed map

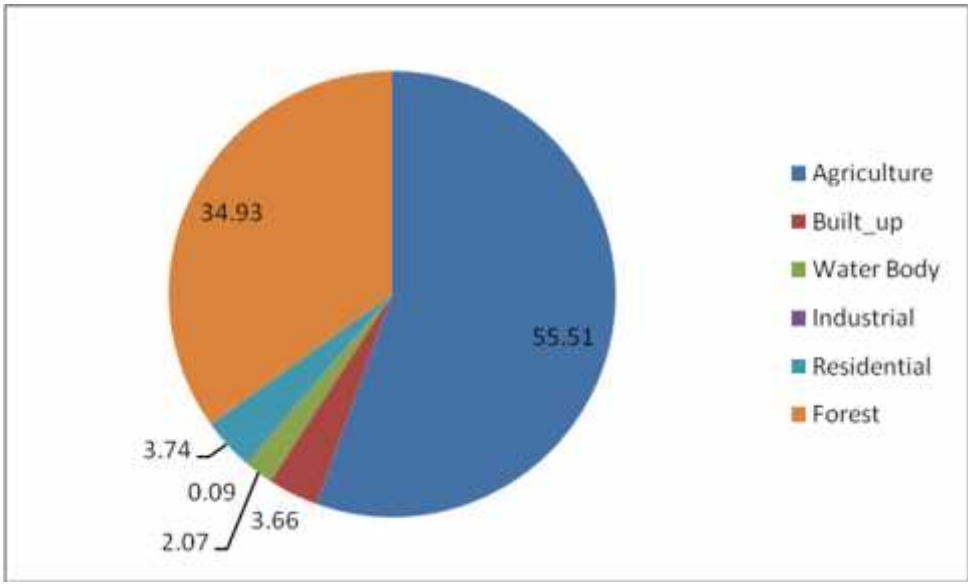


Figure 4.2: Pie diagram showing the percent of superimposed parcels

In overall, the superimpose of parcels regarding present landuse and potential land use zoning of the Municipality confirms almost similar trends. It suggests the owner's of the parcel holders have used their land as per the quality and suitablity of the lands. The landowners of the Municipality could be praised and honoured for their parcel's sutable uses.

Chapter 5

CONCLUSIONS

5.1 Conclusions

The present study intended to pursue an exercise of identifying the existing landuse of the cadastral parcels in relation to potential land use zoning in Illam Municipality of Illam District. The study area lies in middle part of Ilam district. Ilam municipality is located in Ilam District, which is in the hilly region of Mechi zone, Eastern Nepal and covers an area of 27.0 square kilometers. The municipality is surrounded by Mai Khola (River) to the east, Puwa Khola (River) to the west, Barbote VDC (Village) to the north and Mai Khola & Puwa Khola (Rivers) to the south. A detail of this VDC is given in municipality profile later in this report

The exercise is fruitful as per the requirement of the TOR and it provides maps, data base and reports on the task. It is able to link the existing landuse with the parcels of the cadastral data and superimpose on the landuse zoning. Such a database will certainly help the concerned authorities to think of the ongoing practices on the lands, the finite resources of the country. Certainly it will help to develop plan for the local areas and implement accordingly. In this sense the exercise can be regarded as milestone for the planners and authorities working within the area.

5.2 Recommendations

The study team believed that the digital cadastral database provided by the Department of Land Information Archive (DOLIA) are not scientific and reliable. The verification of the cadastral sheets in the field showed overlapping of the parcel's actual location in reality. Similarly, the sheets are not matching with each other appropriately; spatial adjustment was carried overlaying the parcel boundaries with visible actual boundaries of GEO Eye high resolution satellite image. However, several free sheets were lying distant apart even feeding their actual ground co-ordinates collected from the field visit.

Therefore, the study team strongly recommends for a scientific survey of cadastral parcels of Nepal to replace the maps produced with limited technology and manpower in 2026 B.S that is four decade ago.

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