Government of Nepal
Ministry of Land Management, Cooperatives and Poverty Alleviation
Survey Department
Topographical Survey and Land Use Management Division
Minbhawan, Kathmandu, Nepal

FINAL REPORT

MYAGANG RURAL MUNICIPALITY OF NUWAKOT DISTRICT

- Present Land Use
- Soil
- Land Capability
- Risk Layer
- Land Use Zoning
- Cadastral Layer of Superimpose
- Rural Municipality/Municipality Profile

of

Preparation of Rural Municipality/Municipality Level Land Resource Maps (Present Land Use Map, Soil Map, Land Capability Map, Risk Map, Land Use Zoning Map, Cadastral Layer of Superimpose Map and Rural Municipality/Municipality Profile), Database and Reports for F/Y 2077/078

PACKAGE-TSLUMD/CS/QCBS/01/**08**/2077/078

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Asadh 2078

PRESENT LAND USE

Preparation of Present Land Use Report
Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural Municipality.**

The area coverage of Local unit of this package used and analyzed for different purpose under the scope of work of this consulting service are computed from cadastral maps provided by DOLIA Office, Government of Nepal, Ministry of Land Management, Cooperatives and Poverty Alleviation of Nepal. Therefore, the area of Local unit may match to the area computed from Topographic Digital Database provided by the Survey Department of Nepal.

The satellite imageries, GIS database and other outputs produced by this consulting service is owned by Topographical Survey and Land Use Management Division(TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale

Land use planning aspires sustainability by balancing social, economic and environmental needs. Effective land-use planning provides direction in which land-use activities should take place and encourage synergies between different uses. Human needs and environmental features and processes are dynamic in nature and change in land use occurring at various spatial levels and in different time periods are the material expressions of environmental and human dynamics and of their interactions (Briassoulis 2000). With the ever increasing population and rising demand for food, water and energy, sustainable management of natural resources is pivotal in order to secure current and future need. Sustainable management economic and social benefits from the land while maintaining the ecological support functions of the land resources. However, ensuring adequate supply ensuring the long-term productive potential and the maintenance of environmental functions requires careful and appropriate planning, use and management practices. One of the prime pre-requisites for such is information base at local level on existing land use and capability at cadastre plot level, natural hazard risk level, socio-economic status and proper zoning for land use. Zoning in general, segregates land uses into number of categories and zoning regulations provide a legal framework for sustainable development.

Comprehensive land use planning is of utmost importance in the national development process. Land-use planning, however, requires the application of various tools and techniques to collect and display data and information. The collection of basic data is important as a prelude to deciding on land-use allocations (FAO 2008). Modern tools such as satellite remote sensing, GPS and GIS have been providing newer dimensions to effectively monitor and manage natural resources. Due to advances in space science technology, it has been well conceived that remote sensing and GIS have great role to play in land use planning and zoning for sustainable development. The information base developed using these integrating tools and technology is absolute asset to effective land use planning and zoning for government.

Realizing the importance of responsive and appropriate land use planning, Government of Nepal has approved National Land Use Policy of Nepal in 2069 and amended in 2072BS which integrates safeguarding of disaster risk free human settlement development under land use planning. The policy has outlined eleven major land use zones based on the land characteristics, capability and requirement of land which has been revised to ten classes in Landuse Act, 2076. The land use zones include: Agriculture, Residential, Commercial, Industrial, Mining and Mineral, Cultural and Archaeological, Riverine and lake, Forest, Public use, and Other. Within this framework, landuse mapping and zoning of more than 50 districts have been completed under the National Landuse Project. Topographical Survey and Land Use Management Division, TSLUMD at present endeavors on the same to maintain the essence of the amendment on the National Land Use Policy and as mandated by the Land Act 2021 (Sixth Amendment) with the strategy of completion of land use mapping. The current project encompasses the Preparation of Local unit level Land Resource Maps, Database and Reports of twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) under **Package 08** incorporating all six themes outlined in scope of work of ToR.

In this context, the present report is one of the outputs under the consulting service **Preparation of Rural Municipality/Local unit level Land Resource Maps, Database and Reports of Myagang Rural Municipality of Nuwakot District under Package 08** incorporating all themes outlined in the ToR of Topographical Survey and Land Use Management Division (TSLUMD) of Fiscal Year 2077-078.The present land use analysis is based on the following conceptual basis:

- Classification of land use as mandated by Land Act 2021, sixth amendment
- Classification of Agriculture land into comparatively advantageous sub-classes based on land characteristics
- Identification of Low Risk (Secure) residential areas
- Conservation of Natural resources including hazard prone area.

1.2. Objective and Scope of Work

The overall objective of the current work is the **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and superimpose of Cadastral Layers) maps, database and reports. The specific objective of the present work is:

- To prepare present Land use map at 1:10,000 scale, GIS database and Report.

The scopes of the project work under preparation of Local unit level present Land use maps, GIS database and Report cover the following activities:

- Collect all the basic and foundational information from TSLUMD
- Perform DGPS surveying to collect acceptable number of GCP required for the geometric rectification of satellite image provided by TSLUMD.
- Perform necessary rectification of the given satellite image
- Perform feature extraction from the acceptably rectified enhanced satellite images.

- Perform field work to collected relevant land use information.
- Populate the given database with the extracted features.
- Maintain the database as per the specification supplied.
- Prepare present land use maps as per different specified hierarchical levels.
- Discuss the accuracy, reliability and consistencies of data.
- Prepare report describing methodology, existing land use pattern and model of GIS data base.

1.3 Project Area

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the north-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola, Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

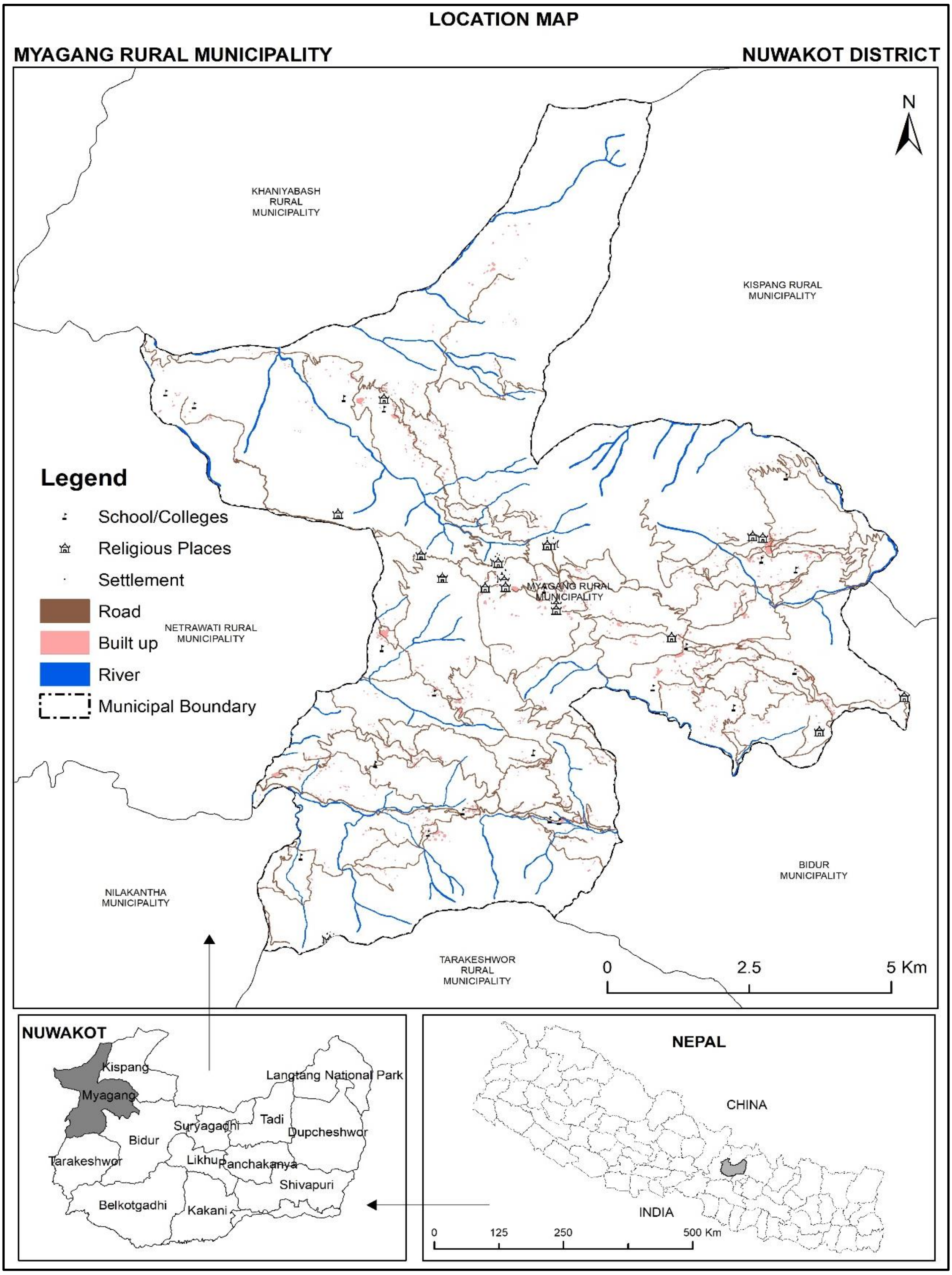

Figure 1.1: Location Map of the project area

CHAPTER 2: CONCEPTUAL BASIS OF LAND USE CLASSIFICATION

2.1 Classification System and Criteria

Land cover and land use classes are divided and exercised in number of classification systems. Land cover refers to the vegetative or non-vegetative characteristics of a portion of the Earth's surface while Land use describes use of land by human for different activities. Land cover classes, in most cases are determined from satellite imagery or aerial photographs. Land use (LU) classes on the other hand generally are determined through observation by inferring human activity or in many cases from satellite imagery or aerial photographs. However, for detailed level land use sub-classes and individual types field verification becomes essential. Supplementary information gathered through checklists or questionnaires is required to assign a land use class since the use is not always apparent through an observation. Land Use Land Cover (LULC) are classified based on local context using well-defined diagnostic criteria of the classifiers. Classification of land use or land cover is performed with a set of target classes in mind; these set are called a classification scheme/system. The purpose of such a scheme is to provide a framework for organizing and categorizing the information that can be extracted from the data (Jensen, 1996). Classification system follow the general criteria for reference classification system to appropriate land cover classes for the specific purposes which are scale independent and source information independent. According to FAO land use land cover reference classification system should be (FAO, 1995):

- comprehensive, scientifically sound and practically oriented which meet the needs of a variety of users (neither single-project oriented nor taking a sectoral approach);
- users can use just a sub-set of the classification and develop from there according to their own specific needs;
- potentially applicable as a common reference system, and facilitate comparisons between classes derived from different classifications;
- be a flexible system, which can be used at different scales and at different levels of detail allowing cross-reference of local and regional with continental and global maps without loss of information;
- able to describe the complete range of land cover features (e.g., forest and cultivated areas as well as ice and bare land, etc.), with clear class boundary definition that are unambiguous and unique;
- adapted to fully describe the whole variety of land cover types with the minimal set of classifiers necessary (the less classifiers used in the definition, the less error is expected and less time and resources are required for field validation); and
- based on a clear and systematic description of the class, where the diagnostic criteria used to define a class must be clearly defined, with pure land cover criteria distinct from environmental criteria (e.g., climate, floristic and altitude), as the latter influence land cover but are not inherent features.

Land cove land use classification system is hierarchical in nature with ability to accommodate different levels of information, starting with structured broad-level classes, which allow further systematic subdivision into more detailed sub-classes (Anderson et al., 1976). However, classification system should fulfill substantial requirements (Meinel and Hennersdorf, 2002): class identification rules, Spatial, temporal and scale consistency, completeness, compatibility, independence from data collection and processing tools. Besides, three types of information are considered in identifying each land cover type in the hierarchical classification system:

- Domain spectral knowledge: Spectral knowledge can be used to construct the hierarchical structure of LULC classes.
- Spectral classification rules obtained from training data: Qualitative spectral knowledge involved in high resolution satellite images has to be transformed to more specific quantitative classification rules. Training data help to generate thresholds to be used later as rules for discriminating and classifying LULC categories more accurately.
- Spatial knowledge: Spectral knowledge alone is insufficient for classification of all LULC types; therefore, spatial rules have to be used to increase the resultant accuracy.

The minimum mapping unit (MMU) is the fundamental factor for the classification system, which is determined by the minimum mapping area to show on the map. The size of the minimum area which can be depicted as being in any particular land use category depends partially on the scale and resolution of the data source from which the land use is identified and interpreted. It also depends on the scale of data compilation as well as the final scale of the presentation of the land use information. When land use classification is done using remotely sensed data certain specific criteria are employed as listed below (Anderson et. al 1976):

- The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85 percent.
- The accuracy of interpretation for the several categories should be about equal, but multiple uses of land should be recognized when possible.
- 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, Aggregation of categories and Comparison with future land use data should be possible.
- The classification system should be suitable for use with remote sensor data 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 sensor data should be possible.

Hierarchical land use classification system has been recommended in ToR provided by the Topographical Survey and Land Use Management Division(TSLUMD) which provides a great flexibility in terms of application. The land use classification applied for current project is as per TSLUMD recommendation which is based on major land use classes identified by National Land use Policy, 2072.

2.2 Land use Hierarchy and Description

Physiography, soil, climatic conditions, settlement pattern, cultural practices and socio-economic factors govern land use practices in any place. Variation in these factors determines land use classes and types and result landscape with different land uses classes and sub-classes. The policy has outlined eleven major land use zones based on the land characteristics, capability and requirement of land which has been revised to ten classes in Landuse Act, 2076. The land use zones include: Agriculture, Residential, Commercial, Industrial, Mining and Mineral, Cultural and Archaeological, Riverine and lake, Forest, Public use, and Other. The National Level Specification for the Preparation of Rural Municipality/Local unit level Land Resource Maps, database and Reports identifies ten landuse classes at level 1 based on the Landuse Act 2076BS. The land use classes and hierarchy recommended in ToR and provided under specification of TSLUMD are adopted. As specified by TSLUMD, six levels of land use classifications to be adopted are presented from Table 2.1 to Table 2.14 in subsequent sub-sections.

2.2.1 Agricultural Land use

Agricultural land comprises primarily land used for production of food and fiber. They are areas which have been used for the production of agricultural products such as cereals, cash crops, orchards, livestock farming etc. Variation in distribution of agricultural land use is found due to variation in climate, physiographic components, topography and cultural practices over the region. Agricultural land use is categorized into three sub classes by LRMP (LRMP, 1986): **Tarai cultivation, Hill slope cultivation** and **Valley cultivation**. The project area lies within **hill** areas of Nepal; therefore, the hierarchy of agricultural land is further extended to level 3 categorization into **dry land cultivation, wet land cultivation** and **mixed land cultivation.** The **wet land cultivation** is sub-categorized into level 4 as **low Khet land cultivation** and **upper Khet land cultivation** (Table 2.1). Similarly, the level 5 hierarchies are used for incorporating the cropping pattern (Table 2.2).

Table 2.1: Hierarchy of Agricultural Land use

Level 1	level 2	Level 3	Level 4	Level 5	Level 6
Agriculture Land use	Hill Cultivation	Wet Land Cultivation	Low Khet land Cultivation (Poorly drained with High bond)	Cropping Pattern (Monsoon-Winter-Dry season) As indicated in Table 2.2	Intense (75-100%) Cultivation
			Upper Khet Land Cultivation-TariKhet (Intermediate land between wet and dry land with well drain lower soil bond)		Medium (50-75%) Cultivation
					Low (25-50%) Cultivation
		Dry Land Cultivation (Upland Pakho / Bhith land Cultivation, Drained, smallest bond height)	Unclassified		
		Mixed Land Cultivation (Diyara land cultivation, commonly found near river course where river has changed the course)	Unclassified		

Table 2.2: Agriculture Land use Level 5

Maize-Oilseeds-m2	Rice-Potato-r8	Rice-Buckwheat-r14	Barley-Buck Wheat-b1
Maize-Pulses-m4	Rice-Potato-Vegetable-r9	Rice-Wheat-Maize-r15	Fruit-Fruit-f1
Maize-Wheat-m5	Rice-Maize-r10	Bamboo-b3	Fruit-Others-f3
Maize - Vegetable-m6	Rice-Vegetable-Vegetable-r11	Pond for Fish farming-p3	Others-Others-o2
Maize-Millet-m7	Rice-Maize-Vegetable-r12	Beekeepig-b4	Others-Others-others-o3
Maize-Potato-m8	Garlic-Vegetable-v2	Cotton-c3	Maize-Rice-Fallow-m1
Maize-Others-m9	Vegetables-Vegetable-v3	Floriculture-f5	
Pulses-Fallow-p1	Fruit+Potato/Vegetable /Buckwheat-f2	Barren Cultivable land-b5	
Pulses-Others-p2	Banana-b2	Livestock Grazing area-g2	
Rice-Fallow-r0	Tea-t1	Maize-Rice-Cereal-m3	
Rice-Rice-r1	Coffee-c1	Rice-Others-r13	
Rice-Wheat-r2	Cardamom-c2	Sugarcane-Sugarcane-s1	
Rice-Wheat-Pulses-r3	Amriso-a1	Potato-Vegetable Crops-v1	
Rice-Oilseed-r4	Ginger-g1	Others-o1	
Rice-Pulses-r5	Livestock/Cattle/buffalo Farm-l1	Shrub from non-forest area- s3	
Rice-Rice-Vegetable-r6	Turmeric-t2	Vegetables-Others-v4	
Rice-Vegetable-r7	Fruits-f4	Sugarcane-Others-s2	

2.2.2 Forest Land use

The forest land use consists of vegetation such as forest, shrub and bush land either completely or partially with naturally grown forest or plantation. The forest land are subdivided into level 5 sub types as per the climatic vegetation zone such as Tropical, Subtropical, Temperate, Sub-alpine and Alpine (Table 2.3). The forest land is further subdivided into level 3 categories by cover type as Hardwood, Coniferous, Mixed, Other and Bushes. The 4th hierarchy covers the dominant species type (Table 2.4). Similarly, the level 5th sub division of forest land could be delineated based on crown density such as Dense, Sparse and Degraded types. The 6th hierarchy-based maturity class and 7th level-based ownership or use rights such as Private, Reserved, National, Community, Leasehold, Collaborative, Religious and Other.

Table 2.3: Hierarchy of Forest Land Use

Level 1	level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Forest	Climatic Vegetation Zone	Cover type:	Species Type:	Crown density	Maturity class	Ownership / Use Right
	Tropical, (<1000m)	Hardwood (H)	As indicated in Table 2.4	Dense(>70% Crown Density)	Mature (To over mature-trees have reached at least estimated rotation age or saw timber size)	Private-1
	Sub-tropical(1000-2000/2100m);	Coniferous (C)		Sparse(40-70% Crown Density)	Immature or small timer size material	Reserve-2
	Temperate,(2000/2100m-3000/3100m)	Mixed (M)		Degraded(<40% Crown Density) followed by name of Dominant species	Regeneration - new generation to pole size	Government-3
	Sub-alpine, (3000/3100-4000/4100m)	Other (O)		Crown Density/Tree density and should be adopted to categorize dense, sparse and degraded forest)		Community -4
	Alpine, (4000/4100m-4500m)					Leasehold-5
		Bushes(B)				Collaborative-6
						Religious-7
						Other-8

Table 2.4: Level 4 for Forest Land Use (Species type)

Forest Species	
Sal forest (Sl)	Juniper wallichiana Forest(Jw)
Cedrusdeodara Forest(Cd)	Upper Temperate Mixed Broadleaved Forest(Um)
Pinusroxburghii Forest(pb)	Wetland area(Wl)
Cupressustorulosa Forest(Ct)	Tropical Deciduous Riverain Forest(Tr)
Quercusincana-Q. lanuginose Forest(Qq)	Rock outcrops/ barren lands(Ro)
Larix Forest(La)	Rhododendron Forest(Rh)
Quercusdilata Forest(Qd)	Sub-tropical Evergreen Forest(Se)
Tropical Evergreen Forest(Te)	Betulautilis Forest(Bu)
Quercussemecarpifolia Forest(Qs)	Terminalia Forest(Tn)
Alnus Woods(Aw)	Abiesspectabilis Forest(As)
Castanopsistribuloides-C.hystrix Forest(Cc)	Dalbergiasissoo-Acacia catechu Forest(Da)
Populus ciliate Woods(Pc)	Tsugadumosa Forest(Td)
Quercus lamellose Forest(Ql)	Sub-tropical Deciduous Hill Forest(Sd)
Hippophae Scrub(Hp)	Pinusexcelsa Forest(Pe)
Lithocarpuspachyphylla Forest(Lp)	Schima-Castonopsis Forest(Sc)
Moist Alpine Scrub(Ma)	Piceasmithiana Forest(Ps)
Aesculus-juglans-Acer Forest(Aa)	Sub-tropical Semi-evergreen Hill Forest(Ss)
Dry Alpine Scrub(Ds)	Abiespindrow Forest(Ap)
Lower Temperate Mixed Broadleaved Forest(Lm)	Other Forest Species(Of)

2.2.3 Residential Land use

The residential land use consists of all the settlement areas including buildings and structures used for shelter and storage purposes. It also covers shelters of domestic animals, buildings and structures for storage and maintenance, courtyards and areas of other uses within residential area. The areas under multi- story buildings/apartments and areas having facilities of roads, electricity, sewerage, and communication with less than 500sq. meters are also included. The resistant land are subdivided into level 2 sub types as per concentration such as dense having concentration ≥ 70%, moderate having concentration between 40% to 70% and sparse having concentration ≤ 40%. The level 3 categories include management and level 4 sub-division of residential land use is based on designated use. The hierarchy of Residential Land Use is shown in Table 2.5.

Table 2.5: Hierarchy of Residential Land Use

Level 1	Level 2	Level 3	Level 4
Residential	Densely Populated	Old Area	Residential cluster-r
	Moderately Populated	Newly Developed Area (Unplanned)	Apartment/Multi-stories-a
	Sparsely Populated	Planned Area (Colony Type, Parcels Plotting Area and Housing Complex, etc.)	Old age care place-o
			Hostel-h
			Dharmasala/ashram-d
			Quarters-q
			Infrastructure developed area-i
			Other-x

2.2.4 Commercial Land use

The commercial land use areas are identified based on the function associated predominantly for the business, sale of products and services. The commercial land use is divided into 4 levels (Table 2.6). The level 2 categories of this land use class are categorized as service areas and business areas. Service areas cover land use units specifically used for different services and facilities. Similarly, business areas are delineated for areas covering under shops, boutique, departmental stores, retail markets, super market. hotel, guest house, fast food, recreation, cyber-cafe, restaurant, bar, cinema, theatre, concert hall, broad casting studio, night club, gaming and gambling sites etc. The Level 4 categories also cover areas under education, health and communication and other areas (Table 2.7). The surrounding area of 100 meters is also included as potential for future business activities.

Table 2.6: Hierarchy of Commercial Land Use

Level 1	Level 2	Level 3	Level 4
Commercial	Service Area	Government Service Area (G)	As listed in Table 2.7
	Business Area	Market Area with specific categories like	
		Market (M)	
		Hotel (H)	
		Recreation(R)	
		Utility(U)	
		Storage(T)	
		Service (S)	

Table 2.7: Commercial Land Use level 4

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

2.2.5 Industrial Land use

The industrial land use categories are areas having buildings, structures and open spaces used for industries, factories or workshop and raw material storage including water purification centers, pumping stations and processing centers and areas used for waste product disposal etc. Industrial land use is divided into 2 levels the level 2 categories of this land use are Small scale industry area, Medium scale industry area, large scale industrial area, Special economic zone, Industrial estate and other industrial category. The hierarchy of Industrial Land Use is shown in Table 2.8.

Table 2.8: Hierarchy of Industrial Land Use

Level 1	level 2	Level 3
Industrial	Small Scale Industry(S)	Type of industries, factories
	Medium Scale Industry(M)	
	Large Scale Industry(L)	
	Special Economic Zone(E)	
	Industrial Estate(I)	
	Other Industrial Category(O)	

2.2.6 Mines and Minerals Land use

Mines and minerals land use include mineral excavation, production or processing as well as Government declared geographic area for future mining activities or discovered one. The mine and mineral land use category also consists of discovered mines area, mining operations area, mineral excavation and production, processing and purification region etc. This land use is divided into 5 levels (Table 2.9). Level 2 categories of mine and minerals include types of rocks and minerals. Sub categories of level 3 of this land use type are Mine minerals - Construction (Materials) sub category (CNSM), Mine minerals - Decorative and Dimension) sub category (DCDEM), Mine minerals – Fuel sub category (FUEL), Mine minerals – GEM sub category (GM), Mine minerals- nonmetallic category (NM), Mine minerals – Metallic sub category (MTL), Other Metallic Minerals. Level 4 hierarchies of mine and minerals land use consists permission status and level 5 hierarchy encompass operation status.

Table 2.9: Hierarchy of Mine and Minerals Land Use

Level 1	level 2	Level 3		Level 4	Level 5
Mine and minerals	Metallic Minerals	Mine minerals - Construction (Materials) sub category (CNSM)	Mine minerals- nonmetallic category (NM)	Licensed	Not Operated So Far
	Non-metallic Minerals	Sands	Clay	Not-Licensed	Currently Under Operation
	Gemstones	Cobbles	Dolomite	Reserved	Other Operation Status
	Construction Minerals (Materials)	Flaggy quartzite	Limestone	Banned	
	Fuel Minerals	Limestone	Magnesite		
	Decorative and Dimension Stones	Pebbles	Mica		
	Other Minerals	Quartzite	Phosphorite		
		River boulders	Quartz		
		Schist	Silica sand		

Level 1	level 2	Level 3		Level 4	Level 5
		Slates	Talc		
		Other Construction Minerals	Other Non-Metallic		
		Mine minerals - Decorative and Dimension) sub Category (DCDEM)	Phyllite		
		Basalt	Mine minerals – Metallic sub category (MTL)		
		Colored sandstone	Iron		
		Granites	Copper		
		Marble	Zinc		
		Quartzite	Lead		
		Other Decorative and Dimension Minerals	Cobalt		
		Mine minerals – Fuel sub category(FUEL)	Nickel		
		Coal	Gold		
		Hot springs	Silver		
		Methane	Tin		
		Petroleum	Tungsten		
		Other Fuel Minerals	Molybdenum		
		Natural Gas	Uranium		
		Mine minerals – GEM subcategory(GM)	Lithium		
		Aquamarine	Lepidolite (Mica)		
		Beryl	Tantalum		
		Garnets	Bismuth		
		Gem	Arsenic		
		Kyanites	Cadmium		
		Quartz crystals	Chromium		
		Ruby	Mercury		
		Sapphire	Titanium		
		Tourmaline	Other Metallic Minerals		
		Other Gemstone Minerals			

2.2.7 Cultural and Archaeological Land use

Cultural and Archaeological Land Use category contains of historically important fortress, palaces, buildings, monasteries, temples, mosques, churches, monasteries and other religious sites, and archaeologically important area. Cultural and Archaeological land use level is shown in Table 2.10.

Table 2.10: Hierarchy of Cultural and Archaeological land use

Level 1	level 2
Historical and Archaeological	Historical, Archaeological and Religious Sub category
	Heritage Site (h)
	Durbar Square (d)
	Gadh (Forts) (g)
	Archaeological Site (a)
	Cultural Site (c)
	Fort (f)
	Temple(t)
	Stupa/Monastery(s)
	Mosque(m)
	Church©
	Bahal(b)
	Patis(p)
	Bihar(v)
	Other(o)

2.2.8 Riverine, Lake and Marsh Area

Riverine, Lake and Marsh Area includes hydrology features such as rivers, rivulets, streams, lakes, ponds, permanent water lodged area, marsh land etc. This land use/cover is divided into second level based on individual water body type. Hierarchy of Riverine, Lake and Marsh Area Riverine, Lake and Marsh Area are shown in Table 2.11.

Table 2.11: Hierarchy of River and Lake Land Use

Level1	Level2
Riverine, Lake and Marsh 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)

2.2.9 Public Use/Services

Public land used for public service activities are categorized in this class. It includes 3 levels. The hierarchy of Public Service Land Use is shown in Table 2.12. The level 2 categories are categorized based on functional use while third level specifies operation category within level 2 (Table 2.13). Finally, the levels 4 sub-divisions of the Public Use deal with Designated Name.

Table 2.12: Hierarchy of Public Use

Level 1	Level 2	Level 3	Level 4
Public Use	Educational		
	Security Services		
	Transportation Infrastructure		
	Health Service		
	Recreational Facility		
	Institution		
	Open Area		

Table 2.13: Public Use at level 3

Sub-Category Transportation- T	**Sub-Category Institutional- I**
Highway - h2	Private Institution - r3
Feeder Road - f2	Public Intuition - p6
District Road - d3	NGO - n2
Local Road - i1	INGO - i4
Other Road - o5	Other intuitional- o8
Bus park - b1	**Sub-Category Recreational- F**
Airport - a2	Public Theatre- c8
Railway - r2	Drama House - d4
Car Park - c4	Stadium - s3
Port - p3	Playground - g4
Pavement - v1	Open space - o9
Cart Track - t3	Other - x2
Other Transportation - x1	Zoo - z1
Bridge - g3	Rest-point-Chautari- r4
	Museum - m1
Sub-Category Education- E	**Sub-Category Security Service- S**
Primary - p5	Police Station - p8
Secondary - s2	Military Area - m2 Military Area - m2
Campus - c5	Armed Force - a3
University - u2	Other Security- o10
Other educational area- o6	
	Sub-Category Health - H
	Hospital - h3
	Nursing Home - n1
	Health Centre - c7
	Pharmacy - f3
	Polyclinic - i2
	Other - o7

2.2.10 Other Land use

The land use which is not included in the above categories falls in other landuse class. Grazing land, orchard, bamboo, barren land, abandoned land and other are included in this class. This includes mixed land uses which are not part of specified land use classes. The level 2 categories of this land use class categorized based on the climatic and vegetation zone as Tropical, subtropical, temperate, sub-alpine and alpine. The hierarchy of this class is shown in Table 2.14.

Table 2.14: Hierarchy of Other Land Use

Level 1	level 2	Level 3	Level 4
Others	Grazing Land-G	Tropical, (<1000m);	
		Sub-tropical,(1000-2000/2100m);	
		Temperate,(2000/2100m-3000/3100m);	
		Sub-alpine, (3000/3100-4000/4100m);	
		Alpine, (4000/4100m-4500m).	
	Others-X		

CHAPTER 3: METHODOLOGY

3.1 Data Sources

Land cover (LC) and land use (LU) of particular area is determined through primary and secondary sources. Ground survey is primary source of land cover-landuse data. Among secondary sources, high resolution satellite images are the most pertinent data source for land cover land use classification. IKONOS, Quickbird, World View, Geo Eye are high resolution satellite images to name some major sources. Other major secondary sources include: existing topographical maps and cadastral maps.

The present land use classification is based on primary data source of 2.1-meter panchromatic and 5.8-meter multispectral imageries of 2018 from ZY3-1 and ZY3-2 satellite constellation provided by TSLUMD. Ancillary vector data such as topographical sheet data and land utilization map of LRMP including Google images were used as secondary sources for enhancing interpretation. Land Use classification was done through visual interpretation with extensive knowledge base and field verification for pre-defined hierarchical classification system. Land use types, cropping pattern, forest types and management were collected during the field work through field observation and discussion with locals using checklists and standard questionnaires. Land use classes obtained from satellite images were verified during the field work. The subsequent sub-sections briefly describe the sources and characteristics of various data source and methods adopted for present land use classification.

3.1.1 Satellite Image: ZY3

ZY-3A (Resource-3A) is the high-resolution stereoscopic Earth mapping satellite system of China which provides data for resource mapping, environmental surveying, disaster monitoring, city planning and national security needs. It simultaneously collects panchromatic imagery at 2.1-meter GSD at nadir and multispectral imagery at 5.8-meter GSD at nadir. It has the ability to generate multispectral imagery, the data can be used for territorial resource investigation and monitoring, and to provide services for disaster warning and reduction, agriculture, forestry, water conservation, ecological environment. The sensor characteristics of ZY3 is described in Table 3.1 and scene with DGPS details used in this project are shown in Table 3.2 and Figure 3.2.

Table 3.1: Specification of ZY3 Image

Parameter	Value
Orbit	Altitude 506 km, Type: Sun synchronous
Spacecraft Size, Mass and Power	497 km × 507 km, 97.49° (#01); 484 km × 500 km, 97.50° (#02) 2636 kg 2 deployable solar arrays, batteries
Sensor Bands	Spectral Range: 500~800 nm
	MSS
	B1: 450~520 nm Blue
	B2: 520~590 nm, Green
	B3: 630~690 nm, Red
	B4: 770~890 nm, NIR
Sensor Resolution	panchromatic images (2.1-meter for nadir,3.5-meter for forward and backward)
	5.8-meter multispectral (red, blue, green, near infrared)
Dynamic Range	≥ 25 (θ=30º, ρ=0.03)
	≥ 126 (θ=70º, ρ=0.3)
	≥ 251 (θ=70º, ρ=0.6)
	Data quantization: 10 bit
Swath Width	Nadir : 51 km
	Forward/backward : 52 km
Revisit Frequency	59 days, Special case 4-5 days
GSD (Ground Sample Distance) at nadir	Nadir camera: 2.1 m, Forward/backward cameras: 3.5 m, Forward/backward cameras: 3.5 m
Datum	WGS84

Table 3.2: Scene description of ZY3 Image of the Project Area

Acquired image file	Acquisition Date	Satellite	Orbit Id	Scene Path	Scene Row
zy302a_mux_008927_079154_20180107132804_01_sec_0004_1801098893.tar.gz	1/7/2018	ZY3-2	8927	79	154
zy302a_nad_008927_079154_20180107132804_01_sec_0001_1801093151.tar.gz	1/7/2018	ZY3-2	8927	79	154
zy301a_mux_038041_080153_20181115130941_01_sec_0004_1811161463.tar.gz	11/15/2018	ZY3-1	38041	80	153
zy301a_nad_038041_080153_20181115130949_01_sec_0001_1811168141.tar.gz	11/15/2018	ZY3-1	38041	80	153
zy302a_mux_009748_080154_20180302132948_01_sec_0004_1803069511.tar.gz	3/2/2018	ZY3-2	9748	80	154
zy302a_nad_009748_080154_20180302132948_01_sec_0001_1803068921.tar.gz	3/2/2018	ZY3-2	9748	80	154

3.1.2 Topographic Maps

The Topographical Maps covering the project area in 1: 25,000 scales with contour interval 40m was used as another reference maps. These maps are published in 1996. Both hard copy and soft copy was obtained from Survey Department of Nepal. The 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, location name, etc. DEM was generated from digital topographical contour map of 40m interval. These DEM was used for ortho-rectification of provided satellite images and created DEM derivatives such as slope, aspect, relief, and hill shade etc. using terrain analysis techniques.

3.1.3 Land Resource Maps (LRMP)

Land Utilization, Land System and Land Capability maps and reports prepared by Land Resource Mapping Project (LRMP), 1986 were used as references for land use classification. These maps and reports were used to get an in depth knowledge of existing LULC classification and land use hierarchical system of Nepal. District level Land Utilization, Land System and Land Capability maps and reports prepared by TSLUMD were also used as reference material for planning the land use classification and other maps.

3.1.4 Reference Satellite Image

The satellite image of the Google Earth platform is another informative resource for understanding land use pattern and land use map preparation of the project area. Several features can be recognized more clearly using this image and land use changes over different times. The images of the Google Earth were used as supporting reference for the interpretation of land use of project area. (Figure 3.1).

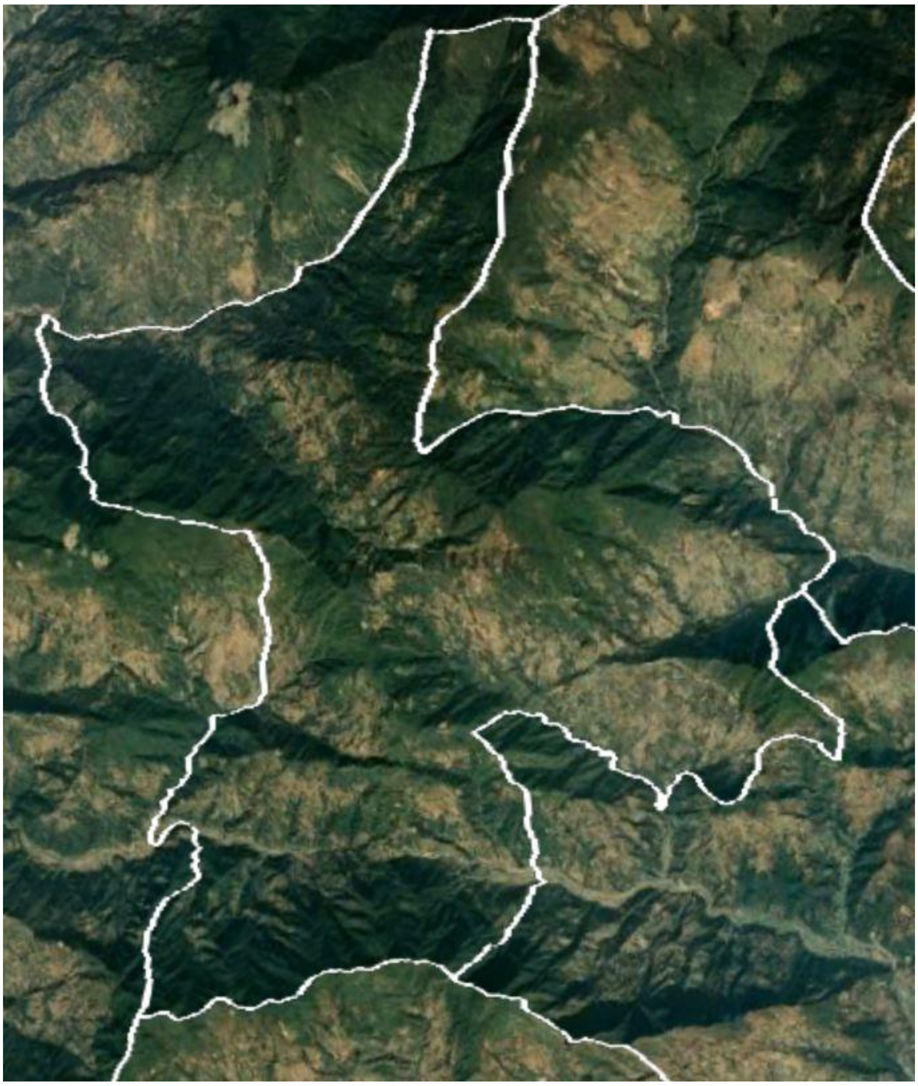

Figure 3.1: Project Area Boundary overlaid on Google Earth image

3.1.5 Ground Control Points

Differential global positioning system (DGPS) survey was carried out for the collection of Ground Control Points (GCPs) including check points. The DGPS survey for the project area was carried out during February 2021. DGPS survey was done using Pentax G3100R1DGPS sets (4 sets) connecting with reference points which is linked with national geodetic network and established by Survey Department. Pentax G3100R1 DGPS is capable of L1/L2 Frequency. The collected data through Pentax G3100R1DGPS receiver with TIAPENG3100R1 antenna type were proceed in GNSS Software Version 5.2 and provided (x,y,z) in terms of easting, northing and ellipsoidal height. The DGPS stations were established on the locations identifiable in the provided satellite imagery as well as on the ground with even distribution for covering entire project area and range of elevation. While 15 DGPS observations were used as control points, 3 offset observations points were used as check points. At each GPS station, reading were made for 2 hours. DGPS readings were later processed using post processing software for co-ordinate adjustment of GPS points. Then, these adjusted co-ordinates were transformed into national co-ordinate system. The co-ordinate list of GCPs used for the project area is shown in Appendix- 1. The distribution of GCPs point location overlay on satellite image is shown in Figure 3.2.

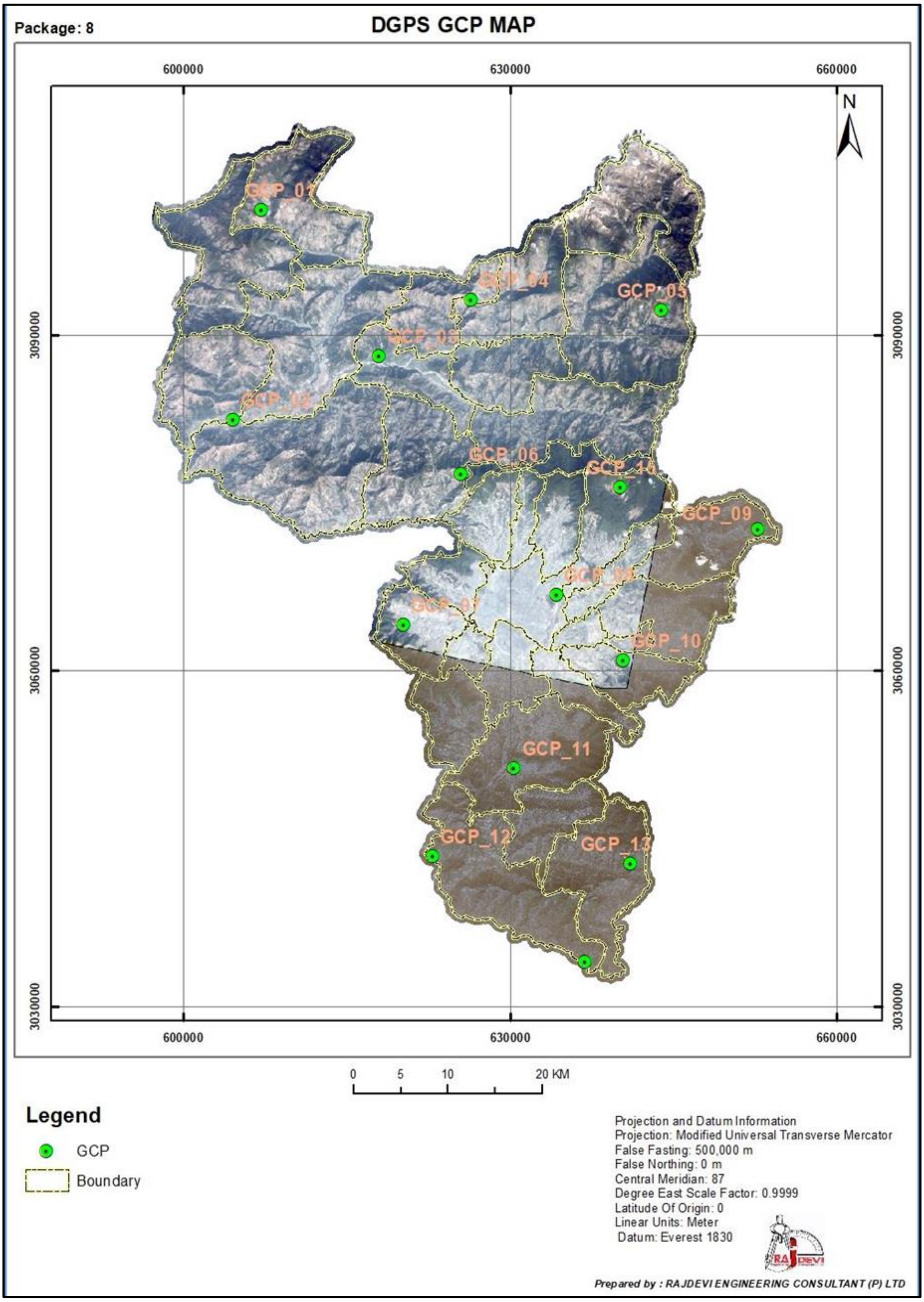

Figure 3.2: DGPS Points in the project Area

3.2 Methods

3.2.1 Methodology for Land use extraction

The methodological steps adopted to generate land use map is shown in Figure 3.3 and explained shortly in subsequent sub-sections. The stepwise procedure adopted to generate the land use map is listed as following:

- Geometric Correction and Ortho-rectification
- Pan-sharpening (Image Fusion)
- Visual image interpretation and classification
- Intensive field verification
- Accuracy assessment
- Present Land Use geo-database preparation
- Present Land Use maps and Reports

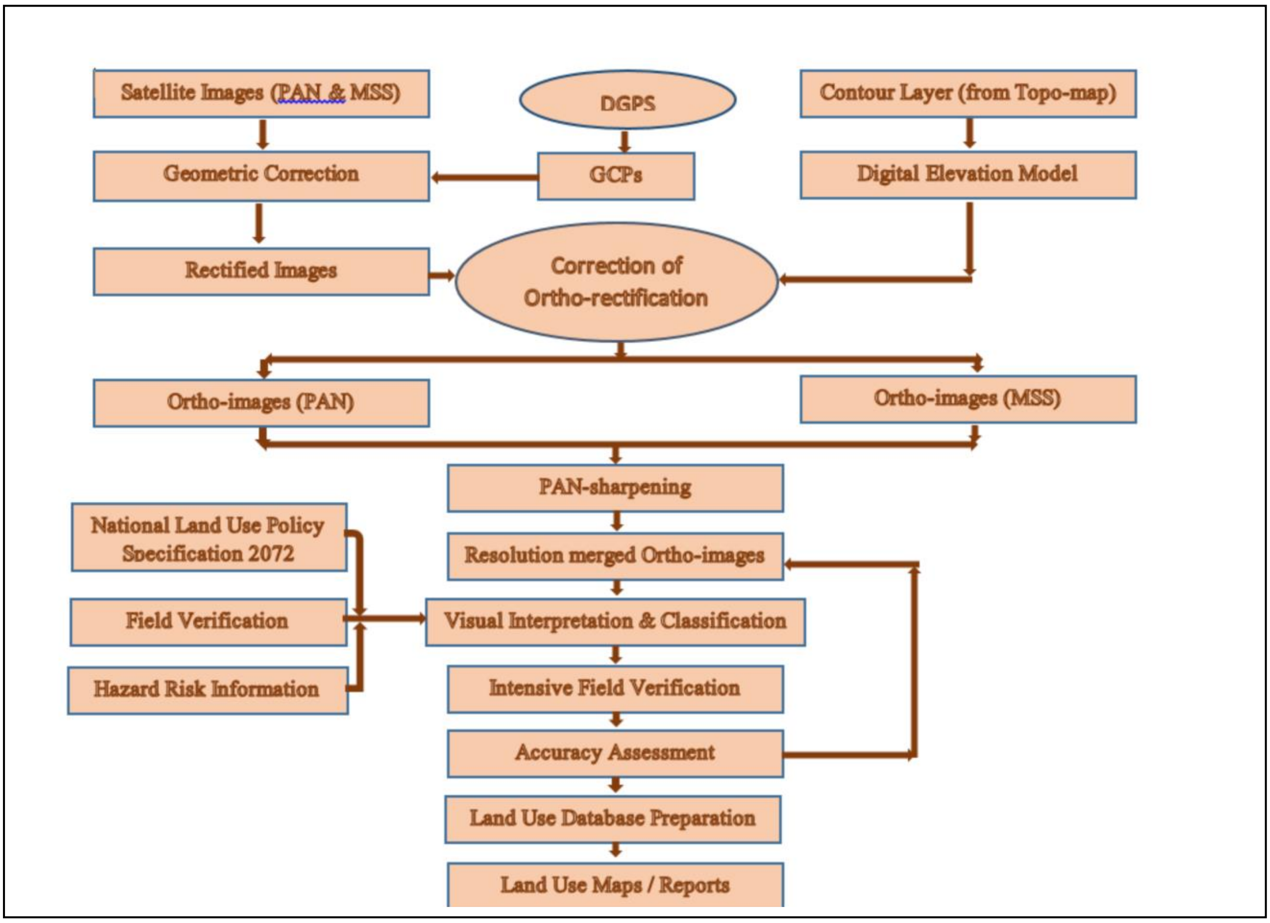

Figure 3.3: Methodology for Present Land use classification

3.2.2 Geometric Correction and Ortho-rectification

Geometric corrections comprise correcting for geometric distortions due to sensor-earth geometry variations, and conversion of the data to real world. So, geometric correction has established the relationship between image co-ordinates of the object with respect to ground co-ordinates of such object in the image. Geometric correction was done to compensate for errors caused by variation in altitude, velocity of sensor platform, rotation and curvature of the earth etc. For the geometric correction of optical images, there are two commonly used mathematical approaches. The first is rigorous sensor model (RSM), a parametric method used in direct geo-referencing techniques and model is an established relationship between the point on the image and the correspondent point on the ground (Kaveh and Mazlan, 2011). The mathematical RSM models build a correlation between the pixels (2D image space) and their corresponding ground location (3D object space) using any other sensor model. This model is termed as rational polynomial functions (RPFs). The second mathematical model is the rational polynomial co-efficient (RPCs) which is non–parametric or generic and advanced form of RPF model. This model provides a standardized and easy to use mathematical model to transform object coordinates to image column and row values of the original image. The RPC model has universally been used for interior and exterior orientation of each satellite images for transformation of image column and row values of the original image to object ground co-ordinates using third order polynomials for numerator and denominator of at least 80 coefficients. This method can be applied without GCPs (because of which it is called terrain-independent), although the accuracy obtained is not very good and generally not applied in the actual geometric correction of the satellite images.

In order to improve the geometric accuracy of the original RPCs, these has to be corrected using GCP collected from ground survey by DGPS survey and geometric adjustment has to be done using least square adjustment with affine transformation for estimating the error between the satellite scene and the reference scene. The corrected image coordinates are computed based on affine transformation and are given by;

$$\begin{aligned} row &= a_0 + a_1 \,.\, rpc_r + a_2 \,.\, rpc_c \\ col &= b_0 + b_1 \,.\, rpc_r + b_2 \,.\, rpc_c \end{aligned} \qquad (3.3)$$

Where rpc_r and rpc_c are the originally rational polynomial coefficients provided by satellite image provider or vendors. The RPCs mathematical model are widely used for geo-referencing the VHRS images (Lehner et al., 2005).

Satellite images do not represent the real-world features/objects in its actual geometric position due to perspective geometry. The effect of object height, terrain relief, and curvature of the earth, systematic error in aircraft flight or satellite system and object displacements introduces geometric error in the image. Due to the perspective projection of the satellite sensor, scale distortion, effect of the tilt and relief displacement is more prominent in outward direction from the nadir point causing the non-uniform scale over the different part of the image (Schenk, 1999). In ortho-rectification process, oriented image and elevation data are used for differential rectification to transfer perspective projection to orthogonal projection in oriented image. Re-sampling process is used for computing the new geometric and radiometric properties of the image of each location after ortho-rectification (Schenk, 1999).

In order to ortho-rectify, a transformation model is required which takes into account the various sources of image distortion mainly caused by elevated objects and its relief displacement at the time of photograph/image acquisition. The quality of ortho-image is dependent on the quality of GCPs, check points and the quality of DEM used in the process of ortho-rectification. The project area satellite image is geometrically corrected images using RPCs mathematical model with RPCs file and GCPs collected with DGPS technique in national co-ordinate system as reference co-ordinate system. Details of Nepalese co-ordinate system is listed below:

- Spheroid: Everest 1830
- Semi-major Axis: 6377276.345
- Semi-minor Axis: 6356075.413
- Inverse Flattering: 300.8017
- Projection: Modified Universal Transverse Mercator (MUTM)
- Origin: Longitude 84 E, Latitude 00 N (Equator)
- False Co-ordinate: 500000m Easting, 0m Northing
- Scale Factor: 0.9999 at Central Meridian

Ortho-rectification was done based on geometrically corrected images and DEM generated from topographical contours. The ranges of positional residual entered in ortho-rectification processes are minimum 0.004m to maximum 0.025 and the overall root mean square error (RMSE) for images is 0.0.013m. The ortho-rectification error assessment report is shown in Appendix-2.

3.2.3 Pan Sharpening

Pan-sharpening method is used to enhance the resolution of lower resolution multispectral data set by the fusion process of higher resolution panchromatic data. A wide range of methods are used for pan-sharpening such as Brovey transform, Multiplicative technique, Principal Component Analysis (PCA), Intensity Hue Saturation (IHS) transform, Wavelet transform, Euler's technique, Gram-Schmidt transform etc. Satellite image in this project is pan-sharpened using Brovey transform technique. The pan-sharpening is applied to visually increase contrast in the low and high ends of an image's histogram (i.e., to provide contrast in shadows, water and high reflectance areas such as urban features).

3.2.4 Visual Image Interpretation and Classification

Visual image interpretation is one of the most common and intuitive method to extract feature from high resolution satellite images. The first step of visual image interpretation is to define the criteria to distinguish the various categories of features in the images. Specific characteristics may determine and separate the proper land use classes for specified classification hierarchy guided by Land Use Policy, 2072. The second important issue for determining and delineating features is the selection of the minimum mapping unit (MMU) to be employed in the process. This refers to the smallest size areal entity to be mapped as a discrete area. The minimum mapping unit (MMU) for delineating feature is 0.25 hectare as specified in land use specification for mapping at scale 1:10000. However, important and essential features smaller than the MMU were also mapped.

The land use land cover feature has been identified with the help of interpretation keys using expert knowledge base. Interpretation of elements based on tone, size, shape, texture, shadow, pattern, site and association were used for digitizing, editing and assigning land use classes. The identified features were verified with extensive field verification. Features were update and finally, land use classes were extracted from the image. Different ancillary layers such as simple ratios: NDVI, NDWI, DEM and DEM derivatives along with field data were used as references. The feature such as forest, agriculture, road, residential area or commercial area in one category, industrial area, river etc. which was easily identified was classified with interpretation element incorporated with expert knowledge. Similarly, hazard prone areas/features were also delineated with expert's knowledge. These features were included in the classification hierarchy.

3.2.5 Field Verification

Land use map prepared after visual interpretation and desk study based classified feature were extensively verified in the field. Changes in any feature at the first level classification was found; classified map were updated accordingly. For lower level classification, object or features within the hierarchy of first level was sub classified based on ground verification. Agricultural land was categorized based on the cropping pattern and its intensity up to six level classification hierarchy schema by group of experts such as horticulture, agriculture expert and agro forester. Forest land was also categorized based on species, cover, type, crown density, maturity status and ownership right of forest by forester up to seven level classification hierarchy schema. This intensive detailed field verification increases the quality of land use classes. Integration of image interpretation and ground knowledge enhanced the classification methods.

3.2.6 Accuracy assessment

Validation of classification results is an important process in the classification procedure. It allows users to evaluate the utility of a thematic map for their intended applications using accuracy assessment. Accuracy assessment is a feedback system for checking and evaluating the objectives and the results. It determines the correctness of the classified image. Classification is not complete until its accuracy is assessed. There are several methods of evaluating the accuracy assessment. In general, one method is to compare the classified image to a reference image with a random set of points generated for the comparison. A second method used to perform accuracy assessment is using a GPS and a random set of points generated over the classified image with ground truth performed by going into the field at the location of each randomly generated point. These methods are used for sample schema and evaluation process is done with generating confusion matrix and its test statistics with kappa coefficients for the test statistics and kappa index of agreement (KIA) for each category of class.

For the present land use classification accuracy assessment, confusion matrix was generated based on the comparison between the classified image and the existing ground / reference data collected using GCPs i.e., the matrix depicts the land cover classification categories versus the field observed land cover type. A total of 328 samples points were taken for confusion matrix generation. The total area covered by one legend unit is not taken into account for other legend unit. A matrix of an 8 x 8 “classified” and “observed” cells corresponding to 8 land cover classes was developed. Classification result is given as rows and reference (ground truth) is given as columns for each sample. The diagonal elements in this matrix indicate numbers of sample in which classification results has matched with the reference data. Off-diagonal elements in each row present the sample that has been misclassified by the classifier during classification process. The error matrix was evaluated by computing the user accuracy, producer accuracy and overall accuracy which was tested statistically with the KIA (Kappa statistics). The KIA was calculated with the following formula (Congalton 1991).

$$K = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r}(X_{i+} * X_{+i})}{N^2 - \sum_{i=1}^{r}(X_{i+} * X_{+i})}$$

Where:

r = is the number of rows in the matrix

X_{ii} = is the number of observations in rows i and column I (along the major diagonal)

X_{i+} = the marginal total of row i (right of the matrix)

X_{+i}= the marginal totals of column i (bottom of the matrix)

N = the total number of observations.

The summary of accuracy assessment is shown in Table 3.3. The overall accuracy represents the percentage of correctly classified pixels; it is achieved by dividing the number of correct observations by the number of actual observations. The overall accuracy and kappa coefficient were found to be 94.512 %and 0.931respectively for the classified land use classes.

Table 3.3: Summary of Accuracy Assessment

Land Use	Agriculture	Forest	Residential	Commercial	Industrial	Public Use	Cultural and Archaeological	Riverine and Lake Area	Other	Total	Producer Accuracy (%)
Agriculture	90	0	1	0	0	1	1	0	1	**94**	**95.74 %**
Forest	0	100	0	0	0	0	0	2	0	**102**	**98.03 %**
Residential	0	0	26	1	1	0	0	0	0	**28**	**92.85 %**
Commercial	0	0	1	13	1	0	0	0	0	**15**	**86.66 %**
Industrial	0	0	0	0	12	0	0	0	1	13	**92.30 %**
Public Use	0	0	1	0	0	23	1	0	0	**25**	**92.00 %**
Cultural and Archaeological	0	0	0	0	0	0	16	0	0	**16**	**100.00 %**
Riverine and Lake Area	0	0	0	0	0	1	0	19	0	**20**	**95%**
Other	1	2	0	1	0	0	0	0	11	**15**	**73.33 %**
Total	**91**	**102**	**29**	**15**	**14**	**25**	**18**	**21**	**13**	**328**	
User's Accuracy (%)	**98.90 %**	**98.03 %**	**89.65 %**	**86.66 %**	**85.71 %**	**92.00 %**	**88.88 %**	**90.47 %**	**84.61 %**		
Overall Accuracy = 94.512 %, Overall, KIA value = 0.931											

CHAPTER 4: PRESENT LAND USE

4.1 Present Land use at Level 1 Hierarchy

The general land use pattern of project area exhibits nine major land use classes at level 1 identified by Land Use Act, 2076BS. The current classification is based on the National Level Specification for the Preparation of Rural Municipality/Local unit level Land Resource Maps, database and Reports, 2019 which identifies ten landuse classes at level 1. As characteristics of most of the Hill region, the largest share is of agriculture and forest. Forest is dominant land use covering more than 54 percent of the total project area. Agriculture occupies second place with more than 41 percent coverage of the total area which is followed by public use class comprising 1.6 percent. Residential use covers 0.73 percent. Besides residential use, commercial, industrial, cultural and archaeological and other use also occupies less than a percent of the total area. Riverine, lake and marsh covers 1.2 percent of the total area. The percentage share of each land use class at level 1 is shown in Table 4.1.

Table 4.1: Level 1 Land use hierarchy and area distribution

SN	Description	Area (Ha)	Percentage
1	Forest	5357.17	54.76
2	Agricultural	4014.51	41.03
3	Public Use	156.10	1.60
4	Riverine, Lake And Marsh Area	117.29	1.20
5	Residential	71.35	0.73
6	Other	62.93	0.64
7	Commercial	3.24	0.03
8	Cultural And Archeological	0.86	0.01
9	Industrial	0.06	0.001
	Total	**9783.49**	**100.00**

The project area covers more than 9783 hectares, among which forest covers more than 5357 hectares and agriculture use covers 4014 hectares. It is followed by public use area with 156-hectare area. Residential area covers 71 hectares. Riverine, lake and marsh area covers 117 hectares whereas industrial, and cultural and archaeological use occupies less than 1 hectare of total project area. Others category however, shares more than 62 hectares which comprises grazing, barren and landslide areas. Distribution of level 1 land use classes are shown in Figure 4.1 and Appendix 3.

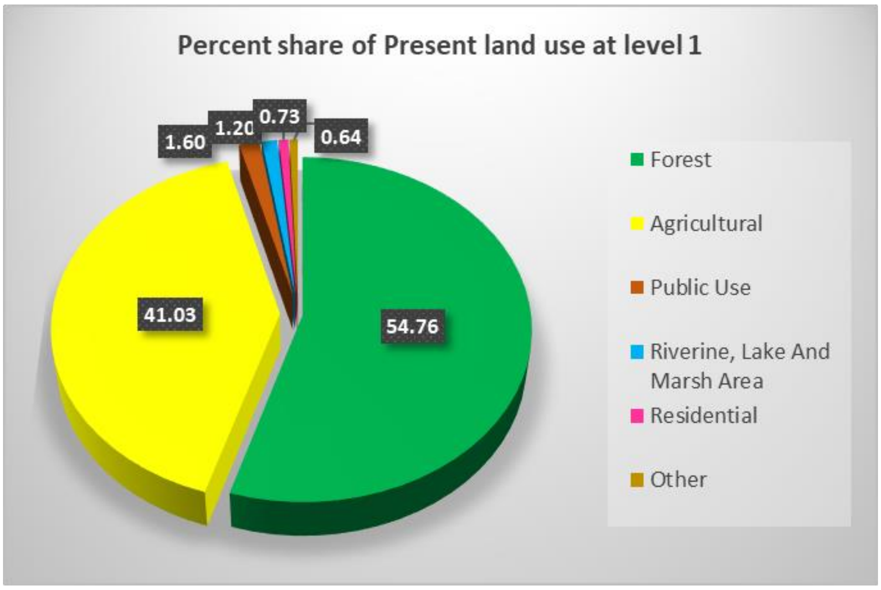

Figure 4.1: Distribution of present land use classes at level 1

4.1.1 Agricultural Land use

Agricultural land use refers to areas which have been used for the production of agricultural products such as cereals, cash crops, orchards etc. Variation in distribution of agricultural land use is found due to variation in physiographic components, topography and cultural practices over the project area. Agriculture area of the project area lies under only hill cultivation at land use hierarchy level 2. At the hierarchical classification level 3, agricultural land use pattern is categorized as level terrace, level terraces upland cultivation, sloping terrace and sloping upland. More than 62 percent agriculture practices are carried out on level terraces and around 37 percent is carried out on sloping terraces. Whereas at level 4 classification, 37 % is under upland sloping terraces, and 34% is under level terrace Pakho land. More than 28% is under level terrace khet land cultivation. Table 4.2 and Figure 4.2 presents the distribution of agriculture land use at level 4.

Table 4.2: Agricultural Land Use Classification at Level 4

SN	Description	Area (Ha)	Percentage
1	Level Terraces Khet Land Cultivation-Tk	1127.10	28.08
2	Level Terraces Upland/Pakho Land Cultivation-Tp	1399.48	34.86
3	Slopping Upland/ Pakho Land Cultivation-Cp	1487.93	37.06
	Total	**4014.51**	**100.00**

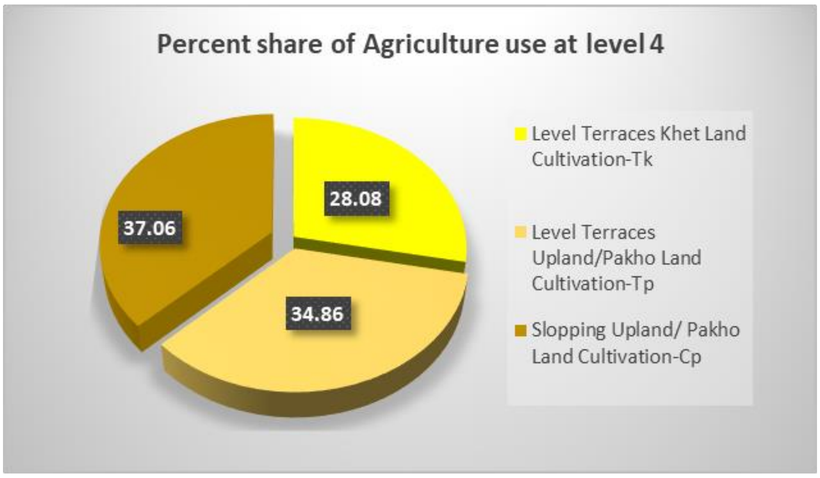

Figure 4.2: Distribution of Agriculture land use class at level 4

Regarding the cropping pattern (i.e. land use hierarchical classification level 5) dominant is food crops with maize-millet- rice-wheat and vegetables combination. Highest percent share is of maize-millet cropping pattern with more than 18 percent area. Shrubs from the non-forest area covers nearly 17 percent whereas rice-maize- vegetables combination covers 11 percent. Different combination of food crops with potato and vegetable area also found. Other combination comprises 3 percent. Cropping pattern under level 5 hierarchies is detailed in Table 4.3. No specific high value crops are found though some off-season farming is in practice.

Table 4.3: Agricultural Land Use Classification at Level 5

SN	Description	Area (Ha)	Percentage
1	Maize-Millet-m7	757.67	18.87
2	Shrub from non-forest area-s3	701.14	17.47
3	Rice-Maize-Vegetable-r12	463.51	11.55
4	Cardamom-c2	460.05	11.46
5	Maize-Wheat-m5	399.56	9.95
6	Rice-Potato-r8	298.72	7.44
7	Maize-Potato-m8	220.21	5.49
8	Barley-Buck Wheat-b1	171.10	4.26
9	Rice-Wheat-r2	129.65	3.23
10	Barren Cultivable land-b5	126.57	3.15
11	Rice-Wheat-Maize-r15	57.78	1.44
12	Rice-Oilseed-r4	55.77	1.39
13	Rice-Maize-r10	41.50	1.03
14	Others	131.28	3.27
	Total	**4014.511**	**100**

4.1.2 Forest Land use

The forest cover in project area is high. It covers more than 54 percent of the total area and of total forest coverage, subtropical forest is dominant with more than 96 percent while tropical forest cover is 4 percent. Regarding the forest cover type (level 3 classification) pre-dominant is mixed cover type with more than 98 percent coverage. It is followed by hardwood but share only 1.29 percent. Bushes cover less than 1 percent of the total forest area. Table 4.4 and Figure 4.3 presents the distribution of forest cover in the project area. So far as management is concerned, only 32 percent is under community management while government/conservation forest, cover 67 percent.

Table 4.4: Forest Land Use Classification at Level 3

SN	Description	Area (Ha)	Percentage
1	Bushes(B)	21.94	0.41
2	Hardwood (H)	69.30	1.29
3	Mixed(M)	5265.92	98.30
	Total	**5357.17**	**100.00**

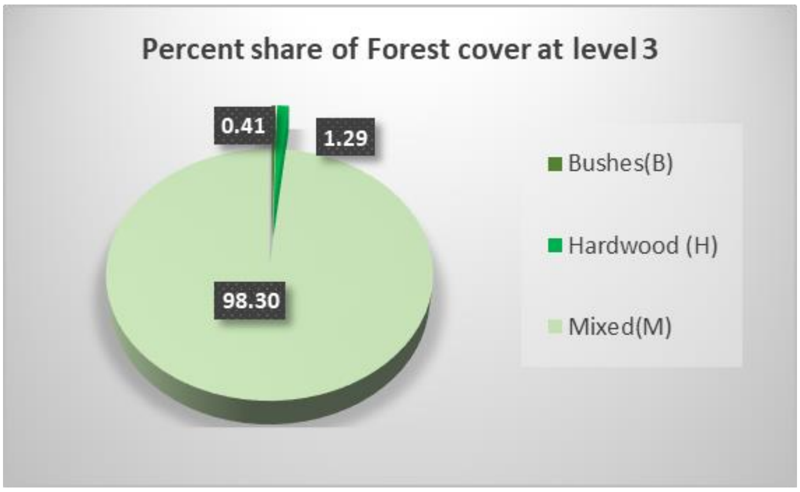

Figure 4.3: Forest distribution at level 3

4.1.3 Residential Land use

The residential land use consists of all the areas including buildings used for the human settlement. The residential landuse is subdivided different sub-classes. The second level sub division is based on density/compactness of residential units such as dense residential use having concentration ≥ 70%, moderate having concentration between 40% to 70% and sparse having concentration ≤ 40%. The residential area is further subdivided into third level based on history of settlement development and management such as Old Area, Newly Developed Area (without planning) and Planned Area. Similarly, the level 4 sub-division of residential land use is done with designated units.

The residential area coverage in the project area is very limited. It covers only 0.73 percent of the project area. The project area is densely populated and settlements are clustered in lower elevation and along river valley floor. Of the total residential use, 61 percent is densely populated whereas 22 percent is comprised of moderately populated residential area. Sparsely populated area occupies around 16 percent of total residential coverage. Distribution of Residential land use at level 2 (by density) is presented in Table 4.5 and Figure 4.4. More than 95 percent area is traditional settlement and newly developed area covers 5 percent of the total residential coverage.

Table 4.5: Residential Land use based on density at level 2

SN	Description	Area (Ha)	Percentage
1	Densely Populated-D	44.14	61.86
2	Moderately Populated-M	15.91	22.30
3	Sparsely Populated-S	11.30	15.83
	Total	**71.35**	**100.00**

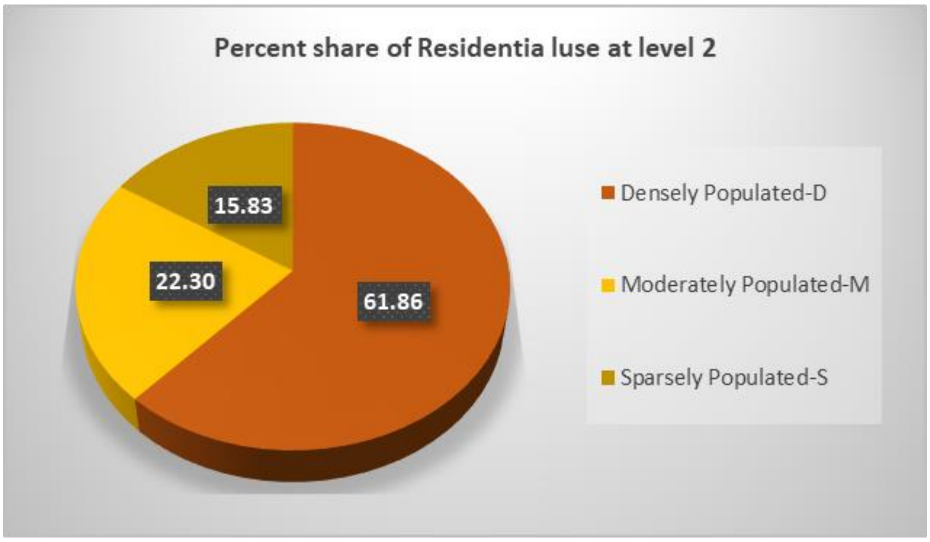

Figure 4.4: Distribution of residential land use at level 2

4.1.4 Public Use

Public use (public services) area includes area utilized for health, education, transportation and other services. It occupies nearly 156 hectares but comprises only 1.60 percent of the project area. The largest share among all public uses is of transportation infrastructure mainly road comprising 96 percent of public use category. It is followed by recreational use with 1.41 percent coverage. Similarly, educational use covers 1.37 percent. All other public use category in total share less than 1 percent which include health, security and other institutional service. The area and percentage coverage of different public use is represented in Table 4.6.

Table 4.6: Categories of Public Use at level 2

SN	Description	Area (Ha)	Percentage
1	Educational (E)	2.14	1.37
2	Health Service (H)	0.51	0.33
3	Institutional Area (I)	0.01	0.01
4	Recreational Area (F)	2.20	1.41
5	Security Service (S)	0.10	0.06
6	Transportation Infrastructure (T)	151.14	96.82
	Total	**156.10**	**100.00**

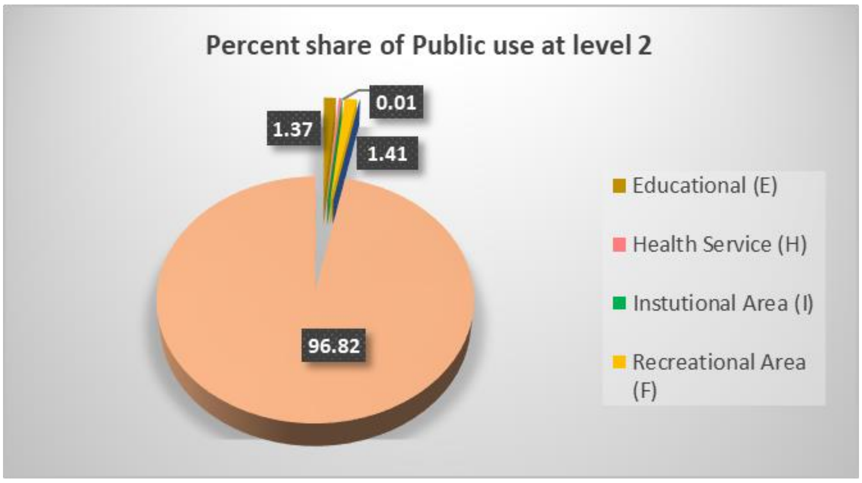

Figure 4.5: Distribution of Public use at level 2

4.1.5 Riverine, Lake and Marsh Area

Riverine, lake and marsh land coverage in the project area occupies 1.2 percent of the total area. Kintang Khola, Thopal Khola, Samari Khola etc. are major rivers flowing through the project area. Besides there are many streams and rivulets. Most of these streams are flowing towards the southward slopes. Of the total riverine area, 99 percent of the area is under river water. The sand area covers 0.53 hectare whereas pond area covers 0.02 percent of the total area. Distribution of riverine, lake and marsh area at level 2 in the project area is shown in Table 4.7.

Table 4.7: Categories of Riverine, Lake and Marsh Area at level 2

S.N.	Description	Area Ha	Percentage
1	Pond (p)	0.02	0.02
2	River (r)	116.65	99.45
3	Sand (d)	0.62	0.53
	Total	**117.29**	**100.00**

4.1.6 Commercial use

The commercial area coverage is very limited covering only 0.03 percent of the total area covering only 3.24 hectares of the total area. At commercial landuse level 2, business area is dominant is with trading and local business covering more than 78 percent while service covers 21 percent of the total commercial use. At the third level of commercial land use, 4 categories are present in the project area (Table 4.8).

Table 4.8: Categories of Commercial land use at level 3

S.N.	Description	Area Ha	Percentage
1	Government Service Area(G)	0.71	21.84
2	Hotel (H)	0.52	15.93
3	Market (M)	1.37	42.33
4	Service (S)	0.64	19.90
	Total	**3.24**	**100.00**

Percent share of commercial use at level 3 is presented in Figure 4.6. Market is dominant covering more than 1.37 hectares and it occupies only 42 percent whereas government services comprises 21 percent. Other services at level 3 occupies less than 1 area.

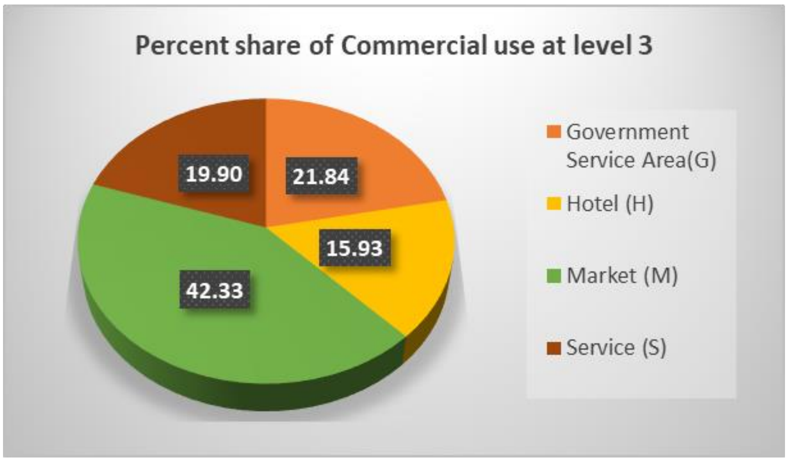

Figure 4.6: Distribution of Commercial use at level 3

Beside these land use classes, other land use categories found in the project area sharing less than 1 percent of the total area are: cultural and archaeological use (01%), and industrial use covering 0.0031 area. Others use category which includes grazing land, landslides and barren land occupies 0.64 percent area covering 62.9 hectare among which dominant is grazing land comprising 98 percent (58 hectares) other 2 percent includes barren land and landslide areas.

4.2 Land use Database

The present land use data of the project area is created and documented as specified by TSLUMD specifications. It is stored in Geo-database format as vector feature data class. The attribute includes hierarchical classification of existing land use classes which can be aggregated and generalized at higher level as required. The present land use map of the project area is created using this Geo-database. The attribute list of present land use classes is shown in Table 4.9.

Table 4.9: Attribute list of Present Land use classes

Field	Data Field	Description
FID	Feature Id	Feature System Identifier
SHAPE	Geometry	Geometric Object type
ID	Long	Unique Object ID
LEVEL 1	String	Land Use Class Hierarchy Level 1
LEVEL 2	String	Land Use Class Hierarchy Level 2
LEVEL 3	String	Land Use Class Hierarchy Level 3
LEVEL 4	String	Land Use Class Hierarchy Level 4
LEVEL 5	String	Land Use Class Hierarchy Level 5
LEVEL 6	String	Land Use Class Hierarchy Level 6
LEVEL 7	String	Land Use Class Hierarchy Level 7
Rural Municipality/Local unit	String	Rural Municipality/Local unit Name
District	String	District Name
Remarks	String	Any remarks related to the feature
Area	Double	Area in m2
Area_HA	Double	Area in Hectare

CHAPTER 5: CONCLUSION

5.1 Conclusion

Among 10 land use classes identified at the highest level, nine classes are found in the project area. Like all other hill region, characteristics is forest land use area comprising more than 54 percent (5357 hectares) of the total project area. Agriculture is second highest land use comprising 41 percent (4014 hectares). Combination of food crops and vegetables is common agricultural practices. Regarding major agriculture product, beside food crop, potato is dominant with few vegetables. Residential use shares 0.73 percent (71 hectare) of the total area. More than 95 percent of the residential use are traditional settlements signifying stable growth. Commercial, industrial use, cultural and archaeological use comprise less than one percent of the total area. Major industries include agro-processing and furniture units. Environmentally sensitive area such as grazing land, barren land and landslides comprise large area with 62 hectares. Mines and mineral use in not evident in the project area.

The methodology adopted includes the visual image interpretation of provided satellite imagery, use of existing reference data and maps such as LRMP maps, DEM, GoogleEarth images, intensive field survey and land use class verification and expert knowledge input. Land use map at the scale 1:10,000 has been generated up to the level five classes including updated road network and other service infrastructure.

The accuracy of the results was assessed and overall accuracy was obtained as 91.39 % with Kappa coefficient value of 0.899. Overall accuracy percentage and Kappa coefficient value is relatively lower due to complex urban land use characteristics of Kathmandu valley specifically between classes like residential, commercial and public use. Generation of land use from very high resolution satellite image resulted a better accuracy together with use of reference maps detailed and intensive verification work. The new satellite imagery data (ZY3 series with 2.1 m PAN and 5.8 m MSS) is used for land cover land use class mapping of the project area. However, the feature extraction of topographically rough and higher hill slope area was slightly difficult from the image and associated uncertainties required longer time for field verification and updating. Similarly, identification and extraction and classification of urban land use classes like commercial and residential is also intricate due to mixed uses in Nepalese urban context.

5.2 Recommendation

Based on the present experience of the project, the following recommendation could be made.

- The data and maps should be utilized for long term change detection and monitoring. However, the new satellite imagery data (with 2.1 m PAN and 5.8 m MSS) is used for land cover land use class mapping of the project area and the imagery used is different than used for earlier landuse mapping projects and the spatial resolution is also lesser. Therefore, a scientific method should be adopted while carrying out historical change detection and mapping for comparative analysis with other areas so that accuracy and class category is maintained.

- Grazing land, barren land with landsides at steeper slopes are the characteristics of hill and mountainous terrain under others category and covers more than 62 hectare of the total project area. Proper safeguarding is required to mitigate land degradation. However, due to low population and moderate settlements growth less human interference is foreseen.
- Agriculture use covers second highest percent and mostly carried out on level and sloping terraces. Proper terracing like contour-based cropping systems and soil erosion mitigation methods should be adopted.
- Cash crop and high value crop farming is very limited. The high value crops could be farmed in available barren cultivable area whereas agro-forestry should be practiced in environmentally sensitive uses such as landslide and grazing land.

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APPENDIX

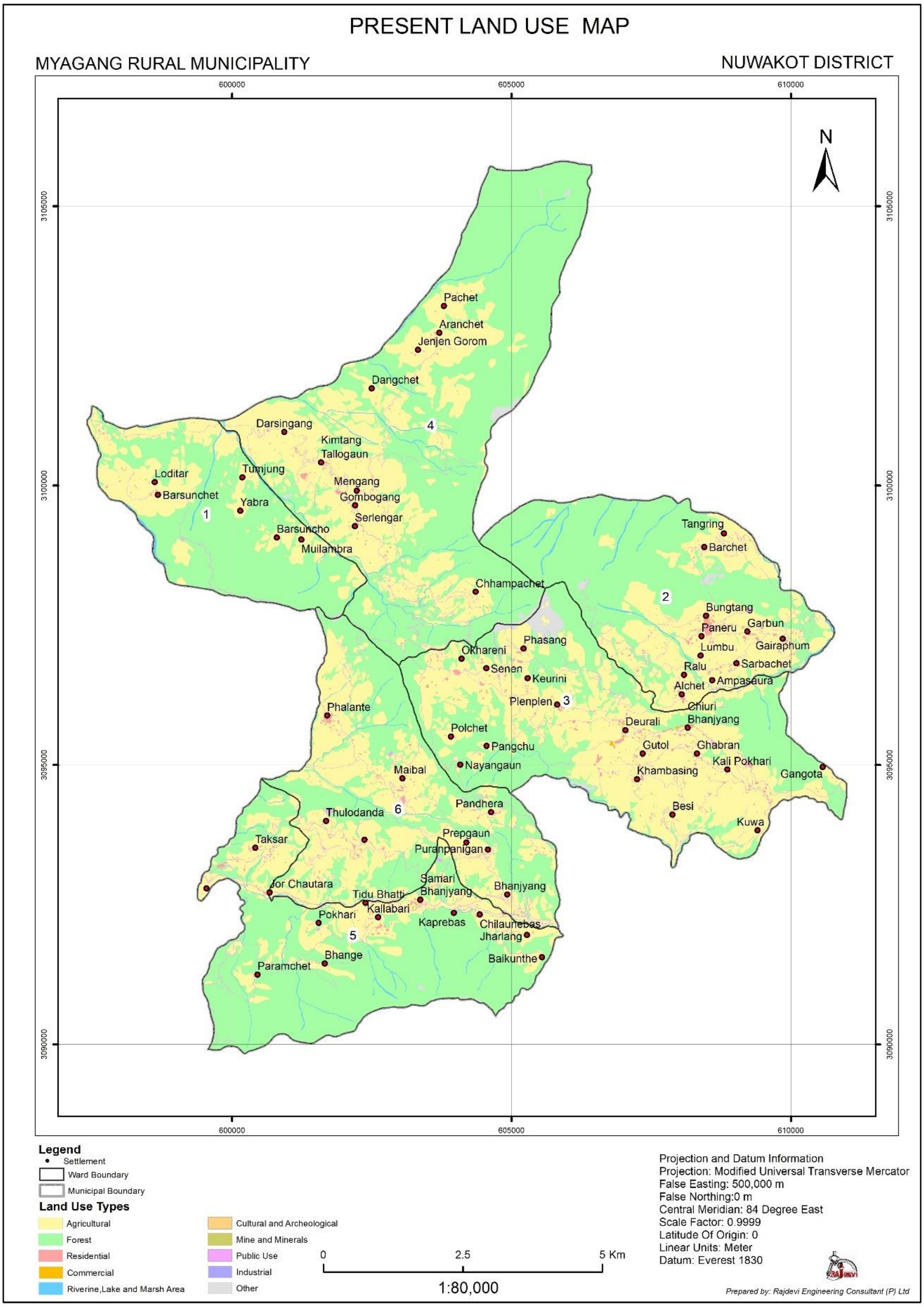
Appendix 1: List of Control Points

SN	NORTHING	EASTING	ELEVATION	REMARKS
1	3060806.500	530809.618	1313.875	Base
2	3086134.587	513732.346	554.855	Base0
3	3100532.046	508435.296	1685.626	GCP1
4	3081971.602	505825.238	428.852	GCP2
5	3087321.463	519178.148	528.205	GCP3
6	3091287.427	544909.974	1824.669	GCP5
7	3076789.360	526441.272	1972.395	GCP6
8	3063242.238	521216.536	1467.245	GCP7
9	3065871.737	535284.862	1284.766	GCP8
10	3071528.250	553877.346	1234.242	GCP9
11	3059929.936	541338.194	1326.561	GCP10
12	3050413.485	531185.778	1463.059	GCP11
13	3042631.879	523637.192	974.089	GCP12
14	3041796.461	541885.821	2068.980	GCP13
15	3033041.522	537575.883	493.959	GCP14
16	3075385.718	541213.461	1954.005	GCP15
17	3067366.013	542315.042	1313.233	OFF1
18	3067623.283	546018.629	1361.888	OFF2
19	3063164.162	533720.515	1282.084	OFF3

Appendix 2: Ortho-rectification Error Report

SN	NORTHING	EASTING	ELEVATION	RMS (m) Horizontal	RMS (m) Vertical	Overall RMS(m)
Base-1	3060806.50	530809.62	1313.88	0.015	0.020	0.025
Base-2	3086134.59	513732.35	554.86	0.004	0.005	0.006
GCP1	3100532.05	508435.30	1685.63	0.007	0.011	0.013
GCP2	3081971.60	505825.24	428.85	0.008	0.015	0.017
GCP3	3087321.46	519178.15	528.21	0.004	0.007	0.008
GCP5	3091287.43	544909.97	1824.67	0.004	0.007	0.008
GCP6	3076789.36	526441.27	1972.40	0.008	0.012	0.014
GCP7	3063242.24	521216.54	1467.25	0.008	0.013	0.015
GCP8	3065871.74	535284.86	1284.77	0.011	0.017	0.020
GCP9	3071528.25	553877.35	1234.24	0.009	0.011	0.014
GCP10	3059929.94	541338.19	1326.56	0.005	0.008	0.009
GCP11	3050413.49	531185.78	1463.06	0.007	0.010	0.012
GCP12	3042631.88	523637.19	974.09	0.002	0.004	0.004
GCP13	3041796.46	541885.82	2068.98	0.015	0.020	0.025
GCP14	3033041.52	537575.88	493.96	0.004	0.005	0.006
GCP15	3075385.72	541213.46	1954.01	0.007	0.011	0.013
OFF1	3067366.01	542315.04	1313.23	0.008	0.015	0.017
OFF2	3067623.28	546018.63	1361.89	0.004	0.007	0.008
Off3	3063164.16	533720.52	1282.08	0.004	0.007	0.008
Total				**0.007**	**0.011**	**0.013**

Appendix 3: Present Land Use Map



SOIL REPORT

Preparation of Soil Report
Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural Municipality.**

The area coverage of Local unit of this package used and analyzed for different purpose under the scope of work of this consulting service are computed from cadastral maps provided by DOLIA Office, Government of Nepal, Ministry of Land Management, Cooperatives and Poverty Alleviation of Nepal. Therefore, the area of Local unit may match to the area computed from Topographic Digital Database provided by the Survey Department of Nepal.

The satellite imageries, GIS database and other outputs produced by this consulting service is owned by Topographical Survey and Land Use Management Division(TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale

Soil is the only place in the universe where life starts after death. Land is one of the most precious resources; unfortunately, it is exploited by human beings in an unsustainable manner. It cannot be denied that healthy soil is a foundation of better agriculture productivity and ecosystem balance. Healthy maintenance of soil resources through sustainable land management (SLM) is one of the most direct solutions of reducing rural poverty, a means through which food, nutritional and water security could be achieved. 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. Working the soil in a judicious manner could help increase food, nutrition and water security; the action which is key to addressing poverty. Integration of soil information must take a central stage to plan and manage natural resources in a sustainable way. The main question that arises is: will it be fair to plan and implement agriculture or any other land-based resource activities without even considering the importance of integrating soil information into it? In absence of this, all attempts made by the Government, the goals that are set in Sustainable Development goals (SDGs) to improve food and nutritional security and eradication of poverty will be obscure and a wild dream.

Soil/Land is considered one of the most precious gifts of nature. There is interdependent relationship between soil and society. 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 1.87% 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 and now it is in the last stage of categorizing land suitability in different subsectors. 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 rural/municipality 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 rural municipality, district or province 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 are an essential step for land use planning of an area. Nepal has been doing land-use planning at rural municipality level from past few years through Survey Department, Topographical survey and Land Use Management Division 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. 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, Survey Department, Topographical survey and Land Use Management Division of Government of Nepal has started to generate the necessary data bases on the land resources of the country for the future planning.

It is well known that the Government of Nepal has approved the National Land Use Policy, 2069 on the 4th Baisakh 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 level at the bottom. It has added further importance to Land use projects on preparation of municipality 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 amendment on the existing Land Use Policy, 2069 which has emphasized 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. Survey Department, Topographical survey and Land Use Management Division 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 3 years to come as directed by the parliamentary committee in 2071.

In the context stated above, the Consultant has been commissioned to carry out the project entitled Preparation of local unit level land resource Maps (Present Land Use Maps, Soil Maps, Land Capability Maps, Land Use Zoning Maps and Cadastral Layer Superimpose, preparation of Risk Layer and Municipality Profile), Database and Reports for land use zoning of Package 8 (4 municipalities of Bhaktapur district; a Metropolitan and 10 municipalities of Kathmandu district; a Metropolitan, a municipality and three rural municipalities of Lalitpur district; and 2 municipality and 10 rural municipalities of Nuwakot district).

1.2 Objectives of the Study

The broad objective of the current project, (2077/078 fiscal year) is to prepare municipality/rural municipality level Land Resource Maps (present land use maps, soil maps, land capability maps, disaster risk zoning maps, land use zoning maps, cadastral layer superimpose and local unit profile), Database and Reports for Package 08 municipalities and rural municipalities.

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 Local units

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

(c) Prepare maps of sample pits covering each land unit/land type of the Local units 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) Analyze 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 Local units at 1:10000 scales.

(g) Populate the given database with the analyzed, collected and lab supplied soil nutritional and other parameters.

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

(i) Prepare reports describing methodology, distribution of different soil types and describe the soil distribution of the area under study.

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

1.3 Study Area

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the central-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

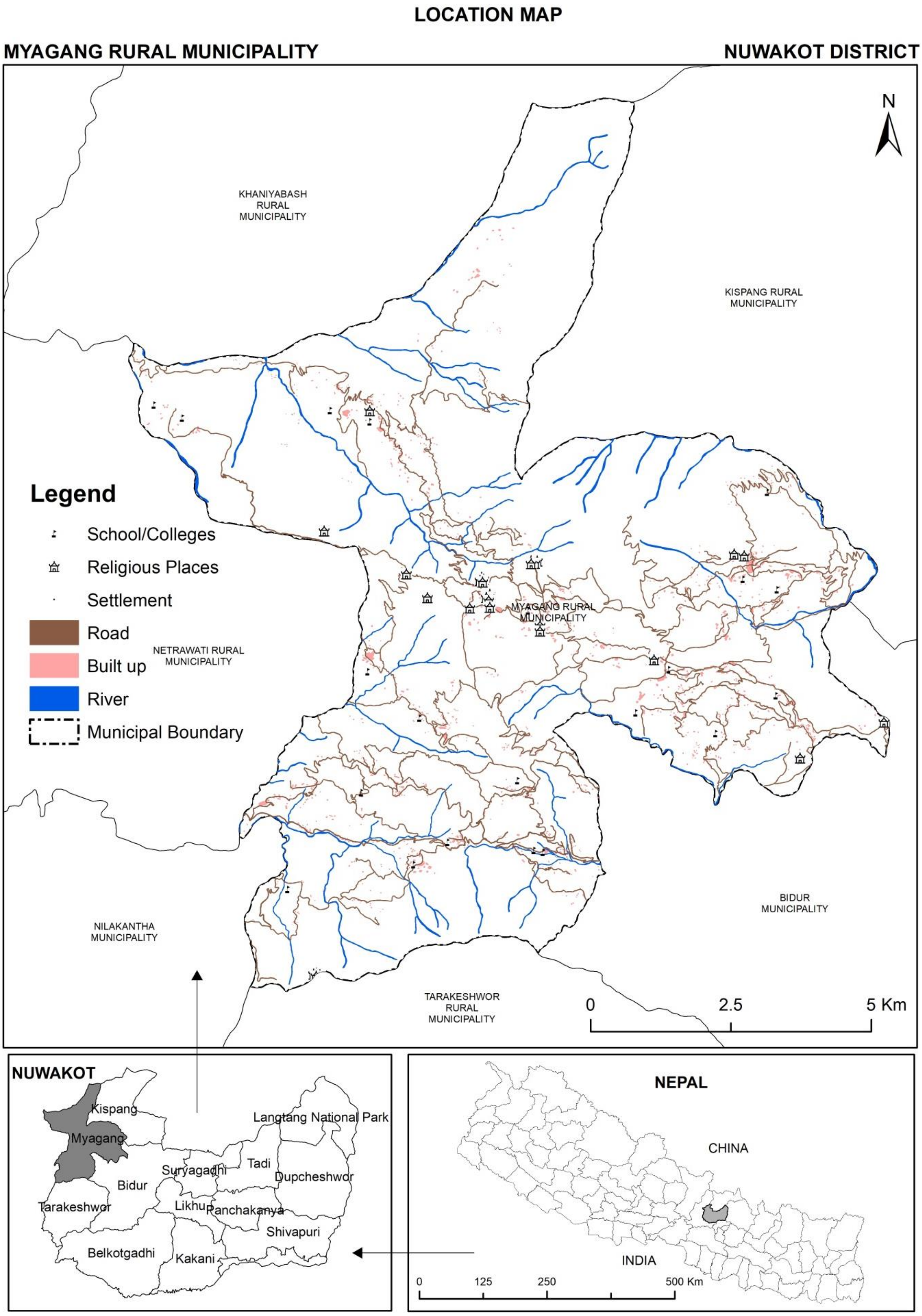


Figure 1.1: Location Map of the project area

CHAPTER 2: BIO-PHYSICAL CONDITION OFTHE PROJECT AREA

Soil is the basis of agriculture and agriculture is the basis of life. Soil is where life begins. American president Franklin D Roosevelt clearly pointed out the importance of soil through his statement "A nation that destroys soil destroys itself". The importance of soil has been aptly described by UN by declaring 2015 as International Year of Soils. Importance of soil has been felts globally and therefore, FAO has been supporting Global Soil Partnership program. 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. A soil scientist has to understand both human made and natural soil process and develop strategies for appropriate remedial action to meet the need of the society. 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.

Soil is a non-renewable natural resource; its loss is not recoverable in the context of a human lifespan. 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 agro-ecological zones, the soils 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 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 Myagang Rural municipality ranges from as high as 722 m to 3202 m AMSL as shown in the Figure 2.1.

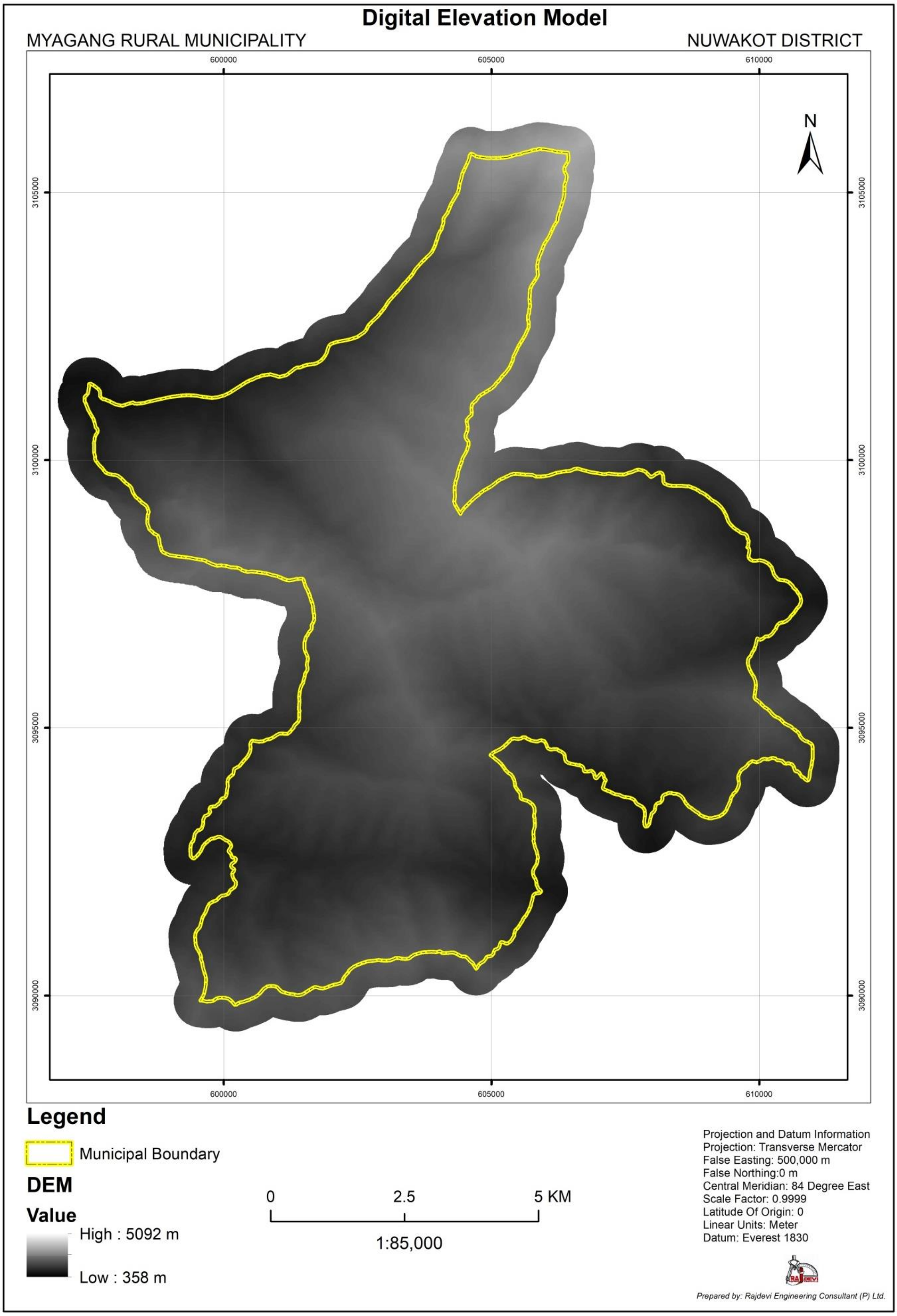


Figure 2.1: DEM Map of Myagang Rural municipality

2.2 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 impacts vegetation type. From the slope map it could be revealed that Myagang Rural municipality has large ranges of slope. It is almost sloppy and most of the area has more or less similar variation in slope. However, the slope ranged from moderate to very highly steep slope (5% to more than 30%) as shown in the map below.

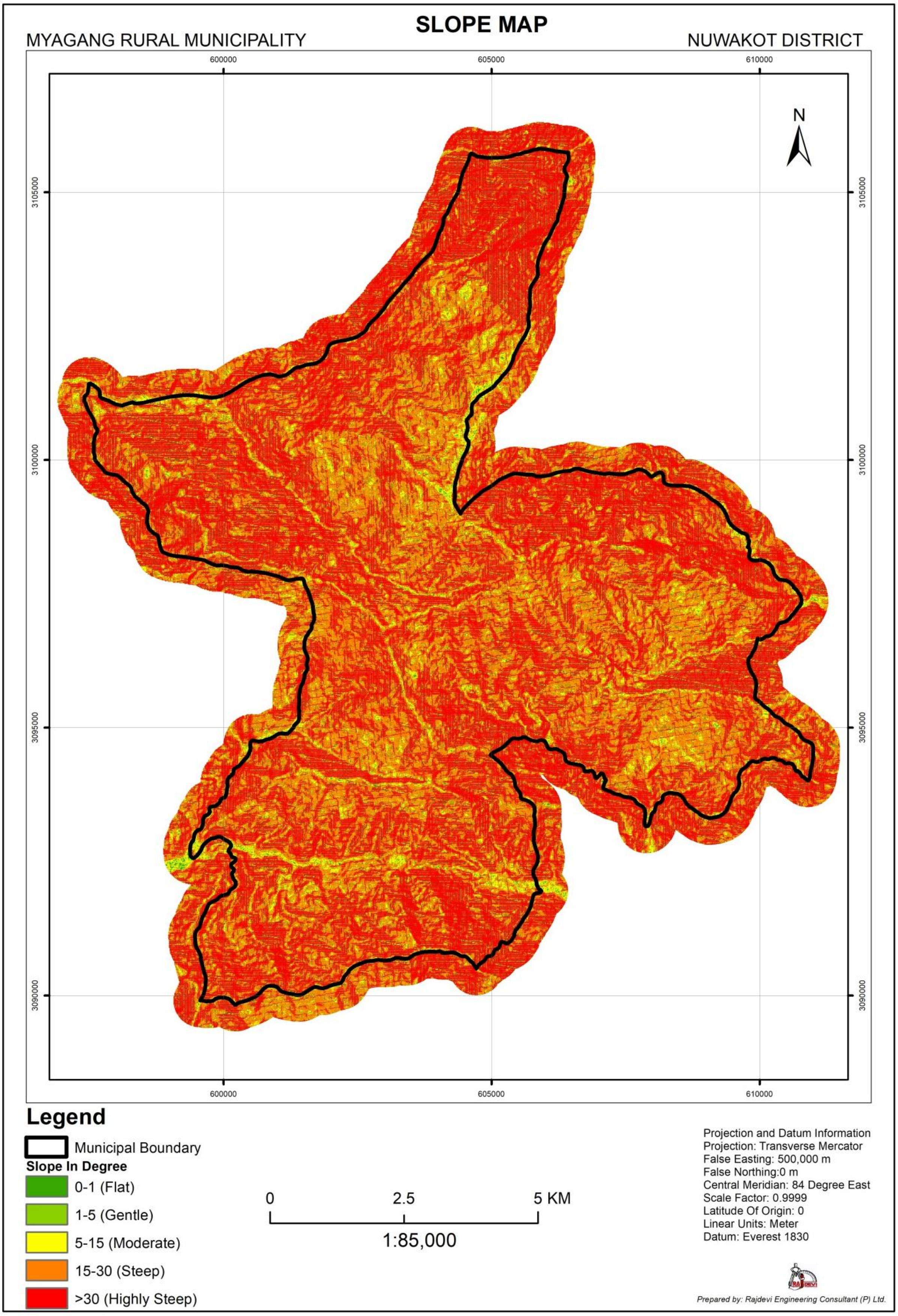


Figure 2.2: Slope Map of the Myagang Rural municipality

2.3 Physiography

Dhital (2015) classified Nepal Himalaya together with Terai into the longitudinal geological zones from south to north (Gansser, 1964; Fuchs and Frank, 1970; Stöcklin, 1980). This includes Terai and Bhabar zone, Siwaliks and intermontane basins, Lesser Himalaya, Higher Himalaya and Tethys Himalaya respectively. The main geological sub-divisions are Terai or Active Himalayan foreland basin, Siwaliks (Sub-Himalaya), Lesser Himalaya (Lesser Himalayan Sequence), Higher Himalaya (Greater Himalayan Crystalline Complex) and Tethys Himalaya which are also referred as the major sub-divisions by Yin (2006) of the North Indian Sequence (Brookfield, 1993).

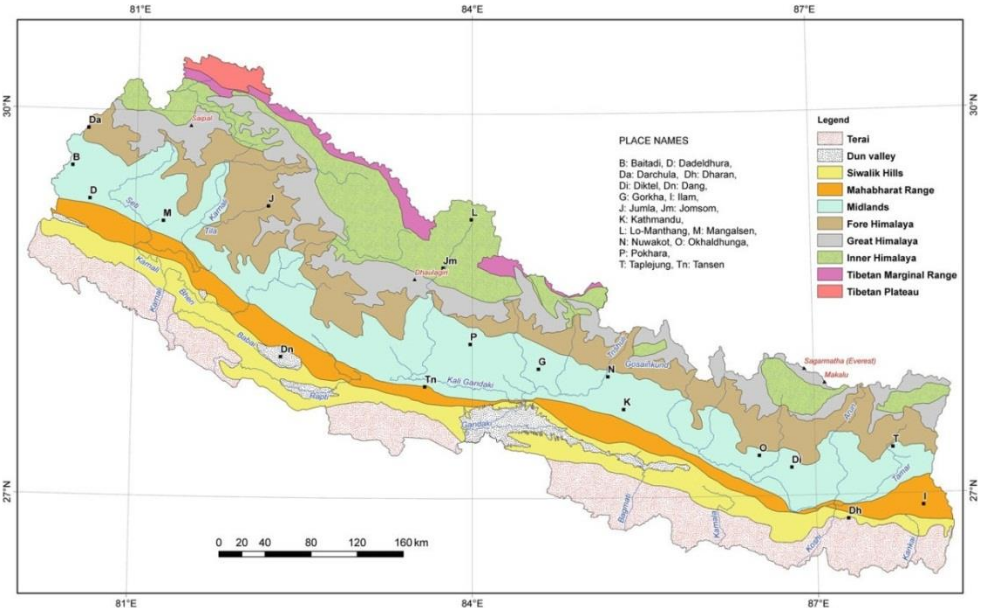


Figure 2.3: Physiographic divisions of Nepal Himalaya (*Source,* Dhital, 2015, Modified from Hagen, 1969).

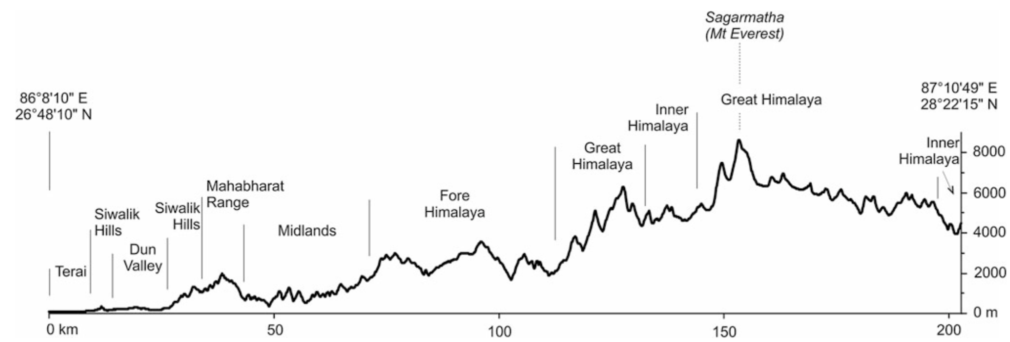


Figure 2.4: Profile of the Nepal Himalaya through east Nepal and position of physiographic regions (Dhital, 2015).

Based on these studies, Dhital (2015) has proposed geological divisions into the following six transverse physiographic regions incorporating watersheds of the major river systems as

- Mahakali-Seti region

- Karnali-Bheri region
- Gandaki region
- Bagmati-Gosainkund region
- Koshi region
- Arun-Tamar region

2.4 Geology

The Myagang Rural Municipality is located in the Lesser Himalayan rocks of the Bagmati-Gosainkund region which is comprised of a relatively wide portion of the Great Midland Antiform in the inner zone between Nuwakot and Dhunche. The Lesser Himalayan rocks are differentiated into two complexes named as Nawakot Complex and Kathmandu Complex (Stöcklin and Bhattarai, 1977 and Stöcklin, 1980). The Kathmandu Complex is overlain on the Nawakot Complex and differentiated each other by the Mahabharat Thrust (MT). The study area is comprised of Proterozoic Era rock sequences representing phyllite, amphibolite, metasandstone and schist. Two different types of geological formations and units of different geological time represent the entire municipality with the coverage of 9783.49ha area. Lithostratigraphy of the municipality represents Ranimatta Formation (Rm) and Ulleri Formation (Ul) of Dailekh Sub Group of Midland Group. The brief characteristics of each geological formation are described in the following sub-sections in detail.

Ranimatta Formation (Rm)

The Ranimatta Formation (Rm) in the Myagang Rural Municipality belongs to Dailekh Sub Group of Midland Group. It is composed of grey greenish grey gritty phyllites grilstones with conglomerates with white massive quartzites in the upper parts. Basic intrusions are noted.Robang is a member of Ranimatta Formation which consists of white quartzites intercalated with phyllites. The areal coverage of the formation in the area is 9518.37ha.

Ulleri Formation (Ul)

The Ulleri Formation (Ul) in the MyagangRural Municipality belongs to the formation of augen gneisses, muscovite biotite gneisses and feldspathic schists. The areal coverage of the formation in the area is 265.12ha.

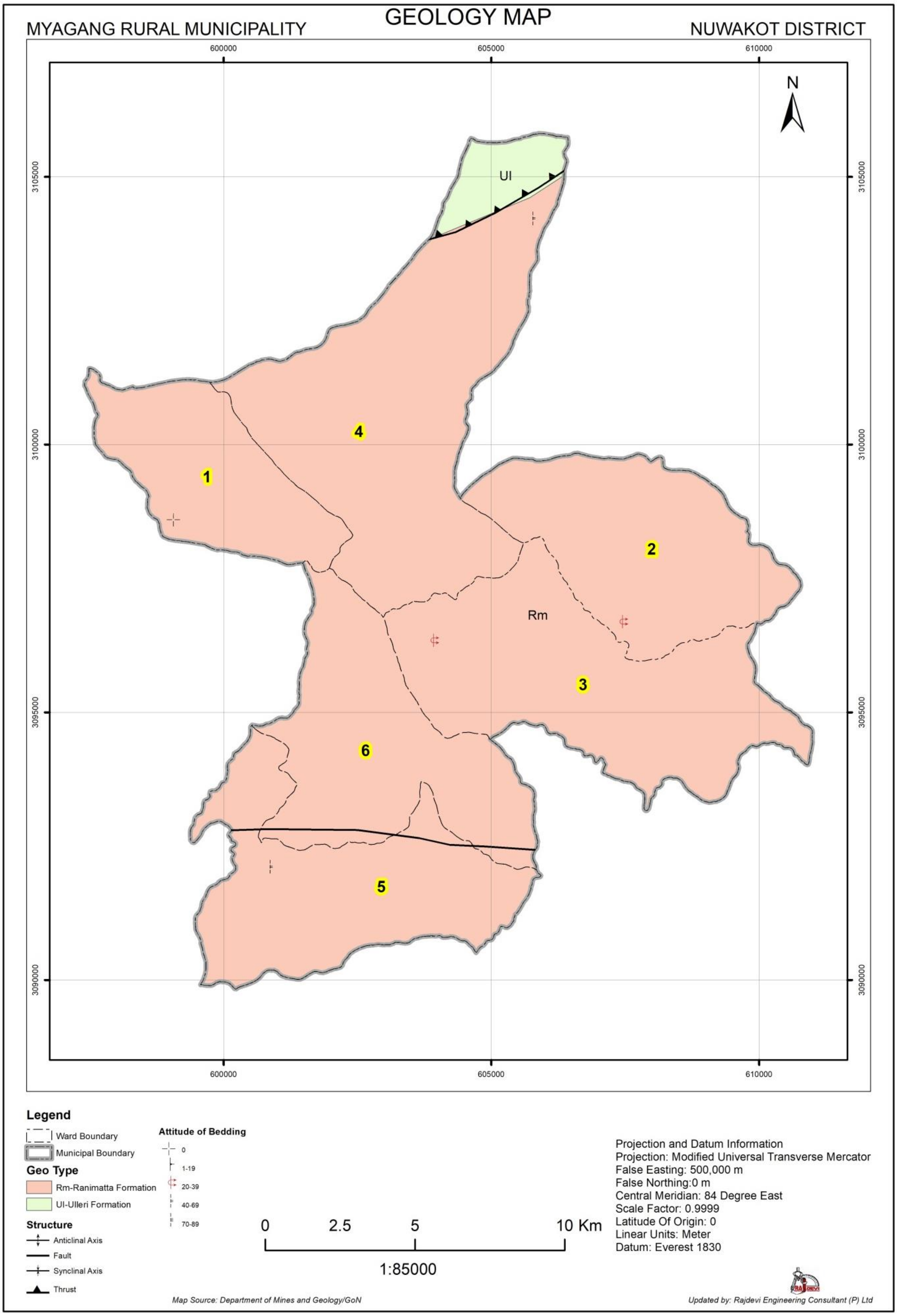


Figure 2.5: Geology map of Project area

2.5 Streams and Canals

There are many rivers flowing in the project area. There are also other small streams and rivulets flowing from the project area which includes Sarakhu khola, Chhap khola, Bhanjyang khola, etc. (Figure 2.6). These rivers are very shallow in winter but during rainy season, they are extremely big. Due to rain, water from streams, canals and other rivulets mixed to these rivers and sometimes it inundates massive alluvial soil and sand as well. They are also the source of irrigation water to major crops.

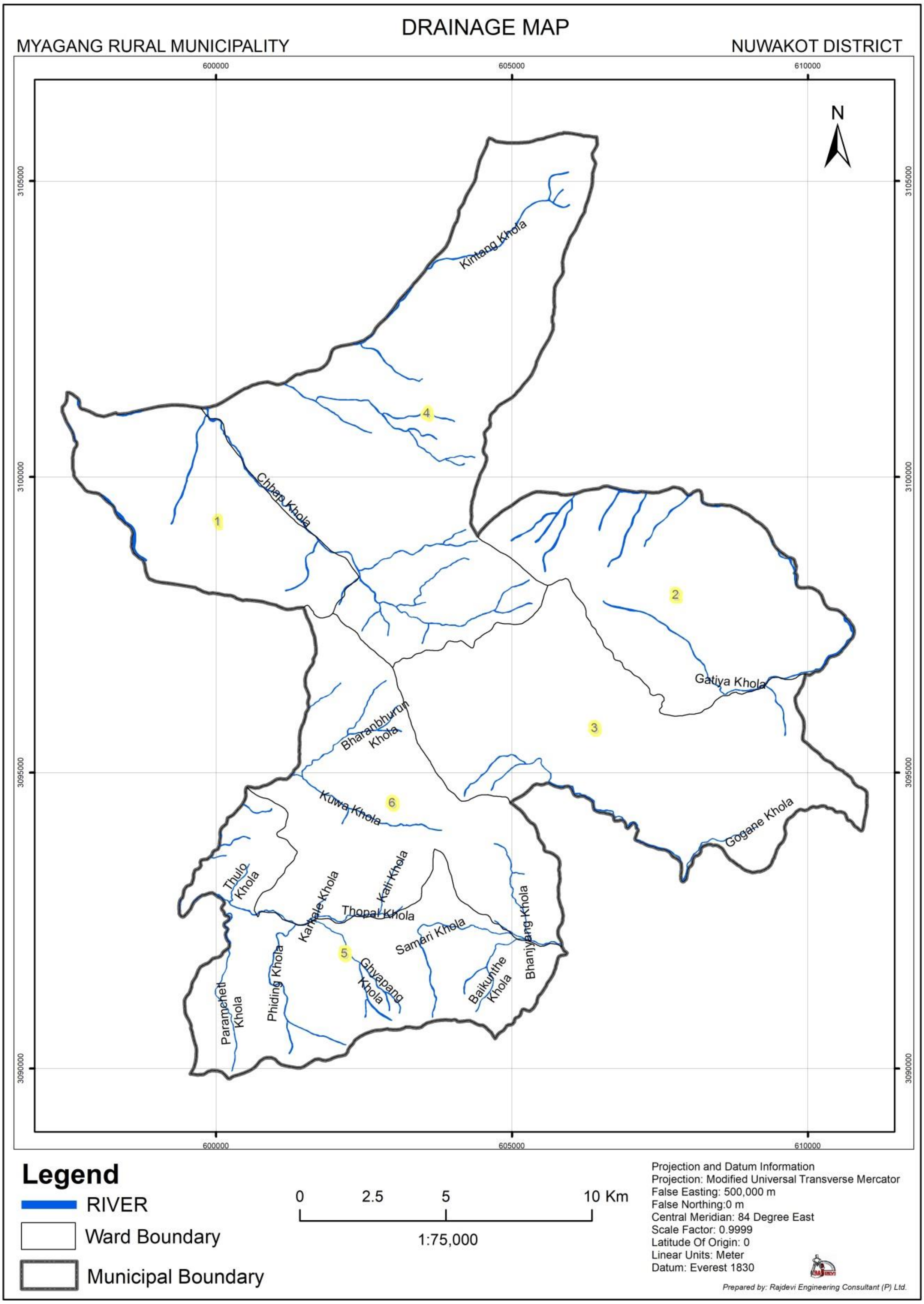


Figure 2.6: Drainage Network map of Project area

2.6 Climatic Condition

Soils tend to show a strong geographical correlation with climate. Sunlight 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, like other local units of hill, is warm temperate. This climate has three distinct seasons. Dry summer season begins in the month of March when the sun starts to move northward from the equator. It lasts till the middle of May when mean minimum temperature reaches up to 16.34^0Celsius (Table 2.1) and mean maximum temperature is nearly 29.62^0 C (Table 2.2). Rainy season starts from the month of May last and ends in September. The amount of rainfall that occurred in this season is about 1295mm (Table 2.3) whereas the mean annual precipitation is only 129 mm. Roughly speaking winter season begins in the month of November 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 (2010-2019). Slightly higher temperature is observed in the month of June and it remains active till September. However, the maximum temperature exceeds 28 degrees from April and reached till 30 degrees in June and there is slight decrease in average maximum temperature from October. Extreme cold starts from October last and last till first week of April. The area is less than 7degree Celsius for 3 months and it also experience freezing cold from November last till February. There is about 9 to 15 degree mean difference in daily maximum and minimum temperature as shown in Tables 2.1 and 2.2 and Figure 2.5.

Table 2.1: Minimum Temperature in ^{0}C (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	3.1	4.8	10.9	13.9	16.8	19.5	20.6	20.6	19.2	14.9	9.9	2.9	13.09
2011	2.4	5.3	8.8	11.9	16.2	19	20.5	20	19.1	14.2	9.5	4.1	12.58
2012	2.7	5.2	8.4	13	16	20.1	20.6	20.2	19	12.7	6.5	4	12.37
2013	1.6	6.1	10.1	12.4	17.1	20.1	20.4	20.2	18.9	15.9	7.7	4.8	12.94
2014	3.9	5.6	9.1	11.9	16.4	20.1	20.9	20.6	19	13.7	10.1	4.8	13.01
2015	4.4	7	9.9	12.6	16.6	19.7	19.8	20.1	18.9	13.7	9.5	4.3	13.04
2016	4	6.3	10.3	14.2	16.2	19.5	20.4	20.1	19.3	15.5	8.5	5.8	13.34
2017	3.2	6.8	9.4	13.4	16	19.6	20.4	20.4	19.3	15.4	9	5.4	13.19
2018	3.2	7	10.1	13.2	16.3	19.3	20.7	20.2	19.2	12.4	7.8	4.3	12.81
2019	3.6	6.1	8.4	13.8	15.8	19.3	20.3	20.6	19.1	14.9	11	4.5	13.12
TOTAL	**32.1**	**60.2**	**95.4**	**130.3**	**163.4**	**196.2**	**204.6**	**203**	**191**	**143.3**	**89.5**	**44.9**	**129.49**
Av	**3.21**	**6.02**	**9.54**	**13.03**	**16.34**	**19.62**	**20.46**	**20.3**	**19.1**	**14.33**	**8.95**	**4.49**	**12.95**

Source: Department of Hydrology and Meteorology

Table 2.2: Maximum Temperature in^{0}C (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	22.3	23.2	29.2	31.9	30.3	31.1	29.5	29.2	28.6	28	24.8	20.8	27.41
2011	19.6	23.8	27	28.7	28.9	29.4	28.6	29.5	28.4	28.1	22.4	18.9	26.11
2012	17.5	22.8	26.6	28.7	31.4	31.2	28.8	29.5	29.4	27.3	22.5	19.3	26.25
2013	18.9	23.8	28.1	29.3	30	30	29.4	29.6	29.8	26.6	22.6	18.8	26.41
2014	18.6	20.9	25.8	29.6	29.7	30.5	29.6	29.3	28.4	26.5	21.9	20.1	25.91
2015	20.2	22.2	24.7	26.4	30.6	31.4	29.5	29.1	29.4	27.2	23.6	18.8	26.09
2016	18.3	23.4	27	31.2	28.9	29.2	28.1	30	27.9	27.4	23.5	20.8	26.31
2017	19.3	23.7	24.1	28.2	28.2	29.9	29.3	29.2	29.7	28	23.6	20.8	26.17
2018	18.5	22.8	26.8	26.2	27.6	29.4	29.5	28.8	29.4	26.3	22.7	18.7	25.56
2019	18.1	20.8	25.1	27.3	30.6	30.7	28.8	30.5	27.4	26.5	23.7	18.1	25.63
TOTAL	**191.3**	**227.4**	**264.4**	**287.5**	**296.2**	**302.8**	**291.1**	**294.7**	**288.4**	**271.9**	**231.3**	**195.1**	**261.84**
AV	**19.13**	**22.74**	**26.44**	**28.75**	**29.62**	**30.28**	**29.11**	**29.47**	**28.84**	**27.19**	**23.13**	**19.51**	**26.18**

Source: Department of Hydrology and Meteorology

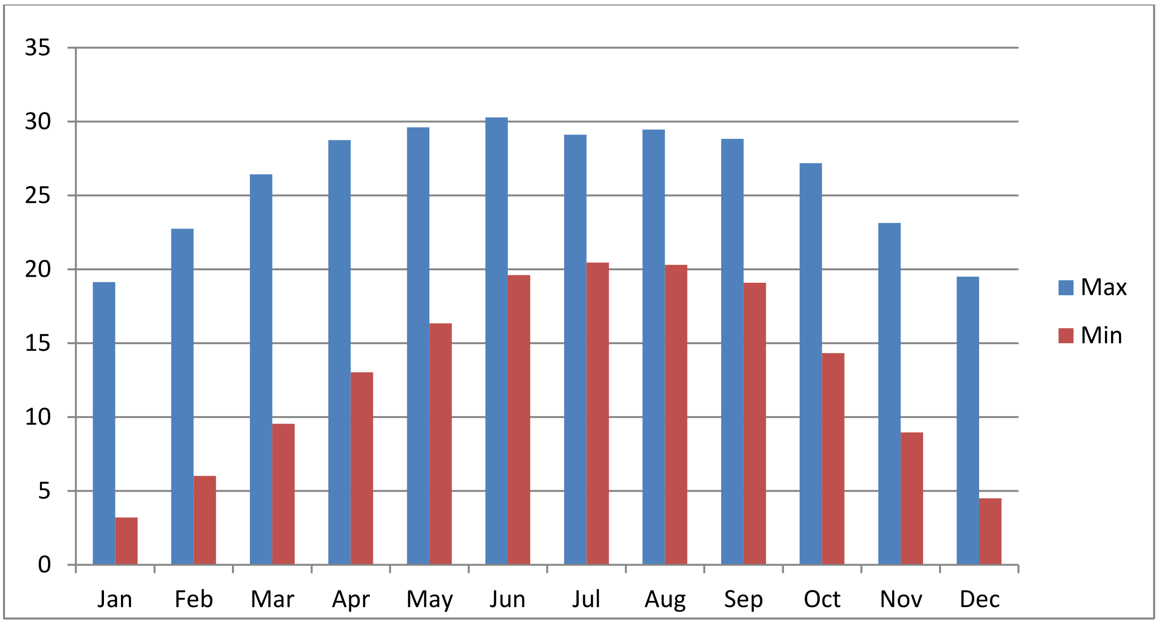


Figure 2.7 Maximum and Minimum Monthly Average Temperature (2010-2019)

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. In ploughed soils, with rainfall the clods are broken down to smaller particles. The physical structure of the soil changes with rainfall. Even chemical properties are enhanced. The concentration of N or acid in rainwater influences the chemical properties of soil. Biological properties are also enhanced with soil moisture. Thus rainfall or annual precipitation affects soil physical, chemical and biological properties of soil. There is no any definite trend of raining. It rains all over the year and sometimes it remains dry for long time. Rainfall most occurs in July and August. Maximum raining is recorded in the month of July and August reaching only 78 and 81 mm in average respectively. Due to the effect of climate change, these days there is erratic rainfall and drought. 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 2.8.

Table 2.3: Average Rainfall (in mm) (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	1.9	23.3	35.7	45.3	148	141.7	354.9	486.3	217.1	24.5	0	0	123.23
2011	6.2	54.9	16.4	56.8	167.4	306	437.8	265.4	318	13	12.9	0	137.90
2012	17.8	41.8	15.6	80.1	42.2	149.2	452.3	289.6	362.2	13.2	0.7	0	122.06
2013	11.5	45.4	27.3	44.5	278.6	299.1	428.5	451.4	217.3	95.7	0	0	158.28
2014	4.2	26.7	58.7	6	153.5	165.8	461.9	294.5	279.4	91.2	0	36.7	131.55
2015	3.4	35.2	98.7	51	155.9	125.6	470.6	452	189.4	67.6	0	0	137.45
2016	0.4	25.3	6.3	11	92.3	370.2	477.8	126.8	281.7	91	0	0	123.57
2017	13.3	0.5	135	75.7	127.4	120.6	282.2	360.6	98.5	63.9	1.5	0.1	106.61
2018	6.1	1.5	27.7	148.8	154.7	240	408.9	402.8	126.6	11.9	0	0	127.42
2019	19.1	85.2	37.4	102.8	55.1	126.4	485.4	226.5	358	0	0	33.4	127.44
Total	**83.9**	**339.8**	**458.8**	**622**	**1375.1**	**2044.6**	**4260.3**	**3355.9**	**2448.2**	**472**	**15.1**	**70.2**	**1295.49**
Mean	**8.39**	**33.98**	**45.88**	**62.2**	**137.51**	**204.46**	**426.03**	**335.59**	**244.82**	**47.2**	**1.51**	**7.02**	**129.55**

Source: Department of Hydrology and Meteorology

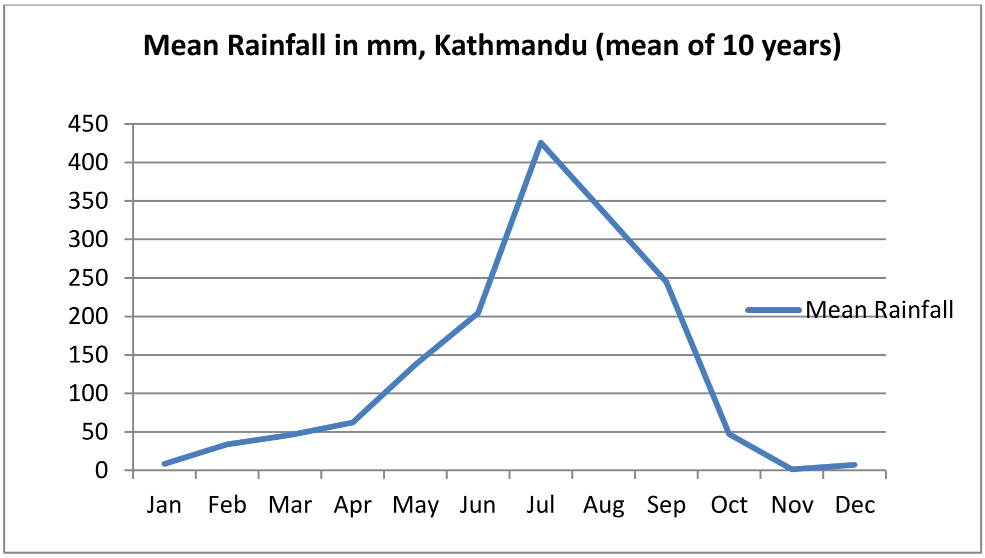


Figure 2.8: Mean monthly rainfall (2010-2019)

2.7 Vegetation/Land use /Land cover

Vegetation is another important active soil forming factors which greatly influences soil evolution. 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 forest and pasture land. Agriculture occupies least area and most of the agricultural land is used for farming.

In Meghang Rural Municipality, out of total 5228 h/h, the highest percentage (around 80%) is involved in agriculture and 8% in livestock. Also, the highest income is accrued from agriculture in this RMP. Agriculture contributes to 80% with livestock 8%. Foreign remittance covers 5% of the income, from business and servicethe income is about 2% each and daily wage earnings 3% in other unspecified jobs *(source: Rural Development Project 2075)*.

The farming system comprises of both irrigated (fully &partially irrigated) and rainfed system. With low lying khet land area under assured irrigation (70%) and upland under rainfed condition, it comprises of three main sub-systems as Crop/Horticulture sub-system,Livestock and Agro-forestry sub-systems. The Crop/Horticulture sub-system in the irrigated low lying khet land area is predominantly paddy based in the monsoon followed by wheat/barley and summer maize while that in the upland area is mainly summer maize followed by winter wheat, barley, millet, tori, black gram and seasonal vegetables(cauliflower/cabbage, tomato, potato, carrot and other leafy vegetables during winter and vine crops such as bitter gourd, sponge gourd, bottle gourd, cucumber, pumpkin and others).Farming includes mostly two cropping system in a year while that under-valley cultivation system with level terrace -khet land and valley riverbed lower foot slope area is with three crops a year which is negligible.

The predominant cultivated crops by acreage are Ricemostly in the low land area followed by maize in both upland and lowland and wheat in low land after rice. The spring maize is most commonly grown in the upland area and in the lowland area after monsoon paddy. Wheat is grown in the low land area after monsoon paddy follower by summer maize in small land area. Pulses& millet, buck wheat and Barley are grown in upland area in a limited scale. The area under fallow/grass land is negligible *i.e.,*around 2%.Among the fruits in around 2% of the area includemainly orangesin 5 ropani area withs annual production 5000 kg.

Following the cropping sub-system, the **Livestock sub-system**is the next important sub-system here in full integration with **Crop/Horticulture sub-system**. Cattle, Buffalo, goat and sheep are the dominant livestock domesticated mainly for milk, meat and draft purposes. Milk production is the main purpose of domesticated cattle and buffaloes.

The**Agro-forestry sub-system** is confined to the upland area in a limited scalearound the vicinity of the settlement area. The fallow/grassland is maintained mainly for raising livestock and Community forestry with timber trees such as *Pines, Sal (Shorearobusta)*, *Simul (Bombaxmulbericum)*, firewood, and fodder trees are common. The households of this RMP are privileged with community forestry in a limited area. The Community forestry, leasehold forestry and private forest area although in a limited area in ward nos. 1, 2, 3, 5 and 6 are being operated. The grass land area as pasture is in ward no. 2 and 3 in this RMP.

In this Rural municipality ward no 1 (1 CF), 2(6 CF), 3 (4 CF),4(1 CF), 5(5 CF), 6(7 CF) have community forests only. At level 1 the forest type is natural and plantation i.e. mix..Climatic vegetation is Subtropical, Temperate and Sub alpine. Cover type is broad leaved, conifers and Bushes. Species types are Uttis, Sal, Katus, Chilaune, Sallo, khotesallo, Banjh, Gurans, Dhupi, Kafal, Jamun Nigalo etc. . Crown cover density is sparse 40-70%. Forests are in mature class. All forests are community forests ownership category.. , Fire, landslides, and erosion are the risks. Slope is steep i.e. more than 45 % somewhere moderate steep also.

Major Species: are Uttis, Sal, Katus, Chilaune, Sallo, khote sallo, Banjh, Gurans, Dhupi, Kafal, Jamun Nigalo, Salla, Botdhangero, Pate sallaetc

NTFP: Amrisho, Ritha, Amala, Tejpat, Kurilo, Burans, Dhupi, Kafal. Harro, Barro, Chiraito, Timur, Majitho, Nagbeli, Lokta, Pakhanved , etc.

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 earlierdays' 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 local unit map and Topographic - thematic layers at 1: 25,000 and ZY-3 image provided by TSLUMD 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 TSLUMD. 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 Project area of Kathmandu district.

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 land system units, land units, land types and land use/land cover types. The major land use/land cover is further subdivided into categories based on minor description of cropping pattern.

Table 3.1: Soil Mapping Unit Description

SIWALIK REGION: Tertiary inter bedded sand stone, shale, conglomerate and quaternary alluvium ; subtropical					
land system	land form	Land unit	Dominant slopes	Dominant texture	Soil Mapping Symbol
4	Active recent alluvial plain	4a sand and gravel bars	<1^0	Sandy / cobby	4a
		4b Low terrace	<1^0	Sandy	4b
		4c Higher terrace	<1^0	variable	4c
5	Fans, Aprons, and Ancient River Terraces	5a very gentle slope	<1^0	Loamy	5a
		5c undulating	<5^0	Loamy	5c
		5d rolling	0-20^0	Loamy	5d
6	Depositional basin	6a: depressional 6b: non dissected high position 6c: gently rolling 6d: highly dissected	<1/2^0 <2^0 1-5^0 0-30^0	Fine loamy Fine loamy Fine loamy Fine loamy	6a 6b 6c 6d
7	Moderately to Steeply Sloping Hilly and Mountainous Terrain		<20^0	Loamy Skeletal	7
8	Steeply to Very Steeply Sloping Hilly and Mountainous Terrain		<20^0	Loamy Skeletal	8

MIDDLE MOUNTAIN REGION Precambrian to Eocene Phyllites, quartzite's, schists, limestone and Gneisses, generally deeply weathered, Subtropical to warm Temperate.					
9	Alluvial Plains and Fans (depositional)	9a river channel	$<1^0$	Fragmental Sandy	9a
		9b alluvial plains	$<1^0$	Loamy/ Bouldery	9b
		9c alluvial fans	$<5^0$	Loamy/ Bouldery	9c
10	Ancient Lake and River Terraces (Tars) (erosional)	10a non dissected	$0\text{-}5^0$	Loamy	10a
		10b dissected	$0\text{-}5^0$	Loamy	10b
11	Moderately to Steeply Sloping Mountainous Terrain		$<30^0$	Loamy Skeletal	11
12	Steeply to Very Steeply Sloping Mountainous Terrain		$>30^0$	Loamy Skeletal	12
HIGH MOUNTAIN REGION:					
13	Alluvial plain fans	13a:active alluvial plain 13b recent alluvial plain 13c: fans 13d:ancient alluvial teraces	$<1^0$ $<2^0$ $1\text{-}10^0$ $<5^0$	Loamy Loamy/Bouldery Loamy/Bouldery Loamy/Bouldery	13a 13b 13c 13d
14	Post glaciated mountainous terrain below upper altitudinal limit of arable agriculture	14 a: moderate to steep slope 14b: steep to very steep slope	$<30^0$ $>30^0$	Loamy Skeletal Loamy Skeletal	14a 14b
15	Post glaciated mountainous terrain above upper altitudinal limit of arable agriculture	15 a: moderate to steep slope 14b: very steep slope	$<40^0$ $>40^0$	Loamy Skeletal Loamy Skeletal	15a 15b
HIGH HIMALAYA REGION					
16	Alluvial, colluvial and morainal depositional surface	16a glacio alluvial plains 16b: morainal deposits 16c: alluvial colluvial fans 16d colluvial slopes	$<20^0$ $<40^0$ $2\text{-}15^0$ $10\text{-}35^0$	Loamy Skeletal Loamy Skeletal Loamy Skeletal Fragmental Loamy	16a 16b 16c 16d
17	Steep to very steep slopping mountainous terrain	17a: a shallow till or colluviums over bedrock 17b: rock headwalls	$<40^0$ $>40^0$	Fragmental Loamy ----	17a 17b

Source: LMRP, 1986

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 11 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 ME and their numerical numbers are used which is presented in Fig 3.1.

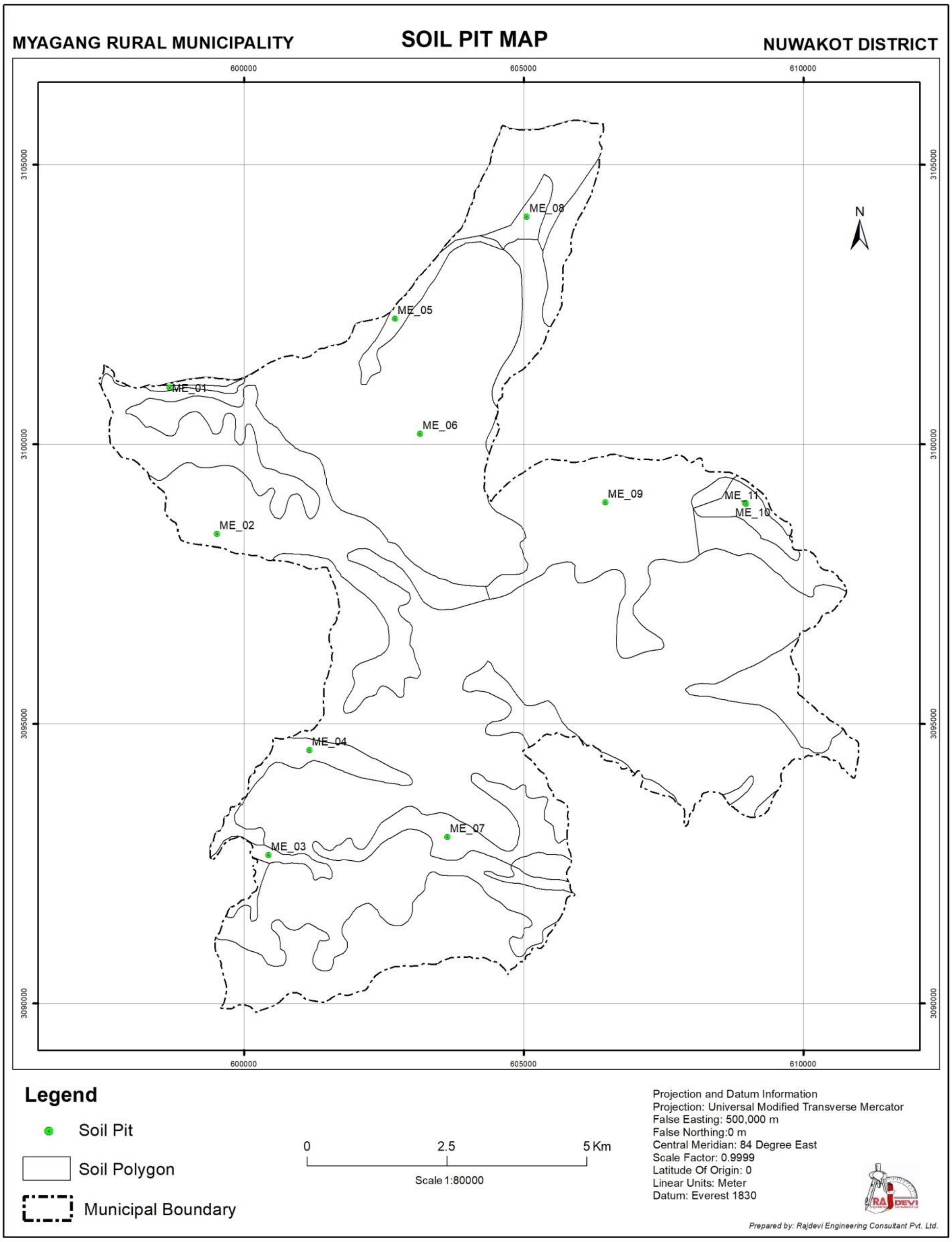


Figure 3.1: Sample soil pit location map

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. There was good discussion with the local unit authority and farmers before starting the field work. The main point of discussion was on soil sampling and analysis, mapping and interpretation of the laboratory based soil test results. People were found eager to know the fertility status of their field. 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, ZY-3 imagery for determination of soil profile. The digging of soil pits was carried out from 2077/10/20 to 2077/12/10 at the concerned local unit 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 are carried out as per the Standard Soil Profile Description Form provided by NLUP, 2015 now TSLUMD. 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. Munsell Soil 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)
    e. Presence of Surface Stones or Rock outcrops
    f. Evidence of Erosion Class
    g. Presence of Salt or Alkaline.
    h. Human Influence
    i. Land Use 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 scale units by incorporating information on soils. Soil scale 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 local unit and ward, land system and land use were made compatible by transforming into the same projection system (MUTM) adopted by Survey Department, TSLUMD. 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	1:2.5 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, vegetation and 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 vary 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 Geomorphological distinction of land 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

Land system is the theoretical unit of land that is classified mainly with the consideration of bio-physical factors. Land after their classification, they are brought to the economic use. LRMP (1986) has classified land under the land system into seventeen major land system types ranging from the land next to river water body of Tarai to the mountain top. Of the total land system classes, Tarai is divided into 3 classes, Siwalik region into 5 classes, Middle mountain region into 3 classes, High mountain into 3 classes and High Himalaya into 2 classes. The land system classes, respective sub-divisions and description are presented in Table 4.1.

Table 4.1: Land system classes

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
3a	Alluvial fan complex, upper piedmont(erosional), very gentle slopes
3b	Alluvial fan complex, upper piedmont(erosional), gentle slopes
3c	Alluvial fan complex, upper piedmont(erosional), undulating
3d	Alluvial fan complex, upper piedmont(erosional), highly dissected
7	Moderately to steeply sloping hilly and mountainous terrain
8	Steeply to very steeply sloping hilly and mountainous terrain
9a	Alluvial plains and fans(depositional), river channel
9b	Alluvial plains and fans(depositional), alluvial plains
9c	Alluvial plains and fans(depositional), alluvial fans
10a	Ancient lake and river Terrace called Tars (Erosion), non dissected
10b	Ancient lake and river Terrace called Tars (Erosion), dissected
11	Moderately to steeply sloping mountainous terrain
12	Steeply to very steeply sloping mountainous terrain
13a	Alluvial plains and fans, active alluvial plains
13b	Alluvial plains and fans, recent alluvial plain
13c	Alluvial plains and fans, fans
13d	Alluvial plains and fans, ancient alluvial terraces
14a	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, moderate to steep slopes
14b	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, very steep slopes (>30)
15a	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, moderate to steep slopes
15b	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, very steep slopes
16a	Alluvial,ColluvialandMorainal Depositional surfaces, glacio-alluvial plains

Land Units	Descriptions
16b	Alluvial,ColluvialandMorainal Depositional surfaces, morainal deposits
16c	Alluvial,ColluvialandMorainal Depositional surfaces, alluvial colluvial fans
16d	Alluvial,ColluvialandMorainal Depositional surfaces, colluvial gans
17a	Steeply to very steeply sloping mountainous terrain, shallow till or colluviums over bedrock
17b	Steeply to very steeply sloping mountainous terrain, rock headwalls

Source: LRMP, 1986

4.2 Land Form and Land Type

Landform and land unit is further subdivision of land system classes. Land units are 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. 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 land slope in the project area is found to be ranging from less than 1° to greater than 30^{o}slope.The classified slopes are presented 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. Based on land system classification of the project area, recent sediments of flood plains and lower alluvial terraces. in northern part: sand and gravel deposits up to boulder size. In central and southern part: clay, sand and fine gravel. Inhomogeneous deposit at foot slopes with constituents of humic clay, silt and sand, at places boulders. Variable thickness > 1 m, increasing towards the center of the deposit. Grey to dark silty clay and clayey silt, at places calcareous nature and phosphate mineral (vivianite). Organic clay, fine sand beds and peat layers common. Occasionally lignite seams up to 2 m. Semi-consolidated sandy, clayey silt interbedded with gravel and clayey sand, peat and lignite of up to 3 m thickness. The soil textures found in project area are given with symbol in table 4.3.

Table 4.3: Soil texture and symbol

Textural classes	Symbol
Loam	L
Silty Loam	SiL
Sandy Loam	SL
Silt	Si
Sandy Clay	SiCl
Clay Loam	CL
Loamy Sand	LS

4.3 Land Units in the Project area

The land units defined by LRMP are further subdivided based on micro-relief and local variation associated with different land form and land use practices. Altogether six land units are found in the project area associated with the local micro-relief variations. The area covered and percent share of each subdivision is depicted in Table 4.4. Of the six land units, dominant land units are steeply to very steeply sloping mountainous terrain comprising land type 12 and ancient lake and river Terrace called Tars (Erosion), non-dissected comprising units 10a.

Table 4.4: Land type units of Project area

S.N.	Land Type Units	Description	Area (Ha)	Percentage
1	11	Moderately to steeply sloping mountainous terrain	5849.24	59.79
2	12	Steeply to very steeply sloping mountainous terrain	3138.23	32.08
3	14a	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, moderate to steep slopes	124.35	1.27
4	14b	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, very steep slopes (>30)	53.75	0.55
5	15a	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, moderate to steep slopes	96.81	0.99
6	15b	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, very steep slopes	314.57	3.22
7	9a	Alluvial plains and fans(depositional), river channel	111.53	1.14
8	9c	Alluvial plains and fans(depositional), alluvial fans	95.01	0.97
	Total		**9783.49**	**100.00**

The characteristic land unit is moderately to very steeply sloping mountainous terrain covering nearly 60 percent of the project area. It is followed by steeply to very steeply sloping mountainous terrain covering around 32 percent. Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, very steep slopes occupies the third position with 3 percent. Other land units are found in very small coverage. The distribution of land units in the project area is presented in Figure 4.1.

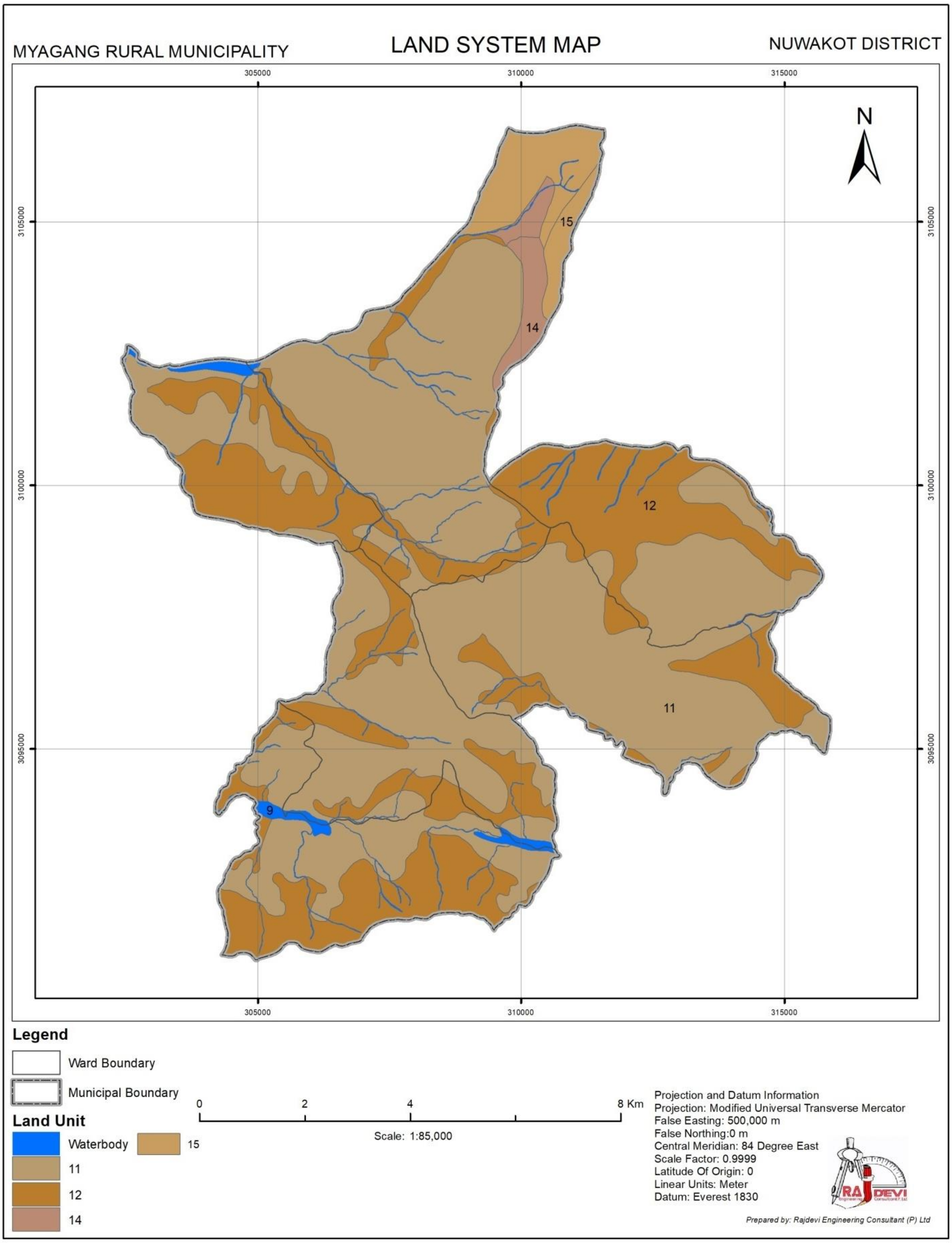


Figure 4.1: Land System Map of Project area

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
Ochri	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 <0.1Mg/m^3or 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	Matiyara
Sandy soil	Baluwamitti
Loamy soil	Dorash
Silt clay loam	Pangochemtodomat

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

FAO System and Name Meanings	US Systems (1975)
GELOSOLS Greek gelid = very cold, permafrost in part	Gelisols
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
LITHOSOLSGreeklithos = 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 soils. No Sub-units	Lithic Haplumbrepts
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 Kathmandu; 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 (Khadka, 2067), NARC 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
8.5-8.9	Strongly alkaline	
> 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	
112- 280	Medium	
56– 112	Low	
<56	Very Low	Low Suitability

Table 5.13: 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

CHAPTER 6: SOIL TYPES AND GIS DATABASE

6.1 Soil Types

In terms of texture, soil type usually refers to the different sizes of mineral particles in a particular sample. Soil is 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.

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, and 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 municipality level soil type of the area.

Soil Types from Order to Sub-group Level

Soils of Project area of Nuwakot district 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, Table 6.2and Figure 6.1 present Soil Taxonomy classification for the soils of Project area.

Table 6.1: Soil Taxonomy Classification of Project area

Order	Sub-order	Great Group	Sub Great Group	Area (Ha)	Percentage
ALFISOLS	USTALFS	HAPLUSTALFS	LITHIC HAPLUSTALFS	10.03	0.10
			TYPIC HAPLUSTALFS	1133.82	11.59
INCEPTISOLS	ANTHREPTS	HAPLANTHREPTS	TYPIC HAPLANTHREPTS	4435.16	45.33
	AQUEPTS	HAPLAQUEPTS	MERIC HAPLAQUEPTS	118.42	1.21
	OCHREPTS	DYSTOCHREPTS	TYPIC DYSTOCHREPTS	943.27	9.64
	UMBREPTS	HAPLUMBREPTS	LITHIC HAPLUMBREPTS	152.24	1.56
			TYPIC HAPLUMBREPTS	2879.09	29.43
Water body				111.45	1.14
Total				**9783.49**	**100.00**

In general, only Inceptisols and Alfisols were found in Project area along with five sub-orders, five great soil groups and seven sub-groups of two orders from the soil survey investigation in Project area of Nuwakot District. Inceptisols is most extensively found in Project area. These types of soils are found in the entire country and covers extensive areas of land. Inceptisols are comparatively older and used for cultivation quite for some time.

Anthrepts, Aquepts, Umbrepts and Ochrepts are the major sub orders found within Inceptisols. Among the greatgroups of Inceptisol, this Municipality has Dystrochrepts, Haplaquepts, Haplanthrepts and Haplumbrepts. In alfisols, only Ustalfs sub orders were found and Haplustalfs great group are available. Typic haplustalfs and Lithic haplustalfs were the sub great group observed during the study.

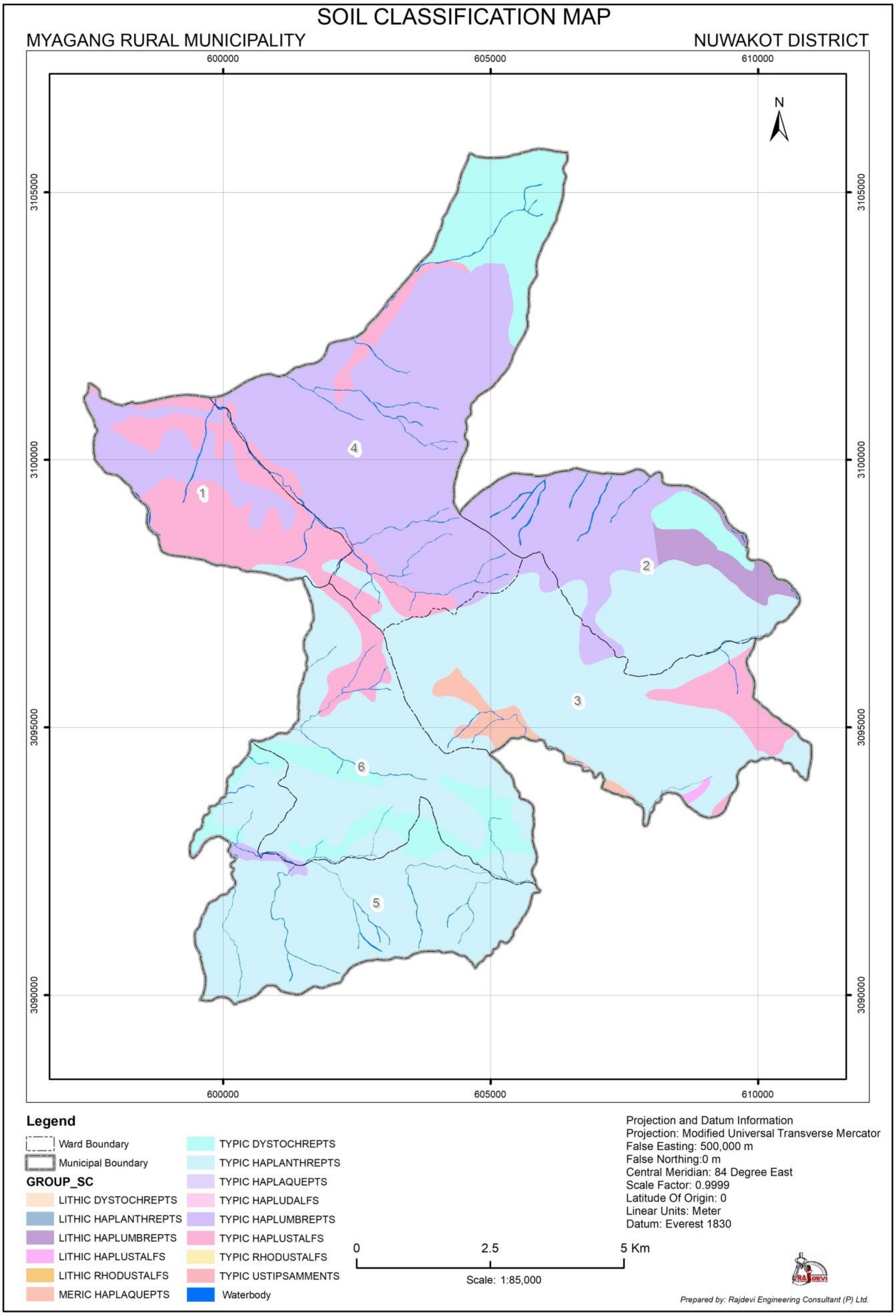


Figure 6.1: Soil map of Project area

Soil Profile Information

Soil Profile Description:

The detail of soil profile description is presented in the appendix. Altogether 11 soil profiles were studied for the purpose.

Among the total area of this Municipality, 98.86% is covered by soil landmasses and 1.14% is covered by waterbodies. Almost all the area (87%) of this rural Municipality is covered by Inceptisols and little area (12%) is covered by alfisols. Our study has found only two soil orders in this rural municipality.

Soil Order Inceptisols are also extensively found in the Project area. 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. In this order, Dystrochrepts, Haplumbrepts, Haplanthrepts and Haplaquepts Great Groups are available in our Project area.

Sub-order Ochrepts: These are the commonest soils in the terai as well as in the middle hills, mostly below 1500 meters (higher on south facing slopes) and have developed on the acidic or neutral bedrock including lacustrine deposits. They have well developed B horizon and base saturation below 60%. They are the single-most common soil found in country and is extensively used for agricultural production. *Ustochrepts* with high base saturation are most prevalent in the Far Western and Mid Western Development regions of Nepal, where the climate is considered to be sub-humid. Subgroups under Ochrepts found in the study are described below.

Dystrochrepts: *Dystrochrepts* has a lower base saturation percentage and are more acidic. They are more commonly found in areas with more humid conditions which create stronger leaching conditions. It is in the *Dystrochrepts* that the problems of soil acidification are most severe. Erosion control on the hill slopes is a must to maintain the productivity of *Dystrochrepts*.

Sub-order Anthrepts: Anthrepts are the more or less freely drained Inceptisols that have either an anthropic or plaggen epipedon. Haplanthrepts is the major great group found in the study area.

Sub-order: Umbrepts:*Umbrepts* are the dark colored Inceptisols that usually occur above 2,000 m (1,500m on northern aspects). They have low base saturation and high organic matter levels in the surface soil. If organic matter oxidized off, their natural acidity becomes limiting to the growth of many agricultural crops. Subgroups under Umbrepts are described briefly below.

Haplumbrets: *Haplumbrets* are the soils of high and middle hill regions (3,500m) and developed in cool temperatures on the acidic bedrocks under mixed forest. They have low base saturation. Soils under forest and on steep slopes are shallow and stony but the cultivated ones are fertile due to a high organic matter content, which inactivates the toxic effect of aluminum by its chelating action. Soil fertility-is maintained by grazing animals, and leaving fallow for 2-3 year periods. Barley, millet and potato are the main crops grown in this soil.

Sub order Aquepts: *Aquepts* are relatively stable soils that are strongly affected by a high water table- at least during the monsoon season. Subsoil is under anaerobic conditions for long periods and this inhibits the plant growth but is conductive to rice production. Depending on the depth and variation of the water table over the year, different cropping systems are possible. Those areas of *terai* that still have high water tables late in the fall cannot take advantage of some of cash-cropping opportunities. Farmers tend to grow two rice crops in these areas. Aquepts are common in lower *terai*, in stable, low relief areas and are commonly associated with infilled back water channels.

Soil Order Alfisols

Alfisols are those soils with significant pedogenetic development, with obvious trans-located clay in the subsoil and a high base saturation percentage. *Alfisols* are characterized by a subsurface diagnostic horizon in which silicate clay has accumulated by illuviation. *Alfisols* are common but do not make up a large percentage of the soils. They represent the most mature landscape positions throughout the sloping lands of the mountain regions and also on older alluvium. The great groups of *Alfisols* found in the study area are briefly described below:

Haplustalfs: The soils that do not meet the color criteria for *Rhodic*, soils are classified as *Haplustalfs*. Haplustalfs are found in very small area in the Municipality.

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.

Physical and Chemical properties of the soil

Altogether 11 pits were dug and soil samples were collected from upper horizon of the pits. Soil samples were analysed following standard procedure and the data of laboratory analysis for different parameters are presented in the table below (Table 6.2).

Table 6.2: Laboratory Analysis of Soil Parameters

Soil pit	pH	N (%)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Texture Type
ME-1	5.27	0.12	13.53	254.6	2.49	43.98	41.82	14.20	Loam
ME-2	5.44	0.18	11.60	174.2	3.77	63.98	23.82	12.20	Sandy Loam
ME-3	5.43	0.08	9.66	294.8	1.68	29.98	53.82	16.20	Silty Loam
ME-4	5.12	0.22	13.53	241.2	4.43	61.98	23.82	14.20	Sandy Loam
ME-5	7.29	0.01	9.66	241.2	0.17	57.98	37.82	4.20	Sandy Loam
ME-6	4.95	0.23	9.66	174.2	4.70	49.98	37.82	12.20	Loam
ME-7	5.66	0.03	7.73	107.2	0.50	61.98	31.82	6.20	Sandy Loam
ME-8	4.71	0.55	17.46	214.4	10.93	61.98	27.82	10.20	Sandy Loam
ME-9	4.50	0.29	19.33	174.2	4.90	23.98	61.82	14.20	Silty Loam
ME-10	5.19	0.23	13.53	134.6	4.63	65.98	29.82	4.20	Sandy Loam
ME-11	5.42	0.31	15.46	187.6	6.17	59.98	31.82	8.20	Sandy Loam

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 Project area were prepared for better understanding of the soil parameters that were investigated in the laboratory. Brief tables of each parameter are presented below.

Table 6.3: Summary Statistics of the Soil Analysis Results

Variable	Mean	SE Mean	St Dev	Variance	Coef Var	Minimum	Median	Maximum	Range
pH	5.362	0.219	0.725	0.525	13.52	4.5	5.27	7.29	2.79
N %	0.2045	0.0458	0.1519	0.0231	74.28	0.01	0.22	0.55	0.54
P2O5 kg/ha	12.83	1.09	3.6	12.97	28.07	7.73	13.53	19.33	11.6
K2O kg/ha	199.8	16.7	55.3	3061	27.69	107.2	187.6	294.8	187.6
O.M.%	4.034	0.901	2.987	8.924	74.06	0.17	4.43	10.93	10.76
Sand %	52.89	4.33	14.38	206.69	27.18	23.98	59.98	65.98	42
Silt %	36.55	3.64	12.08	145.82	33.04	23.82	31.82	61.82	38
Clay %	10.56	1.29	4.27	18.25	40.45	4.2	12.2	16.2	12

General analysis of the soil of Project area:

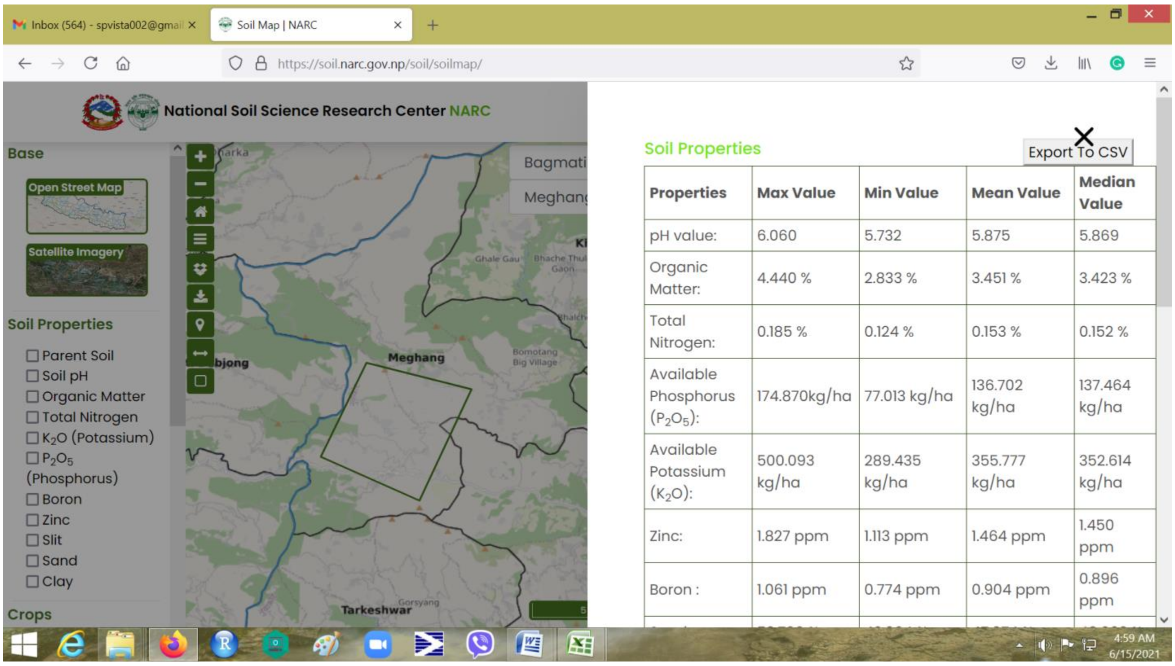
There are different types of soil in Nepal. Various factors such as geology, climate and vegetation types have resulted in variations in soil properties. So far, soils of Nepal can be divided into six broad types such as alluvial soil, sandy gravel soil, lacustrine soil, rocky soil and mountain soil. Alluvial soils 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 fluvial 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 Project area varies from 4.5 to 7.29 ranging from very highly acidic to neutral. Mean soil reaction of the area is 5.3 that fall under the category of strongly acidic, which is fairly suitable for most of the crops. Almost all soils of Project area were within the strongly acidic range that is fairly suitable for most local crops. The soil pH being moderately acidic, macro and micronutrients will be in available form. Vegetables and most food crops can be grown in such type of soil but with adequate care. However, for commercial farming and gaining higher productivity, liming should be done in most areas with proper care.

The organic matter content of the soil ranged from 0.17 to 10.93%. Mean organic matter content of the sampled soil is 4% which falls under the category of medium. Most of the soils of Project area are under the category of medium organic matter content. However, there are places with critically very low organic matter content in the area. 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 local unit ranged from 0.01 to 0.55% which falls under the category of very low to very high. Mean N content of the soil is 0.2%, which is high 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 medium and high category. Care should be taken to grow crops with ample incorporation of organic manure in this area in order to obtain higher crop yield. Available phosphorus of the soils, in general falls within wide range and depending upon the soil types, it ranges from 7.73 to 19.33 kg/ha that falls in the category of very low to low. Mean Phosphorus content of the soil is only 12.8 kg/ha which is low and there may be problem of phosphorus in the soils of the study area in near future. But the amount of available potassium in the soils of Project area is low to high which ranged from 107 to 294 kg/ha. The mean value of the available potassium in the soil is 199 kg/ha which falls under the category of medium. Most of the soils contain high amount of available K. Most soil parameters of Project area were found to be in low range and soil pH seems to be critical for crop production. However, management efforts should be carried out in soils where critical situation appears. Soil nutrients and pH should be well managed in this area.

Majority of the soils of study area are sandy loam, loam and silty loam. Sandy loam type of soil is dominating in the study area. Based on the soil analysis report, it could be concluded that the soils of Project area is good enough for cultivating food and vegetable crops at the moment because of good soil type but all nutrients are scarce in the soil. It is recommended to apply higher amount of fertilizer as they are in low range along with liming.

Recently NARC has launched Digital Soil Map of Nepal and we have tried to verify our soil properties with the DSM and our soil analysis result has also shown at par with the DSM recently launched. A screen shot of the result has been attached for verification.



Properties	Max Value	Min Value	Mean Value	Median Value
pH value:	6.060	5.732	5.875	5.869
Organic Matter:	4.440 %	2.833 %	3.451 %	3.423 %
Total Nitrogen:	0.185 %	0.124 %	0.153 %	0.152 %
Available Phosphorus (P_2O_5):	174.870kg/ha	77.013 kg/ha	136.702 kg/ha	137.464 kg/ha
Available Potassium (K_2O):	500.093 kg/ha	289.435 kg/ha	355.777 kg/ha	352.614 kg/ha
Zinc:	1.827 ppm	1.113 ppm	1.464 ppm	1.450 ppm
Boron :	1.061 ppm	0.774 ppm	0.904 ppm	0.896 ppm

6.2 Soil GIS Database (Geo-database)

Soil GIS database was prepared at two levels: Soil Pit and Soil Mapping Unit. Soil Mapping Units were formed or delineated based on integration of Land System, Landform and Land units along with micro relief variation in relation to physio-soil characteristics. Individual pit level information was aggregated at soil mapping units because it contains multi-pits or pedons. Soil pit contains site characteristics including physical attribute and also soil profile at horizon level information. It also includes physical and chemical properties or attribute of soil. Soil horizon level information was contained in soil pit. The soil GIS database has stored and maintained as related to geo-database linking shape file to its attribute in attribute table. The soil GIS Database contains soil unit GIS database, soil pits GIS database including soil profile horizon information. Furthermore it contains soil chemical (lab) test database table. GIS "shape" files and "dbf" are also maintained for comprehensive use. Based on the soil test report, summary statistics were also prepared for all the tested parameters of soil samples.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Based on the laboratory analysis of the soil of the area, soil fertility map is prepared. Soil map of Project area of Kathmandu District 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 (Inceptisol and Alfisol). A total of 11 soil pits were taken in the field representing varied micro topography. Soil analysis report of all the 11 pits showed that the soil of Project area is fairly suitable for all types of crops to be grown based on the soil types. 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, OM was found in medium, total Nitrogen in high range and available phosphorus content in the soils of Project area was found to be in low range and soil pH seems to be critical for crop production. However, management efforts should be carried out in soils where critical situation appears. Available potassium is in medium range with strongly acidic soil pH. Sandy loam type of soil is dominating in the study area. Based on the soil analysis report, it could be concluded that the soils of Project area is good enough for cultivating food and vegetable crops at the moment but may have nutrient deficiency shortly. It is recommended to apply higher amount of all fertilizers and organic matter in a balance way as they are in very low range and also go for liming program.

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 Local units of Nepal for optimum land use planning and sustainable development of Local units 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 Epipedon also needs to be analyzed. Based on the analysis of nutrient status it is recommended to supply organic manure in adequate quantity as well as appropriate crops as per the suitability of the soil. The soils of Project area were found to be suitable for most of the crops based on soil types. Nutrients are very limited and soil is strongly acidic. Therefore, balanced application of nutrients and organic matter is recommended. If possible, terracing should be done in sloppy areas of the local unit. Therefore, continuous and balanced application of organic matter as well as chemical fertilizers is mandatory in order to prevent soil from extreme nutrient mining and for enhanced crop production. Terracing should be done to conserve the soil nutrients and moisture. Agroforestry should also be practiced in slopy areas.

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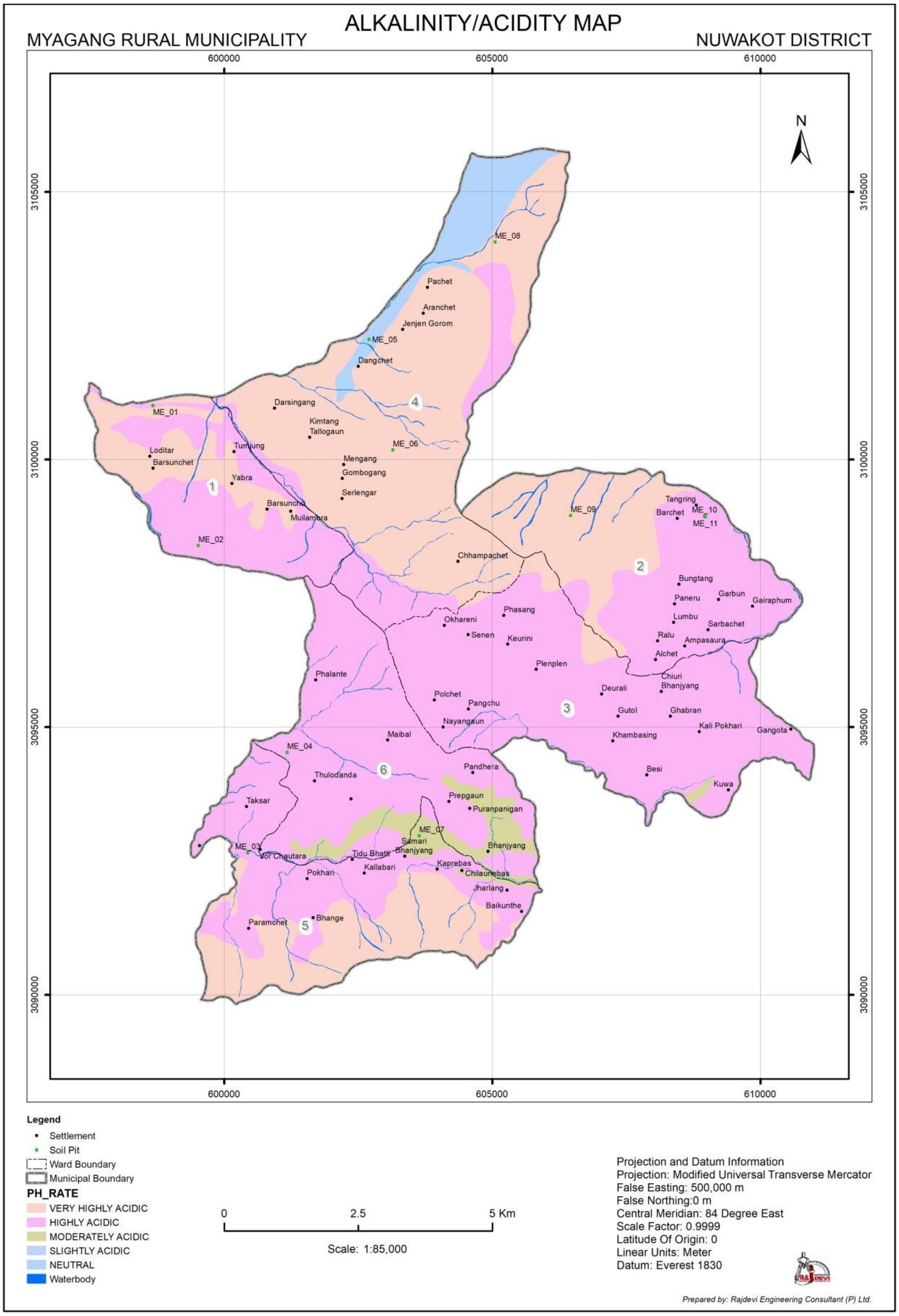
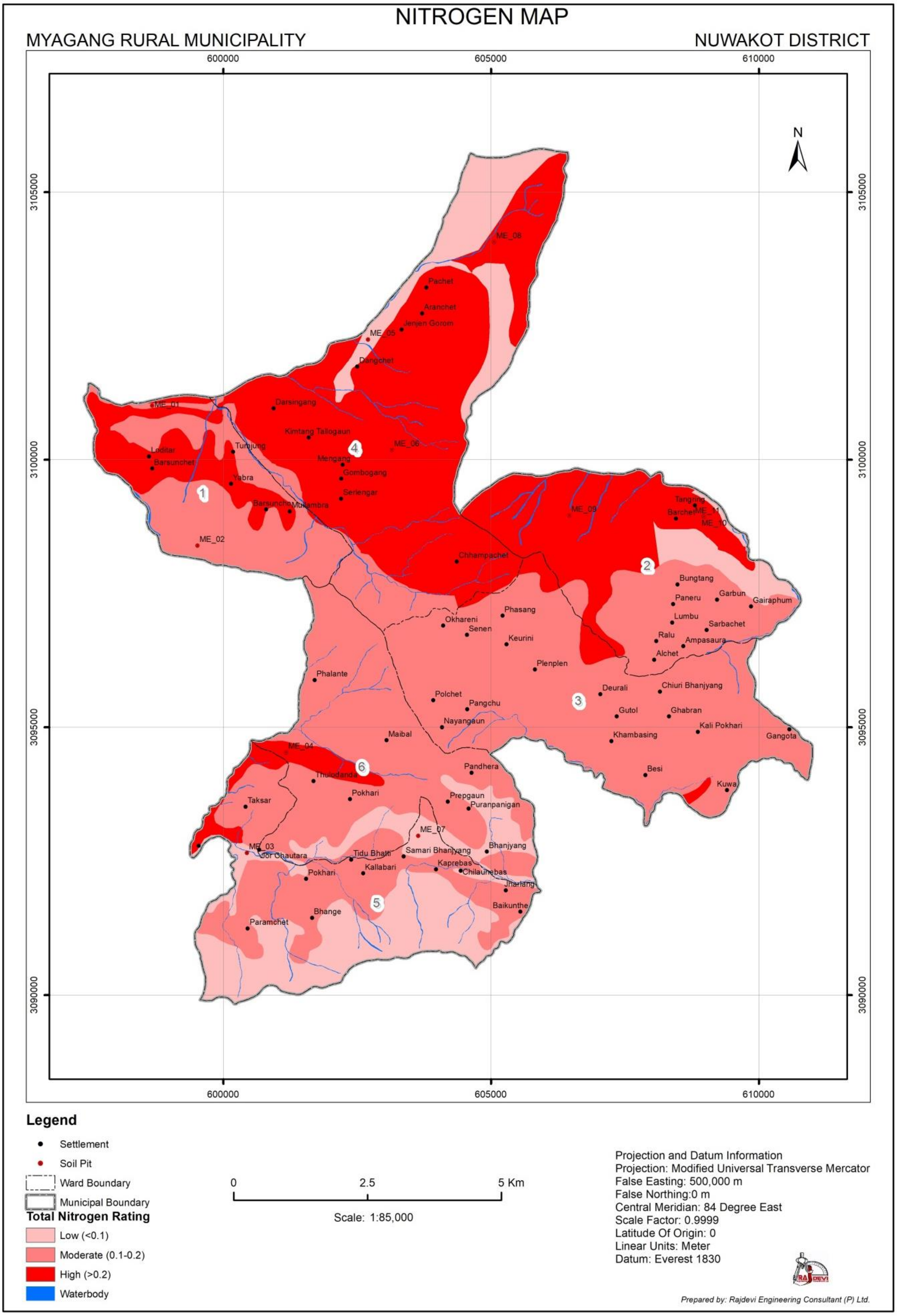
Appendix 1: Soil Nutrients Maps of Myagang Rural Municipality

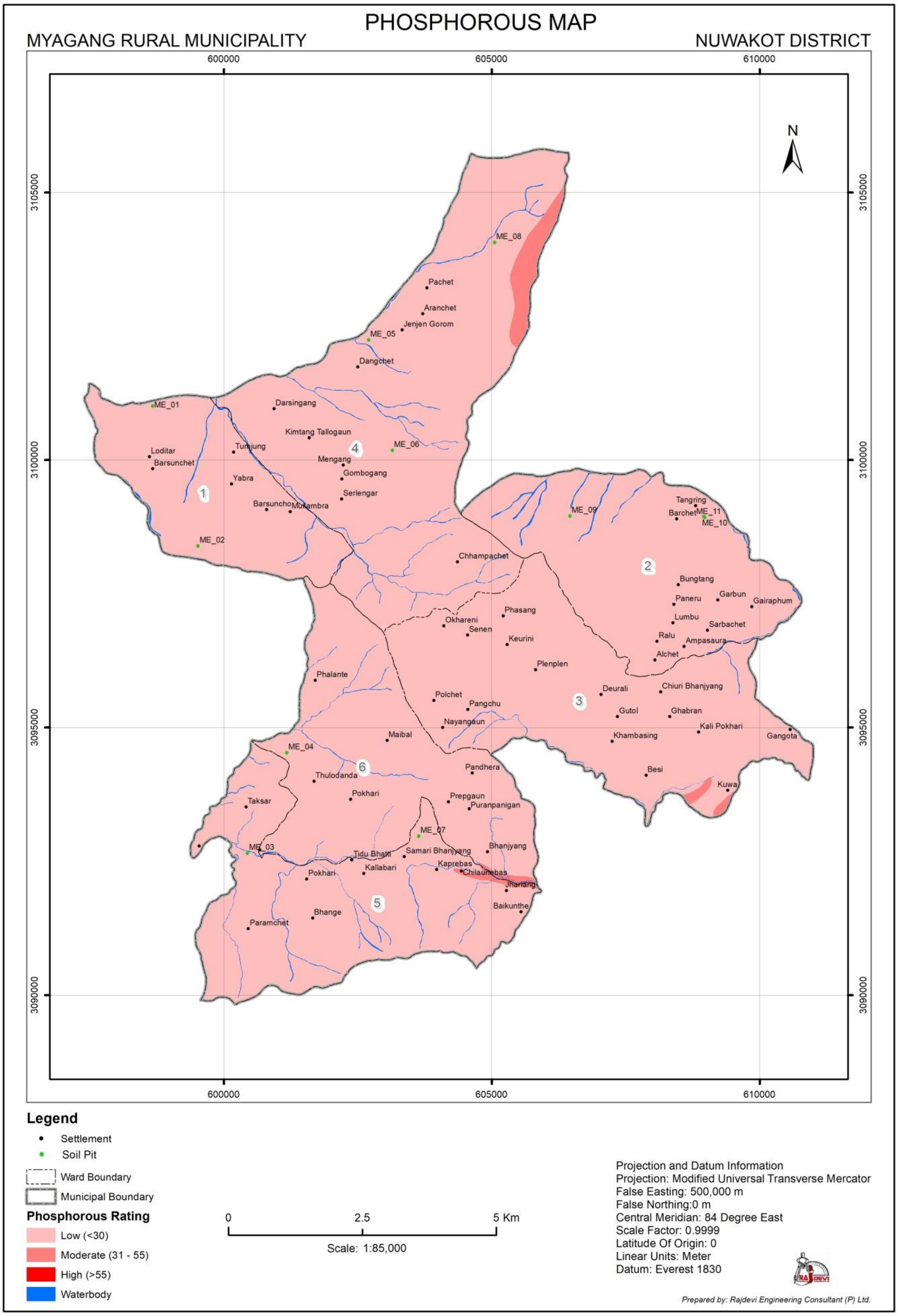
Appendix 1a: Soil Alkalinity and Acidic Rating Map of Myagang Rural Municipality



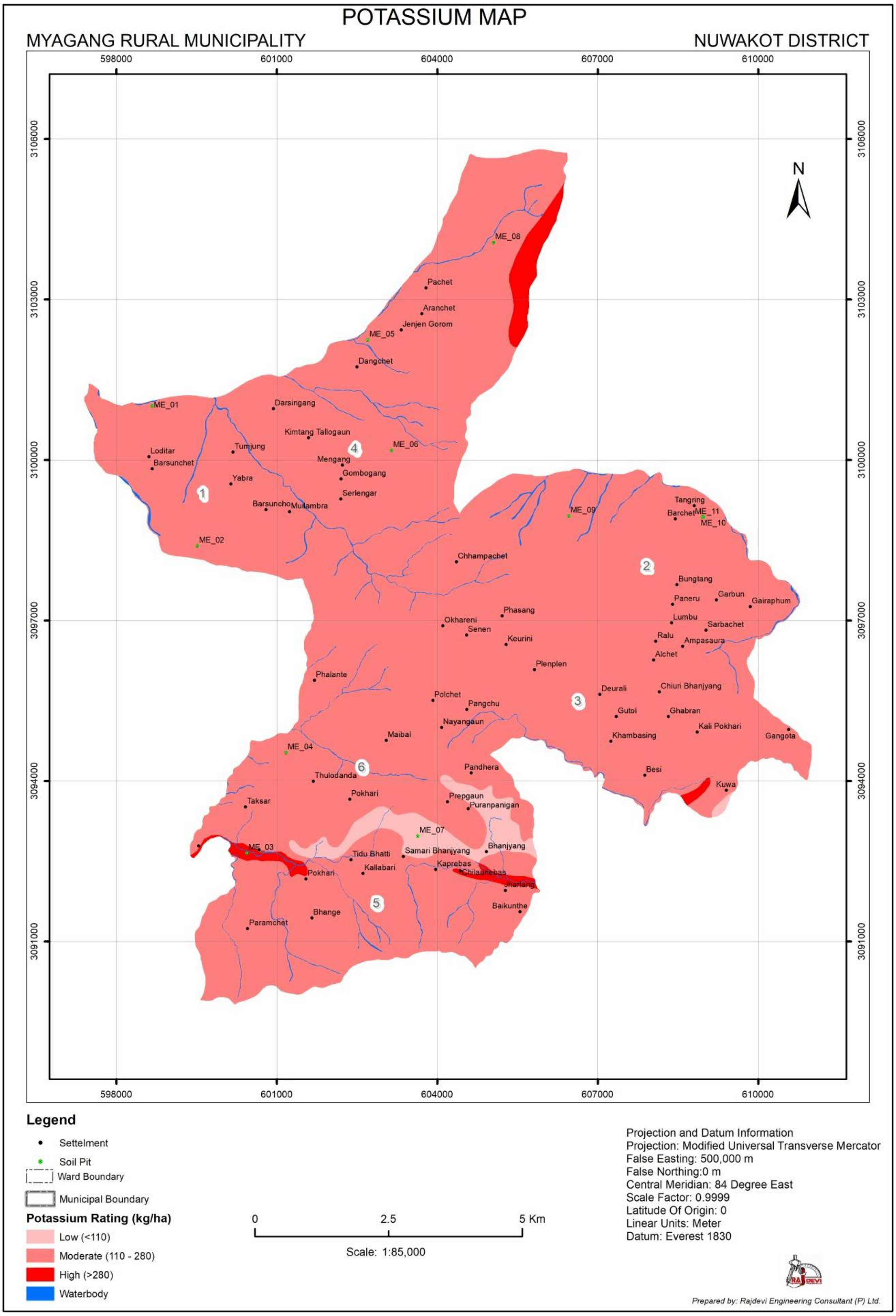
Appendix 1b: Soil Nitrogen Rating Map of Myagang Rural Municipality



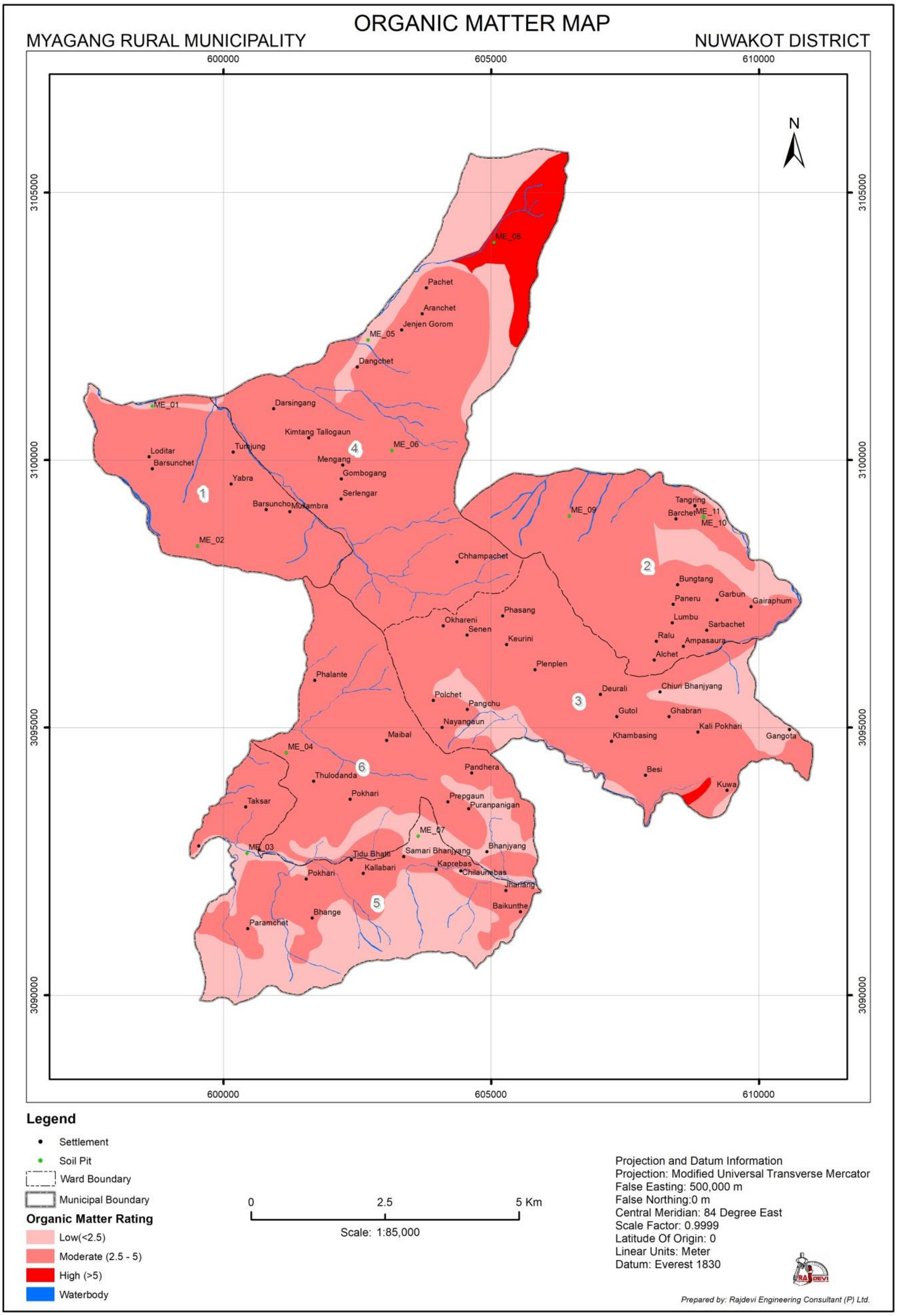
Appendix 1c: Soil Phosphorus Rating Map of Myagang Rural Municipality



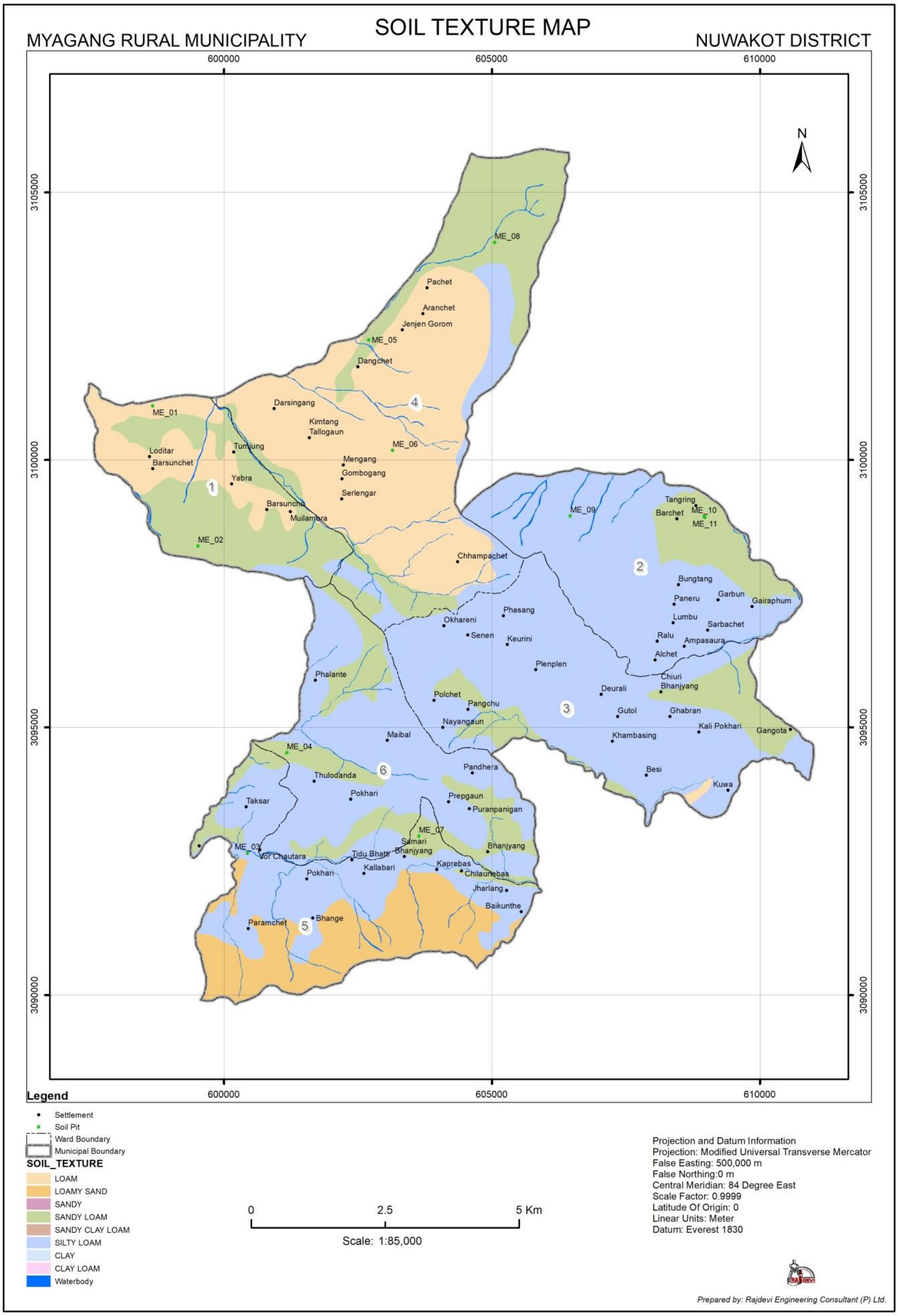
Appendix 1d: Soil Potassium Rating Map of Myagang Rural Municipality



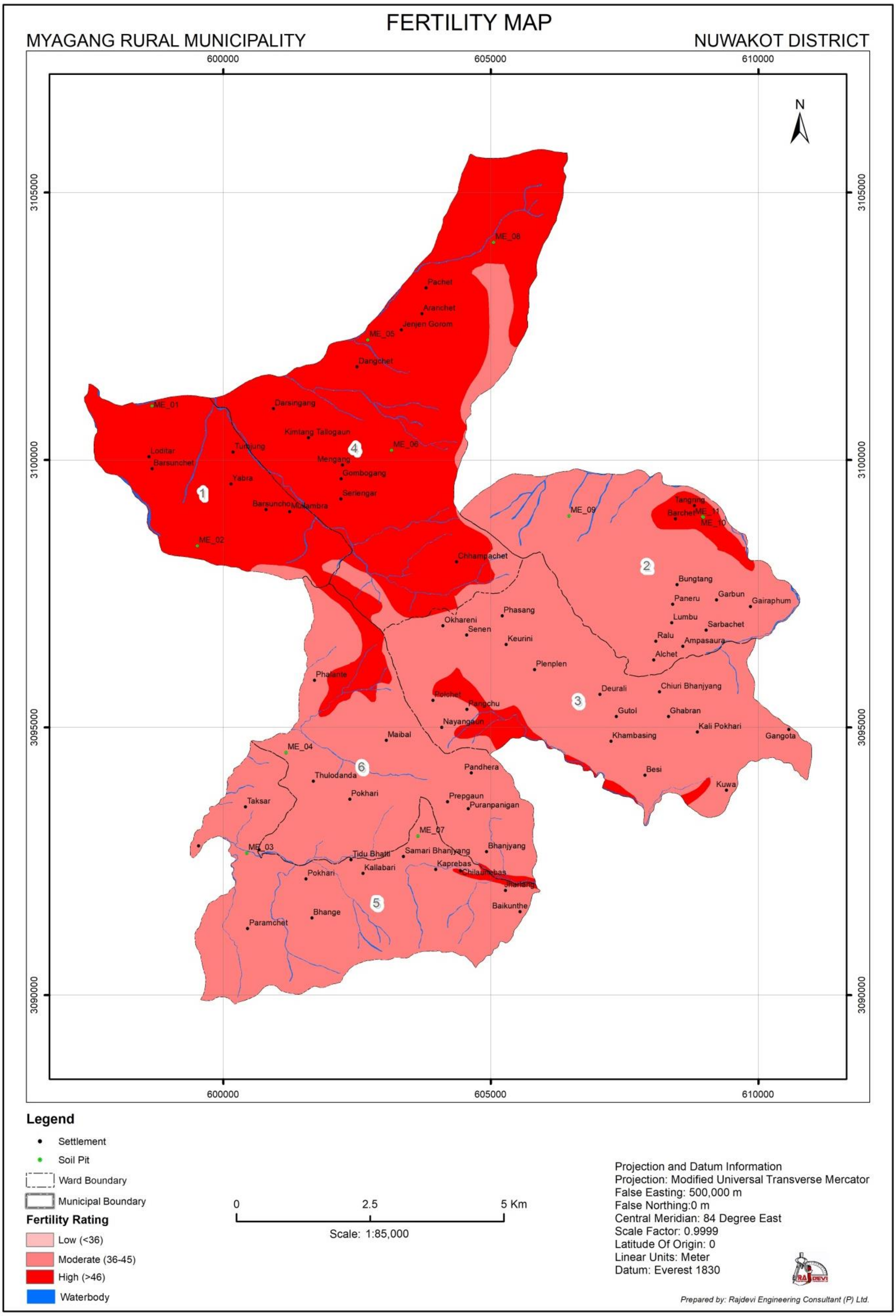
Appendix 1e: Soil Organic Matter Contains Map of Myagang Rural Municipality



Appendix 1f: Soil Texture Map of Myagang Rural Municipality



Appendix 1g: Soil Fertility Map of Myagang Rural Municipality



Appendix 2: Soil Pits Desriptions of Myagang Rural Municipality

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/ Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_01**
Date : 2077.11.06
Location : CHAPKHARKA

General Instruction

Coordinates : 598645 **East**; 3100955 **North;**
Slope : 45 Degree
Slope Direction :
Parent material : ALLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status : RILL
Land Use : AGRICULTURE (BARI/KHET)
Elevation : 847
Soil Moisture Condition :
Drainage Class : POORLY DRAINED
Irrigation :
Cropping Pattern : MAIZE_VEGETABLE
Soil Depth :

Classification

Soil Order : ALFISOL
USDA Soil Classification : TYPICHAPLUSTALFS
Family : STRONGLY ACIDICLOAMTYPICHAPLUSTALFS

Depth	Horizon	Description
0_13	A1	ABRUPT, SMOOTH;;LIGHT YELLOWISH BROWN; 10YR 6/4; COMMON, FINE, FAINT; SAND; ; WEAK, FINE, COLUMNAR PRISMATIC; FEW, FINE; VERY FRIABLE; ; MANY, FINE; ;
13_29	A2	ABRUPT, SMOOTH; ; YELLOWISH BROWN; 10YR 5/4; MANY, MEDIAN, FAINT; SANDY CLAY; ; MODERATE, MEDIUM, ANGUKLAR BLOCKY; COMMON, MEDIUM; FIRM; ; COMMON, MEDIUM; ;
29_45	B1	CLEAR, IRREGULAR; ; YELLOWISH BROWN; 10YR 5/6; MANY, FINE, DISTINCT; ; ; MODERATE, COARSE, SUBANGULAR BLOCKY; COMMON, VERY FINE; FIRM; ; COMMON, MEDIUM; ;
45_65	B2	GRADUAL, IRREGULAR; ; LIGHT YELLOWISH BROWN; 10YR 6/4; COMMON, FINE, PROMINENT; SILTY CLAY; ; MODERATE, COARSE, GRANULAR; COMMON, MEDIUM; FIRM; ; COMMON, MEDIUM; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.27	0.12	13.53	254.6	2.49	43.98	41.82	14.2	L

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_02**
Date : 2077.11.06
Location : WAGA

<u>General Instruction</u>

Coordinates : 599645 **East**; 3098400 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status : SPLASH
Land Use : FOREST
Elevation : 2183
Soil Moisture Condition :
Drainage Class : WELL DRAINED
Irrigation :
Cropping Pattern :
Soil Depth :

<u>Classification</u>

Soil Order : ALFISOL
USDA Soil Classification : TYPICHAPLUSTALFS
Family : STRONGLY ACIDICSANDY LOAMTYPICHAPLUSTALFS

Depth	Horizon	Description
0_18	O	ABRUPT, SMOOTH; FEW, FINE, FAINT; CLAY; ; WEAK, FINE, ANGUKLAR BLOCKY; FEW, FINE; FRIABLE; ; MANY, VERY FINE; ;
18_35	A1	ABRUPT, SMOOTH; COMMON, MEDIAN, DISTINCT; CLAY LOAM; ; MODERATE, MEDIUM, GRANULAR; COMMON, MEDIUM; FIRM; ; COMMON, FINE;
35_57	A2	GRADUAL, IRREGULAR;COMMON, MEDIAN, DISTINCT; CLAY LOAM; ; MODERATE, MEDIUM, GRANULAR; COMMON, MEDIUM; FRIABLE; ; COMMON, MEDIUM; ;
57_75	B	GRADUAL, IRREGULAR; MANY, MEDIAN, DISTINCT; SILTY CLAY; MODERATE, MEDIUM, COLUMNAR PRISMATIC; MANY, FINE; FRIABLE; COMMON, FINE;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.44	0.18	11.6	174.2	3.77	63.98	23.82	12.2	SL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_03**
Date : 2077.11.06
Location : JORCHAUTARA

General Instruction
Coordinates : 600444 **East**; 3092658 **North;**
Slope : 10 Degree
Slope Direction :
Parent material : ALLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : ALLUVIAL DEPOSIT
Climate : SUB_TROPICAL
Erosion Status : SPLASH
Land Use : AGRICULTURE (BARI/KHET)
Elevation : 975
Soil Moisture Condition : USTIC
Drainage Class : WELL DRAINED
Irrigation :
Cropping Pattern : MAIZE_VEGETABLE
Soil Depth :

Classification
Soil Order : INCEPTISOL
USDA Soil Classification : TYPICHAPLUMBREPTS
Family : STRONGLY ACIDICSILTY LOAMTYPICHAPLUMBREPTS

Depth	Horizon	Description
0_13	A1	ABRUPT;UMBRIC;YELLOWISH BROWN; 10YR 5/4; FEW; LOAM; GR; WEAK, FINE, ANGUKLAR BLOCKY; FEW; ; ; VERY FEW; ;
13_19	A2	ABRUPT; UMBRIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW; LOAM; GR; MODERATE, FINE, ANGUKLAR BLOCKY; FEW; ; ; VERY FEW; ;
19_45	B1	ABRUPT; USTIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW; SANDY LOAM; ST; MODERATE, VERY FINE, CRUMBLY; FEW; ; ; VERY FEW; ;
45+	B2	CLEAR; USTIC; LIGHT YELLOWISH BROWN; 10YR 6/4; FEW; SAND; ST; STRONG, VERY FINE, CRUMBLY; FEW; ; ; VERY FEW; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.43	0.08	9.66	294.8	1.68	29.98	53.82	16.2	SiL

Soil Pit Sample Description

District Name	:	**NUWAKOT**
Package No	:	**PACKAGE_08**
Municipality/ Rural Municipality	:	**MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID	:	**ME_04**
Date	:	2077.11.06
Location	:	THULDADA

General Instruction

Coordinates	:	601376 **East**; 3094198 **North;**
Slope	:	40 Degree
Slope Direction	:	NORTH_WEST
Parent material	:	COLLUVIUM
Physiographic	:	MIDDLE MOUNTAIN
Landform	:	MOUNTAIN TERRACE
Climate	:	SUB_TROPICAL
Erosion Status	:	SPLASH
Land Use	:	FOREST
Elevation	:	1578
Soil Moisture Condition	:	USTIC
Drainage Class	:	MODERATELY WELL DRAINED
Irrigation	:	
Cropping Pattern	:	
Soil Depth	:	

Classification

Soil Order	:	INCEPTISOL
USDA Soil Classification	:	TYPICDYSTROCHREPTS
Family	:	STRONGLY ACIDICSANDY LOAMTYPICDYSTROCHREPTS

Depth	Horizon	Description
0_20	A1	ABRUPT;UMBRIC;YELLOWISH BROWN; 10YR 5/6; COMMON; CLAY; ST; STRUCTURE LESS, MEDIUM, ANGUKLAR BLOCKY; FEW; FIRM; ; COMMON, FINE; ;
20_30	A2	ABRUPT; OCHRIC; BROWNISH YELLOW; 10YR 6/8; FEW; SILTY CLAY; ST; STRUCTURE LESS, MEDIUM, ANGUKLAR BLOCKY; FEW; FIRM; ; COMMON, MEDIUM; ;
30+	B	ABRUPT; OCHRIC; YELOWISH BROWN; 10YR 5/8; FEW; SILTY CLAY; ST; STRUCTURE LESS, COARSE, PLATY; FEW; VERY FIRM; ; FEW, COARSE; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.12	0.22	13.53	241.2	4.43	61.98	23.82	14.2	SL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_05**
Date : 2077.11.06
Location : KIMLANG

General Instruction

Coordinates : 601835 **East**; 3101816 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : ALLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status : SHEET
Land Use :
Elevation : 1151
Soil Moisture Condition :
Drainage Class : POORLY DRAINED
Irrigation :
Cropping Pattern :
Soil Depth :

Classification

Soil Order : ALFISOL
USDA Soil Classification : TYPICHAPLUSTALFS
Family : NEUTRALSANDY LOAMTYPICHAPLUSTALFS

Depth	Horizon	Description
0_16	A1	ABRUPT, SMOOTH;;LIGHT YELLOWISH BROWN; 10YR 6/4; COMMON, FINE, FAINT; SAND; ; WEAK, FINE, COLUMNAR PRISMATIC; FEW, FINE; FRIABLE; ; FEW, FINE; ;
16_30	A2	ABRUPT, SMOOTH; ; YELLOWISH BROWN; 10YR 5/6; MANY, MEDIAN, DISTINCT; SANDY CLAY; ; MODERATE, MEDIUM, GRANULAR; COMMON, MEDIUM; VERY FRIABLE; ; FEW, FINE; ;
30_49	B1	GRADUAL, SMOOTH; ; YELLOWISH BROWN; 10YR 5/4; MANY, MEDIAN, FAINT; SANDY LOAM; ; MODERATE, MEDIUM, CRUMBLY; MANY, MEDIUM; FRIABLE; ; FEW, FINE; ;
49_60	B2	GRADUAL, SMOOTH; ; YELOWISH BROWN; 10YR 5/8; ABUNDANT, MEDIAN, FAINT; SILTY CLAY; ; MODERATE, MEDIUM, CRUMBLY; ; FRIABLE; ; FEW, FINE; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
7.29	0.01	9.66	241.2	0.17	57.98	37.82	4.2	SL

Soil Pit Sample Description

District Name	**:**	**NUWAKOT**
Package No	**:**	**PACKAGE_08**
Municipality/ Rural Municipality	**:**	**MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID	**:**	**ME_06**
Date	:	2077.11.11
Location	:	KHOLTALAPA
General Instruction		
Coordinates	:	602656 **East**; 3099972 **North;**
Slope	:	40 Degree
Slope Direction	:	NORTH_SOUTH
Parent material	:	COLLUVIUM
Physiographic	:	MIDDLE MOUNTAIN
Landform	:	MOUNTAIN TERRACE
Climate	:	SUB_TROPICAL
Erosion Status	:	SPLASH
Land Use	:	GRAZING
Elevation	:	2005
Soil Moisture Condition	:	USTIC
Drainage Class	:	MODERATELY WELL DRAINED
Irrigation	:	
Cropping Pattern	:	TEA
Soil Depth	:	
Classification		
Soil Order	:	INCEPTISOL
USDA Soil Classification	:	TYPICHAPLUMBREPTS
Family	:	VERY STRONGLY ACIDICLOAMTYPICHAPLUMBREPTS

Depth	Horizon	Description
0_28	A1	ABRUPT, SMOOTH;MOLLIC;BROWNISH YELLOW; 10YR 6/6; ; LOAM; GR; WEAK, FINE, ANGUKLAR BLOCKY; COMMON, FINE; FRIABLE; ; COMMON, MEDIUM; ;
28_49	A2	ABRUPT, SMOOTH; UMBRIC; YELLOWISH BROWN; 10YR 5/6; ; SILTY CLAY; ST; MODERATE, MEDIUM, SUBANGULAR BLOCKY; FEW, FINE; FIRM; ; COMMON, MEDIUM; ;
49+	B	CLEAR, SMOOTH; UMBRIC; BROWNISH YELLOW; 10YR 6/8; ; CLAY; ST; MODERATE, MEDIUM, SUBANGULAR BLOCKY; FEW, FINE; FIRM; ; FEW, FINE;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
4.95	0.23	9.66	174.2	4.7	49.98	37.82	12.2	L

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_07**
Date : 2077.11.06
Location : SAMARI BHANJYANG

General Instruction

Coordinates : 603770 **East**; 3092639 **North;**
Slope : 45 Degree
Slope Direction : NORTH_SOUTH
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status : SPLASH
Land Use : FOREST
Elevation : 1256
Soil Moisture Condition : USTIC
Drainage Class : WELL DRAINED
Irrigation :
Cropping Pattern :
Soil Depth :

Classification

Soil Order : INCEPTISOL
USDA Soil Classification : TYPICDYSTROCHREPTS
Family : MODERATE ACIDICSANDY LOAMTYPICDYSTROCHREPTS

Depth	Horizon	Description
30	A	ABRUPT;MOLLIC; LOAM; ST; STRUCTURE LESS, FINE, ANGUKLAR BLOCKY; FEW; COMMON; ;
30+	B	ABRUPT; UMBRIC; SILTY CLAY; ST; MODERATE, FINE, SUBANGULAR BLOCKY; FEW; FEW; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.66	0.03	7.73	107.2	0.5	61.98	31.82	6.2	SL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_08**
Date : 2077.11.05
Location :

General Instruction

Coordinates : 605205 **East**; 3103665 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : SLOPPY
Climate : TEMPERATE
Erosion Status :
Land Use : FOREST
Elevation : 2400
Soil Moisture Condition : MOIST
Drainage Class : WELL DRAINED
Irrigation : NONE
Cropping Pattern :
Soil Depth : MOD

Classification

Soil Order : INCEPTISOL
USDA Soil Classification : LITHICDYSTROCHREPTS
Family : VERY STRONGLY ACIDICSANDY LOAMLITHICDYSTROCHREPTS

Depth	Horizon	Description
15	O	ABRUPT, SMOOTH;;DARK BROWN; 10YR 3/3; FEW, FINE, FAINT; WEAK, VERY FINE, GRANULAR; COMMON, VERY FINE; LOOSE; COMMON, VERY FINE;
16_35	A1	ABRUPT, SMOOTH; ; DARK YELLOWISH BROWN; 10YR 4/4; FEW, FINE, FAINT; MODERATE, FINE, ANGUKLAR BLOCKY; FEW, FINE; VERY FRIABLE; ; COMMON, FINE; ;
36_65	A2	CLEAR, WEAVY; ; YELLOWISH BROWN; 10YR 5/6; COMMON, MEDIAN, DISTINCT; MODERATE, MEDIUM, ANGUKLAR BLOCKY; FEW, FINE; FRIABLE; FEW, FINE; ;
65+	B	CLEAR, WEAVY; YELOWISH BROWN; 10YR 5/8; COMMON, MEDIAN, DISTINCT; MODERATE, MEDIUM, SUBANGULAR BLOCKY; FEW, FINE; FIRM; VERY FEW, COARSE; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
4.71	0.55	17.46	214.4	10.93	61.98	27.82	10.2	SL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_09**
Date : 2077.11.11
Location : DEULARI DADO

General Instruction
Coordinates : 607123 **East**; 3096512 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status : SPLASH
Land Use : BARREN
Elevation : 1656
Soil Moisture Condition : USTIC
Drainage Class : WELL DRAINED
Irrigation :
Cropping Pattern :
Soil Depth :

Classification
Soil Order : INCEPTISOL
USDA Soil Classification : TYPICHAPLUMBREPTS
Family : VERY STRONGLY ACIDICSILTY LOAMTYPICHAPLUMBREPTS

Depth	Horizon	Description
1_32	A1	CLEAR, SMOOTH;MOLLIC;LIGHT YELLOWISH BROWN; 10YR 6/4; FEW, FINE, FAINT; CLAY LOAM; GR; MODERATE, FINE, ANGUKLAR BLOCKY; COMMON, FINE; FIRM; ; COMMON, MEDIUM; ;
32_39	A2	CLEAR, SMOOTH; UMBRIC; YELLOW; 10YR 8/8; FEW, FINE, FAINT; CLAY LOAM; GR; MODERATE, FINE, SUBANGULAR BLOCKY; FEW, FINE; FIRM; ; COMMON, MEDIUM; ;
39+	B	UMBRIC; BROWNISH YELLOW; 10YR 6/8; FEW, FINE, FAINT; SILTY CLAY LOAM; GR; MODERATE, FINE, ANGUKLAR BLOCKY; FEW, FINE; FRIABLE; FEW, MEDIUM; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
4.5	0.29	19.33	174.2	4.9	23.98	61.82	14.2	SiL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/
Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_10**
Date : 2077.11.06
Location : MEGHANG

General Instruction

Coordinates : 609360 **East**;
3098467 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status :
Land Use : AGRICULTURE (BARI/KHET)
Elevation : 1092
Soil Moisture Condition :
Drainage Class : WELL DRAINED
Irrigation : STREAM
Cropping Pattern :
Soil Depth :

Classification

Soil Order : INCEPTISOL
USDA Soil Classification : TYPICDYSTROCHREPTS
Family : STRONGLY ACIDICSANDY LOAMTYPICDYSTROCHREPTS

Depth	Horizon	Description
1_18	A1	CLEAR, SMOOTH;MOLLIC;DARK YELLOWISH BROWN; 10YR 4/4; COMMON, MEDIAN, FAINT; SILT LOAM; GR; WEAK, VERY FINE, GRANULAR; COMMON, FINE; FIRM; ; COMMON, MEDIUM; ;
18_49	A2	CLEAR, SMOOTH; UMBRIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW, FINE, FAINT; SILTY CLAY; GR; MODERATE, FINE, SUBANGULAR BLOCKY; FEW, FINE; FIRM; COMMON, MEDIUM; ;
49+	B	CLEAR, SMOOTH; UMBRIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW, FINE, FAINT; SILTY CLAY; GR; MODERATE, FINE, ANGUKLAR BLOCKY; FEW, FINE; FIRM; FEW, FINE; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.19	0.23	13.53	134.6	4.63	65.98	29.82	4.2	SL

Soil Pit Sample Description

District Name : **NUWAKOT**
Package No : **PACKAGE_08**
Municipality/ Rural Municipality : **MEGHANG RURAL MUNICIPALITY**
Soil Profile No/Pit. ID : **ME_11**
Date : 2077.11.06
Location : BARCHET

General Instruction

Coordinates : 608988 **East**; 3098904 **North;**
Slope : 60 Degree
Slope Direction :
Parent material : COLLUVIUM
Physiographic : MIDDLE MOUNTAIN
Landform : MOUNTAIN TERRACE
Climate : SUB_TROPICAL
Erosion Status :
Land Use : AGRICULTURE (BARI/KHET)
Elevation : 1215
Soil Moisture Condition :
Drainage Class : WELL DRAINED
Irrigation :
Cropping Pattern :
Soil Depth :

Classification

Soil Order : INCEPTISOL
USDA Soil Classification : TYPICDYSTROCHREPTS
Family : STRONGLY ACIDICSANDY LOAMTYPICDYSTROCHREPTS

Depth	Horizon	Description
1_18	A1	CLEAR, SMOOTH;MOLLIC;YELLOWISH BROWN; 10YR 5/4; FEW, FINE, FAINT; SILT LOAM; GR; WEAK, VERY FINE, GRANULAR; COMMON, FINE; FIRM; ; COMMON, MEDIUM; ;
18_36	A2	CLEAR, SMOOTH; UMBRIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW, FINE, FAINT; LOAM; GR; MODERATE, FINE, ANGUKLAR BLOCKY; FEW, FINE; FIRM; ; COMMON, MEDIUM; ;
36+	B	CLEAR; UMBRIC; DARK YELLOWISH BROWN; 10YR 4/4; FEW, FINE, FAINT; SILT LOAM; GR; MODERATE, FINE, ANGUKLAR BLOCKY; FEW, FINE; FIRM; ; FEW, MEDIUM; ;

Soil Properties

PH	TOTAL_N2	P2O5	K2O	OM	SAND	SILT	CLAY	SOIL_TEXT
5.42	0.31	15.46	187.6	6.17	59.98	31.82	8.2	SL

LAND CAPABILITY

Preparation of Land Capability Report
Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Municipality Level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Risk Layer Map, Land Use Zoning Map, Rural Municipality/Municipality Profile and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar Municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Shivapuri, Suryagadhi and Tadi Rural Municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi Municipalities and Bagmati, Konjyosom and Mahankal Rural Municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak Municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha Municipality) and this report covers **Myagang Rural Municipality.**

The Municipality areas analyzed for different themes of the TSLUMD Project are computed from cadastral maps provided by Department of Land Management and Achieve (DOLMA) Office of Nepal. Therefore, the areas of the Municipality may not be the same as computed from Topographic Database provided by the Survey Department of Nepal.

The consultant is obliged to state that the Imageries, GIS database and other out puts produced for the project is owned by Topographic Survey Land Use Management Division (TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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The consultant and team members would like to thank **Mr. Aasha Tamang** (Chairman) and **Mr. Pawan Kumar Pyakurel** (Chief Administrative Officer) the local people, members of the different political parties and staffs of the Rural Municipality and local institutions of **Meghang Rural Municipality of Nuwakot District** for providing their valuable time to the study team in discussing different aspects of the project. Without their support this work could not have been completed.

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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.

The large 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 already declared its constitution. Still it is in the institutionalization 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, renamed now as Survey Department, Topographical survey and Land Use Management Division to generate the necessary data bases on the land resources of the country. At present, this Project has been handled by Survey Department, Topgraphical Survey and Land Use Management Division.

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 Terai districts and mid hills. It is expected that within few years all the districts in high hilly region will be completed and it may take some more years to complete all local units of Nepal. These digital data base includes municipality/rural municipality/metropolitan city/local unit level present land use, soil, land capability, land use zoning, cadastral layers and municipality 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. Later, in 2072, it is amended with some modifications and generally it is known by Land Use Policy, 2072.The policy has encouraged to make different eleven land use zones (see Land Use Policy- 8-1) through the analysis of geology, capacity and suitability of land; present land use and/or as per necessary. Land use policy 2072 (policy 13) has focused on the development of land use planning information system through the preparation of land use/land resources maps, land capability maps, hazards maps and generated database. 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 Land Use Policy, 2072 has directed for an institutional set up of the Department of Land Use Management at the top to the Division offices, and Implementation and Coordination Committee at the bottom. It has added further importance to the TSLUMD projects on preparation of municipality level maps and database.

In this regards, the TSLUMD has awarded us to conduct the project entitled Package 8: Preparation of municipality level land resources maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map and municipality Profile for Land Use Zoning Map and Superimpose of Cadastral Layers), Data base and Reports of Kathmandu

District to our consultancy for fiscal year 2077/078. The Package covers 4 municipalities of Bhaktapur district;a Metropolitan and 10 municipalities of Kathmandu district; a Metropolitan, a municipality and three rural municipalities of Lalitpur district; and 2 municipality and 10 rural municipalities of Nuwakot district.

Concepts:

a) Preparation of land capability maps of the municipality 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 agricultural 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) Indirectly, 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 the TSLUMD Project package 8 (2077/078 fiscal year) 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 for 4 municipalities of Bhaktapur district; a Metropolitan and 10 municipalities of Kathmandu district; a Metropolitan, a municipality and three rural municipalities of Lalitpur district; and 2municipality and 10rural municipalities of Nuwakot district of Nepal. In order to fulfill the broad objective, the present study aims to prepare a land capability map of Myagang Rural Municipality based on high resolution satellite image (ZY-3), detailed field survey and laboratory test analysis of soil characteristics. The specific objective of the study is to prepare Land Capability Maps, GIS database and Reports for Myagang Rural Municipality at 1:10,000 scales.

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 municipality 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

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the central-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59’ 26‘’ to 85^0 17‘16’’ East longitude and 27^0 55‘25’’ to 28^0 04‘02’’ North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

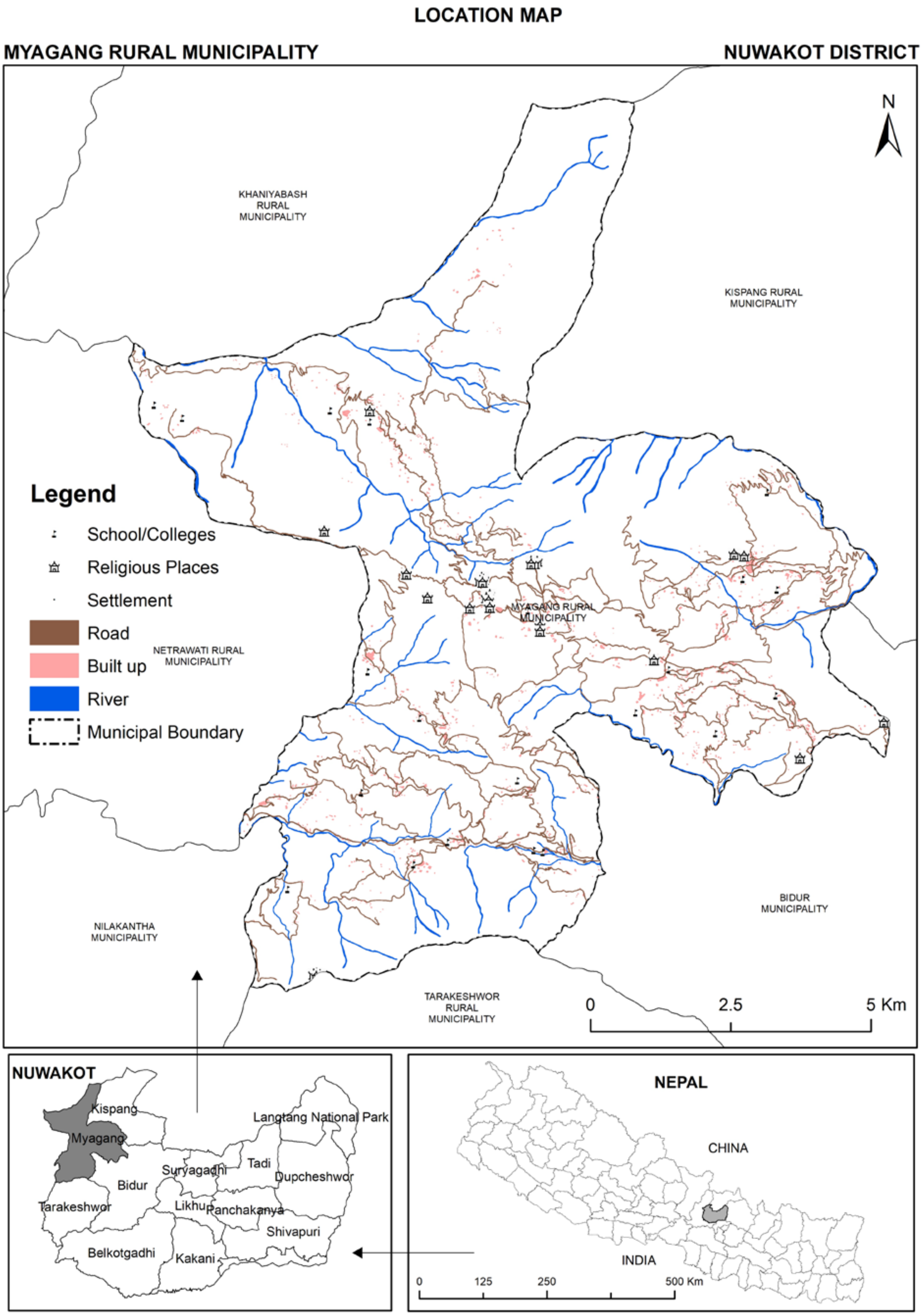

Figure 1.1: Location Map of the Study Area

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 municipality 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 land forming 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 municipality level requires assessment of each individual physiographic land unit for agricultural land use as in the case of Myagang Rural 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 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 (>30º 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 Rural Municipality Level Land Capability Classification

The present study at municipality level on land capability classification follows 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 municipality, 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.

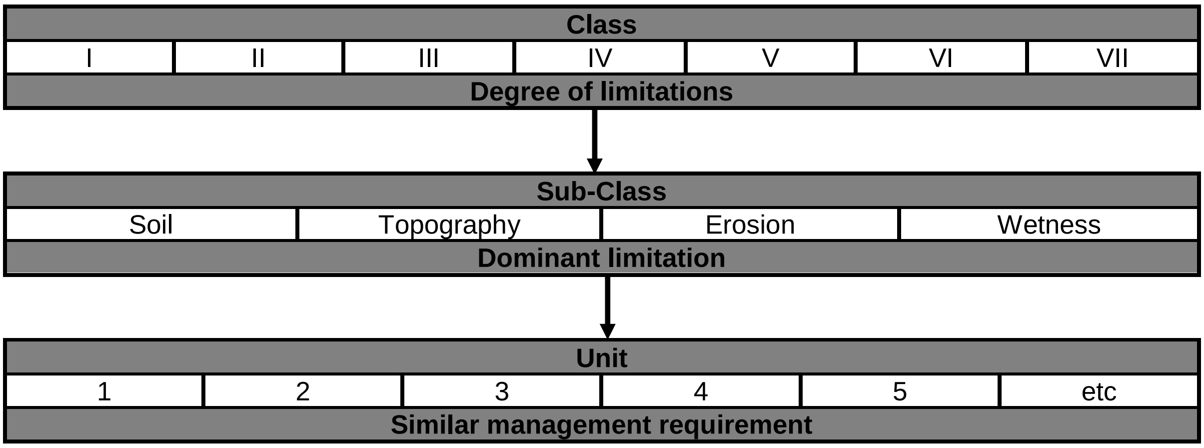

Figure 2.1: Land Capability Hierarchy (adopted from Grose, 1999)

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 applied for 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 municipality 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**$1/4^{th}$ of a square centimeter** in map scale.

v) The map layout and legends are as specified by National Level specification for the Preparation of municipality Level Land Resource Maps, Database and Reports, 2072.

vi) The municipality 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 TSLUMD office.

vii) The municipality 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 TSLUMD office.

viii) The report covers details of the methodology adopted in preparation of the soil capability maps of the selected municipality. 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 from Table 3.1 to 3.12.

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	
5-10	High	High Suitability
2.5 – 5	Medium	
1.0 – 2.5	Low	
<1	Very low	Low Suitability

Table 3.6: Soil Total Nitrogen Rating

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	
10 – 30	Low	
<10	Very Low	Low Suitability

Table 3.8: Soil Available Potassium Rating

Available K_2O (kg/ha)		
>504	Very High	High Suitability
280 – 504	High	
112- 280	Medium	
56 – 112	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.

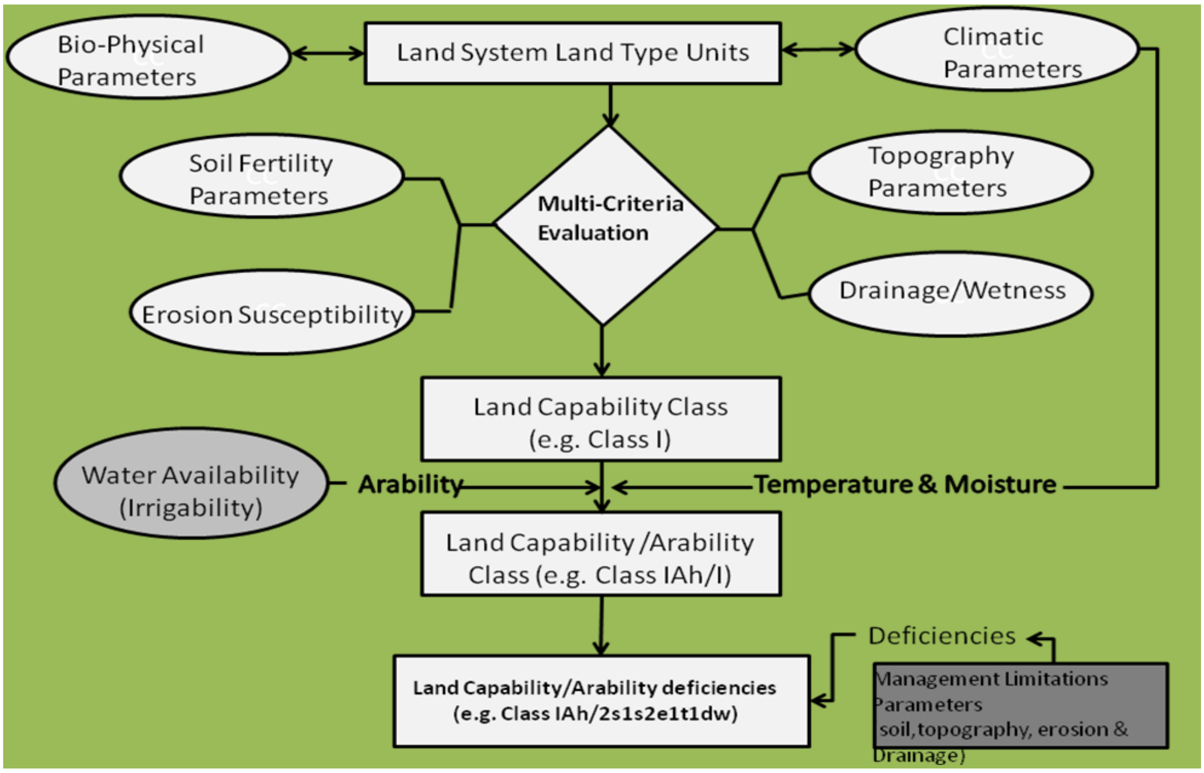

Figure 3.1: Land Capability Classification Method Flow Diagram

Weighted Composite Score (WCS): Weighted Composite Score (WCS) is a systematic procedure for developing factor weights required for preparing capability map. The weights assigned to different factors were obtained by subjective to expert judgment. The larger the weight, the more important is the criterion in the overall capability class.

In developing the weights, an individual factor were ranked as low, medium, and high and very high weight are assigned as 1, 2, 3 and 4 respectively as given below. Factors or criteria were rated according to the following 4-point scale. Weighted Composite Score (WCS) was employed based on parameter weight and individual weighted value as 4, 3, 2 and 1 corresponding to very high, high, medium and low rank of concerned factor respectively. The final value of weighted composite score (WCS) for each soil mapping unit was calculated by summing all individual factors value obtained by multiplying individual factor weight rank value with their corresponding weight of parameters. The equation of calculation of WCS is given below:

Weighted Composite Score (WCS) = Soil depth weightage value*4+pH weightage*3+ Soil texture weightage value*3+ OM weightage value*3+ K_2O weightage value*2+ P_2O_5 weightage value*2+ Nitrogen weightage value*1.

Total fertility level is 58 and minimum is 18 and hence 48-58 is high 38-47 as medium and below 38 is low fertility.

CHAPTER 4: LAND CAPABILITY OF THE STUDY AREA

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 Myagang Rural 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 Myagang Rural Municipality

The capability classification in Myagang Rural 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, its climate is denoted by A/B/C. The climate of the hilly region is humid/perhumid region indicated by h/p. Most of the land area in this municipality has gentle slope to steep slope and ununiformly distributed. Having good soil properties but many limitations including soil depth (moderate depth) this land is classified as Class III, V and VI. Altogether 11 different land capability classes were observed in the study area. Class V land is dominating and it is almost 89% and Class III occupies 4% while class VI occupies 7% of the total area. The total area of Myagang Rural Municipality is 9783.5 ha and out of which forest covers 55%, Agricultural land occupies 41%, residential area covers 0.73%, public use occupies 1.6% area of the Municipality as shown in table 4.0. Other areas are present in least amount. Commercial area occupies 0.03%, riverine, lake and marsh area occupies 1.2%, Cultural and archeological area occupies 0.01% and other area occupies 0.64% of the total area of the Municipality. Land which is not used for agriculture is not assigned the capability class (Table 4.1).

Table 4.1: Land use and Land Capability Classes

S.N.	Description	Area (Ha)	Percentage
1	Agricultural	4014.51	41.03
2	Commercial	3.24	0.03
3	Cultural And Archeological	0.86	0.01
4	Forest	5357.17	54.76
5	Industrial	0.06	0.001
6	Other	62.93	0.64
7	Public Use	156.10	1.60
8	Residential	71.35	0.73
9	Riverine, Lake And Marsh Area	117.29	1.20
	Total	**9783.49**	**100.00**

The total land of Myagang Rural Municipality is 9783.5 ha. This Municipality has 11 different land capability classes as described below.

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 (3º-28º 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 IIIAh/2: This type of land covers only 34.35 ha of the total land of project area and it covers an area comprising 0.35%. This type of land is moderately suitable for diversified crops.

Class IIIAh/5: This type of land covers only 235.5 ha of the total land of Myagang Rural Municipality and it covers little area comprising 2.41%. This type of land is non-arable due to seasonal inundation.

Class IIIAh/6: This type of land covers only 111.45 ha of the total land of Myagang Rural Municipality and it covers little area comprising 1.14%. This type of land is non-arable due to complex topography.

Class V

Class V consists of lands with severe limitations that restrict its use for agriculture and forestry. These lands have slopes (<28º 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 VAh/1Rtd: This type of land covers 109 ha of the total land of Myagang Rural Municipality and it covers area comprising 1.12%. This type of land is highly suitable for diversified crops and rice but has topographic and drainage deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/1t: This type of land covers 3105.99 ha of the total land of Myagang Rural Municipality and it covers area comprising 31.75%. This type of land is highly suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/2t: This type of land covers 1514.79 ha of the total land of Myagang Rural Municipality and it covers area comprising 15.48%. This type of land is moderately suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAp/1t: This type of land covers 118.4 ha of the total land of Myagang Rural Municipality and it covers area comprising 1.21%. This type of land is highly suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/1te: This type of land covers 24.35 ha of the total land of Myagang Rural Municipality and it covers area comprising 0.25%. This type of land is highly suitable for diversified crops but has topographic and erosion deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/2t: This type of land covers 3772.3 ha of the total land of Myagang Rural Municipality and it covers area comprising 38.56%. This type of land is moderately suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VBp/1t: This type of land covers 53.75 ha of the total land of Myagang Rural Municipality and it covers area comprising 0.55%. This type of land is highly suitable for diversified crops but has topographic and erosion deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

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 VIAh/2t: This type of land covers 703.25 ha of the total land of Myagang Rural Municipality and it covers area comprising 7.19%. This type of land is moderately suitable for diversified crops but has topographic deficiency with shallow soil depth and steep slopes.

The laboratory analysis of soil of this Municipality would be more helpful in making decision of the soil producing capacity. The soil reaction of Project area varies from 4.5 to 7.29 ranging from very highly acidic to neutral. Mean soil reaction of the area is 5.3 that fall under the category of strongly acidic, which is fairly suitable for most of the crops. Almost all soils of Project area were within the strongly acidic range that is fairly suitable for most local crops. The soil pH being moderately acidic, macro and micronutrients will be in available form. Vegetables and most food crops can be grown in such type of soil but with adequate care. However, for commercial farming and gaining higher productivity, liming should be done in most areas with proper care.

The organic matter content of the soil ranged from 0.17 to 10.93%. Mean organic matter content of the sampled soil is 4% which falls under the category of medium. Most of the soils of Project area are under the category of medium organic matter content. However, there are places with critically very low organic matter content in the area. 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 local unit ranged from 0.01 to 0.55% which falls under the category of very low to very high. Mean N content of the soil is 0.2%, which is high 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 medium and high category. Care should be taken to grow crops with ample incorporation of organic manure in this area in order to obtain higher crop yield. Available phosphorus of the soils, in general falls within wide range and depending upon the soil types, it ranges from 7.73 to 19.33 kg/ha that falls in the category of very low to low. Mean Phosphorus content of the soil is only 12.8 kg/ha which is low and there may be problem of phosphorus in the soils of the study area in near future. But the amount of available potassium in the soils of Project area is low to high which ranged from 107 to 294 kg/ha. The mean value of the available potassium in the soil is 199 kg/ha which falls under the category of medium. Most of the soils contain high amount of available K. Most soil parameters of Project area were found to be in low range and soil pH seems to be critical for crop production. However, management efforts should be carried out in soils where critical situation appears. Soil nutrients and pH should be well managed in this area.

Majority of the soils of study area are sandy loam, loam and silty loam. Sandy loam type of soil is dominating in the study area. Based on the soil analysis report, it could be concluded that the soils of Project area is good enough for cultivating food and vegetable crops at the moment because of good soil type but all nutrients are scarce in the soil. It is recommended to apply higher amount of fertilizer as they are in low range along with liming.

In a nutshell, Myagang Rural Municipality possesses eleven different land capability classes with the following properties as described in Table 4.2.

Table 4.2: Land Capability Classes

S.N.	Land capability classes	Area (Ha)	Percentage	Description
1	IIIAh/2	34.35	0.35	Subtropical, humid, moderately suitable for diversified crops
2	IIIAh/5	235.50	2.41	Subtropical, humid, non arable due to seasonal inundation
3	IIIAh/6	111.45	1.14	Subtropical, humid, non arable due to complex topography
4	VAh/1Rtd	109.32	1.12	Subtropical, humid, highly suitable for diversified crops and rice but has topography and drainage deficiency with restrictions to forestry and agriculture
5	VAh/1t	3105.99	31.75	Subtropical, humid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
6	VAh/2t	1514.79	15.48	Subtropical, humid, moderately suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
7	VAp/1t	118.42	1.21	Subtropical, perhumid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture

8	VAp/1te	24.35	0.25	Subtropical, perhumid, highly suitable for diversified crops but has topography and erosion deficiency with restrictions to forestry and agriculture
9	VAp/2t	3772.30	38.56	Subtropical, perhumid, moderately suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
10	VBp/1t	53.75	0.55	Warm temperate, perhumid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
11	VIAh/2t	703.25	7.19	Subtropical, humid, moderately suitable for diversified crops but has topography deficiency with shallow soil depth and steep slopes
	Total	9783.49	100.00	

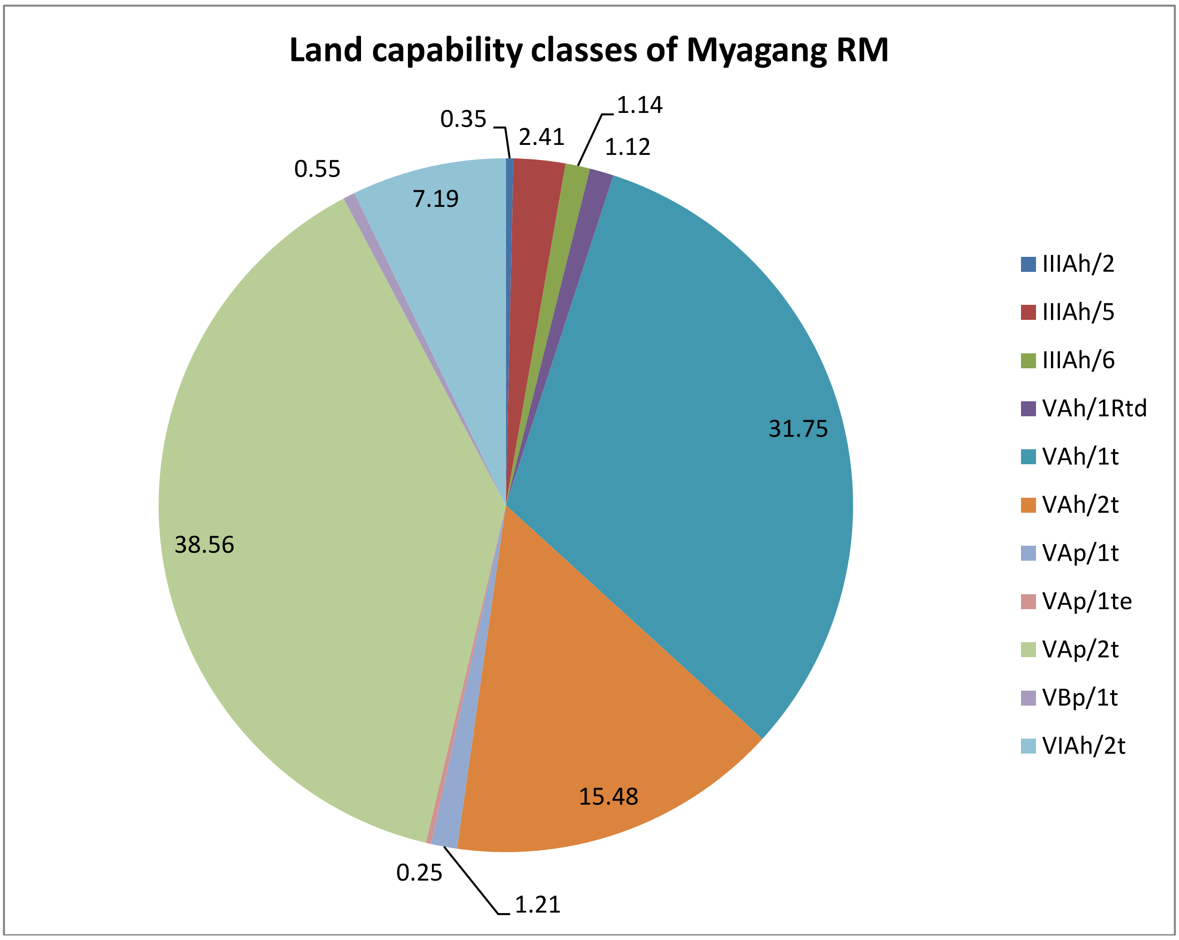

Figure 4.1: Land Capability Classes distribution of Myagang Rural Municipality

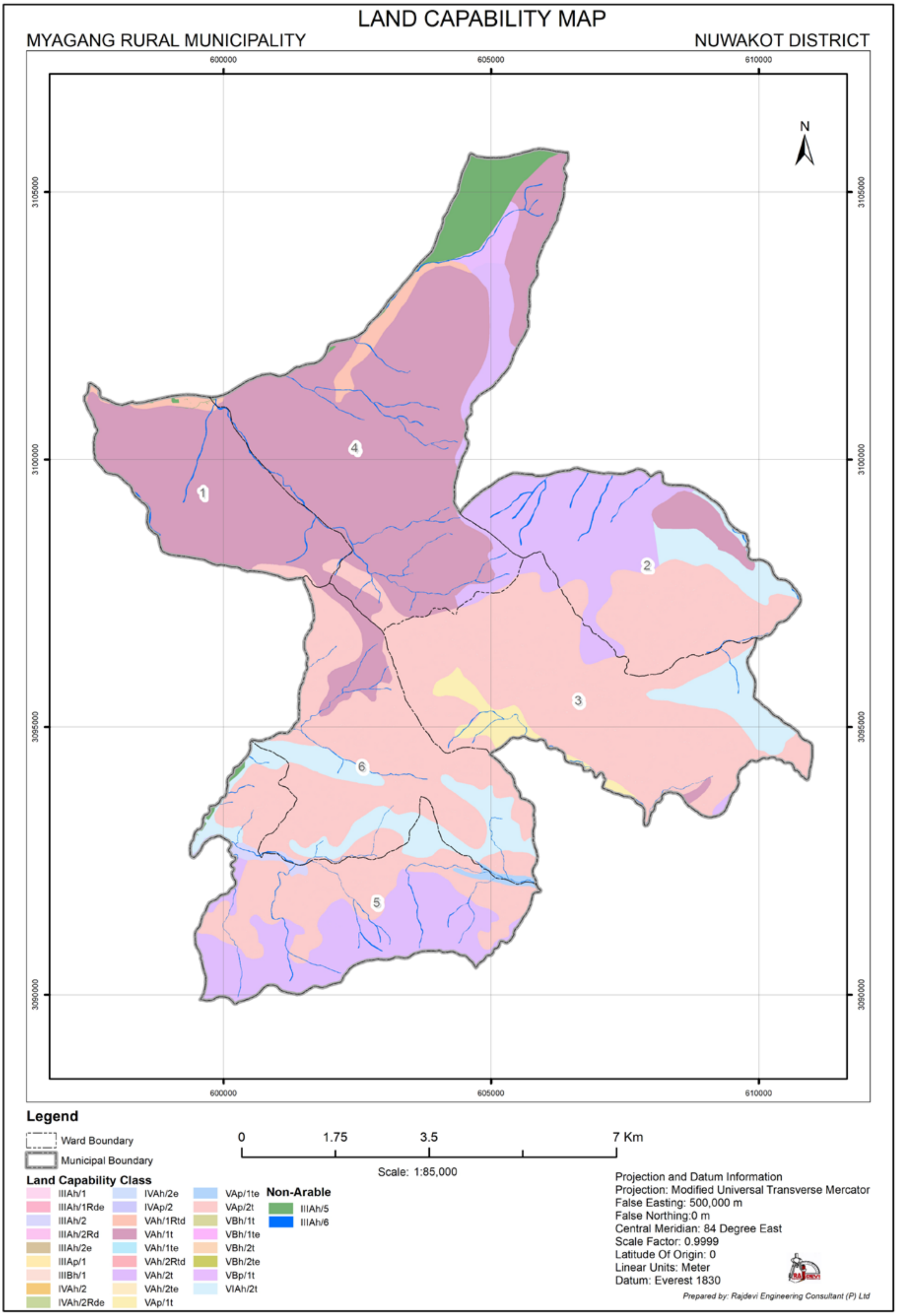

Figure 4.2: Land Capability Map of Myagang Rural Municipality

4.2 Land Capability GIS Database

The land capability GIS data is stored in vector geo-database and "shape" files 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
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
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 Myagang Rural 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,) climatic factors, erosion hazard and land management. The classified lands are suitable for agricultural uses but have limitations as described by various classes above. 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.

Most of the land area in this municipality has gentle slope to steep slope and ununiformly distributed. Having good soil properties but many limitations including soil depth (moderate depth) this land is classified as Class III, V and VI. Altogether 11 different land capability classes were observed in the study area. Class V land is dominating and it is almost 89% and Class III occupies 4% while class VI occupies 7% of the total area. The total area of Myagang Rural Municipality is 9783.5 ha and out of which forest covers 55%, Agricultural land occupies 41%, residential area covers 0.73%, public use occupies 1.6% area of the Municipality as shown in table 4.0. Other areas are present in least amount. Commercial area occupies 0.03%, riverine, lake and marsh area occupies 1.2%, Cultural and archeological area occupies 0.01% and other area occupies 0.64% of the total area of the Municipality.

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 Myagang Rural Municipality. The changes due to implementation of this recommendation should be studied and replicated in wider scale for sustainable land management. Most of the areas fall under steep slope, therefore, agriculture should be done by terracing. Fruit crops and medicinal plants should be encouraged to grow in areas with higher land classes while grazing should be restricted. Beside agriculture, tourism, recreational area, trekking, mountaineering, etc. should be promoted in higher altitudes. Since most of the area is Class V which is restricted for agriculture and forestry, this land should be fully utilized for other purposes as mentioned above. However, agroforestry should be practiced in slopy areas. All areas suitable for agriculture should be used for higher agricultural production with best management practices.

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RISK LAYER

Preparation of Risk Layer Report
Myagang Rural municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Municipality level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural municipality.**

The project areas analyzed for different themes of the TSLUMD Project are computed from cadastral maps provided by Department of Land Management and Achieve (DOLMA) Office of Nepal. Therefore, the areas of the Municipality may not be the same as computed from Topographic Database provided by the Survey Department of Nepal.

The consultant is obliged to state that the Imageries, GIS database and other out puts produced for the project is owned by Topographic Survey Land Use Management Division (TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale

Land use planning aspires sustainability by balancing social, economic and environmental needs. Effective land-use planning provides direction in which land-use activities should take place and encourage synergies between different uses. Human needs and environmental features and processes are dynamic in nature and change in land use occurring at various spatial levels and in different time periods are the material expressions of environmental and human dynamics and of their interactions (Briassoulis 2000). With the ever increasing population and rising demand for food, water and energy, sustainable management of natural resources is pivotal in order to secure current and future need. Sustainable management economic and social benefits from the land while maintaining the ecological support functions of the land resources. However, ensuring adequate supply ensuring the long-term productive potential and the maintenance of environmental functions requires careful and appropriate planning, use and management practices. One of the prime pre-requisites for such is information base at local level on existing land use and capability at cadastre plot level, natural hazard risk level, socio-economic status and proper zoning for land use. Zoning in general, segregates land uses into number of categories and zoning regulations provide a legal framework for sustainable development.

Comprehensive land use planning is of utmost importance in the national development process. Land-use planning, however, requires the application of various tools and techniques to collect and display data and information. The collection of basic data is important as a prelude to deciding on land-use allocations (FAO 2008). Modern tools such as satellite remote sensing, GPS and GIS have been providing newer dimensions to effectively monitor and manage natural resources. Due to advances in space science technology, it has been well conceived that remote sensing and GIS have great role to play in land use planning and zoning for sustainable development. The information base developed using these integrating tools and technology is absolute asset to effective land use planning and zoning for government.

Realizing the importance of responsive and appropriate land use planning, Government of Nepal has approved National Land Use Policy of Nepal in 2069 and amended in 2072BS which integrates safeguarding of disaster risk free human settlement development under land use planning. The policy outlines eleven major land use zones based on the land characteristics, capability and requirement of land. The land use zones include: Agriculture, Residential, Commercial, Industrial, Mining and Mineral, Cultural and Archaeological, Riverine and lake, Forest, Public use and Open space, Excavation and Other. Within this framework, landuse mapping and zoning of 21 districts have been completed under the National Landuse Project. Topographical Survey and Land Use Management Division, TSLUMD at present endeavors on the same to maintain the essence of the amendment on the National Land Use Policy and as mandated by the Land Act 2021 (Sixth Amendment) with the strategy of completion of land use mapping. The current project encompasses the Preparation of Local unit level Land Resource Maps, Database and Reports of twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) under the project incorporating all six themes outlined in scope of work of ToR.

In this context, the present report is one of the outputs under the consulting service Preparation of Rural Municipality/Municipality Local unit level Land Resource Maps, Database and Reports of **Myagang Rural municipality** of Nuwakot district under Package 08 incorporating all themes outlined in the ToR of Topographical Survey and Land Use Management Division(TSLUMD) of Fiscal Year 2077-078.The current project is carried out to investigate the risk factors associated with different land uses and vulnerability in the project area.

1.2 Objective and Scope of Work

The overall objective of the current work is the **Preparation of Rural Municipality/Municipality level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Municipality Profile for Land use zoning, and Superimpose of Cadastral Layers), database and reports. The specific objective of the present work is:

- To identify the areas, which are more prone to risk events potentially caused by flood, landslide, earthquake, fire and industry within the project area.

The scopes of the project work under Disaster risk zone identification, GIS database and Reports cover the following activities:

- Identify areas that are of high risk from impacts of flood prone areas.
- Identify areas that are of high risk from impacts of landslide areas.
- Identify areas that are of high risk from impacts of earthquake areas
- Identify areas that are of high risk from impacts of other risks

1.3 Project Area

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur

Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality, the project area, is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the north-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola, Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

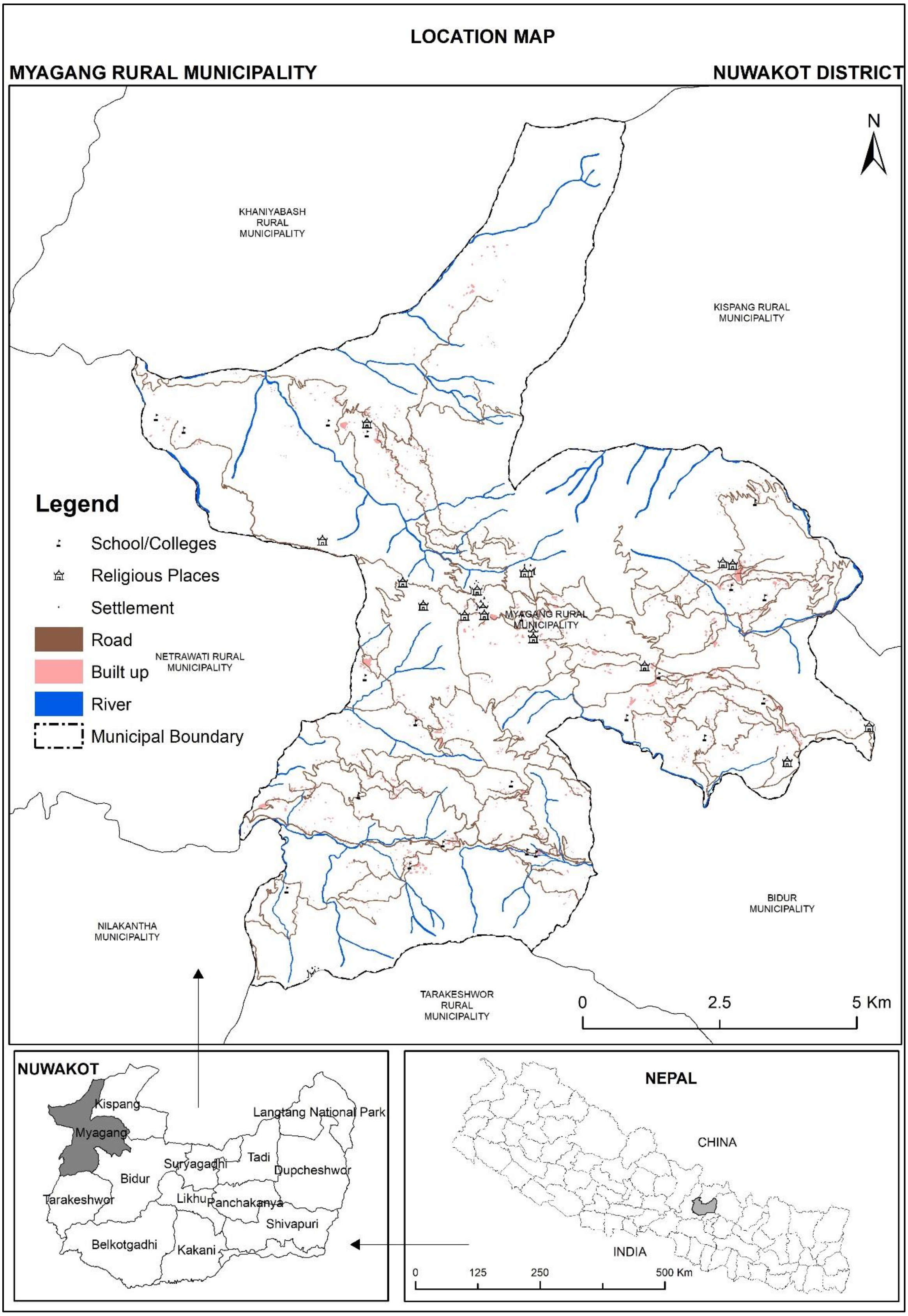

Figure 1.1: Location Map of the project area

CHAPTER 2: CONCEPTUAL BASIS OF RISK MAPPING

The present chapter describes the conceptual basis and principles of risk for land use zoning. The chapter includes detailed description of different types of risk and associated vulnerability.

2.1 Land use Planning and Disaster Risk Reduction

The population, buildings and engineering works, economic activities, public services utilities, other infrastructures and environmental values in the area potentially affected by the hazard are deemed as elements at risk. The assets at risk from disaster can be enormous and include private housing, transport and public service infrastructure, commercial and industrial enterprises, and agricultural land. Risk is a measure of the probability and severity of an adverse effect to health, property or the environment. Risk is often estimated by the product of probability of a phenomenon of a given magnitude times the consequences. However, a more general interpretation of risk involves a comparison of the probability and consequences in a non-product form. Zoning is the division of land into homogeneous areas or domains and their ranking according to degrees of actual or potential hazard or risk or applicability of certain hazard-related regulations.

Land use planning (LUP) or zoning is an essential planning tool for successful and systematic disaster risk reduction (DRR). It further clarifies that the use of policies, non-structural measures and planning tools like LUP can reduce exposure of vulnerability of communities and assets to hazards. Land use planning can reduce the vulnerability of people and infrastructure identifying appropriate locations for settlement and construction by applying adequate building standards during implementation of plan. LUP in corporation with DDR is a method applied to achieve safer and more sustainable development as it aids in protecting communities, houses, livelihoods, schools, hospitals and other components from disaster. Risk-sensitive land use planning is useful for controlling main spatial exposure to risk. The spatial exposure refers to people, property, systems, or other elements present in hazard zones. LUP can reduce exposure of risk hazard and vulnerability as it involves policy and provisions which target, and seek to reduce specific aspects of vulnerability such as poor construction, poor transportation and road access, lack of evacuation routes and evacuation sites, poor drainage systems and waterways etc.

2.1.1 Disaster Risk Reduction in Nepal

Many acts and policies have been formulated for disaster mitigation activities in Nepal. Natural Disaster Relief Act, 1982 is the first Act of Government of Nepal. It has recognized earthquake, fire, storm, flood, landslide, heavy rainfall, drought, famine and epidemics as disaster. This Act defines natural disaster relief work to be carried out in the area affected or likely to be affected by the natural disaster in order to rehabilitate the victims from natural disaster. This Act is defined to control and prevent the natural disasters to prevent loss of life and property(Asia, Seminar, & Mapping,2009).Ministry of Home Affairs is the apex body to deal with disaster management in Nepal with following functions:

- Formulation of national policies and their implementation,
- Preparedness and mitigation of disaster,
- Immediate rescue and relief works,
- Data collection and dissemination,
- Collection and distribution of funds and resources

The structure of disaster relief committee in Nepal is shown in Figure 2.1.

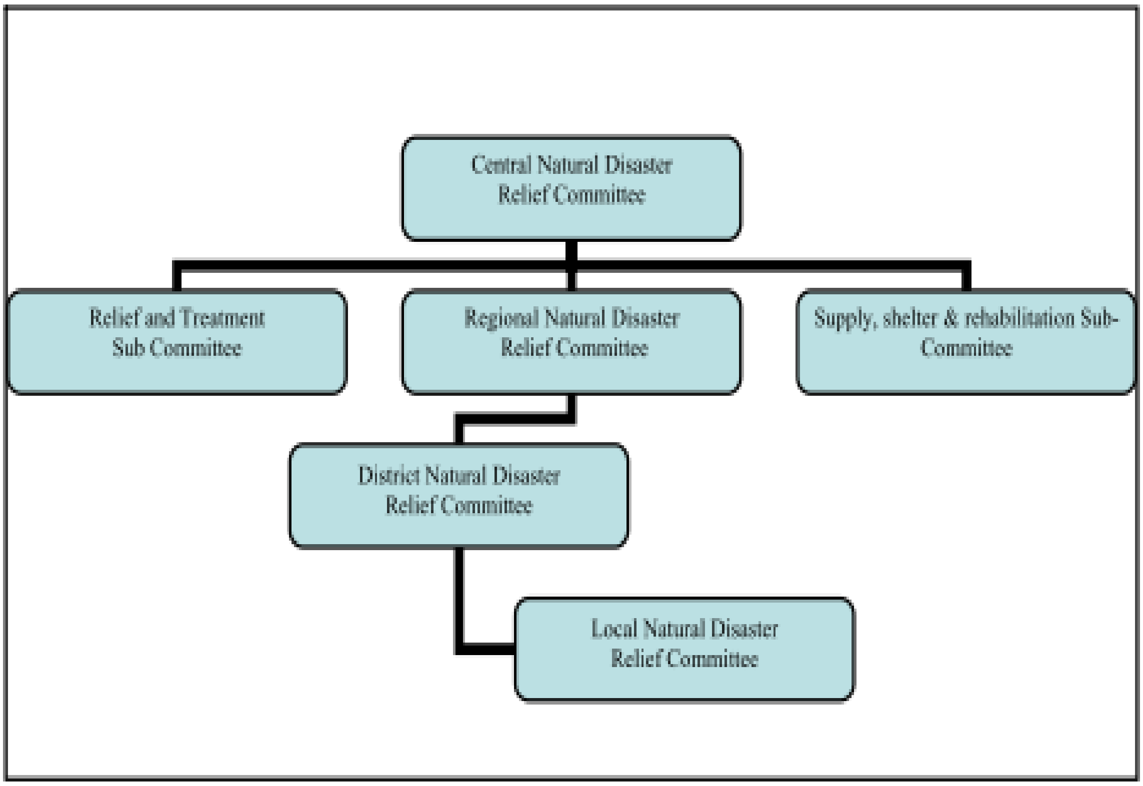

Figure 2.1: Disaster Relief Committee framework of Nepal

Some related act and regulation formulated in Nepal for disaster management are as following:

- Natural Calamity Relief Act 1982 (Amended in 1982 & 1992)
- Water Resources Act 1992
- National Action Plan on Disaster reduction 1996
- Environmental Protection Act 1996
- Local self-governance act (LSGA, 1999)
- National Water Resource Strategy, 2002

- National Water Plan, 2005
- Three Year Interim Plan (2008-2010)

2.2 Relation of Vulnerability and Hazard with Risk

The relationship between hazard, vulnerability and risk in disaster context

2.2.1 Hazard

It is a prime component of risk. It is expressed as the probability of a potentially damaging event of a certain magnitude occurring within a certain period of time. Hazards depend on site-specific and seasonal climatic conditions. Hazard is a condition with the potential for causing an undesirable consequence. The description of landslide hazard should include the location, volume (or area), classification and velocity of the potential landslides and any resultant detached material, and the probability of their occurrence within a given period of time. Similarly, other hazard includes corresponding parameters relevant to them.

Hazard is to be understood as a source of potential harm. It poses a threat or condition that may cause loss of life or initiate any failure to the natural, modified or human systems.

The initiating causes of a hazard may be either an external (e.g. earthquake, flood or human agency) or an internal (defective element of the system e.g. an embankment breach) with the potential to initiate a failure mode. Hazards are also classified as either of natural origin (e.g. excessive rainfalls, floods) or of man-made and technological nature (e.g. sabotage, deforestation, industrial site of chemical waste). Regarding hazard identification and estimation, two approaches can be identified based on the ANCOLD Guidelines (2003) and the ISDR principles (2004):

- ***Traditional deterministic approach:*** It is a first level estimation of the potential adverse consequences, if the hazard occurs, in order to classify the system under threat, identify the necessity or not of further investigation. This approach is also the most comprehensive way of estimating man-induced and /or technological hazards, e.g. a forest fire hazard that cannot be captured by a probability distribution.
- ***Probabilistic approach:*** It is based on the theory of probability and regards hazard estimation as the estimation of the probability of occurrence of a particular natural event with an estimated frequency within a given period of time. It can be applied on hazards of natural origin and it represents a very common method used in most flood plain delineation studies when the potential for loss of life is considered negligible in terms of historical floods. The probabilistic approach tends to assume that events in the future are predictable based on the experience of the past.

2.2.2 Vulnerability

The degree of loss to a given element or set of elements within the area affected by the landslide. It is expressed on a scale of 0 (no loss) to 1 (total loss). For property, the loss will be the value of the damage relative to the value of the property; for persons, it will be the probability that a particular life (the element at risk) will be lost, given the person(s) is (are) affected by the disaster event.

One of the best-known definitions of vulnerability was formulated by the International Strategy for Disaster Reduction (ISDR, 2004), which regards it as "a set of conditions and processes resulting from physical, social, environmental and economic factors, which increase the susceptibility of a community to the impact of hazards". A basic consensus has emerged, that the concept of vulnerability addresses a double structure consisting of an external side (exposure) (Bohle, 2001), and also that vulnerability is:

- Multi-dimensional and differential (varies across physical space and among and within social groups).
- Scale-dependent (with respect to time, space and units of analysis, such as individual, household, region, system).
- Dynamic (characteristics and driving forces of vulnerability change over time, certainly exceeding that time of the extreme event itself).

Generally, the vulnerability of a system against a certain hazard is not easily assessed. Three routes for the assessment can be distinguished:

(i) economic
(ii) social
(iii) cultural

The vulnerability function could be treated as a function between 0 and 1. However, the most appropriate approaches for the case of vulnerability of the society and the cultural heritage are thought to be qualitative. A vulnerability analysis in the event of a hazard like flood considers the population and structures at risk within the affected area. In the start of the analysis, a reference level of the system's vulnerability should be determined that usually refers to existing flood protection systems of the affected area. The vulnerability analysis evaluates the potential costs of disaster event in terms of damages to buildings, crops, roads, bridges and critical infrastructure etc.

It refers to the physical and social elements at risk that lacks the capacity to cope with the negative impact of a hazardous event. The concept of vulnerability not only includes physical or socio-demographic characteristics, but also non-tangible factors like lack of knowledge about the hazard, so it is difficult to measure. Common understanding and definition of vulnerability has not yet been found. The concept of vulnerability describes the characteristics but not the number of people or volume of infrastructure exposed to a hazard. Disaster occurs when Hazard and vulnerability is combined.

2.2.3. Risk

Risk refers to the potential disaster losses (in terms of lives, health status, livelihoods, assets and services) which could occur to a particular community or a society over some specified future time period (UNISDR, 2017). It considers the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environmentally damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions. Risk cannot only be determined as a function of hazard, describing the possibility of physical harm, but must also include the vulnerability of the element at risk. Vulnerability is also dependent on the socio-economic and cultural context. The relationship between hazard, vulnerability and risk is illustrated in Figure 2.2.

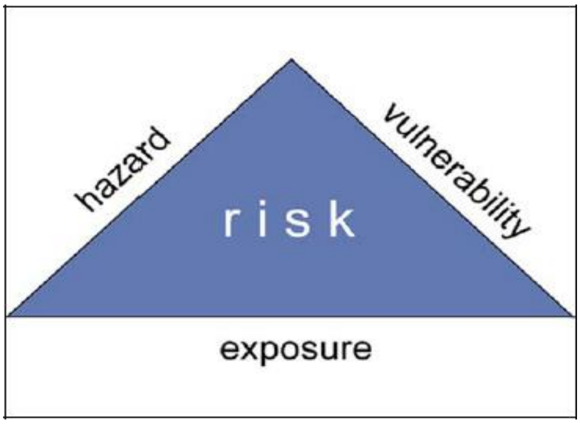

Figure 2.2: The Risk Triangle (Crichton, 1999)

2.3 Risk types and their Descriptions

Depending upon the types of factor causing an area to expose into vulnerability and hazard associated with it, risk can be classified into various categories. However, for the land use planning and management process, risk factors have been specified related to the following event:

- Flood
- Fire
- Landslide
- Earthquake (Seismic event)
- Industrial hazard

2.3.1 Flood Risk

Flood risk is the likelihood of a flood event together with the actual damage to human health and life, the environment and economic activity associated with that flood event (EU Directives, 2006). It can be considered as the actual threat of flood hazard to the affected areas. The quantification of flood risk results either in monetary units or in loss of life units, if the losses are measurable, or in qualitative terms (e.g. allocation in classes) in the case of intangible damages (social, environment, cultural) to the affected areas.

Flood occurs repeatedly in low plains of Nepal causing loss of lives and properties. Nepal has more than 6000 rivers and rivulets (Manandhar, 2010).Major sources of water are glaciers, rivers, lakes, rainfall, ponds, groundwater etc. Mountains are the perennial source of water. Intensity of approximately 224.7 billion m^3or in terms of flow rate; it is 7,125m^3/sec(Asia et al., 2009). It further adds that Nepal suffers from frequent water induced disaster like flood, landslide, erosion, debris flows, glacial lake outburst, drought and epidemic. This phenomenon occurs mainly in Monsoon. Intense monsoon rainfall causes flooding in many rivers of Nepal Altogether, water induced rainfall with average 1700 mm annually contributes to surface water flow in average annually of disasters causes average annual loss of 309 lives and affects 27654 families (Asia et al., 2009).Four types of flash floods resulting loss of life and properties have been reported from Nepal. Those flash floods are associated with i) extreme local scale precipitations (Khanal et.al, 2015).

2.3.2 Fire Risk

Fires are the prominent hazards particularly during the drier-months. There are very few studies carried to fire hazard risk mapping in Nepal. But it is found that forest fires, fires caused by inflammable building materials, petrol pump and gas stations are major events which cause maximum losses to life, property and natural resource like forest. Awareness of the local people towards fire risk is the major parameters for identifying fire hazard risk areas and proper management and protection. Fire risk is common during the dry, stormy season between April and June when temperature increases in the area of wooden and inflammable building materials which are extremely vulnerable to incendiary lighting strikes, suffers from numerous fire outbreaks mainly during the process of cooking. In the winter, the major cause of fires is the short circuiting of electrical appliances, particularly heaters. In urban and other areas, houses are built in close proximity; these too are vulnerable, as fires easily leap from one house to the next. This fire cause great loss of life and property and can have a devastating impact on local economies.

Similarly, forest fires also occur every year in Nepal, particularly in the forests of Tarai and Hills. Government of Nepal has given less priority in managing forest fire due to limited resources. Nepal has adopted various forest management approaches including community forestry, leasehold forestry, protected forestry and government managed forestry. All categories of forests are affected by fire albeit the magnitude varies. Community forests and leasehold forests are less affected as compared to protected forests and government managed forests. Forest fire is considered as a problem in forest management systems in Nepal since we have not been able to use it as a management tool. The fire management is an important initiation to safeguard forest, biological resources environment and public heath, by reducing fire damages through mobilizing government, non-government, private sector, civil society and local people.

2.3.3 Landslide Risk

A landslide is the gravitational movement of a mass of rock, earth or debris down a slope. Landslide hazards are usually classified on the basis of the material involved (rock, debris, earth, mud) and the type of movement (fall, topple, avalanche, slide, flow, spread). Thus, the generic term landslide also refers to mass movements such as rock falls, mudslides and debris flows. Landslide hazard zonation is defined by the mapping of areas with an equal probability of occurrence of slope failure within a specified period of time. Slope failure is largely controlled by two different factors; i) Intrinsic factors (bedrock geology, geomorphology, soil depth, soil type, slope gradient, slope aspect, slope convexity and concavity, elevation, engineering properties of the slope material, land use pattern, drainage pattern) and ii) Extrinsic factors (rainfall, earthquakes and volcanoes).

The causes of landslides in Nepal can be assigned to a complex interaction of several factors which are natural as well as human activity related. High relief, concentrated monsoon rainfall, withdraw of underlying as well as lateral supports by toe cutting and bank erosion, presence of weaker rocks, active neo-tectonic movements and a complex geological history, etc. are the natural factors causing landslides in Nepal (MoHA, 2011).

2.3.4 Seismic Risk

Nepal experienced a major earthquake with magnitude of 7.6 on 25 April, 2015. The catastrophic earthquake had resulted over 8,800 casualties and over 22,000 injuries together with displacement of 100,000 people. It is estimated that the lives of eight million people, almost one-third of the population of Nepal, have been impacted by these earthquakes (NPC-PDNA, 2015). The Himalaya seismicity, in general, owes its origin to the continued northward movement of Indian plate after the continental collision between Indian plate and Eurasian plate. The magnitude, recurrence and the mechanism of continental collision depend upon the geometry and plate velocity of Indian plate in relation to southern Tibet (Eurasian Plate). Recent results suggest that the convergence rate is about 20 mm/year and the Indian plate is sub-horizontal below the Sub- Himalaya (Tarai) and the Lesser Himalaya.

The problems of seismic-tectonic events of Himalaya are not fully understood though the knowledge is increasing with new accumulation of research results and data analysis. However, now-a day a simple method of preliminary investigation of maximum credible earthquake and peak ground acceleration for an assessment of seismic hazard is also popular. The analysis is basically made by deterministic evaluation of earthquake sources in the vicinity with the state of art consideration of attenuation for the Himalayan terrain. The result of micro seismic investigation, geodetic monitoring and morpho-tectonic study of the Central Nepal has depicted that the more frequent medium sized earthquakes of 6 to 7 magnitude are confined either to flat decollment beneath the Lesser Himalaya or the upper part of the middle crustal ramp. The ramp is occurring at about 15 km depth below the foothills of the Higher Himalaya in the south of MCT surface exposures. Big events of magnitude greater than eight are nucleated near the ramp flat transition and rupture the whole ramp-flat system up to the Main Boundary Thrust (MBT) of the Sub-Himalaya (Pandey et. al. 1995).

2.3.5 Industrial Risk

Industrial hazards are also recognizing one of the important risks for the neighboring areas. Particularly, it is true in the case of developing countries where industries are developed haphazardly without taking concerns of the industrial effluents as well as the industrial pollutions which might act as the risk for the surrounding people by causing different diseases and other threats. Beside risk from heavy and bigger industries and hazardous materials and chemical industries, medium, small and cottage industries and plants such as wood industries and saw mills and agro-processing plants also possess industrial risk.

CHAPTER 3: METHODOLOGY

The methods applied for risk mapping and risk zone identification is explained in this chapter. Based on the multi-criteria spatial analysis of different criteria for different type of risk namely, floods, landslide, fire, industrial and seismic is carried out by using GIS tool.

3.1 Flood Risk

Flood is a natural event of rising water level in a stream, lake, reservoir or coastal region (Friesecke, 2004). A flood is caused by heavy rainfall that causes river / oceans to over flow. It can happen at any time. Flood can happen very quickly when lots of heavy rain falls over a short period. Such type of flood is called flash flood, which can occur with little or no warning. This can cause huge damage on human life than any other type of flooding. Coastal areas are also at risk from sea flooding, as it has been threatened by storms and big waves which bring seawater onto the land. The flooding can be worst if storms, ‘spring tides’ and low atmospheric pressure occur at a time (Singh, 2013). Floods can distribute large amounts of water and suspended sediment over vast areas, restocking valuable soil nutrients ruining crops, destroying agricultural land / buildings and drowning farm animals.

Natural hazard and flood events are part of nature that have always existed and will continue to exist. Floods are climatologically phenomenon, which is influenced by geology, geomorphology, relief, soil, and vegetation conditions. Meteorological and hydrological processes can produce flash floods or more predictable, slow developing floods causing riverside floods. In some cases, floods are invited by the failure of dam and landslides. Mitigation and non-structural measures are found to be more effective and long term solution for the water related problem. The local flood protection measures create negative effect in both upstream and downstream. Therefore, whole river basin should be taken into account. Flood plain should be identified before assigning any land use in such area(UN/ECE, 2003). The identification of flood plain can be performed by preparing flood hazard maps by the responsible authorities. This can be helpful to consider development activities according to risk sensitivity in immediate risk areas.

3.1.1 General Approach and Methodology for Flood Risk

Various methodological frameworks is in practice for flood hazard modeling. It is generally accepted that the flood risk management framework should be mainly oriented towards non-structural measures (e.g. land use planning, flood warning systems, evacuation plans, insurance policy). Those are mainly driven by the need of cultural heritage protection and also by the socioeconomic conditions of the area concerned. WECS/DHM (1990) method is the unique method for Nepal and found to be accurate comparing to others. In this method, the whole country is considered as single hydrological region. As per flood records, a low flows, a long term flows and a high flood flows sub regions are divided. The method is first developed jointly by Water and Energy Commission

Secretariat (WECS) and Department of Hydrology and Meteorology of Nepal in 1982. Later it is modified and came up in improved form in 1990. World Meteorological Organization (WMO), Water and Energy Resource Development Project, until 1989 (WERDP) and WECS/NEA Institutional Support Programme (WISP) are major partner to develop this method. In this context, an adopted methodological framework of current project for flood risk assessment is WECS/DHM (1990) method as shown in the Figure 3.1.

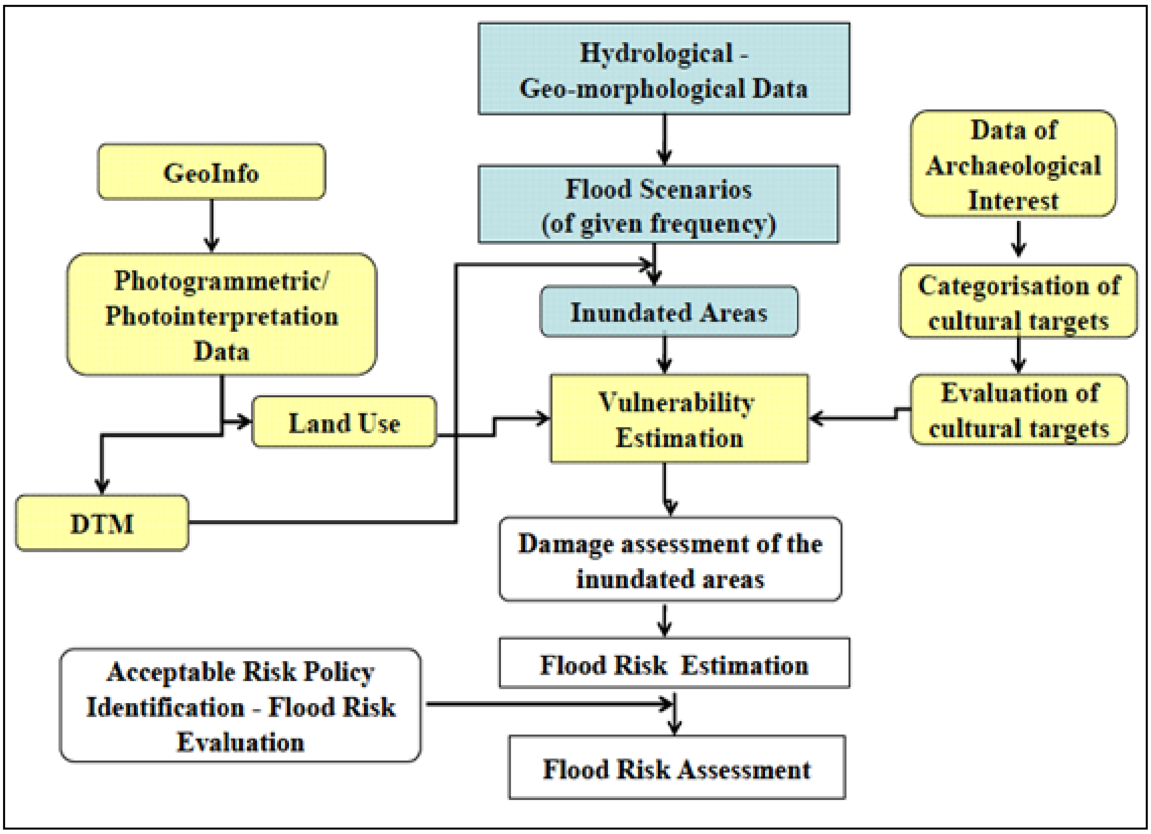

Figure 3.1: Flood risk mapping methodology

3.1.2. Data and Methods for Flood Risk

In order to obtain the set objectives defined in TOR regarding flood risk, spatial and non-spatial data were collected. Both Qualitative and Quantitative approach were adopted for data generation. Primary sets of data were acquired using the method of interview with the people, residing in flood prone area and government officials. Secondary data were collected from National Land Use Project. The census of 2011 was obtained from website of CBS. Data for the Flood Risk Study are classified as: Land Use / Land Cover, Elevation, Hydrologic parameters (Such as Catchment area, Cross-sectional data at defined interval, River bank lines, Flow path geometry, Stream center line etc., Discharge data at strategic points, oil type and flood plain property etc.

Data for the Flood Risk Study can be classified into various groups as follows:

- Land Use / Land Cover Data,

- Elevation Data (Such as Spot height, contour, elevation model),
- Hydrologic parameters such as Catchment area, Cross-section data at defined interval, river bank lines, flow path geometry, stream centre line, etc., and
- Discharge data at strategic points, manning's constant, river boundary information, etc.

Primary data Collection: Primary data was obtained using the method of interview with the people residing in flood prone area to get the answer for the frequency of occurrence of flood and the methods they adopted to cope with. This information was collected through the written questionnaire and interview/conversation with local people. Non-probability, purposive sampling was used.

Conversation with Key informants: The data are collected through the extensive consultation with government representatives at various levels, experts, professionals, local communities and industrial stockholders. Additionally, interactive methods are adopted to collect the data among local government representatives, community forestry user groups and local communities to find out the impact, status and extent of impact.

For calculation of water discharge, rivers/streams mori khola, trisuli ganga nadi, salakhu khola, phalakhu khola, samari khola, tadi khola, chhahare khola, ghatte khola, Likhu khola, tadi khola, chandrawati khola, bhyaure khola, kholpu khola, etc. this package area was digitized from the Zy-3 image. Digital elevation modelwas prepared by using contour and station point from the topographic map. The process for the discharge calculation using watershed area is shown in figure 3.2 and Water discharge for return period 100 years were calculated with the determination of watershed area.

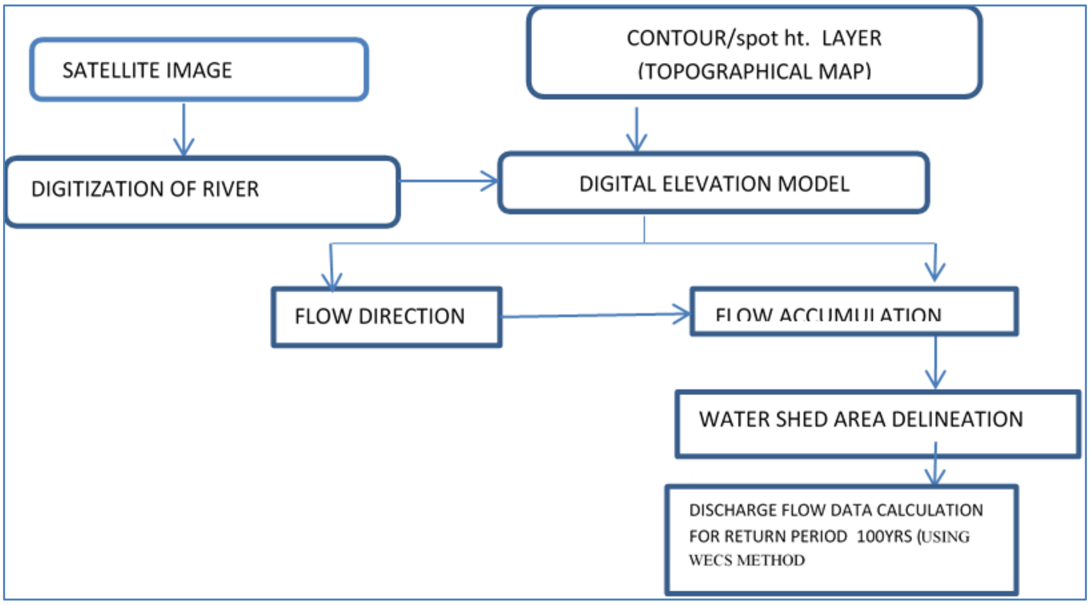

Figure 3.2: Process for discharge calculation

Table 3.1: Discharge calculation for different rivers for 100-year Return Period

River	Station (m)	Catchment Area (sq km)	Q 100-yrs Return Period
Mori khola	5121.61	4149.03	9891.998
Trisuli ganga nadi	1024.06	4274.29	10124.78
Salakhu khola	7795.03	58.45	357.2612
Trisuli ganga nadi	9250.98	4454.83	10457.7
Phalakhu khola	9298.46	141.65	708.4606
Trisuli ganga nadi	8500.83	4618.95	10757.8
Samari khola	9020.11	67.89	400.913
Trisuli ganga nadi	5038.38	5305.22	11988.68
Tadi khola	7921.04	616.5	2228.849
Chhahare khola	7093.35	24.45	183.9811
Ghatte khola	10507.57	119.54	621.0194
Likhu khola	6872.98	548.2	2033.581
Tadi khola	1400.83	142.59	712.1097
Tadi khola	20019.5	212.21	970.1471
Chandraawati khola	5437.11	43.29	283.7819
Trisuli ganga nadi	11229.53	5345.73	12060.21
Bhyaure khola	1588.61	16.01	134.246
Kholpu khola	1524.15	5618.4	12538.68
Kholpu khola	65.48	5734.54	12740.93
Kholpu khola	4520.06	139.62	700.5623

3.2 Fire Risk

Fires are the prominent hazards particularly during the drier-months. But it is found that building materials, proximity to the neighboring buildings, proximity to roads, proximity to forest, and proximity to hazardous elements (petrol pump and gas stations etc. and socio-economic status and awareness of the local people on the hazard are the major parameters for identifying fire hazard risk areas in Nepal. Fire risk is common during the dry, stormy season between April and June when temperature increases, houses in the region are wooden inflammable which are extremely vulnerable to incendiary lighting strikes, suffers from numerous fire outbreaks mainly during the process of cooking. In the winter, the major cause of fires is the short circuiting of electrical appliances, particularly heaters. In urban and other areas, houses are built in close proximity; these too are vulnerable, as fires easily leap from one house to the next. This fire cause great loss of life and property and can have a devastating impact on local economies.

Common Cause of Fire are as following:

- Very few fires are naturally caused in Nepal (NBS, 2002). It is observed that 40% of forest fires in the mid-hills are caused by accidents while 60% are started deliberately e.g. shifting cultivation and forest encroachment etc. (Karki,1991).
- Cattle grazing for new grass and smokers in forest area are known causes of forest fires.
- Although it is not common, local communities identified bamboo as a fire igniters. Friction exerted between bamboo culms within the clumps sometimes produce fire.

- In settlement areas, due to negligence while cooking, firing is common for house and shelter.
- Faulty wiring and electrical equipment, candles, home heating and cooking, children activities, flammable liquids (fuels, solvents, adhesives, paints, and other raw materials – can ignite or explode if stored improperly) and careless smoking were the main sources of firing in houses and settlements areas.
- Industrial and chemical fires occur when hazardous materials such as petrochemicals spill or leak and subsequently explode, technology fails, vehicles collide, and factories catch on fire. Within minutes, an entire industrial area can be aflame and billions of rupees of property swallowed up. They also take lives and destroy the environment.

3.3 Landslide Risk

Landslides are a form of erosion and are an important process in the shaping and reshaping landscapes and landforms. Landslides re-distribute soil and sediments in a process which can be extremely rapid or very slow. Landslide hazard, defined as the annual probability of occurrence of a potentially destructive landslide event. In Nepal, high susceptibility zone of landslide are identified in the areas of high intensity rainfall and earthquake hazard. Earthquake induced hazard are distributed in center (hill) zone of Nepal, which is largely dependent on Pick Ground Acceleration (PGA) values. For example, more than 25 percent areas of middle mountains are prone to high landslides triggered by high intensity rainfall and earthquake whereas one third of the areas are highly landslide susceptible zone as per 500 years' earthquake return period assessment (MoHA, 2011).

Landslide susceptibility refers to the classification, area spatial distribution of potential landslide occurrence area. Landslide susceptibility zoning refers to the division of land into homogeneous area or domain and their ranking according to degree of potential landslide susceptibility, hazard or risk. Landslide inventory, susceptibility and hazard zoning for local areas for preliminary level risk zoning and the advance stages of planning for larger engineering structures are carried out at 5000 to 2500 scale covering are from 10 to 1000 square km (Fell et. al., 2005).

3.3.1 General Approach and Methodology for Landslide Risk

Landslide susceptibility assessments are based on different methods. Some common landslide susceptibility mapping methods are: Geomorphologic mapping, Inventories, Statistical modeling, index based Heuristic analysis and Process based mapping and analysis. The current landslide susceptibility is based on process based mapping. The overall methodology applied is presented in Figure 3.2 and the approach followed for landslide mapping includes:

- Inventory of existing landslides from satellite image
- Verification of landslides in the field
- Mapping landslide susceptibility based on susceptibility factors integrating scientific methodology and field landslide data characteristics.

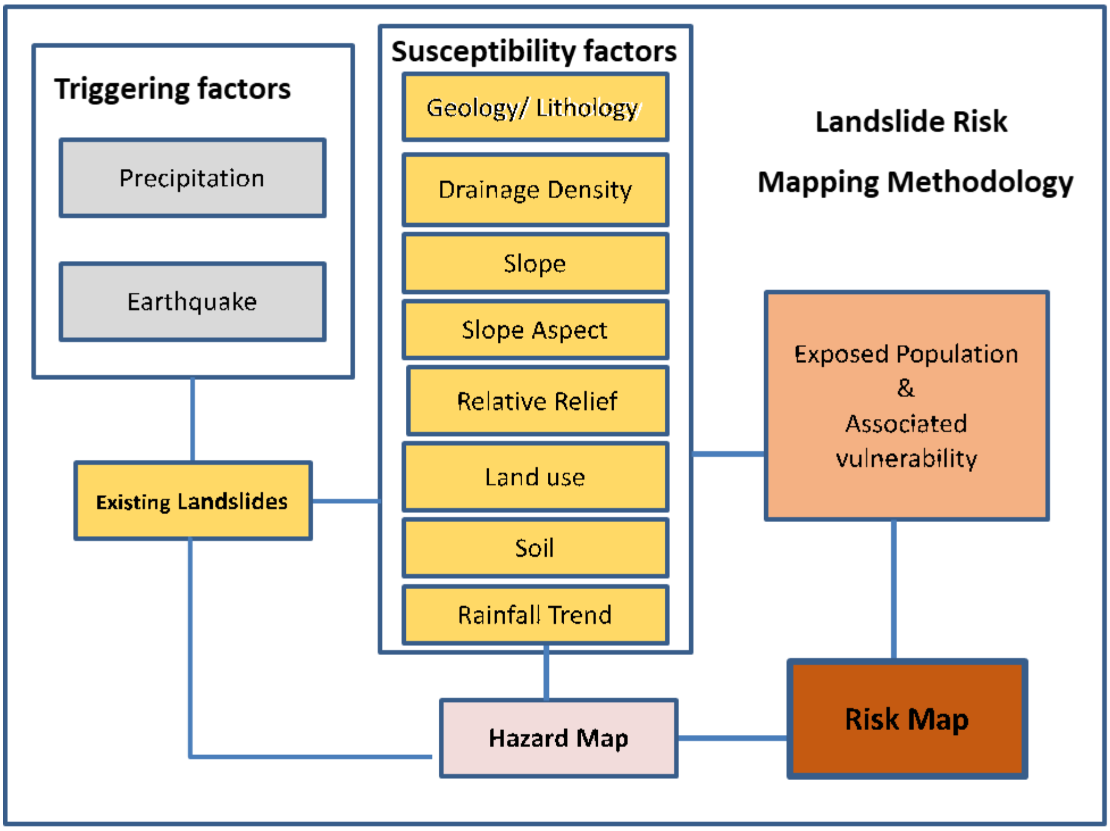

Figure 3.3: Landslide Risk Mapping Methodology

3.3.2 Data and Methods for Landslide Risk

Data: Landslides are the result of triggering natural factors mainly extreme precipitation, rainfall intensity and seismicity and susceptibility factors namely: slope, slope aspect/direction, lithology/geology, soil moisture and land cover and land use. Peak of monsoon usually correlate with high landslide events in Nepal due to high precipitation. Data on the importance of earthquake triggered vs. precipitation triggered in terms of fatalities may not be easily available. However, it is known that in some cases, a significant share of the earthquake fatalities is killed by triggered landslides. All relevant spatial data at available geographical coverage and format are collected, compiled and processed in GIS platform and spatial multi-criteria analysis (SMCA) was carried out for the landslide susceptibility analysis.

Data collected for land use resource mapping and topographical, soil and geology data are used for landslide susceptibility analysis. Data and source of data are detailed below:

- Land cover land use (present land use, Satellite image 2018),

- Slope and Slope Aspect (from DEM, Satellite image 2018)
- Relative Relief (derived from DEM)
- River network: Drainage density (Present land use, Satellite image 2018 & Topographical sheets, 1995-97)
- Geology: Fault and lineament, Lithology and Rock type (DoMG, 2009),
- Soil (Land system, SOTER 2009), and
- Rainfall/ precipitation trend (DHM, 2009-2018).

Method: Landslide susceptibility zoning with existing landslide data integration provides quantitative measure on landslide distribution with the assumption of continuous landslide density in space. Landslide susceptibility zoning usually involves developing an inventory of landslides which have occurred in the past together with an assessment of the areas with a potential to experience land sliding in the future, but with no assessment of the frequency (annual probability) of the occurrence of landslides (AGS, 2007).

Landslide susceptibility zoning is carried out in a GIS-based system with spatial multi criteria analysis, SMCA using number of spatial data layers so that the zoning can be readily be applied for land use planning and can be up-dated as more information becomes available. Standard processing and conversion methods are adopted in this analysis to minimize data error and methodology is devised accordingly. Landslide susceptibility mapping was carried out based on Nepal hazard assessment methodology (MoHA, 2011) and weights are assigned as specified in landslide hazard zonation mapping in mountainous terrain guideline (Bureau of Indian standards, 1998) combining triggering factors (mainly extreme precipitation and seismicity) and susceptibility factors (slope, lithology, and soil moisture). The Equation 1 formula was used for weighted spatial analysis using SMCA:

Landslide Susceptibility Ranking (LSR): **LSR** = $\Sigma (Pc_{rn} + Eq_{rn}) + (Ge_{rn} + Dd_{rn} + Lu_{rn} + Slp_{rn} + So_{rn} + RR_{m} + SA_{m})$………..(**Equation 1)**

Where, rn = Rank,

Factors: *Pc*= Precipitation, Eq = Fault and Lineaments, Ge = Lithology/Geology, Dd = Drainage density, Lu = Land use/Land cover, *Slp*=Slope, So = Soil texture *RR*=Relative Relief, SA=Slope Aspect

Individual class of each layer was assigned 1 to 9 class weight value based on AHP method and all nine layers were given differential weights. Based on landslide inventory, geology, topography and geomorphology, soil and land cover/ land use, and using equation 1, weighted value are calculated and summed. Rank 1 to 3 are assigned for each susceptibility factor and high to low susceptibility rank were summed and final rank grouped as **High, Moderate** and **Low** through Jenk's natural break method.so, Higher the rank (i.e. value 1) higher the landslide susceptibility (High) and vice-versa.

3.4. Seismic Risk

Nepal lies within the seismic hazards zones of the world. The Himalaya seismicity, in general, owes its origin to the continued northward movement of Indian plate after the continental collision between Indian plate and Eurasian Plate. The magnitude, recurrence and the mechanism of continental collision depend upon the geometry and plate velocity of Indian plate in relation to southern Tibet (Eurasian Plate). Recent result suggests that the convergence rate is about 20mm/ year and the Indian plate is sub-horizontal below the sun-Himalaya and the Lesser Himalaya.

The project area is located in the Lesser Himalayan rocks of the Bagmati-Gosainkund region which is comprised of a relatively wide portion of the Great Midland Antiform in the inner zone between Nuwakot and Dhunche. The rocks are repeated in the Okhaldhunga tectonic window which is separated from the inner zone by the Gosainkund tectonic bridge. A narrow and discontinuous Lesser Himalayan band is extended along the foothills of the Mahabharat Range and a few of its slices crop up amid the Siwaliks in the Bagmati River and north of the Marin Khola. The Lesser Himalayan rocks are differentiated into two complexes named as Nawakot Complex and Kathmandu Complex (Stöcklin and Bhattarai, 1977 and Stöcklin, 1980). The Kathmandu Complex is overlain on the Nawakot Complex and differentiated each other by the Mahabharat Thrust (MT). Listhostratigraphically, the rocks of Nawakot Complex are represented as the oldest rocks of the Lesser Himalaya from Proterozoic Era.

3.4.1 General Approach and Methodology for Seismic Risk

The seismicity deals with the preliminary investigation of maximum credible earthquake and seismic coefficient of the project area. The result of micro seismic investigation, geodetic monitoring and morpho-tectonic study of the central Nepal has depicted that the more frequent medium sized earthquakes of 6 to 7 magnitudes are confined either to flat decollment beneath the lesser Himalaya or the Upper part of the Middle crustal ramp. The ramp is occurring at about 15 km depth below the foothills of the Higher Himalaya in the South of MCT surface exposures. Beg events of magnitude greater than eight are nucleated near the ramp flat transition and rupture the whole ramp-flat system up to the blind thrust (MBT) of the Sub- Himalaya (Pandey et al. 1995)

Preliminary seismic hazard assessment of the country using Gamble's third asymptotic extremes with the instrumental seismicity database of ISC is carried out by Bajracharya (1994) for different return periods 50, 100, 200, and 300 years, Attenuation model with mean value of McGuire and Oliveira is used for Horizontal acceleration.

Return period (years)	Peak horizontal acceleration (g)
50	0.10
100	0.15
200	0.20

300	0.25

Several seismicity studies have been carried out for the various projects in the country during the engineering design phase and seismic design coefficient have been derived for the project. There are several methods to convert the maximum acceleration of the earthquake motion into the design seismic coefficient. Generally three methods are commonly used to establish the seismic coefficient. These are:

i. Simplest method
ii. Empirical Method
iii. Dynamic analysis method using dynamic model

The effective design seismic coefficient is determined by using the simplest method, the following equation:

$A_{eff} = R^{*}A_{max}/980$

Where A_{eff} is effective design seismic coefficient

R= Reduction factor (empirical value R=0.50-0.65)

The result obtained from this method is found to be similar in the recent studies carried out by using the dynamic analysis and the static analysis. Therefore, this method is considered to be the most common method to establish the design seismic coefficient at present.

The third method is the dynamic analysis method using the dynamic model. This method is considered to be the most reasonable method at present. However, to apply this method parameters like the design input motion, the soil structure model, the properties of the rock materials have to be known, and therefore, it means that a detailed study is required to use this method. Therefore, the empirical method is considered to be the best to establish the design seismic coefficient for this level of the study.

3.4.2 Data and Method for Seismic Risk

Data: The analyzed data has been taken from the secondary sources. The data has been extracted from maps of epicenter of the Earthquake in Nepal Himalaya, Probabilistic seismic hazard assessment map of the Nepal Himalaya (2002), and seismic zonation of map the Nepal Himalaya from NSET. The project area lies in the seismic gap area according to these data sources.

Method: The effective design seismic coefficient is determined by using the simplest method, using the following equation:

$A_{eff} = R^{*}A_{max}/98\ 0$

Where $A_{eff}$is effective design seismic coefficient

R= Reduction factor (empirical value R=0.50-0.65)

Maximum acceleration A_{max}=200 gal according to seismic hazard map of Nepal. This method has been adopted for the current seismic risk mapping of the project area.

3.5. Industrial Risk

Industrialization is one of the basic causes of pollution which poses risk to human health and environment. To fulfill the unlimited demand of population growth, industrialization is going rapidly. As a result, this has led to the environmental changes that have become harmful to all living beings and environment. So, we have to take proper step to reduce the industrial pollution. Both, public and government should take proper step to reduce pollution. The risk types and their descriptions are discussed below:

Flora and fauna: The industrial pollution has impact on the native fauna and flora. It could lead to decrease the species diversity of animals, reptiles and amphibians and birds. In addition, a wide range of aquatic creatures and other living organism could be victims of the industrial pollution affecting wetlands, lakes, village ponds, reservoirs, rain water ponds and paddy fields. The by-products of industrial activity, particularly cement sludge, paper sludge and ghee sludge are discharged into rivers without any treatment. This could lead decrease in surface and ground water quality near to the industrial sites.

Air quality: In Nepal, most of the cement factories do not use regular water sprinklers in order to reduce the negative impact of fugitive industrial emissions. Meteorological parameters such as wind velocity, temperature, humidity, rainfall, cloud coverage and solar radiation determine the dispersion, diffusion and transportation of particulate matter and emissions into the atmosphere.

Soil quality: Industrial pollution, has serious impact on soil quality, the soil was found to be alkaline around the industrial area. Beside this, trace amount of metal, plastic, dye, petro-chemical, pesticides were also found around the industrial areas. In Nepal, the soil is also harmed by fugitive effluent from the cement factories. Anecdotal evidence indicates that as a result of the accumulation of dust, crop yields near the industrial site have dramatically decreased compared to the pre-industry era. During the flowering periods, photosynthesis and pollination are disturbed by dust accumulation on plant surfaces and in the soil.

Noise levels: In Nepal, Cement manufacturing plants and other industry adjacent to residential, institutional and educational areas use heavy industrial equipment such as fans, engines and generators causing noise pollution.

Water Pollution: Water pollution, by the discharge of wastewater from industry (intentionally or through spills) into surface water is in the risk of chemical contaminants. This could lead the impact on ground water too.

Others Form of pollution include light, visual, thermal, plastic and pesticides pollution etc. The adverse impacts caused by industrial pollution and expansion within the zone needs to be identified and assessed to conserve the environment, living organism, as well as the biodiversity of the region for promoting the sustainable development of the surrounding communities in a deliberate and tactful way. The major risk area has to be identified so that the proper planning for settlement and other development activities can be done in planned and sustainable way followed by land use planning. The areas nearer to the industries are in high risk in all aspect such as health, environmental, water ecology, agricultural productivity etc.

3.5.1 General Approach and Methodology for IndustrialRisk

General Approach: The general approaches for the industrial risk layer data collection are as follows:

- Identification of Industrial area
- Identification of Industrial type and category
- Identification of environmental risk, risk characterization and environmental effects
- Identification of probable industrial risk area

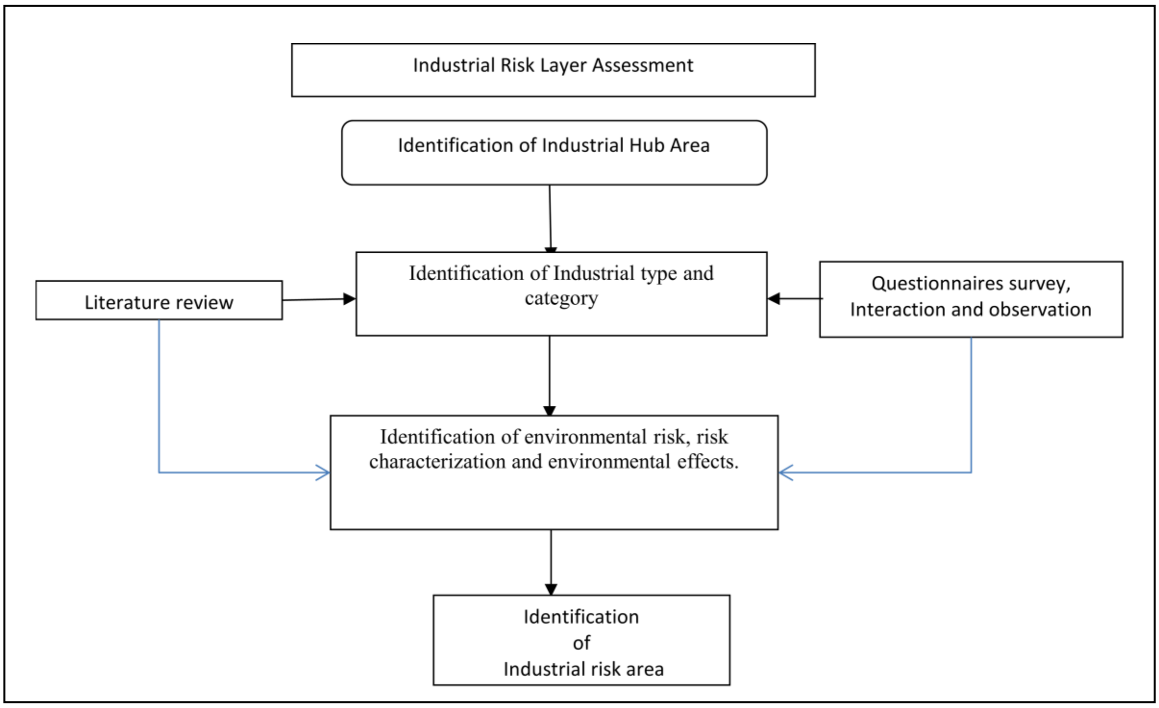

Figure 3.4: Industrial Risk Mapping Methodology

3.5.2 Data and Methods for Industrial Risk

Data: The identification of fire risk areas is a difficult process. However, attempts can be made to identify the risk areas based on the past occurrences (hot spots), survey of industrial buildings and locations, observation of building density, and socio-economic status of the residents etc. The present analysis tried to evaluate the industrial risk areas by collecting data through the consultation with government representatives, experts and local communities as well as based on the observation during the field visit of the area and GIS mapping of industries.

Methods: The methods adopted for the data collection and industrial risk mapping were literature review, field investigation, questionnaire survey and GIS mapping.

Literature Review: The relevant information is collected from various books, publications, journals etc. to access the industrial risk. Similarly, different types of maps such as topographical map, images are also studied. Required relevant information has been drawn from different websites.

Field Investigation: A detailed field investigation is carried out for the data collection. The project area is visited during the field study. The data regarding to industry type, category, capacity and probable environmental impact created by that environment are collected.

Questionnaires Survey and Interaction approach: The data are collected through the extensive consultation with government representatives at various levels, experts, professionals, local communities and industrial stockholders. Additionally, interactive methods are adopted to collect the data among local government representatives, community forestry user groups and local communities to find out the impact, status and extent of impact.

3.6. Soil Erosion Susceptibility Mapping

Erosion susceptibility is the major soil factor limitation that affects soils and agriculture production. Some common approaches used for soil erosion susceptibility assessment are: relative probability of occurrence of soil erosion based past events, relative probability of occurrence based on set of causative factors. In the area where erosion events are not recorded and studied, assessment based on causative factors becomes imperative. With the technological advancement, soil erosion assessment based on remote sensing, GIS and statistical techniques are becoming universal (Abdulkadir, et. al., 2019).

Climate particularly the rainfall intensity, soil, topography**,** and landuse are the four major factors which determine rates of soil erosion in an area.

3.6.1 Soil Erosion Susceptibility Mapping Methodology

Though erosion is directly related to the **forces applied to the soil** by **erosive agents,** field conditions at the site and management practices also play a major role. In general, soil high in silt content, low in clay and low in organic matter content are most erodible. Stable soil structures infiltrates water easily, which reduces overland water flow and hence, top soil flow Organic matter contributes in binding soil particles in order to form stable structure. The greater the intensity and duration of a rainfall, the higher the erosion potential. The direction, shape and length of slope triggers water runoff and rate to infiltrate which increases soil erodibility. The greater the slope length, the greater the soil erodibility. GIS based spatial multi-criteria analysis (SMCA) method is adopted for the current assessment. The data layers used for soil erosion susceptibility is listed below and methodology adopted is shown in Figure 3.5.

- Land cover land use (present land use, Satellite image 2018),
- Slope (derived from DEM, Satellite image 2018)
- Slope Aspect (derived from DEM, Satellite image 2018)
- River network: Drainage density (Present land use, Satellite image 2018 & Topographical sheets, 1995-97)
- Soil properties (Land system, SOTER 2009), and Field survey 2021
- Rainfall/ precipitation trend (DHM, 2009-2018)

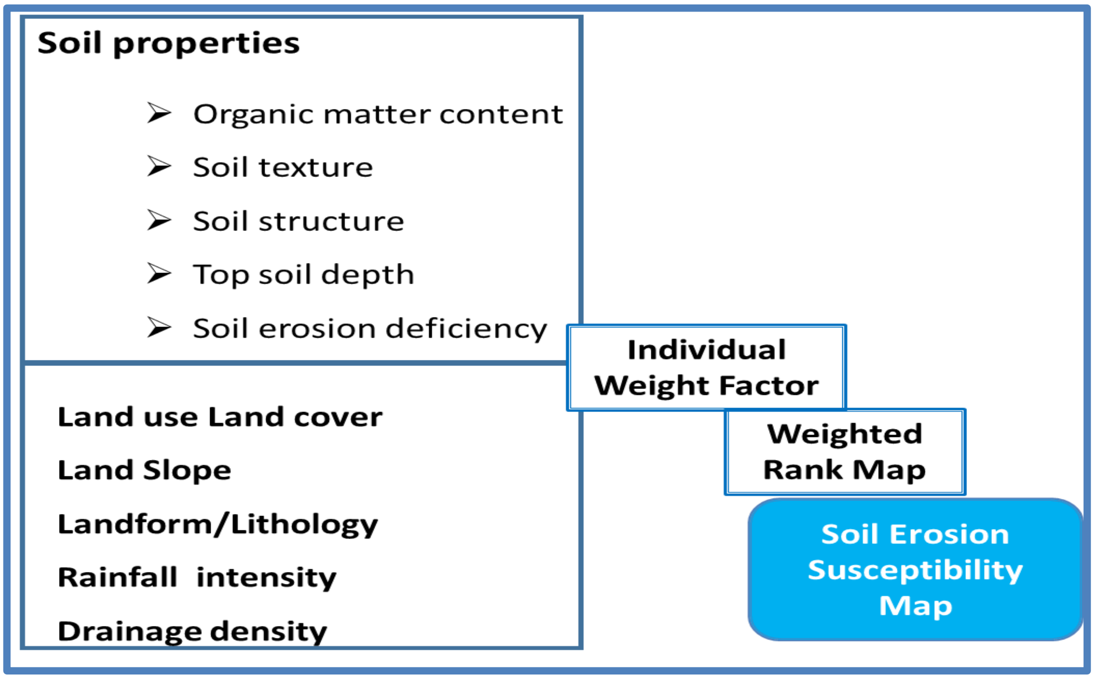

Figure 3.5: Soil Erosion Mapping Methodology

CHAPTER 4: RISK IN THE PROJECT AREA

4.1 Existing risk in the project Area

This chapter discusses different susceptibility of different hazards, risk factors and their distribution and potential effect to land use, human settlements and infrastructures.

4.1.1 Flood Risk

Result: A total of 10.69 ha areas in the project area (0.11% of the total area) are at risk of different flood levels due to 100-year return period flood. Out of this flood risk area 10.04 ha of agriculture land followed by 0.38 ha of forest and the rest of other land uses are likely to be inundated due to 100-year return period flood at different depths. Out of the total flood risk area, 5.03 ha is likely to be flooded with high level depth (more than 1.5 m), 3.12 ha with medium level (0.5 m to 1.5 m) and the rest 2.54 ha with Low level (less than 0.5 m). The land use-wise inundated area is shown in Table 4.1 and flood risk map of the project area is presented in Figure 4.1. Gairihaun and Jharlang are likely to be at risk of 100-year return period flood.

Table 4.1: Land use-wise inundated area in the project area

Landuse Type	High (Ha)	Medium (Ha)	Low (Ha)	Total Risk Area (Ha)	No Risk Area	Total Area
Agriculture	4.98	2.98	2.07	10.04	4004.48	4014.51
Commercial	0.00	0.00	0.00	0.00	3.24	3.24
Cultural and Archeology	0.00	0.00	0.00	0.00	0.86	0.86
Forest	0.04	0.06	0.28	0.38	5356.78	5357.17
Minerals	0.00	0.00	0.00	0.00	0.06	0.06
Other	0.00	0.00	0.00	0.00	62.93	62.93
Public	0.00	0.05	0.18	0.24	155.86	156.10
Residential	0.01	0.02	0.004	0.04	71.31	71.35
Hydrology	0.00	0.00	0.00	0.00	117.29	117.29
Total Area (Ha)	**5.03**	**3.12**	**2.54**	**10.69**	**9772.79**	**9783.49**

Discussion: This report presents a systematic approach in the preparation of hazard, and risk maps with the application of steady flow models and GIS. The result acquired through the analysis reveals the fact that highest area of 5.03 ha of the total flood prone area will be flooded with high level followed by 3.12 ha by medium level and 2.54 ha by low level due to 100-year return period flood.

The assessment of the flood area indicates that vulnerable area lying in flood plain area, need immediate action to take against flood such as river training or embankment or levee construction to protect the given area from further degradation due to flood. Settlements along or nearby lower reaches of Trishuli River, Tadi River, Thopal Khola, Koshi Khola, Chandrawati Khola, etc. specially Panchmure, Dandagaun, Dhansar, Tadipul, Besithok, Kashitar, Panchkhale, Chanaute, Khalte, Gairigaun, Ratmatetar, Kalchedi, Rajwodargaun, Kolputar, Bhalayotar, Kolputar, Majhi Biruwatar, Dandakateri, Biruwatar, Mahabir, Betrawati, Karmetar, Sole Najar, Dandathok, Uparkhutteltol, Agitar, Chhipitar, Akkare Bajar, Bhainse, Chanautetar, Angutar, Distiltyank. Bejal, Rimaghat, Pandegaun, Trishuli Bajar, Dhunge Bajar, Bandre, Pokharithok, Gauribesi, Devighat Koloni, Mandredhunga, Gairitar, Bhorletar, Buwanibesi, Tukanahiti, Majhitar, Devighat, Phirkep Devighat, Kumaltar, Trishuli Koloni, Majhigaun, Baguwa Bajar, Dhade, Ajingare, Anptar, Bhendiswanra, Salle, Kaphle, Dhuseni, Bhyangle, Tulasidanda, Jagatedanda, Jamune, Chyampeswanra, Ranibar, Chaughada, Gankar Bagaincha, Doban Pati, Bachchhala, Sheradil, Thansinphat, Dobate, Amilbote, Dude Bagincha, Pattabari, Gurudanda, Dhikure Bajar, Ladbu, Lavaletar, Chaukhuda, Dumrigaun, Malakot, Gairihaun, Jharlang, Simara, Shreretar Anpraha, Kanle, Mishraphant, Rautal, Anpdanda, Kanelthok, Birtathok, Suntaletar, Chhabise, Athbise, Dumre, Phedibesi, Machha Pokhari, Bakhre, Kutunje, Sano Borle, Barabote, Satbise, Barhabise, Kharaniphant, Budenphant, Bahunbesi Anpra, Darshantar, Dhodbesi, Tarubesi, Birtaphat, Majhitar, Pimaltar etc. villages/settlement are more prone to floods as revealed by the study. The people in such areas are at risk of flood hazard and so, these people need to be shifted from these areas to the safer areas without the risk of being flooded and other risks.

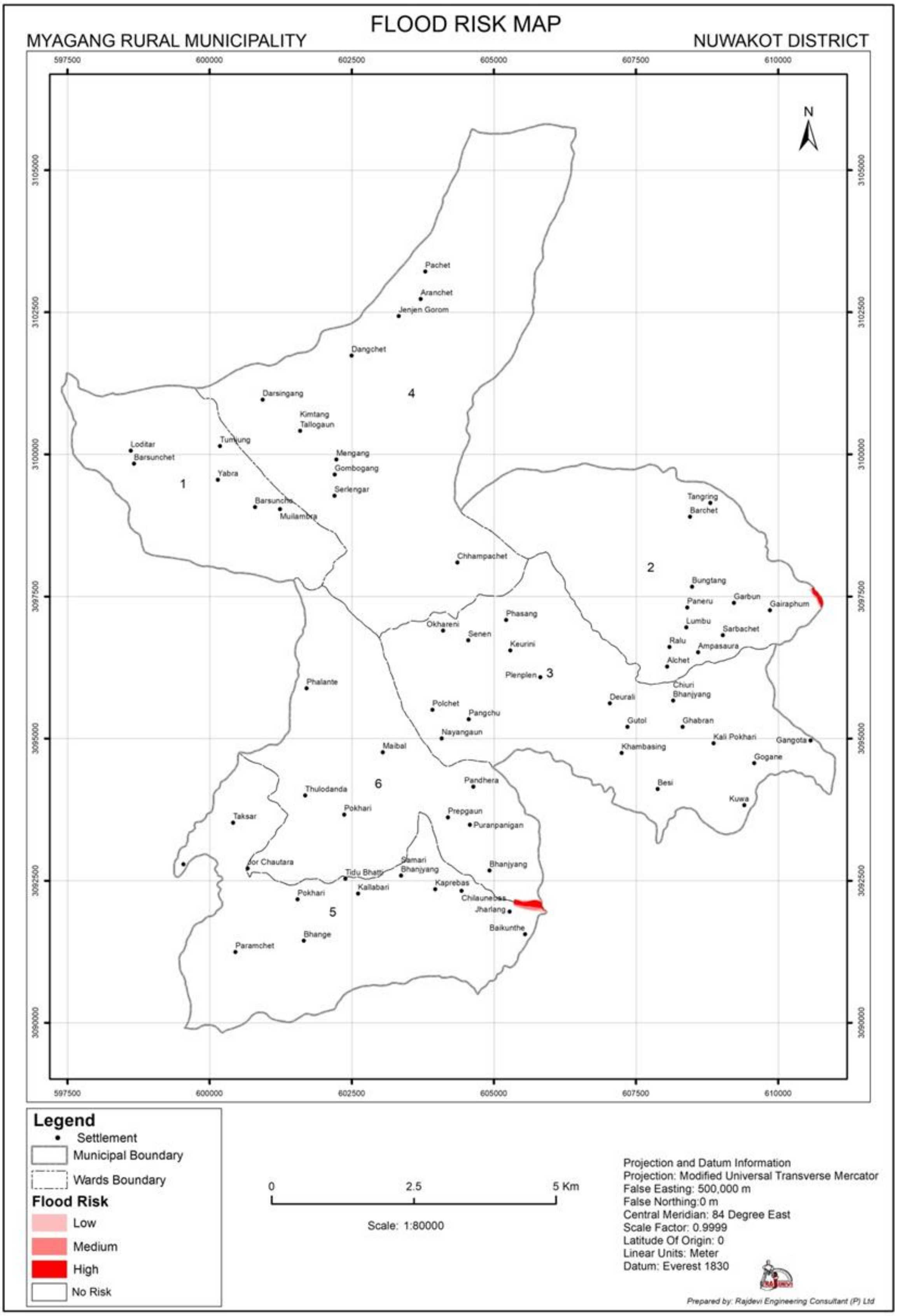

Figure 4.1: Distribution of flood risk area

4.1.2 Landslide Risk

Result: The landslide mapping of Package 08 is carried out using the susceptibility methodology outlined under the methodology chapter by using overlay analysis in the GIS environment. Landslide susceptibility is relatively high covering more than 38 percent of the total area through the forest coverage in the project area is relatively high with 55 percent area under forest. Table 4.2 details the area under different landslide susceptibility classes. Out of the total susceptible area, more than 83 percent area is under high landslide susceptibility class covering 3110 hectares which are lower as compared to other susceptibility classes. More than 16 percent area is under moderate susceptibility to landslide occurrence and 0.18 percent area is under low susceptibility. The central of the project area has higher landslide susceptibility due to higher slopes, western and south western part has moderate to low vulnerability to landslides. Southern parts of the project area are not susceptible due to lower slopes and valley floors.

Table 4.2: Percent share of Landslide susceptible area

S.N	Susceptibility class	Area Ha	Percentage
1	High	3110.94	83.16
2	Moderate	623.16	16.66
3	Low	6.66	0.18
	Total susceptible area	3740.76	38.24
	Total Area	9783.49	

The percent share of high landslide susceptibility class is higher because of characteristic steep slopes despite higher forest cover and human interferences like agriculture, settlement. Overall, landslide vulnerability is high in the project area. Settlement and road infrastructure distribution are dispersed all over the project area and hence landslide vulnerability of settlement and infrastructure is also variable. The percent share of different levels of landslide susceptibility and spatial distribution is presented in Figure 4.2 and Figure 4.3 respectively.

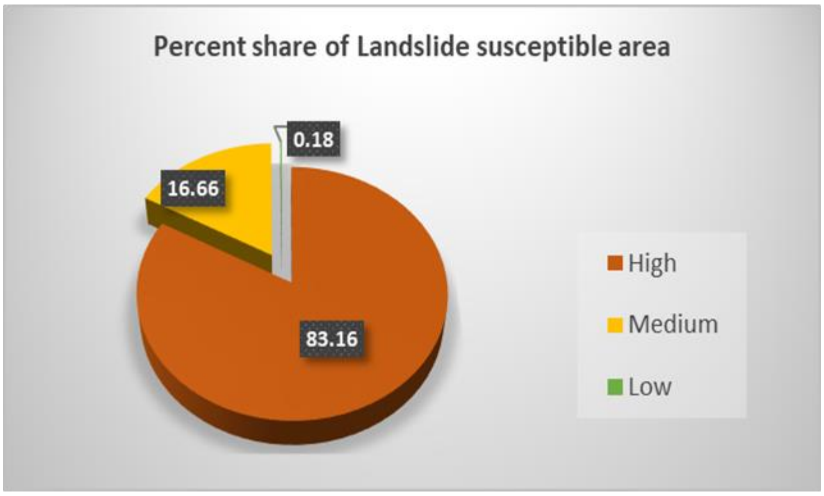

Figure 4.2: Distribution of landslide susceptible area

Discussion: Landslide susceptibility zoning is based on assumption of continuous landslide density in space. Hence while land use planning and zoning, factors which minimizes landslide risks could be excluded such as in flat area and dense forest cover and slopes of up to 15 degrees. Similarly, in identified landslide susceptible area of varying degree, potential landslides may be of varying likelihood of occurrence based on management practices and protection measures in the area. Agriculture practices in the sloppy area, moderate forest cover and moderate to steep slopes is characteristic of the project area. Hence, conservation, management strategies and protection measures should be implemented for agriculture practices, settlement and infrastructure development.

The assessment of landslide susceptibility based on Multi criteria analysis in GIS environment indicate that there is a close relationship between slope, land cover land use and geology and landslide susceptibility. Beside, infrastructure construction mostly road construction in higher slope area with weak geology is another major factor along roadside landslide occurrence. A study by DWIDP in 2003 also reported that transport infrastructure in Nepal is heavily affected by landslide incidences every year. A field survey conducted in 2003 in arterial routes of Nepal, it was found that small- to medium-scale roadside landslides very often occur as partial landslips within existing large-scale landslides in the area. Therefore, better planning of newer transportation routes, and safe land-use planning, it is very important to understand the distribution pattern of large-scale landslides so as to mitigate the risk. Rapidly increasing construction of infrastructure, such as roads, irrigation canals, and dams without due consideration of natural hazards is contributing to triggering of landslides and debris flows (Thapa, 2015).

Landslide record reveals that road and human settlement slopes are more vulnerable to landslides than ordinary natural slopes. This suggests that there is significant influence of human intervention, particularly in terms of road slope cutting, land development, agricultural practices, etc., on the occurrence of landslides and related failures in Nepal (McAdoo et. al., 2018). Nepal hazard risk assessment report 2011 states Slope, lithology, soil moisture, and precipitation are controlling factors for landslide hazard, while earthquake and rainfall are triggering factors. The report also highlights the paucity of data on the importance of earthquake triggered vs precipitation triggered in terms of fatalities may not be easily available. High severity zone areas are relatively governed by specific lithology condition and slope degree. Based on analysis, more than 20 % of geographical areas are prone to high landslides triggered by high intensity rainfall. Landslides typically occur in hilly areas and primarily affects the road sector. At the national scale, the damage caused by landslides is negligible in comparison to that caused by earthquakes, floods and droughts. These three disasters (earthquakes, floods and droughts) impact large geographical areas, covering almost all parts of the topography of Nepal.

An approach is required to integrate hazard maps developed by different organizations at suitable scale and used for disaster resilient development. The hazard risk map of particular area should be revised from time to time after major, extreme precipitation, and earthquake and major development infrastructure which may have affected.

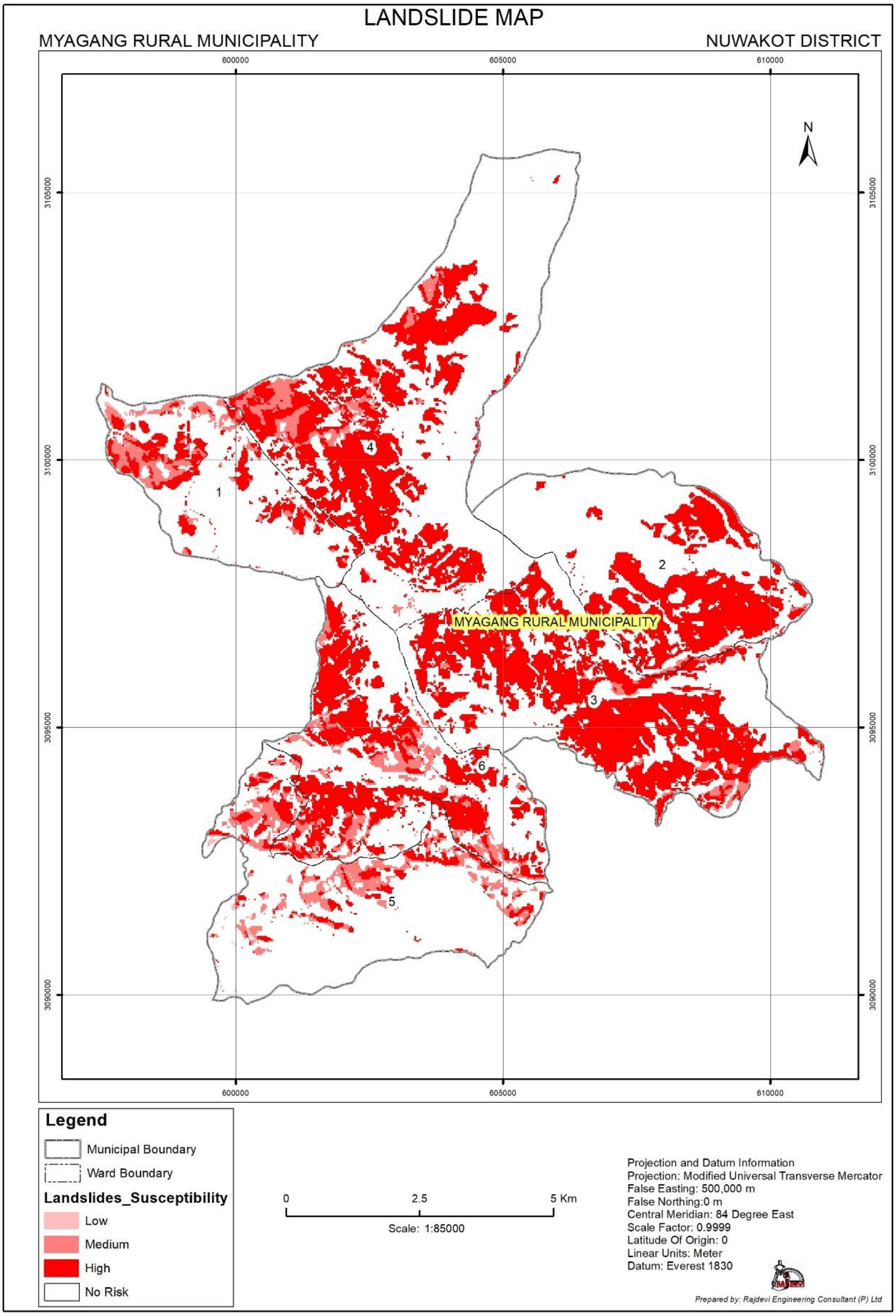

Figure 4.3: Landslide Risk map of the project area

4.1.3. Industrial Risk

Result

According to the Focus Group Discussion (FGD), field visits, and literature review it has been found out that there are several small-scale, medium and large-scale industries operating within The project area. Multinational companies and those related to cold drinks, beverage, and automobile have been set up there. Small scale businesses operating with the Municipality include, dairy industries, tailors, retail shops, furniture, readymade cloth shops, hotel, stationery and book shop, fruit & vegetable shops, jeweler shops, mobile phone shops, agro- veterinary, liquor shops, private clinics, tea shops, mill, computer center, hardware shops, fresh house, motor garage, photo studio, and kitchen utensil shops. Besides there are multiple health institutes in the municipality including hospitals, clinics and pharmacists. Project area does not have any system for collecting and managing medical waste or any other type of special waste separately so the hazardous medical waste from these establishments is dumped along with regular municipal waste.

Hospital wastes (general waste and hazardous wastes) are mixed to municipal solid waste stream despite the government regulation, requiring every hospital to properly dispose of waste (The Solid Waste Management Act 2011, states: "the responsibility for processing and management of hazardous waste, medical waste, chemical waste under the prescribed standards shall rest with the person or institution that has generated the solid waste").

In the project area, the practice of discharging industrial waste and other waste directly into the drains are creating a nuisance to the surroundings and health risks to the public and workers. Residential areas and the neighboring areas are affected from unwanted bad odor smell of the waste water. Such waste water contains various types of untreated organic and inorganic toxic materials that leads to the formation of various toxic gases such as hydrogen sulphide, Sulphur dioxide, etc. and also will be the favorable place for the survival of insects and rodents like mosquito and others. Such polluted environment causes the risks of spreading water-borne diseases including malaria, dengue fever, etc. in the local as well as neighboring areas.

According to the Industrial Statistics of 2076/2077 by Ministry of Industry, Commerce, and Supplies, the total number of registered Industries in Nepal was 8,247 out of which 3,638 were registered within the Nuwakot district (where Project area is located) up to the fiscal year 2076/2077. In Project area itself, the number of industries is found to be 45 in numbers. Due to the presence of the small, medium, and large-scale industries, Project area has high risk related to the industries.

Discussion

The risks from the industries in Project area are high in nature, for long-term duration and high in magnitude. As stated above, the majority of the industries generate effluents and solid wastes that need to be disposed in an environmentally acceptable manner.

Project area considers the municipal waste as only the waste generated from households. The large-scale commercial businesses and factories those generate waste in huge quantities are not included as the source of municipal waste and they are supposed to manage their waste in their own. Hospitals and industrial wastes are also not included in municipal waste generators. However, the practice of self-managing the generated waste by large scale businesses and industries remains only in theory so far. Therefore, segregation of general waste, hazardous waste of industries, and hazardous medical wastes of healthcare institutions need to be seriously and immediately considered. Appropriate regulatory measures need to be strictly enforced by the government.

In concurrence with the regulatory requirements, the industries need to adopt a sustainable approach to the waste management. The effluents generated by agro-based industries are biodegradable and non-toxic and treated by physical, chemical and biological processes. With the application of appropriate technologies, it is possible to minimize the pollution and also to recover the water and other useful materials from the waste streams.

The best way to reduce the industrial risk would be a land use planning and zoning. Industries need to abide by the environmental rules and regulations and other statutory provisions of the Government of Nepal. The discharges from the industries need to meet the requirements of quality standards as set up by the Government of Nepal. To assure the public and concerned stakeholders about the minimization of industrial risk, the Government of Nepal needs to initiate an effective monitoring system and its thorough implementation.

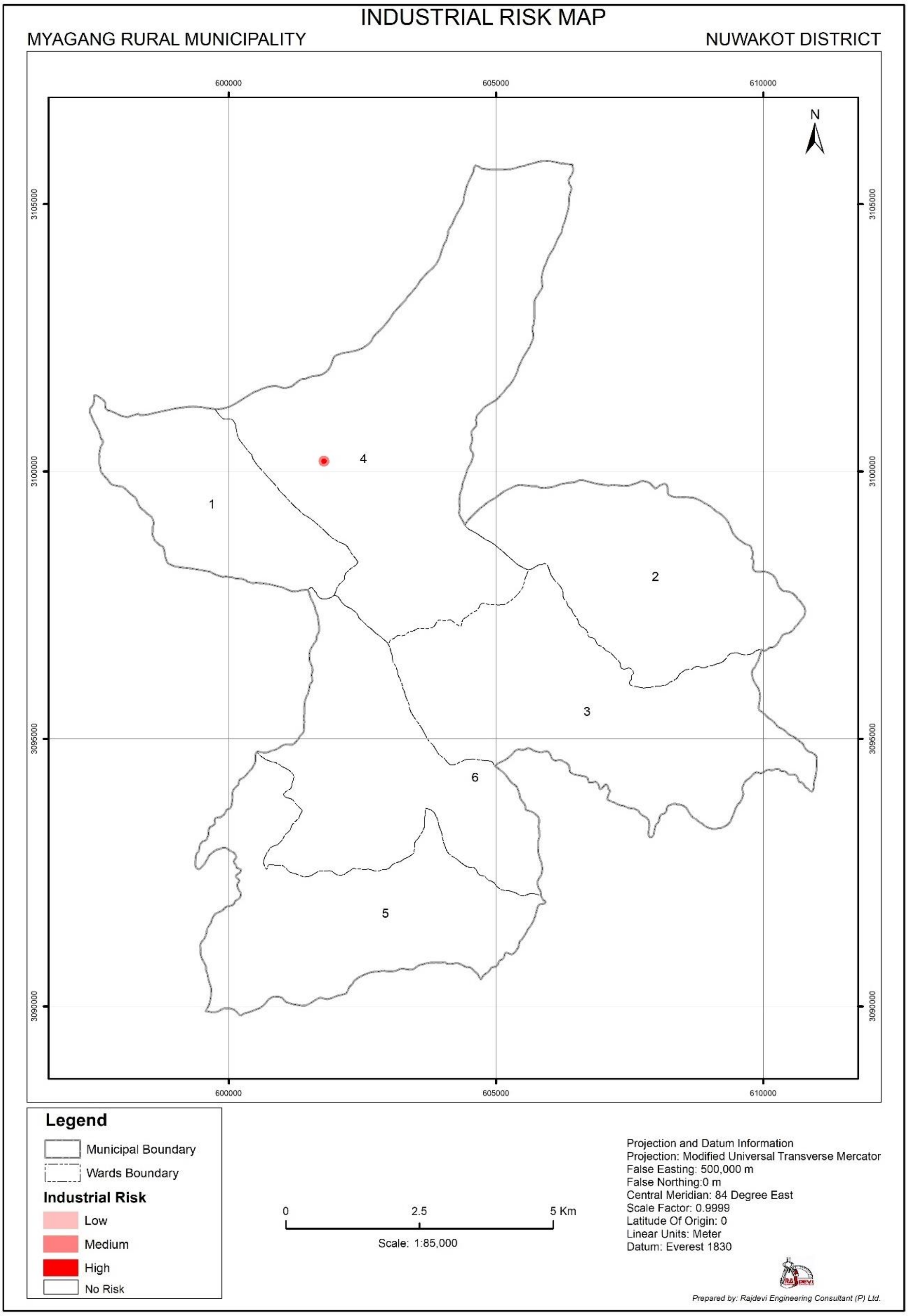

Figure 4.4: Industrial Risk Map of the project area

4.1.4. Fire Risk

The risk in the area is fire risk spreading in summer. A fuel station within major settlement area has increased the risk of fire. Further, many of the households store inflammable cooking fuel material inside which increases spreading of fire over the settlement. So proper security measures need to be identified and implemented. Fire risk around fuel stations are the potential area of fire hazard.

Transmission lines are the other potential sources to cause disaster. The transmission line passes through the project area. Therefore, new residential should not be proposed within a buffer distance of 30m, 15m, 9m and 3m from a transmission line of 132, KV, 66 KV and 33 KV respectively.

Besides, larger forest cover is potential to forest fire during dry summer. The fire occurrence was found in ward no 3 and 6 with fire frequency of 4 during 2019/20 and 2021 is listed in Table 4.3 and Figure 4.5 (Source: MOHA/DRRNepal portal).

Table 4.3: Fire hazard incidents in project area

SN.	Ward No.	Incident Place	Incident Date	Incident
1	6	Bhanjyang	5/11/2019	Fire
2	6	Pokhari	1/30/2020	Fire
3	3	Deuraly	4/20/2020	Fire
4	6	Bhanjyang	5/11/2019	Fire

It is reported that number of families were affected due to fire in different wards. The fire in the forest was not estimated. The fire took place in different, workshops, electric pole, households etc.

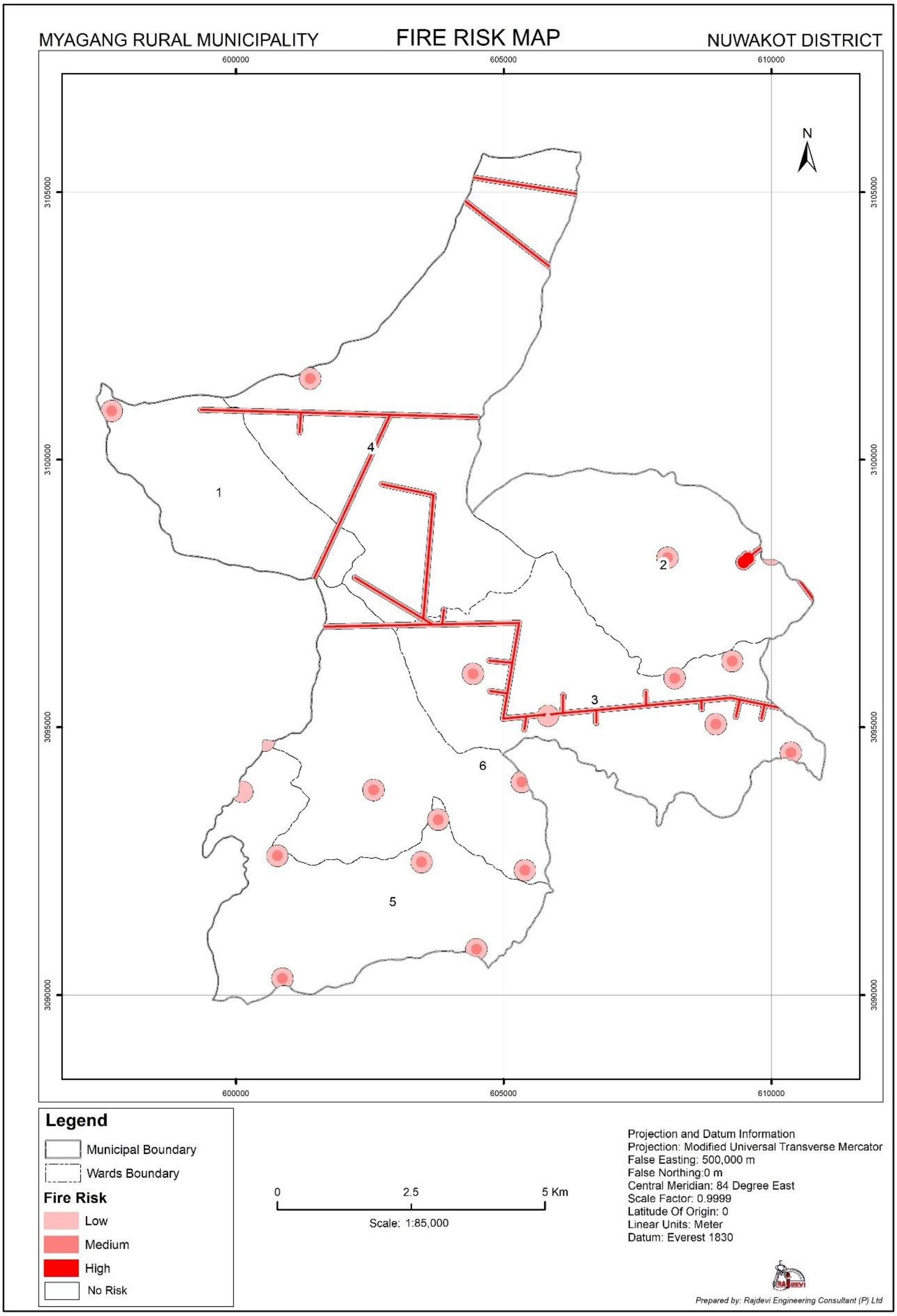

Figure 4.5: Fire Risk Map of Project area

4.1.5 Seismic Risk

Kathmandu Valley is represented by fluvio-lacustrine soft sediments formed in the Plio-Pliestocene age (alternative layers of clay, silt and sand) of more than 550 m thick unconsolidated sediment at valley centre. The lower fluvial granular sediments (gravel, sand and silt) of about 200-250 m thick is overlain by lacustrine clay sediments of about 200-300 m thick (Sakai et al., 2002). When seismic waves pass through rocky terrain and encounter the soft sediments (soils), the seismic waves amplify more. Closer to the epicentre the effects will be higher. Consequently, the frequency of seismic amplification is responsible for damages to frequency matched buildings and other infrastructures (Manandhar et al., 2016). In this project, a common Simplest Method is applied to determine the hazard of the municipality. The effective design seismic coefficient is estimated using the following formula.

$A_{eff} = R*A_{max}/980$

Where, A_{eff} is effective design seismic coefficient

R = Reduction factor (empirical value R = 0.50-0.65)

A_{max} = Maximum acceleration according to Seismic Hazard Map of Nepal

A_{max} = 200 gal

Result: The project area covers maximum acceleration of 350 gal based on Seismic Hazard Map of Nepal (Pandey et al., 2002). The seismic hazard map revealed by Parajuli et al., 2012 determines that the project area covers the Seismic Zone 2 of the Nepal Himalaya. Therefore, the basic horizontal seismic coefficient is calculated for both given reduction factors of 0.50 and 0.65 and averaged ones. Table 4.4 below shows the estimated effective design seismic coefficient is approximately 0.2053 for the averaged reduction factor and the coefficient is ranged between 0.1786 and 0.2321 respectively.

Table 4.4. Estimation of Effective Design Seismic Coefficient.

Maximum Acceleration (gal)	Reduction Factor (R)	Effective Design Seismic Coefficient (A_{eff})
350	0.5	0.1786
	0.65	0.2321
	0.575 (averaged)	0.2053

Discussion

The project area lies in the seismic zone which is low seismic hazard area (Figure 4.6) and is vulnerable in terms of less seismic activities in comparison to other parts of Nepal. No major fault line lies near the project area. However, a due consideration is required before planning the large scale projects like hydropower development, tunnel construction, reservoir development, highway construction, large irrigation projects and landslide mitigation techniques. That’s why geotechnical considerations are the must before starting any kind of development activities in the area.

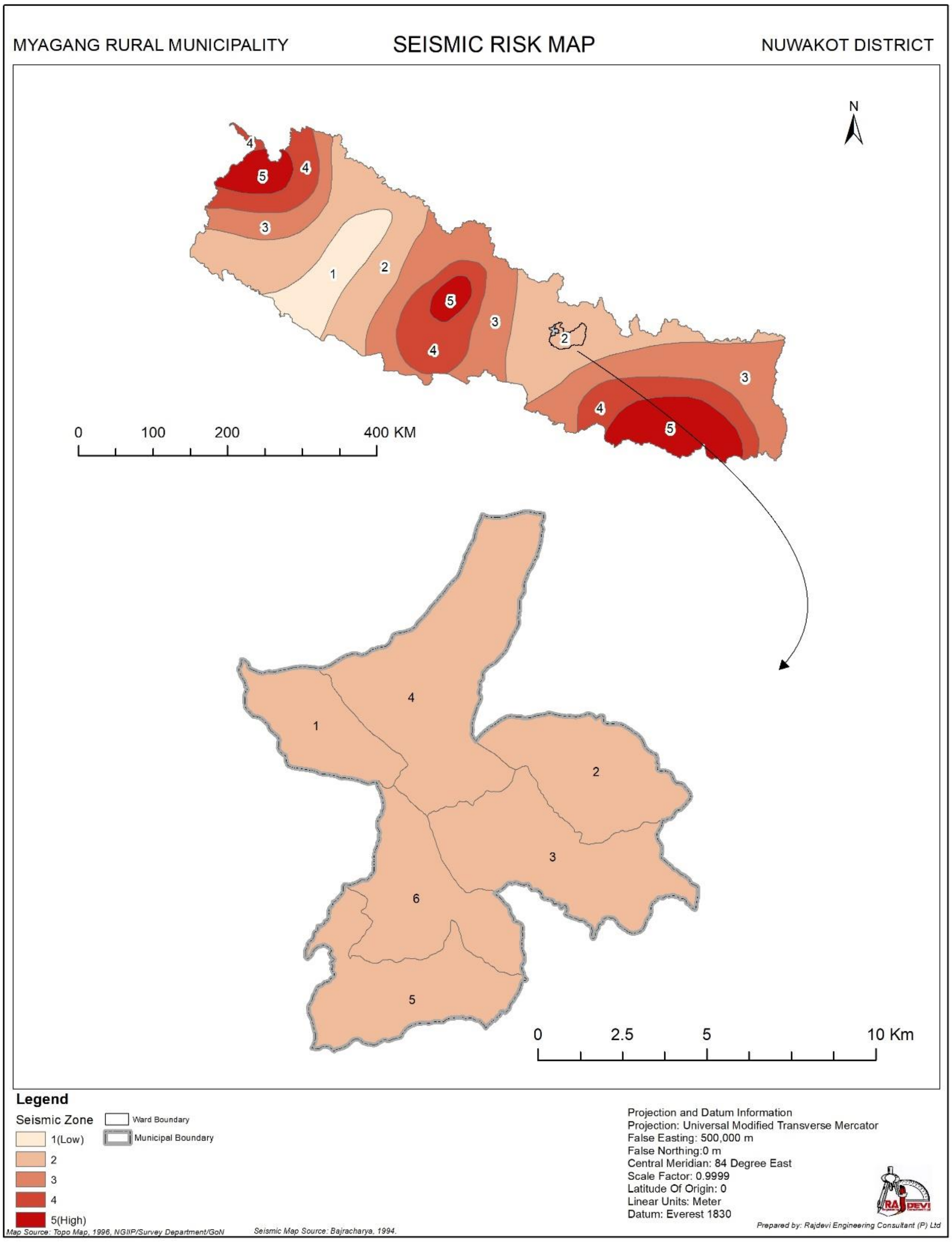

Figure 4.6: Seismic Risk Map of the project area

4.1.6. Soil Erosion Susceptibility

Result: The project area is composed of varying landforms, topography, slope, landuse and soil. The soil erosion susceptibility is high covering more than 41 percent of the total area. Table 4.5 details the area under different soil erosion susceptibility class. Among total soil erosion susceptible area, more than 16 percent area is under high susceptibility class covering 675 hectares while 45 percent area has moderate susceptibility. Area with low susceptibility constitute 37.8 percent. The north-western part of the project area is vulnerable to soil erosion as compared to other parts of the project area.

Table 4.5: Distribution of soil erosion in the project area

S.N	Soil Erosion	Area Ha	Percentage
1	High	675.54	16.61
2	Medium	1850.94	45.51
3	Low	1540.89	37.88
	Total Susceptible area	4067.37	41.57
	Total area	9783.49	

The percent share of each susceptibility class is presented in Figure 4.7. Of the total susceptible area, maximum percent is shared by medium susceptibility class whereas high susceptibility class share lowest percent coverage. Distribution of soil erosion susceptible area in the project area is presented in Figure 4.8.

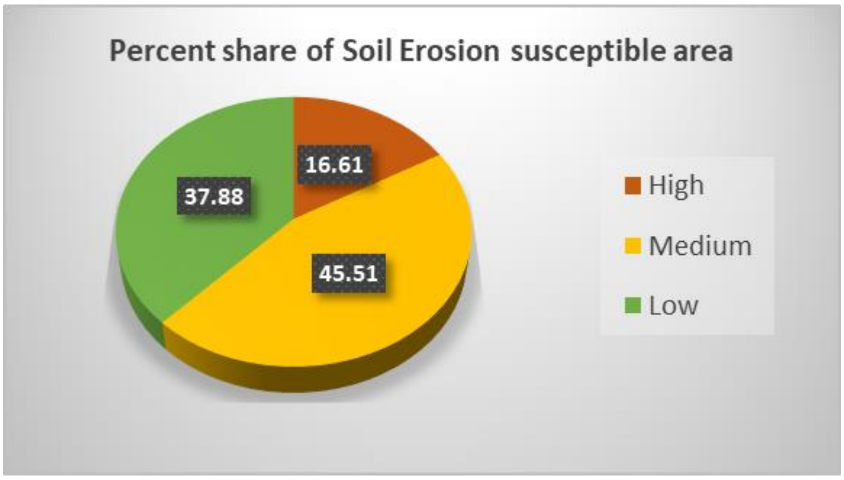

Figure 4.7: Percent share of soil erosion susceptibility in the project area

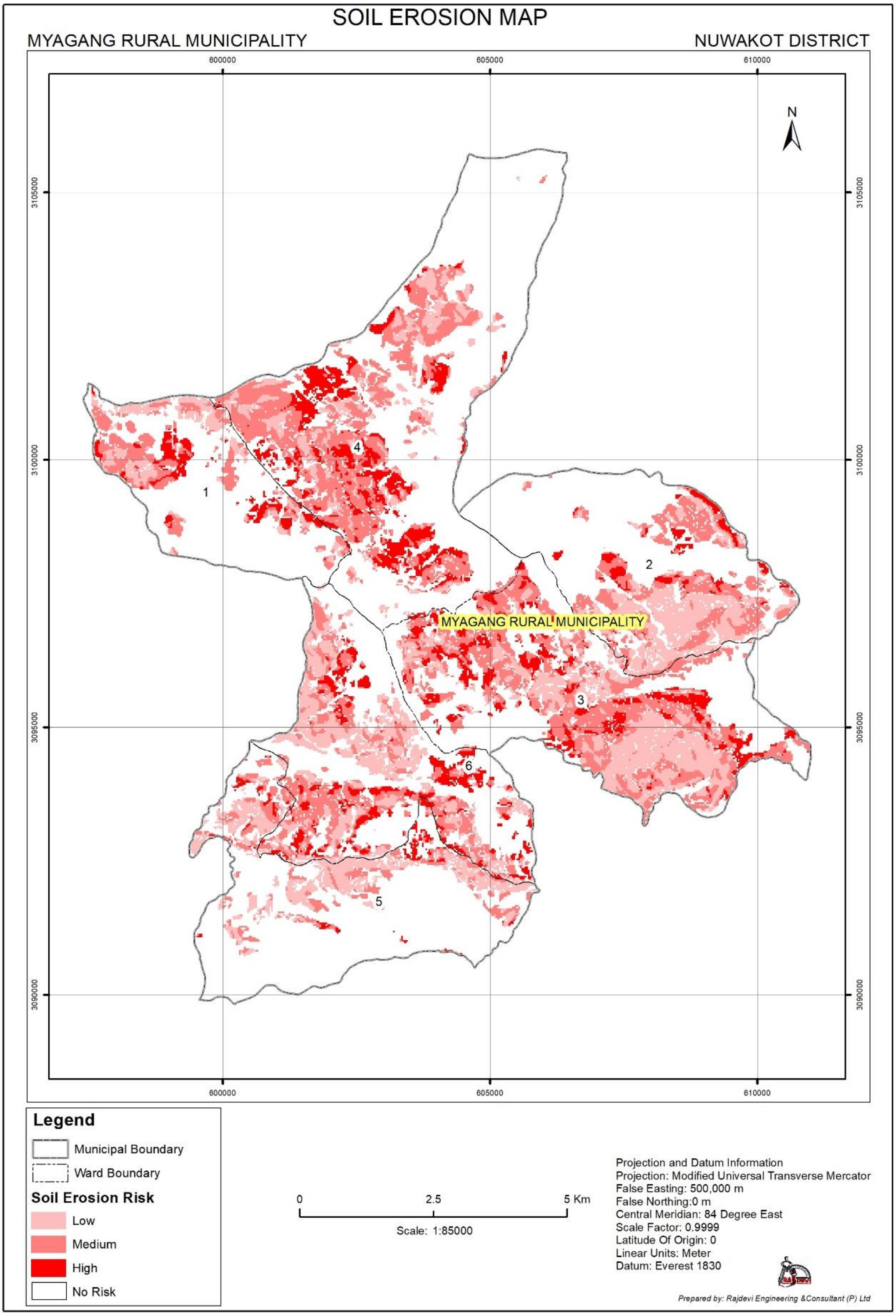

Figure 4.8: Soil erosion map of the project area

Discussion: Number of studies has shown that various factors have various level of effect on soil erodibility and it is obvious because, plot level or field level studies doesn't represent the general erosion process of whole local administrative unit. A single local administrative unit covers range of geological, topographical, agro-ecological and soil conditions as well as different management practices (Gurebiyaw, Addis, & Teklay, 2018). The application of computer based tools like GIS and Remote sensing and statistical techniques help identify area of soil erosion susceptibility with integrating spatial data and processes and management activities on erosion. Universal Soil Loss Equation (USLE) and revised (RUSLE) is the most extensively used empirical soil erosion model. However, this model requires rainfall and runoff erosivity data which in Nepalese context is very difficult to estimate due to low coverage of rainfall stations particularly in the hill and mountain region.

Human activities such as changing pattern of land use, intensive farming, excessive fertilizer use damage the soil and land. Housing development activities, infrastructure construction such as road need heavy earthworks, cuts resulting change and loss of soil and if not enough attention is paid to rainwater flow management and maintenance will in long run results soil erosion. Different cropping systems produces different rate of soil erodibility (Kunwar, Bergsma & Shrestha, 2016). A selection of the cultivation system that reduces erosion most effectively could be suggested based on soil erosion susceptibility assessment.

4.2. Potential Risk in the Project Area

The potential hazard risk in the project area includes earthquake in all over project area, landslides in higher slopes and inundated flooding in lower area along river and stream corridors during rainy season. Besides these forest fire and pollution area and other hazards found in the project area. The earthquake of 2072 Baisakh 12 (April, 2015) has a major effect in the project like all other local units of the district. The earthquake caused death and injury of number of people. Similarly, the earthquake caused damage to physical infrastructure and 3972 residential buildings. However, the project area lies in central thrust area which may cause high hazard risk in case of earthquake.

There are no major flooding events occurred in the project area because most of the area is sloping terrain and no big and rapid rivers flow through area. However, 10.69 ha areas in the project area (0.11% of the total area) are at risk of different flood levels due to 100-year return period flood. Out of the total flood risk area, 5.03 ha is likely to be flooded with high level depth (more than 1.5 m), 3.12 ha with medium level (0.5 m to 1.5 m) and the rest 2.54 ha with Low level (less than 0.5 m). The assessment of the flood area indicates that vulnerable area lying in flood plain area, need immediate action to take against flood such as river training or embankment or levee construction to protect the given area from further degradation due to flood. Settlements along or nearby Gairihaun and Jharlang are likely to be at risk of 100-year return period flood.

However, flooding along river and stream banks in lower plain area is common during rainy season largely due to encroachment of river and stream corridors. Degradation of forest and agricultural land and river bank cutting are reported to be common due to flooding in the area. Though the risk of flooding is fair but some inundation and bank cutting is probable near river banks.

The project area is at high risk of landslides susceptibility with more than 38 percent coverage. Central part of the project area is highly susceptible as compared to other area. Out of the total susceptible area, more than 83 percent area is under high landslide susceptibility class covering 3110 hectares which are lower as compared to other susceptibility classes. More than 34 percent area is under moderate susceptibility to landslide occurrence and nearly 52 percent area is under low susceptibility. Settlement and road infrastructure distribution is dispersed to all over the project area and hence landslide vulnerability of settlement and infrastructure is also variable. As compared to other local units, the area under landslide susceptibility is relatively high. Of the total landslide susceptible area, the largest area cover is of forest occupying 5351 hectares followed by agriculture land with 4007 hectares. A total of 71 hectares of residential area is under different risk of landslide susceptibility. Details of the area and percent share of each land-use class under potential landslide risk are provided in Table 4.6.

Table 4.6: Distribution of Land use under risk of Landslide susceptibility

	Area (Ha)						
Land use	High	% High	Medium	% Medium	Low	% Low	Total susceptible area
Agriculture	2757.33	88.79	543.77	89.68	4.78	78.69	4007.23
Commercial	2.12	0.07	0.35	0.06	0.00	0.00	3.24
Cultural/Archaeological	0.55	0.02	0.10	0.02	0.00	0.00	0.86
Forest	160.71	5.18	29.96	4.94	0.73	11.94	5351.23
Industrial	0.06	0.00	0.00	0.00	0.00	0.00	0.06
Other	43.69	1.41	1.23	0.20	0.00	0.00	62.93
Public	82.10	2.64	17.57	2.90	0.53	8.81	155.81
Residential	51.29	1.65	9.77	1.61	0.03	0.55	71.33

Another risk in the area is fire risk spreading in summer. Large part of the project area in the higher slopes is under forest and during dry season forest fire risk is higher. Besides, storage of combustibles for households, livestock and industrial purpose inside or adjoining area also increases spreading of fire over the settlement. So proper regulations for industries and security measures need to be identified and implemented. Distribution of composite of different risk factors is shown in Figure 4.9.

Northern part of the project area has glaciers flowing towards the south. There is no glacier related hazards events recorded to date but, there may be hazards like ice avalanches, glacier instability, upstream flash flood or debris flow, hazard incidents which may affect downstream settlements. However, are no nearby settlements to those areas.

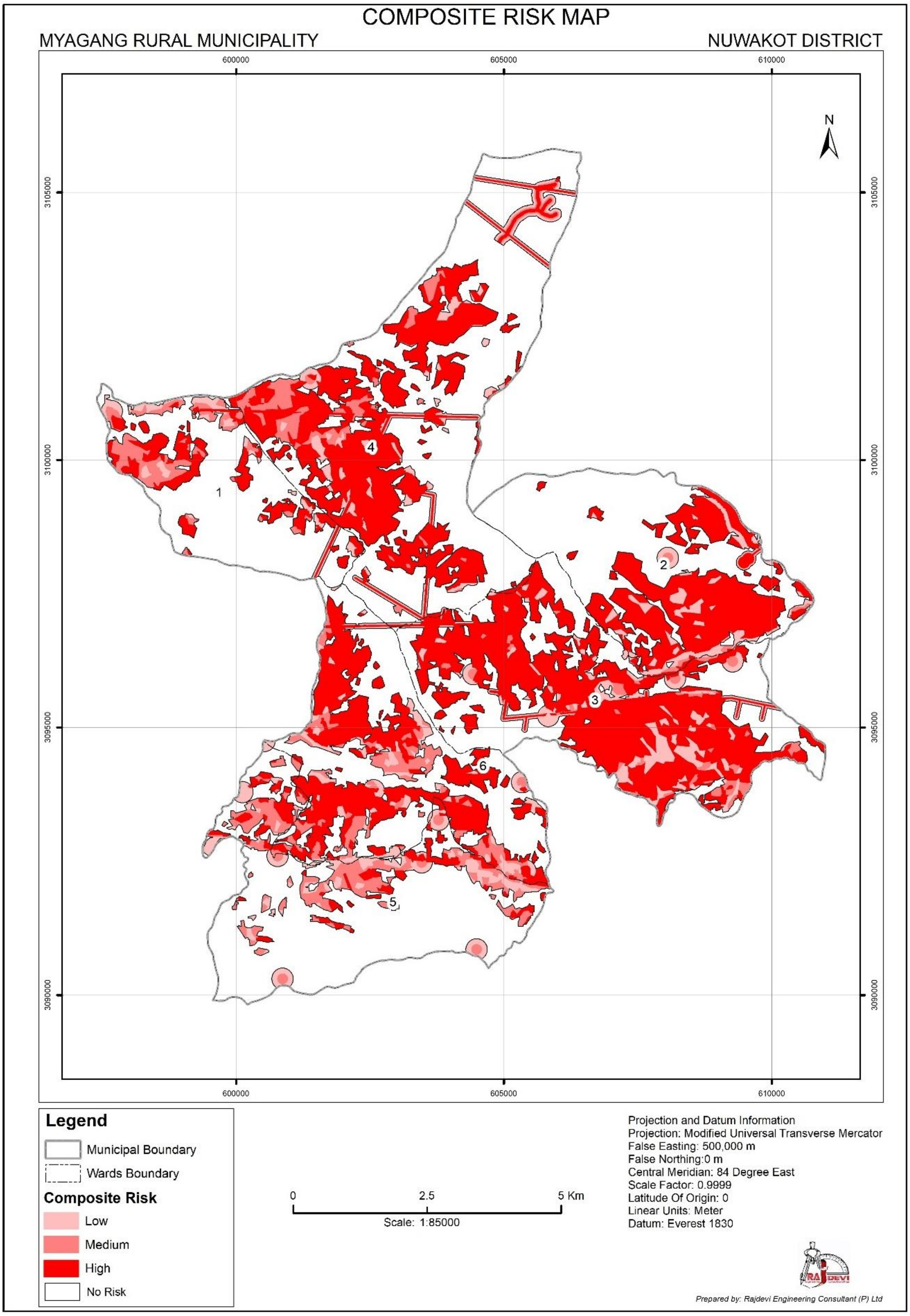

Figure 4.9: Composite Risk Map of the project area

4.3. Risk Data Model

The database schema developed for Risk data model is shown in Table 4.7.

Table 4.7: Risk data model

Field	Data Type	Description
OBJECT ID	Object	Feature
SHAPE	Polygon Geometry	Geometric Object type
RISK ID	Short	Unique Object ID
RISK Type	Text	1. Flood Risk
		2. Fire Risk
		3. Landslide Risk
		4. Seismic Risk
		5. Industrial Risk
RISK LEVEL	Text	High
		Medium
		Low
VDC	Text	VDC Name
DISTRICT	Text	District Name
REMARKS	Text	Any remarks regarding the feature
SHAPE LENGTH	Double	Meter
SHAPE AREA	Double	Area in m^2

CHAPTER 5: CONCLUSION

5.1. Conclusion

The present risk mapping of the project area is based on the available data and information and data collected from the field. Based on the types of factors causing exposure and vulnerability and hazard associated with it, risk can be classified into various categories. Risk factors for the current project have been specified related to flood, fire, earthquake (seismic event), landslides and industrial hazards.

The identification of potential risk areas are predicted based on the existing hazard risk areas of the project area. Therefore, the existing risk areas identified through the mapping of available hazards are not suitable for future land use zoning for residential, commercial or public use zones. These hazard risk areas could be suggested for forests, plantations, agro-forestry or as the open areas.

The project area is at relatively high risk of landslides as compared to other local units of the district Out of the total area, more than 38 percent area is under different level of landslide susceptibility. Central part of the project area has higher landslide susceptibility due to steeper slopes and settlements Gogane, Gotul, Garbun, Lumbu, Senen, Plenplen, Mengang, Komo Salme are highly vulnerable to landslide susceptibility. Other part has moderate to low landslide susceptibility.

There are no major flooding events occurred in the project area because most of the area is sloping terrain However, total of 10.69 ha areas in the project area (0.11% of the total area) are at risk of different flood levels. Out of the total flood risk area, 5.03 ha is likely to be flooded with high level depth (more than 1.5 m), 3.12 ha with medium level (0.5 m to 1.5 m) and the rest 2.54 ha with Low level (less than 0.5 m). Settlements along or nearby Gairihaun and Jharlang are likely to be at risk of 100-year return period flood.

So far as the seismic risk of the project areas are concerned, the whole project area falls under the medium seismic risk zone. The project area lies in central thrust area which may cause high hazard risk in case of earthquake. The 2015 earthquake caused damage to physical infrastructure and 3972 residential buildings. Major fire risk sources identified are; fuel station, storage of combustible materials for household use, and traditional practices and household equipment. Improper use of which can cause fire risk. On the other hand, near by the settlements of the forest areas are also risk potential if forest fire occurs.

These databases could be used in land zoning and for planning, analyzing and decision making process on the sustainable, equitable and economic use of the land and sustainable land development of the project area.

5.2. Recommendation

Based on the present experience of the exercise, the following recommendation could be made for future undertaking of similar projects.

- Structural measures like defense structures and restoring rivers' natural flood zones by controlling encroachment is suggested along settlements of Gairihaun and Jharlang.
- Landslide treatment measures like proper land husbandry through land use improvement practices and strengthening slope stability through bio engineering techniques in the area of high human interference is suggested in settlements like Gogane, Gotul, Garbun, Lumbu, Senen, Plenplen, Mengang, Komo Salme.
- On-farm conservation should be made obligatory in sloping terrace Pakho land for sustainable land management. Proper terracing like contour-based cropping systems and soil erosion mitigation methods should be adopted.
- The present exercise produced preliminary results on the risk areas of the selected hazards. These out puts should be considered for the purpose of the delineating the land use zoning of the project area.
- Future users of the data set are recommended to carefully notice the limitations of the datasets and use accordingly for analyzing in depth studies of their researches based on the present data sets for the analysis of the risk areas.
- The present risk map and data may be useful for land use planners and environmentalist who uses geospatial tools. It could also be useful for preliminary devising sustainable environmental planning strategies for the rural development of the area. However, for the DRR implementation updates and field verification is suggested.

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LAND USE ZONING

Preparation of Land Use Zoning Report
Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural Municipality.**

The area coverage of Local unit of this package used and analyzed for different purpose under the scope of work of this consulting service are computed from cadastral maps provided by DOLIA Office, Government of Nepal, Ministry of Land Management, Cooperatives and Poverty Alleviation of Nepal. Therefore, the area of Local unit may match to the area computed from Topographic Digital Database provided by the Survey Department of Nepal.

The satellite imageries, GIS database and other outputs produced by this consulting service is owned by Topographical Survey and Land Use Management Division(TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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CHAPTER 1: INTRODUCTION

1.1 Background and Rationale

Land use zoning is the type of land use regulation which controls the haphazard development of private land through proper use and preservation requirements promoting the sustainable environmental objectives. Land, water and forest are principal natural resources upon which almost all the livelihood and development activities are dependent. In Nepal more than 75 percent population depend upon land for livelihood and nearly all economic activities depend on land. Despite being so important, ever increasing population has led to encroachment and haphazard use of these natural resources. Proper management and sustainability of land has been thus a major challenge in the absence of effective land use planning and zoning and implementation. In this context, the Government is trying to cope with various land related issues at national and local level. The highly fertile agricultural land is getting urbanized haphazardly in many urban/ semi urban areas. In many places, agricultural lands have been left unused and abandoned. The available land is not being used at its optimum level. Crop production is not based on the suitability and capability of the land. In many places, irrational human activities are causing major threat. Consequently, the country is facing problem of food security, haphazard development settlements, unhealthy habitat, lack of urban infrastructure, natural disaster, and environmental degradation. To cope with these challenges, available land should be managed rationally and appropriately. Land use planning is one of the tools for proper use and utilization of available resources.

In this context, Government of Nepal has identified land use zoning as an important device to design a detailed land use plan and policy. This policy is expected to implement with the help of land use zoning maps. In this context, the Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division (TSLUMD) has taken an initiative to prepare land use zoning maps of Nepal in different level such as district and **Rural Municipality/Municipality** level. 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 and urban oriented rural 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, 2072 with amendment on the existing Land Use Policy, 2069 emphasizing proper land use planning and safe and secure settlement along with the environmental protection and food security. Within this framework, landuse mapping and zoning of more than 50 districts have been completed under the National Landuse Project. The policy has outlined eleven major land use zones based on the land characteristics, capability and requirement of land which has been revised to ten classes in LandUse Act, 2076. The different land use zones as per the Land Use Policy, 1972 are made in appropriate hierarchy as per the requirement of the data model, which include hierarchy of 10 types of land use zones namely: *Agricultural Zone, Residential Zone, Commercial Zone, Industrial Zone, Mining and Mineral Zone, Cultural and Archaeological Zone, River, Lake and Marsh area, Forest Zone, Public Use Zone and Others*.

In this context, the present report is one of the outputs under the consulting service **Preparation of Rural Municipality/Municipality level Land Resource Maps, Database and Reports of Myagang Rural Municipality of Nuwakot District** incorporating all themes outlined in the ToR of Topographical Survey and Land Use Management Division (TSLUMD) of Fiscal Year 2077-078.The current project is carried out to identify different land use zones in the project area.

1.2 Objective and Scope of Work

The overall objective of the current work is the **Preparation of Rural Municipality/Municipality level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Municipality Profile for Land use zoning, and Superimpose of Cadastral Layers) maps, database and reports. The specific objective of the present work is:

- To perform land use zoning of the project area using different available data sources based on multi-criteria analysis in GIS.
- To produce land use zoning map at 1:10,000 scale showing different zones and sub-zones as per TSLUMD specifications.
- To prepare GIS database of proposed land use zones.
- To prepare detailed report containing conceptual basis, methodology, criteria of land use zoning, distribution of different land use zones and data models of GIS database.

The scopes of the project work under preparation of Land use zoning maps, GIS database and Report cover the following activities:

- Studying the existing relevant maps, documents, and database of the project area
- Preparing land use zoning maps of the selected project area at 1:10000 scale and identify different zones and sub zones as per specifications.
- Designing appropriate GIS database logically on land use zoning for the project area
- Discussing accuracy, reliability and consistency of data
- Identify the areas which are prone to risk events potentially caused by flood, landslide, earthquake, fire and industry within the project area.

1.3 Project Area

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the central-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

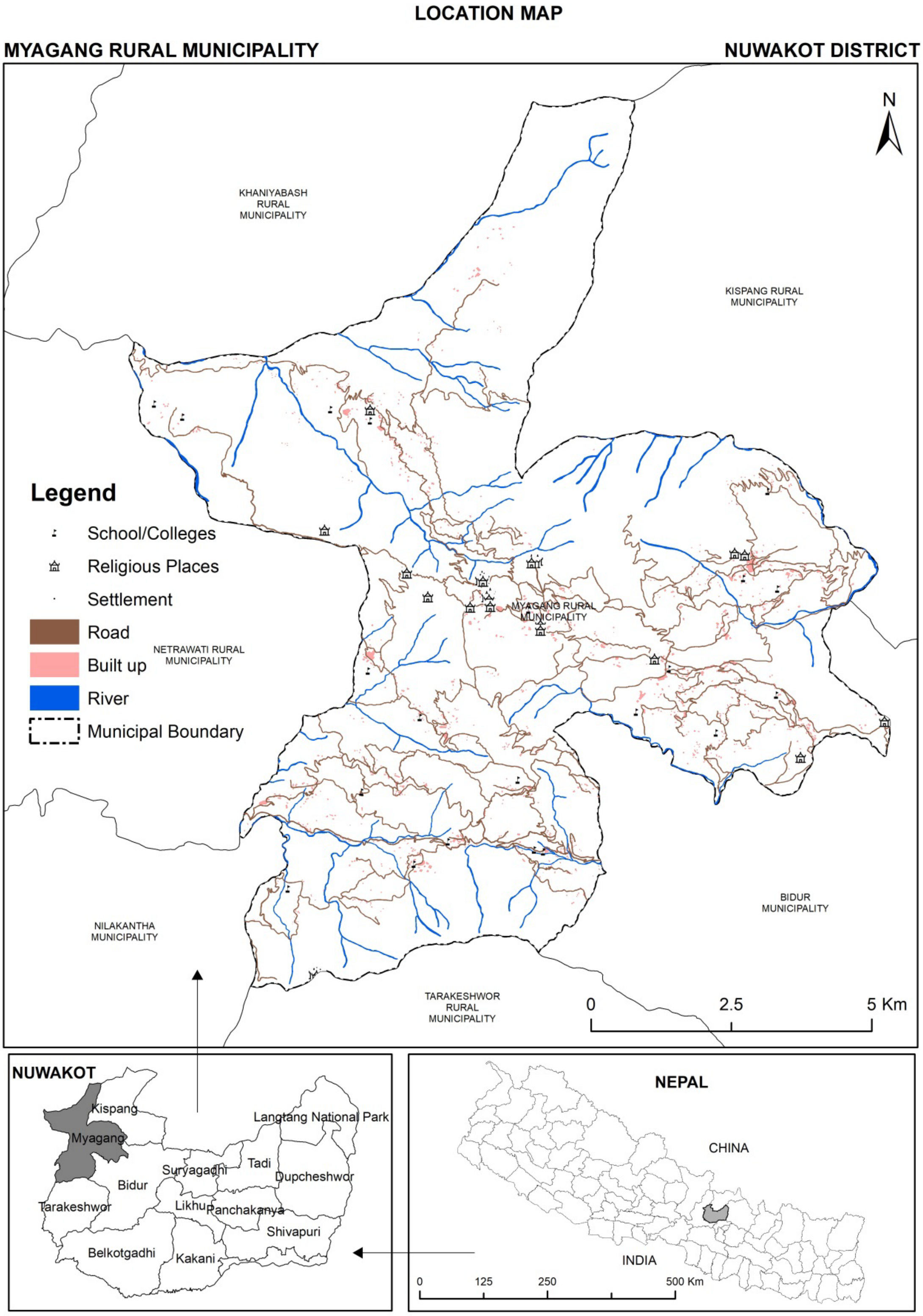

Figure 1.1: Location Map of the project area

CHAPTER 2: CONCEPTUAL BASIS OF LAND USE ZONING

This chapter presents the conceptual basis and principles of land use zoning. The land use zones and their detailed description as mentioned in the National Land Use Policy 2072 and the general criteria used for land use zoning is discussed.

2.1 Land use Zoning principles and Criteria

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 local level units. 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.

2.1.1 Land Use Zoning Principles

The main principles adopted for land use zoning are

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

Land use zoning process 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 Archaeological heritages for the 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

2.1.2 Land use Zoning Criteria

Based on the above objectives and principles of land use zoning, following criteria and guidelines are adopted for land use zone classification:

- The zoning of the project area 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 analyzed.

- 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 use zone.
- Analysis of hazard risk must be done before working on the 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 project area to accommodate the expected growth in population and other growth needs of the project 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 zone
    a. Most of the agricultural areas are kept intact but it is almost impossible to retain all 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 further sub classification of agricultural land.

2. Residential zone:

   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. Not in the flood plain of any river
      v. Geologically stable
      vi. Not 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 zone

   a. The existing commercial area is kept intact as they are established 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. Not in the flood plain of any river
      v. Geologically stable
      vi. Not in the vicinity of dense forests

vii. The land should be of marginal utilization, i.e. the land should be less capable for agricultural crop production

4. Industrial zone
   a. Most of the existing industries in the rural area are small and 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. Accessibility of roads if possible
      v. Not 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. Not in the international boundary but can be in the bordering area of two or more administrative units (Rural Municipality /Municipality) so that there would be opportunity to share benefits of the resources of both administrative units
5. Forest zone
   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 utility and open 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 Quarrying area in future
8. Cultural and Archaeological Zone
    a. Existing religious, cultural, Archaeological areas as defined and described by National Land Use Policy 2072
    b. Area defined as cultural heritage and their master plans
9. Rivers,Lake and Marsh Zone
    a. Existing rivers and water bodies as defined and described by National Land use Policy 2072
10. Other Zones prescribed as required
    a. As per the prescription of experts and decision of the government
    b. If any land use can't not be fit in any class mentioned above

2.2 Land use Zones Description

The following ten land use zones are identified and mapped based on National Land Use Policy 2072 BS, and TSLUMD specifications:

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 center, 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. **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.

6. **Public Use Zone**

   Public utilities and open zone means land occupied by schools, colleges, vocational educational centers, academic institutions including the universities, security agencies, health centers, 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.

7. **Other Zones 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.

8. **Mine and Minerals Zone**

   Mining and quarrying 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.

9. **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.

10. **Riverine Lake and Marsh zone**

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

The present project also follows guidelines of National Land Use Policy 2072 and TSLUMD specifications and the zones and sub zones are categorized accordingly as shown in Table 2.1.

Table 2.1: Land use Zoning Scheme

Class	Zone	Zone Type	Code	Sub zone	Description
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 6B	Areas under River/stream, canals, water sources, ponds, sand/gravel etc.
				Zone 6C	Open spaces, picnic spots, playing grounds and stadiums etc.
				Zone 6E	Public health/education/library, police station, fire station, telephone /electricity areas etc.
				Zone 6F	Grazing Land
7	Zone 7	Other area	OTH	Zone 7Ot	as per requirement
8	Zone 8	Mine and Minerals Zone	MIN	Zone 8A	Existing Mines and mineral area
				Zone 8B	Potential areas for Mines and mineral
9	Zone 9	Cultural and Archaeological Zone	CULARCH	Zone 9A	Existing cultural and archaeological area
				Zone 8B	Potential cultural and archaeological areas
10	Zone 10	River, Lake and Marsh zone	HYD	Zone 10A	Existing rivers and riverine area
				Zone 10B	Potential hydrographic areas

CHAPTER3: METHODOLOGY

The methods applied for land use zoning is explained in this chapter. Based on the multi-criteria spatial analysis of soil, land capability and risk criteria, land use zoning is carried out by using GIS tool. A multi-criteria evaluation rule was developed to classify different land use zone. Qualitative analysis and expert knowledge is also incorporated for the zoning purpose. The details of the methodology are discussed in the following sections.

3.1 Data Sources

Various data sources are used for the land use zoning. Major data sources include

- Ortho rectified very high resolution satellite image World View 2 of the project area
- Present Land use
- Land capability and Land system,
- Soil
- Administrative and Socio economic data such as agriculture, production, commerce and trade, religion, caste/ethnicity, migration etc.
- Demographic and Decadal Population Growth rate, population density
- Existing Infrastructure and Services

3.2 General Approach and Methodological Framework

The National Land Use Policy enacted in 2072 by Government of Nepal and amendments after 2015 earthquake includes potential risk areas among zoning criteria the shall be identified through review and analysis of natural, topographic and geological factors. Risk hot spots shall be marked in the land use zoning maps so as to sustainably secure the development of settlements, townships and infrastructure in an earthquake 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 current land use

The land use zone for a particular area shall be determined on the basis of current land use of that same 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 land use zones in urban areas may be determined through micro zoning heeding to their relative sensitivities. 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

Different methods are adopted by different countries for the land use zoning based on the purpose of the zoning. In the present project, mainly two methods are used 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. GIS based spatial analysis was carried out using multiple criteria analysis on several available data sets. GIS vector data (shape file) and raster data of land capability, land system, present land use or socio economic data was used as a factor maps. A general rule has developed by using multiple criteria on the basis of expert knowledge by focus group discussion with stakeholders or Analytical Hierarchy Process (AHP) using pair wise comparison for land use zoning. These criteria were used to identify a suitable land use zone; and to identify a potential area for future land use. These data files comprised the various parameters like soil characteristics, land form, land type, arability, slope, drainage system, topography, existing land use, crop patterns, population density and other necessary parameters used for land use zoning. A simple rule base was developed by using multiple criteria on the basis of expert knowledge for classification of land use zone. These criteria were used to identify a suitable zone for a particular type of land use zone. 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 specified criteria. For example, the potential residential area zone; the following criteria were used:

- Not in a flood prone-risky area.
- Not in highly land productive agricultural land
- Within slopping terrace of $28^0$and lesser.

Multiple criteria are evaluated and suitable land for particular use is identified with the help of GIS software.

b. Potential Risk Analysis

A general interpretation of risk involves a comparison of the probability and consequences in a non-product form. Zoning is the division of land into homogeneous areas or domains and their ranking according to degrees of actual or potential hazard or risk or applicability of certain hazard-related regulations. For the land use planning and management process and land use zones, risk factors have been specified related to the following event:

- Flood
- Fire
- Landslide
- Earthquake (Seismic event)
- Industrial hazard and other in any exists in the project area

c. Right of Way and Open Spaces

Right of way and open spaces to be allocated for roads, rivers and canals, open spaces etc. as specified by specific authorities such as road department, local administrative authorities have been analyzed and incorporated during identification of land use zones.

d. Qualitative Analysis

Expert evaluation and qualitative analysis of existing infrastructure and services, trend of population growth and migration, analysis of planning and project documents of different stakeholders, development and government organizations, demand and requirements of the local area etc. is carried out for land use zone identification as beside multi criteria analysis in GIS environment. As an example, although, if a small piece of land is found suitable for agricultural use but it surrounded by residential area, then it is placed in the residential area. Similarly, if the land is found suitable for agricultural area 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 through schematic diagram in Figure 3.1.

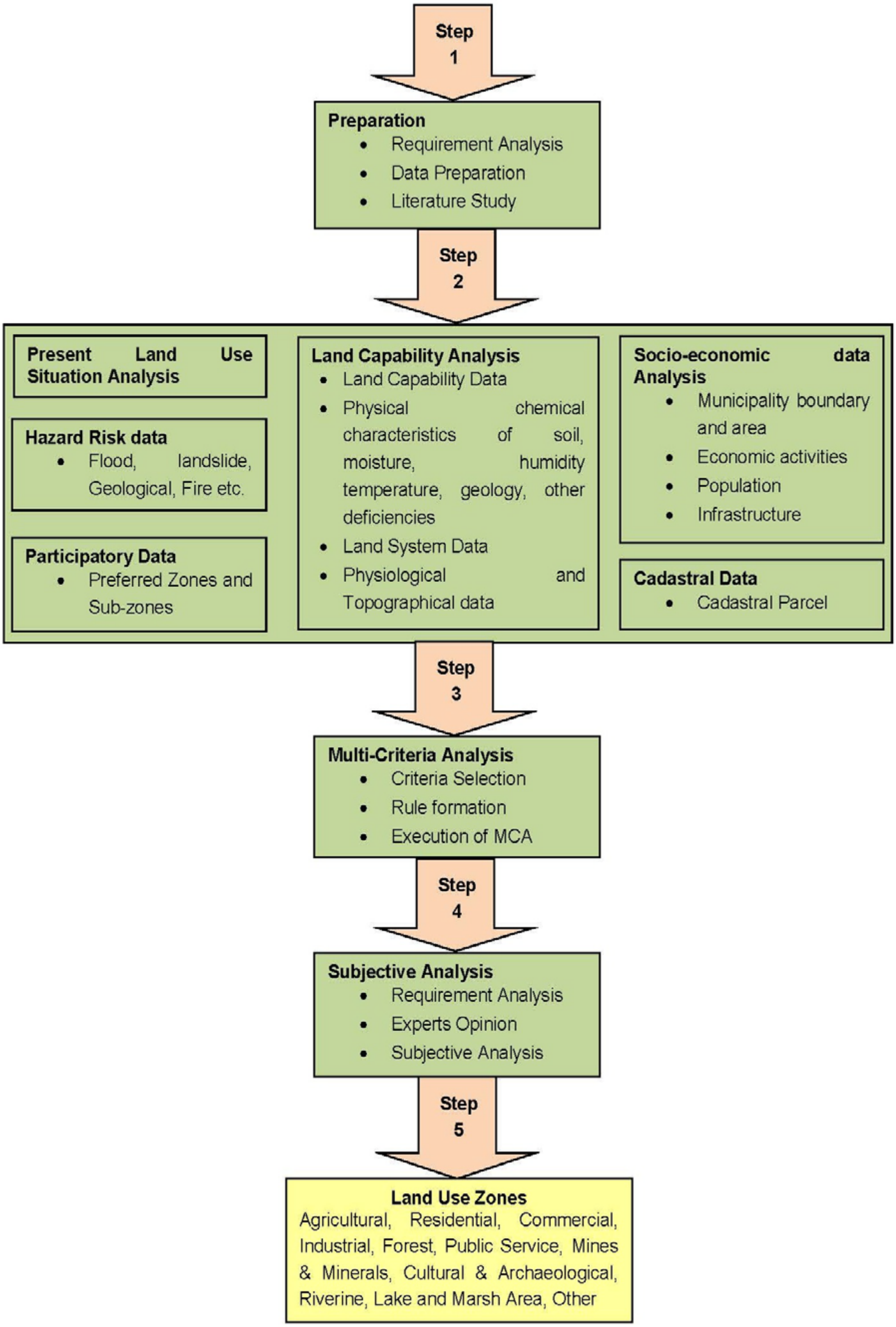

Figure 3.1: Methodological Framework for Land use Zoning

CHAPTER 4: LAND USE ZONES OF THE PROJECT AREA

4.1 Land use Zones of the project Area

Land use zones and sub-zones are identified based on the integrated analysis of multi-criteria analysis and expert evaluation. The methodological framework as outlined in Figure 3.1 is adopted and GIS analysis is performed at different levels beside expert opinion and qualitative analysis for land use zoning. The Land Use Zones identified in the project area and detailed sub-zones covered by each land use zone is summarized in Table 4.1 and Table 4.2. Similarly, percentage share of identified land use zones and area coverage is summarized in Figure 4.1 and geographical distribution of land use zones are shown in Figure 4.2.

Table 4.1: Land use Zones at Classification level 1

SN	Land use Zone	Area Ha	% of Total
1	Forest	5351.63	54.70
2	Agriculture	3988.22	40.76
3	Public use	244.14	2.50
4	Riverine Lake and Marsh	117.13	1.20
5	Residential	74.72	0.76
6	Commercial	3.39	0.03
7	Other	2.30	0.02
8	Industry	1.14	0.01
9	Cultural and Archaeological	0.82	0.01
Total		**9783.49**	**100.00**

Highest percent of the project area is covered by forest zone comprising 54percent of the total area. It is followed by agriculture zone with more than 40 percent coverage. Public use is the third largest zone sharing 2.5percent. Higher coverage of public use zone is due to inclusion of right of way of roads defined by national and local authorities such as Department of Roads and municipalities/ rural municipalities. Riverine lake and marsh zone comprises 1.2 percent of spatial coverage. Residential zone is the fifth highest coverage but with less than1 percent share. All other land use zones comprise less than 1 percent of the total area. Limited commercial area mostly is along major road network and local market centers scattered in different locations providing different levels of trading and business services. Land use zone and percent share of each class is shown in Figure 4.1 and geographical distribution is depicted in Figure 4.2.

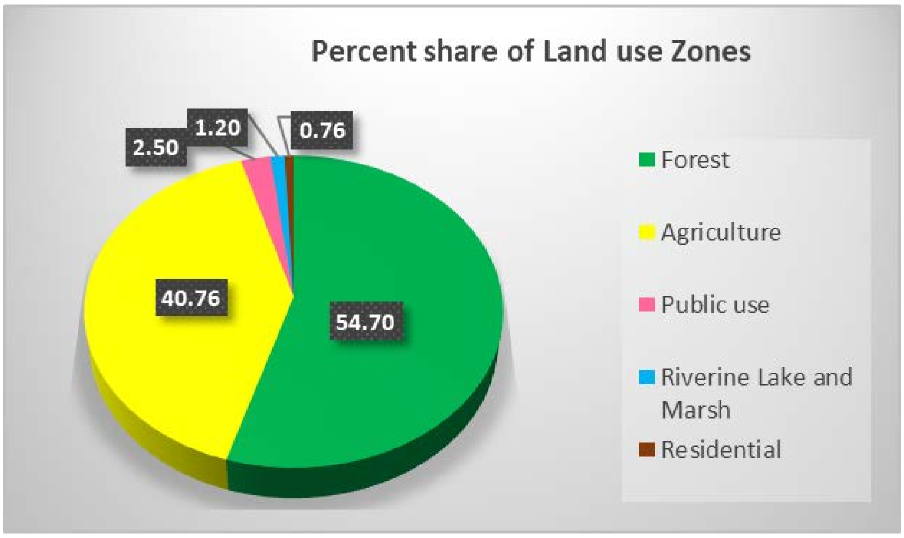

Figure 4.1: Percentage share of Land Use Zones

There are20different land use sub zone in the project area, identified based land use classification level 1. Among those identified sub-zones, agriculture use includes 5 sub-zones, public useincludes4 sub-zones, commercial, industrial, forest and residential zone each includes 2 sub-zones and cultural & archaeological, other use zone, and riverine, lake& marsh, zone includes 1 sub-zone category. The area coverage and percent share of each sub-zone is detailed in Table 4.2. Noteworthy among these sub zones beside existing forest are, business area, potential area for industrial use, potential residential zone, agro-forestry, cash crop production and, areas under transportation sub zones.

Table 4.2: Land use Sub-zones area coverage

Zone	Sub zone	Area Ha	% Area
Agriculture	1A-Cereal Crop Production area	2233.83	56.01
	1B-Cash crop area	499.26	12.52
	1C-Horticultural area	15.13	0.38
	1D-Animal husbandry area	1.11	0.03
	1E-Fish Farming area	0.00	0.00
	1F-Agro forestry area	1238.94	31.06
	1G-Other Agricultural area	0.00	0.00
	Sub Total	3988.27	100.00
Residential	2A-Existing Residential Zone	70.27	94.05
	2B-Potential area for residential zone	4.45	5.95
	Sub Total	74.72	100.00
Commercial	3A-Governmental Service areas	0.66	19.69
	3B-Business area	2.69	80.27
	Sub Total	3.35	99.96
Industrial	4A-Areas under industrial use	0.06	4.88
	4B-Potential area for industrial use	1.08	95.05
	Sub Total	1.14	99.92
Forest	5A-Existing Forest	5349.68	99.96

	5B-Potential area for forest including barren lands, wet lands etc.	1.96	0.04
	Sub Total	5351.63	100.00
Public Use	6A-Areas under roads, railways, bus parks, airport and landfill site etc.	180.59	73.97
	6C-Recreational, Picnic spots, playground etc.	2.20	0.90
	6E-Health/Education/Security/Utilities, fire station, telephone / electricity areas etc.	2.71	1.11
	6F-Grazing land	58.63	24.02
	6G-Government Institutional Area	0.01	0.01
	6H-Open Area	0.00	0.00
	Sub Total	244.14	100.00
Other Use	7Ot-Other areas (e.g. landslide areas)	2.30	100.00
	Sub Total	2.30	100.00
Mines and Minerals	8A-Existing Mine and Mineral Area	0.00	0.00
	8B-Potential Mine and Minerals Area	0.00	0.00
	Sub Total	0.00	0.00
Cultural and Archeological	9A-Existing Cultural and Archaeological Areas	0.82	100.00
	9B-Potential Cultural and Archaeological Areas		
	Sub Total	0.82	100.000
Riverine, Lake and Marsh Area	10A-Existing Riverine, Lake & Marsh Area	117.13	100.00
	10B-Potential Riverine, Lake & Marsh Area		
	Sub Total	117.13	100.00
	Total Area	235.90	

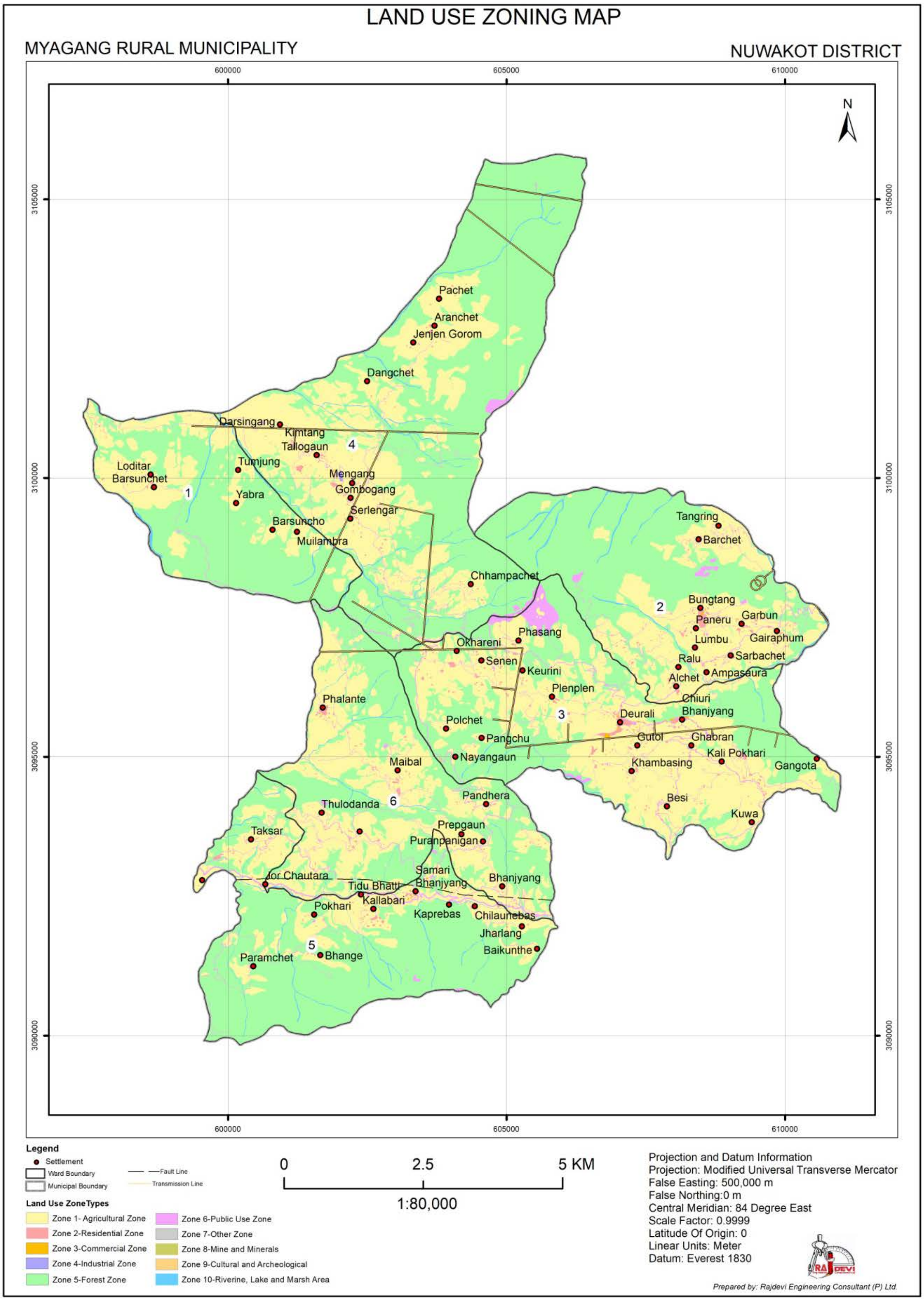

Figure 4.2: Land use Zone Map of the project area

4.2 Discussion

The project area is one of the remote regions of Nuwakot district. Characteristics to remote rural region, it has forest as a dominant land use zone, followed agriculture and then public use zone. Residential and commercial area coverage is relatively low.

Clustered traditional settlements are characteristics. Potential residential zone allocation is centered on considerations like adjacency to existing residential area, low arability of soil and land capability, proximity to road network and lower slopes. Land with marginal capability for agriculture production adjoining to existing residential and commercial area is allocated for potential residential area at most possible.

The agricultural area coverage decreased while zoning. The main reason behind this decrease is that existing growth is taking place in agriculture land because no other land use is available for urban expansion.

The average annual population growth rate of the project area is negative with -1.17 percent, which is low as compared to national growth rate of 1.35 and district growth rate of -0.39(CBS, 2014). It has been observed that there are very few new residential growths. The rate of outmigration is higher than internal migration; therefore, relatively very low growth can be seen in the residential zone.

The commercial area coverage is very limited covering only 0.03 percent of the total area and hence, there is limited economic and commercial activities. The markets are mostly related to retailing, and small wholesaling. The foreseeable commercial economy is limited and agro- based activities.

The project area hasvery small household level agro-processing and natural resource based (such as NTFP) processing units. There is potential of NTFP and medicinal and herbal processing products.

Combination of food crops and vegetables is the agricultural practices. Cardamom and Tea is the major cash crop beside some off-season farming practice. Cash crop farming is potential towards western part. Hence very highly suitable area for diversified crop is allocated for cash crop. Regarding major agriculture product, potato is dominant with off-season vegetables and medicinal plants.

Cash crop and agro-forestry are two major sub-zones identified in the area as potential agriculture diversification. This could be a very appropriate solution as better food supply to tourist services and to raise income level of the people and shift from subsistence to commercial activity. This will also help maintain the greenery. Besides, area under right of way of the river/stream is assigned as agro-forestry which can increase the greenery and can be used as green belts.

4.3 Risk in the Project area

The potential hazard risk in the project area includes earthquake in all over project area, landslides in higher slopes and flooding in lower area along river and stream corridors during rainy season. Besides these forest fire is another hazard found in the project area. The earthquake of 2072 Baisakh 12 (April, 2015) has a major effect in the project like all other local units of the district. The earthquake caused death and injury of number of people. Similarly, the earthquake caused damage to physical infrastructure and completely destroyed residential buildings.

Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area. Besides there are many streams and rivulets. Most of these streams are flowing towards the southward slopes. There are no major flooding events occurred in the project area. But few lower plain areas along rivers are in risk of inundation and flooding during heavy rain and monsoon. Out of the total project area less than 1 percent area(0.13%) is under different flood risk zone, of which nearly 53% (6 hectare) is under high flood risk and 20% is under medium risk.

Degradation of forest and agricultural land and river bank cutting are reported to be common due to flooding in the area. Though the risk of flooding is fair but some inundation and bank cutting is probable near river banks.

The project area is at high risk of landslides though the forest coverage in the project area is relatively moderate with more than 54% coverage. Out of the total project area, nearly 38 percent area is under different level of landslide susceptibility of which more than 83 percent is under high landslide susceptibility. Similarly, 16 percent of the area is under medium risk of landslide susceptibility. Central and eastern part of the project area is highly vulnerable to landslide susceptibility compared to other part. Settlement and road infrastructure distribution is dispersed to all over the project area and hence landslide vulnerability of settlement and infrastructure is also variable. As compared to other local units, the area under landslide susceptibility is relatively high.

Another risk in the area is forest fire due to high forest cover and dry wind spreading in summer. The clustered residential and commercial area nearby are in the risk of fire hazard. Besides, the transmission line also passes through the project area which necessitates safety measures to reduce the risk of fire over the settlements.

4.4 Analysis of Present Land Use and Potential Land use Zone

The project area has forest as a dominant land use type both in terms of present land use and land use zoning context. It is followed by agriculture and public use zone. Major shift in area under agriculture and public use zone is noteworthy vis-à-vis land use zone context. Major area and percent change categories among existing land use and land use zone are agriculture (due to conversion to potential residential zone and to public use under right of way, RoW of road). Slight decrease in area of all other zone is also due to right of way of major roads. (Table 4.3 and 4.4).

Table 4.3: Present Land Use and Potential Land Use Zone

SN	Landuse	Land use Zone		Present land use		Difference	
		Area (Ha)	Percent	Area (Ha)	Percent	Area (Ha)	% Change
1	Agriculture	3988.22	40.76	4014.51	41.03	-26.29	-0.27
2	Commercial	3.39	0.03	3.24	0.03	0.15	0.00
3	Cultural and Archaeological	0.82	0.01	0.86	0.01	-0.04	0.00
4	Forest	5351.63	54.70	5357.17	54.76	-5.53	-0.06
5	Industry	1.14	0.01	0.06	0.00	1.08	0.01
6	Mines and Minerals	0.00	0.00	1.00	0.01	2.00	0.02
7	Other	2.30	0.02	62.93	0.64	-60.63	-0.62
8	Public use	244.14	2.50	156.10	1.60	88.05	0.90
9	Residential	74.72	0.76	71.35	0.73	3.37	0.03
10	Riverine Lake and Marsh	117.13	1.20	117.29	1.20	-0.15	0.00
		9783.49	100.00	9783.49	100.00		

As detailed in Table 4.3 and 4.4, decrease in area is obvious on agricultural use. Notable increase is in public use with more than 88hectares due to assignment of area under right of way and shifting of grazing land from others category to public use zone. Slight decrease in forest area is due to inclusion into RoW of public use zone. Decrease in all other zones is due to shifting of area which fell into right of way of road to public use zone. Decrease in other sub-zone (60 hectare) and agriculture area is also prominent with more than 26hectares, which again due to allocation of two new sub zones: residential (2B) and public use (6A). Agriculture patches next to residential zone are allocated to future residential zoning because the trend show that settlements will be expanded to available agriculture land around major existing market centers and residential areas. Similarly, some agriculture area along near cash crop farming is shifted to potential agro-processing industrial zone.

To allocate agricultural land for new residential and area, land capability data and risk factors were analyzed and suitability analysis was done. Land of marginal utilization with low capability of agricultural production is allocated for Agro-forestry and in some areas horticulture area as far as possible. The negative change between different land use area is visible in Table 4.3. and category wise change is detailed in Table 4.4.

Table 4.4: Area Change between Present Land use and Land Use Zone

Land use zone/ Present Lan use	Agricultural	Commercial	Cultural and Archaeolo	Forest	Riverine, Lake and Marsh Area	Industrial	Mines and Minerals	Other	Public Use	Residential	Total
Agricultural	3988.27	0.23				1.08			20.49	4.45	**4014.52**
Commercial		3.12							0.12		**3.24**
Cultural and Archaeological			0.82						0.04		**0.86**
Forest				5349.68					7.49		**5357.17**
Riverine, Lake and Marsh Area					117.13				0.15		**117.29**
Industrial						0.06					**0.06**
Mines and Minerals							0.00				**0.00**
Other				1.96				2.30	58.67		**62.93**
Public Use									156.10		**156.10**
Residential									1.08	70.27	**71.35**
Total											**9783.49**

4.5 Land Use Zoning GIS Database

The Table 4.5presents database schema used for preparation of GIS database:

Table 4.5: Database schema used for land use zoning

Field	Data Type	Description	Remarks
FID	Feature ID	Feature	
SHAPE	Geometry	Geometric Object Type	
CLASS	Short Integer	Class Code of the land use Zone	
ZONE NO.	String	Zone No	
ZONE TYPE	String	Zone type	
SUB ZONE TYPE	String	Subzone Type	
Description		Description of the zone (sub) type	
Shape Length		length of the feature (auto generated field)	
Shape Area		area of the feature (auto generated field)	

CHAPTER 5: CONCLUSION

5.1 Conclusion

The dominant landuse of the project area is forest followed by agriculture and public use. The agriculture zone in a project area comprises 40% of which, 31% is suitable for agro-forestry due to higher slopes and land capability limitation. More than 50 percent of the project area is above 35-degree slope. The flat area suitable for cash crop along river plain comprise around 12%. Combination of food crops and vegetables is the common agricultural practices. Major agriculture product, is potato besides food crop and herbal/medicinal plants. The fertile belt along Kintang Khola is most potential for vegetable cash crops like beans, chilies, tomatoes, cauliflowers, cabbage and other vegetables.

Hence very highly suitable area for diversified crop is allocated for cash crop with organic farming method towards the area of access for marketing. This could be a very appropriate solution as better food supply to tourist services and to raise income level of the people and shift from subsistence to commercial activity.

Agriculture in steeper slopes and inside floodway/right of way of river under suggested for agro-forestry sub-zone agriculture zone. But still food crop area is dominant with more than 56% agriculture area. The forest area which constitute more than 54 % of the total project area provides eco-system services like timber, firewood, fodder, air purification, water supplies sources, recreation and soil conservation

Due to Land capability limitations (soil and topography class) some existing agriculture area are proposed to residential sub-zone which requires proper regulations as per building bye-law for construction.

Clustered traditional settlements are characteristics with very low residential growth. Average annual population growth is negative -1.17 which is very low compared to national and district rate of -0.39 and hence future residential growth will be very limited and concentrate around major road network. The rate of outmigration is higher and internal migration is limited; therefore, low growth can be seen in the residential zone.

There is moderate level of economic and commercial activities. The major commercial economy is agro- based activities. Commercial activities are mostly confined to storage, wholesaling and retailing besides business houses along and around major road junctions. Nearly all of the industries are agro-processing and natural resource based (such as NTFP) processing plants.

Most of the areas are higher slope and higher elevation area with high degree of agriculture practices, hence are relatively high in landslide risks. Similarly, flooding inundation risk is moderate in lower floor area and largely is along river/stream banks which require check dams and proper drainage management.

5.2 Recommendation

- Cash crop farming should be promoted over existing cereal crop farming. Regarding major agriculture product, potato is dominant with off-season vegetables (potato, beans, chilies, tomatoes, cauliflowers, cabbage) in the western part under agriculture zone is suggested.
- Cardamom and Tea is the major cash crop beside some off-season farming practice. Cash crop farming is potential towards central west part. Besides medicinal plants in agro-forestry zone is also suggested. This could be a better market supply to tourist services and to raise income level of the people and shift from subsistence to commercial activity.
- Plantation should be practiced in environmentally sensitive area like landslide susceptible zone. Agriculture activities on higher slopes should be directed to agro/NTFP production. Proper terracing like contour-based cropping systems and soil erosion mitigation methods should be adopted.
- The project area lies in the moderate earthquake hazard risk zone and has relatively moderate seismic hazard risk. But natural disaster particularly, landslides at the higher elevation and slope area is prevalent besides flood in lower valley plains and fire risk. Such risk should be checked and proper care should be taken through strict implementation of bylaws and regulation at local level. Regulations and guidelines should be implemented for building and larger construction.
- The data and map products of this project could be valuable tool to local authority for planning and implementation of activities as well as conservation measures. The land use zoning to specific use such as residential growth around industries and fuel storage sites should be incorporated and imbedded with any existing Disaster Risk Reduction Plan, DRRP and coordination with concerned authority for implementation is hence recommended.

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CADASTRAL SUPERIMPOSE

Preparation of Cadastral Superimpose Report Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Meghang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural Municipality.**

The area coverage of Local unit of this package used and analyzed for different purpose under the scope of work of this consulting service are computed from cadastral maps provided by DOLIA Office, Government of Nepal, Ministry of Land Management, Cooperatives and Poverty Alleviation of Nepal. Therefore, the area of Local unit may match to the area computed from Topographic Digital Database provided by the Survey Department of Nepal.

The satellite imageries, GIS database and other outputs produced by this consulting service is owned by Topographical Survey and Land Use Management Division (TSLUMD), Minbhawan, Kathmandu. Therefore, the authorization from the TSLUMD is required for the usage and/or publication of the data in part or whole.

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CHAPTER 1: INTRODUCTION

1.1 Background

Since Nepal is an agricultural country, most people of the country have excessive reliance on land. All developmental efforts made for the overall development including social and economic changes, land or land resource is to be directly or indirectly utilized, and without its appropriate management, building of a prosperous nation can never be imagined. On the other hand, paying attention on sensitivity of common people's integration with land, it will be the nation's main responsibility to establish good governance by upgrading judicial access, feeling of security of land ownership, and effectiveness in service effluence. If land resource is imbalanced and uncontrolled due to lack of timely and appropriate management of changes caused by the improper utilization of land to fulfill increasing human needs along with the continuous increment in population, beginning of environmental imbalance, decrease in land productivity, and lastly, a situation, in which next generation will not be able to supply inevitable entities- lodging, fooding and clothing to sustain their life, will be created. In addition to this, productivity has been declining because of shortage of agricultural labors due to heavy outmigration of young manpower to foreign countries, and by dividing cultivable land into pieces and preserving them for building site, the land is being left uncultivated, lack of sufficient irrigation and maximum plotting system are also the causes of it. Similarly, maximum profit from land could not be achieved due to unplanned settlement and uncontrolled urbanization. Though majority of people's life style, even today, is based on agriculture, it has been a challenge for food security and ownership on land. Thus, to follow necessary methods for eradication of all these challenges appeared at present and to gain maximum profit permanently by utilizing land and land resource on time, land use mapping has been necessary. By classifying land on the basis of utility and appropriateness, and if possible by adopting policy for utilizing land accordingly, maximum benefit from land resource can be achieved.

In this background the Government of Nepal has adopted National Land use Policy 2015 with a vision of achieving sustainable social, economic and environmental development through optimum use of land resources. For this purpose, it has assigned a goal of classifying the lands into different classes on the basis of landscape characteristics, quality of soil, capability, and needs. The classes are agricultural, residential, commercial, industrial, forests, public use and others. As this land use policy is on its way of implementation, data which is the most important and necessary infrastructure is obviously required. Understanding that only data driven decision making are the most effective ones, the project has decided to build data inventory of its own comprising of these most important indicators for identifying the lands' current use, the capacity it holds and the zone it belongs to.

Land use planning means the scientific, aesthetic, and orderly disposition of land, resources, facilities and services with a view to securing the physical, economic and social efficiency, health and well-being of urban and rural communities (CIP 2000).Land use planning is a key function which includes long-range land use policy, growth management, capital budgeting and regulatory or implementation of planning process (Wehrmann, 2011). It generally involves zoning of appropriate types and forms of land uses, as well as infrastructure and open space planning directed at the efficient utilization of land in order to provide benefits to the broader population, the economy and the environment. Land use planning is an important aspect of regional planning, which also encompasses social and economic concerns.

Except sporadic attempts for the urban areas (GoN, 2002), Nepal has not practiced landuse 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. The National Land Use Policy 2012 envisages landuse planning to be applied at three broad levels: national, district and local municipality/rural municipality. Local level planning is about a detailed outline of 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. The available database on land use, land system and land capability produced by Land Resource Mapping Project (LRMP, 1986) could be useful as reference material for national and regional or district level planning. However, it needs detailed information for local level planning at the Municipality/ Rural Municipality level. Use of present day geo-information technology like satellite Remote Sensing (RS) and the Geographic Information System (GIS) can be helpful in acquiring spatial/temporal data, and preparing different thematic digital database like current land use at this level. These spatial databases together with data on different land characteristics collected from the field survey and secondary sources are used to prepare land use zoning maps at local Municipality/Rural Municipality level.

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 Bhaktapur municipalities at larger scales. Finally, NLUP was mandated to prepare land resource maps of Nepal for local level planning through outsourcing modality. These digital data base includes Municipality/Rural Municipality/Nagarpalika level present land use, soil, land capability, risk layers land use zoning, cadastral layers and Municipality/Rural Municipality/Nagarpalika profile with bio-physical and socio – economic data base.

On the 4th *Baishakh* of 2069, the Government of Nepal has approved the **National Land Use Policy, 2069**. The same policy was modified by the amendment of **National Land Use Policy, 2072.** On the 6th *Bhadra* of 2076, the Government of Nepal has approved the **Land Use Act, 2076**. It has intended to manage land use according to land use zoning policy of the government of Nepal and outlined eleven zones such as ***Agricultural area; Residential area; Commercial area; Industrial area; Forest area; Public Use area; Mine and Mineral area; Cultural and Archaeological area; Riverine, Lake and Marsh Area; and Others***. 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 Land Use Act, 2076 has clearly directed for an institutional set up of **Federal Land Use Council** at national level, **Provincial Land Use Council** at province level, **Local Land Use Council** at local level, and Implementation Committee at ***Municipality/Rural Municipality*** **level** at the bottom. At, present, it has added further importance to the Survey Department, Topographical Survey and Land Use Management Division (TSLUMD) are responsible for the preparation of Municipality/Rural Municipality level land resource maps and database. Similarly due to limited usability of hard copy cadastral maps and to achieve the optimum usability of the maps government decided to prepare digital cadastral databases.In 2000, the government of Nepal established the Department of Land Information Archive (DOLIA) with the objective of creating digital cadastral database based on analogue cadastral survey data. DOLIA has been performing the management of digital cadastral database thethrough concerned district offices and the projects of preparing digital cadastral database simultaneously.

Land use information at cadastral level is very 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. 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.

Thus, in this context, in this fiscal year 2077/78 Topographical Survey and Land Use Management Division (TSLUMD) has awarded the project of “Preparation of Municipality/Rural Municipality level land resource maps, databases and reports” for Municipality/Rural Municipality of Nuwakot District. This reportis a part ofthe project, which deals with the cadastral data superimpose on present land use and land use zoning.

Rationale of the Study

The rationale for the preparation of Municipality/ Rural Municipality level superimposition of cadastral maps on land use and land use zoning maps by TSLUMD are to identify individual parcels according to present land use and proposed land use. For all land related decision making, land ownership and land tenure information provides essential ingredients. The implementation of land use plan cannot succeed without the active and positive support of the individual land owners. Therefore, the main rationale of superimposition of cadastral maps on land use and land use zoning maps is to support in the formulation and implementation of land use plans and land use zoning policy within the Municipality/ Rural Municipality at parcel level. More specifically, this information is necessary for the following:

- Classification of land parcels on the basis of its types for the purpose of nonagricultural land uses.
- Delineation of land parcels according to land use zoning areas i.e. 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 Municipality/ Rural Municipality level database and maps using GIS for the implementation of Municipality/ Rural Municipality level land use plan.

- Management of land resources on the basis of land characteristics as well as the conceived policy.

1.2 Objectives of the Study

The main objective of the study is to prepare maps of cadastral layer superimpose on land use zone at 1:10,000 scales, GIS database and reports for Myagang Rural Municipality of Nuwakot District.

In order to fulfill the objective, the scope of the present study includes following activities:

- Collect and prepare cadastral geo-database from existing cadastral map.
- Collect land use zoning maps and present land use maps at 1:10,000 scale
- Overlay of cadastral layer on present land use and land use zoning and prepare cadastral superimposed map at 1:10,000 scale.
- Classify the cadastral parcels according to present land use and land use zoning.
- Maintain GIS database on cadastral parcels with zoning characteristics and current land use as per the specification provided by TSLUMD.
- Analyze the accuracy, reliability and consistencies of data, and
- Report describing methodology, distribution of cadastral layers as per land use zones and present land use, and model of GIS database.

1.3 Study Area

The package 08 project area comprise of four districts, namely, Bhaktapur, Kathmandu, Lalitpur and Nuwakot with 18 municipalities (including Kathmandu and Lalitpur Metropolitan) and 13 rural municipalities The total project area covers 1857.17 km^2 area. Two protected areas, viz. part of Langtang national park and Shivapuri wildlife reserve also lie within the project area.

Myagang Rural municipality is one of the 12 local administrative units of Nuwakot District located in the Bagmati Province. It is situated in the central-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

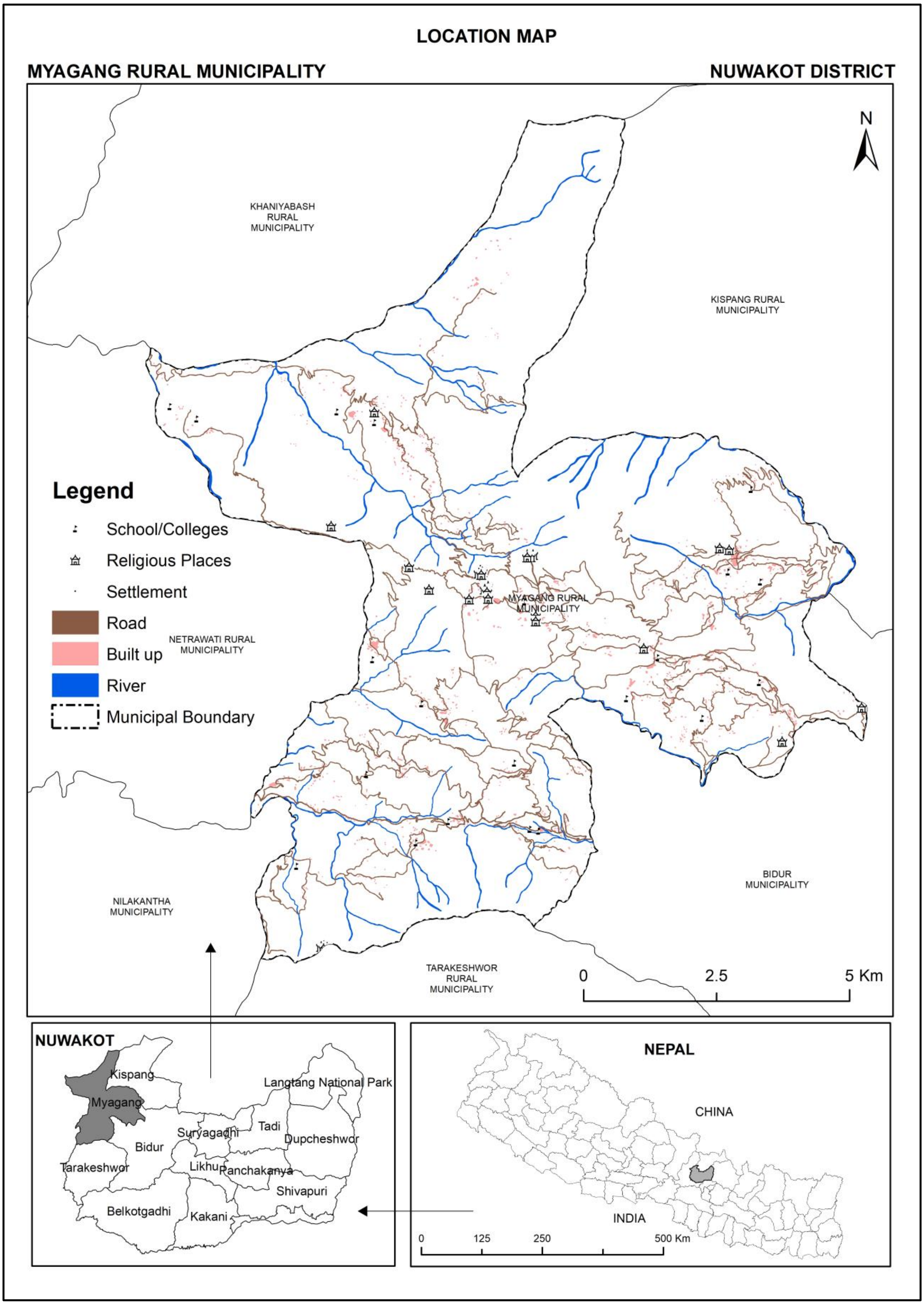

Figure 1.1: Location Map of Myagang Rural Municipality

CHAPTER 2: CONCEPTUAL BASIS OF CADASTRAL LAYER SUPERIMPOSE

2.1 Concepts

The superimposing of the land use zoning in cadastral layer is useful for implementation of the national land use policy at the local level i.e. Municipality/ Rural Municipality of the country. This will provide information regarding the proposed land use directly in relation with the land owner, its tenant, current land use and the shape and size of the individual parcel. It will subsequently relate the concerned land owner with the country wide property information. Therefore, the local governments can develop a comprehensive plan and administer the land use regulations 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 several databases with a cadastral layer as base information together with the existing land use and a land use zoning layer.

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,1985). 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.

In Nepal, a systematic cadastral survey was carried since 2021 B.S. using the plane tabling techniques at the scales of 1:2400 and 1:4800 in the beginning, but later shifted to 1:2500, 1:1250 and 1:500 depending upon the size and density of the parcels. The district survey offices maintain the mutations of each parcel upon fragmentation due to transactions. Though the accuracy of plane tabling survey cannot be considered too high, it is more than enough here since the superimposition is carried out at the 1:10,000 scales. The digital data provided by TSLUMD is from the digitization of the existing up to date maps from the cadastral Survey Division at the date of digitization. Though with the passage of time some of the parcels may have been outdated at the time of implementation, the parcel history available at the Survey Office may be linked to update such information when needed.

Land use maps are those types of map which provide information about current and or proposed land use of any area. There are a number of different applications for such maps, and in many nations, land use maps are prepared by several government agencies, for a variety of reasons. Individual groups and organizations can also generate maps with land use information. Often, such maps are publicly available, so that people who are interested in land use trends can access them.

One form of land use map is a zoning map. Zoning maps are used to mark out areas designated for specific types of land use, so that people developing land know which kinds of uses are allowed by land use regulations in a particular area. The creation of zoning maps is a part of the overall process of community planning, in which communities decide how they want to develop their land and vicinity in the future. Zoning decisions can include things like setting aside green space, isolating industrial land, and so forth. Another type of land use map is a map which shows utilization. Utilization maps are often used in zoning decisions to determine whether or not zoning changes need to be made. Utilization land use maps show how land is being used, and may also indicate historic utilization information, and provide information about how long land has been developed. Utilization maps can be very detailed and tremendously useful. They can highlight a variety of activities, including farming, mining, residential use, light industrial area, heavy industrial area, waste storage, and so forth so that people get a clear visual impression of how land in a particular area covered by the map is being used. Utilization land use maps can also be important from a development perspective because they provide data about historical use; land used for a tannery, for example, might not be a great place for a residential development.

Land use maps records, and archives are maintained by competent authorities as a coherent record. Researchers who want to study land use or the history of a region can access these archives, as can developers who want to know more about their land use options, and government officials who monitor land use. These maps can become important in zoning and property disputes, as people may be able to use them to prove or argue their case.

2.2 Spatial Function related to Spatial Database

The overlay process of two spatial data layers (cadastral and zoning map) having same reference system facilitates to prepare a composite map and databases (Figure 2.1). It leads to generate a new set of polygons that explain the relations between the two inputs of spatial data (land use zone class and parcel id). The overlay of seamless cadastral map layer and present land use map provides information on which parcel belongs to which present land use. Similarly, the overlay of cadastral layer over proposed zoning map provides information on proposed use of the particular parcel. The overlay function provides information on the proposed change of parcel wise use, and also provides a summary on the overall change in land use anticipated upon the implementation of the land use zoning.

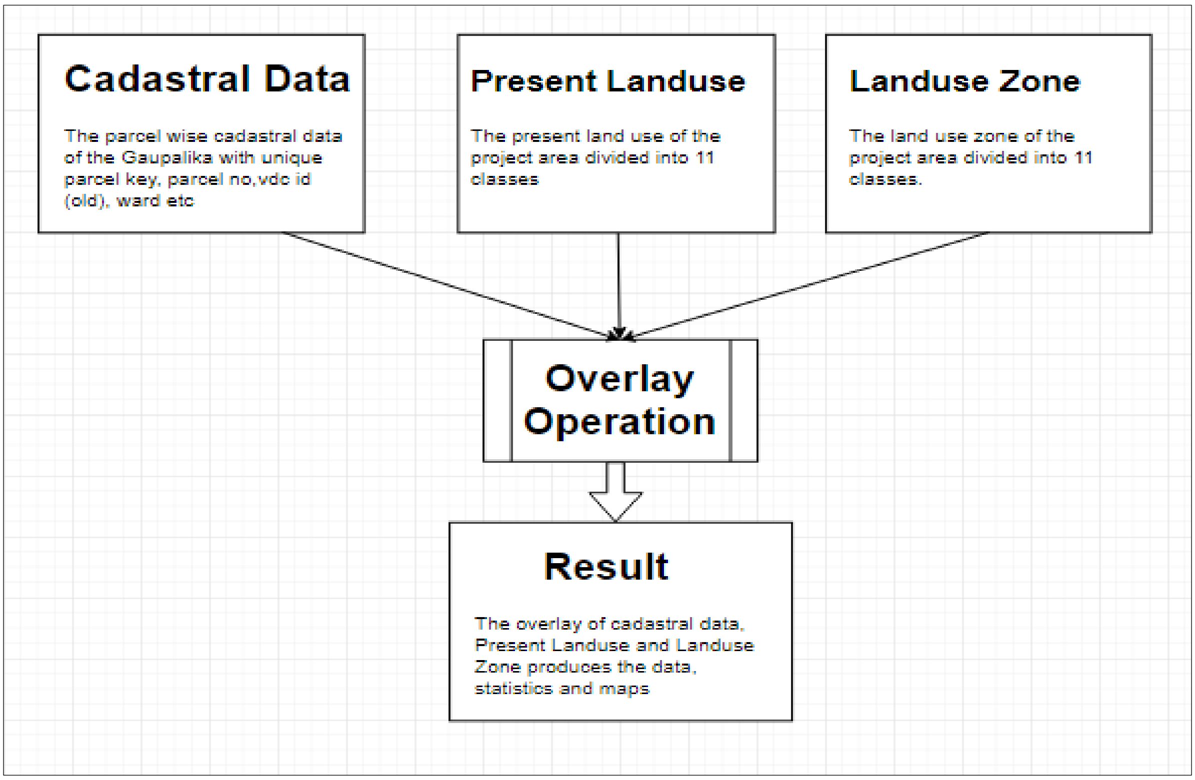

Figure 2.1: Spatial function related to spatial databases

2.3 Attribute Data Management

The connections between graphical and alphanumerical database is based on the use of a GIS internal table as a linkage with other tables in external databases. These data are usually managed by a relational database management system (RDBMS). The procedures are based in the connection of each graphical element to a line of column of the alphanumerical table containing its attributes. The attribute table used for superimposing land use zoning map on cadastral layers are prepared and managed in GIS environment.

CHAPTER 3: METHODOLOGY

Superimposing cadastral parcels on the land use and land use zoning enables land use classification and zoning at parcel level required for micro planning of land based resources in the smallest unit of administrative division i.e. Municipality/ Rural Municipality. For the preparation of the cadastral layer to be superimposed on land use and land use zoning maps of the project area, the following methodological approach was adopted. The overall methods adapted to superimpose cadastral parcel on land use zoning map are discussed below:

3.1 Acquisition of Cadastral Maps

The cadastral maps for the Myagang Rural Municipality of Nuwakot District were acquired from the Survey Office. The Survey Office maintains the original cadastral maps and records, and those cadastral maps were digitalized by DOLIA and stored as sheet wise geo-database. This was made available to the TSLUMD for this exercise. TSLUMD has provided digital copies of island cadastral maps in vector format together with the attribute database. The data thus obtained were not referenced in national reference frame due to its nature while surveying. The data were based on the digitization of related cadastral maps available with the Survey Office and current to the date of digitization by DOLIA through Cadastral Survey Division.

3.2 Scanning

Although a digital cadastral database was made available in compatible data format by TSLUMD, some digital cadastral maps were missing. Therefore, the consultant visited the District Survey Office, Nuwakot and collected the Ammonia Print of the missing cadastral maps. This collected Ammonia Print of cadastral maps was scanned in 300dpi with large format scanner with high radiometric quality.

3.3 Geo-referencing of Cadastral Data

As sheet wise free-sheet digital cadastral database was available for the project there was necessity of geo-rectification. The geo-rectification process makes the cadastral maps geometrically oriented and corrected to ground scale as well as to the national reference frame. The geo-rectification of free sheets of digital cadastral database and scanned cadastral images was carried out with the help of ortho-rectified satellite image of the project area. Geo-referencing is the process of aligning cadastral parcel maps on to the geometrically oriented and corrected to ground scale and in terms of national reference frame. As the cadastral vector data obtained from TSLUMD were not geo-referenced in national reference frame, the following method was applied. The details of ortho-rectification are given in land use section.

Tie points were identified through field survey as surveyors collected tie points from field based survey. The image registration was carried out using these tie points, the sharply identified edges of the cadastral sheet and important features in image like roads, rivers, major residential areas.Geo-correction of vector layer of cadastral data need Tic Points at least on the four corners of the map sheet, however, to maintain the accuracy, and ensure even distribution of errors, 16 to 20 Tic Points in one cadastral map sheet were used for geo-referencing. A 3rd degree polynomial transformation was applied for rectification of the vector layer of cadastral dataset after assigning the required Tic Points. Due to larger errors in source data, mainly due to the method of plane tabling using limited local controls, some of the cadastral maps still were not free of overlapping and gap errors even after affine rectification. However, this has limited consequence due to the scale of end product (1:10,000). Moreover, the gaps and overlaps occurred in the margin of separate cadastral map sheets which were generally road, stream, and jungle/unsurveyed public land in some other cases. Accuracy of individual cadastral map sheet transformation has been assessed properly and corrected if any discrepancies were found. The overall methods adapted to superimpose cadastral parcel on land use zoning map are shown in Figure 3.1.

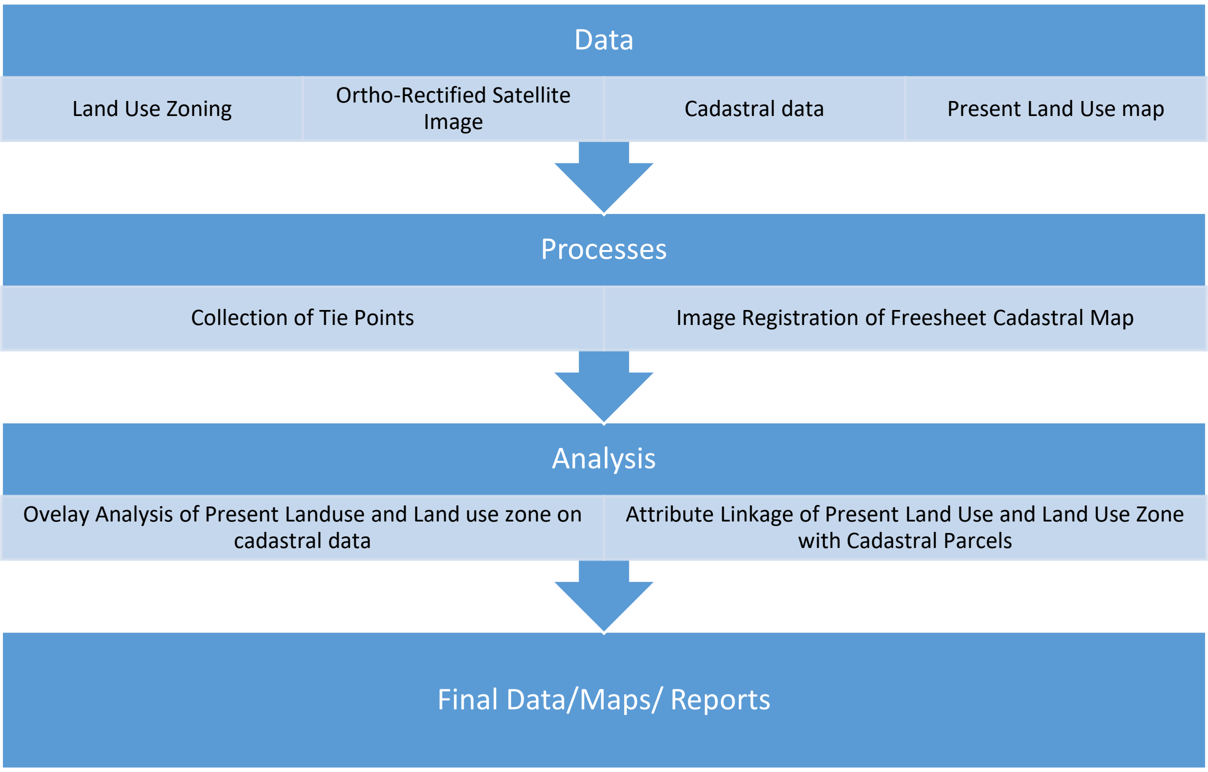

Figure 3.1: Schematic Diagram of Methodology Adopted

There were some constraints that were faced during the rectification process which are listed below:

- Difficulties in identification of ground points corresponding to distinct features.
- Identification of adjacent sheets to match through the scanned cadastral images and the sheet indicators as some cadastral maps lie surrounded by forest areas and similar patches of lands exist within the project area.

Detail of the national reference coordinate system used is provided in the Table 3.1.

Table 3.1: Coordinate reference system used

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	84^0 E, 0^0 N
False Coordinate	500,000 m E, 0 m N
Scale Factor at Central Meridian	0.9999

3.4 Digitization and Preparation of Digital Data

Scanned cadastral maps were digitized to convert analogue format into digital format of cadastral datasets. These datasets were stored as sheet-wise cadastral geo-database in .gdb format. These geo-database has used for preparation of seamless cadastral database of Ward or Municipality/Rural Municipality.

3.5 Preparation of Municipality/Rural Municipality Level Seamless Cadastral Dataset

A ward level and subsequently Rural Municipality level seamless cadastral datasets was prepared by spatial analysis process of merging of different geo-reference cadastral map sheets in GIS environment. An error of overlapping and gap between individual cadastral map sheets was noticed during the spatial merging process; however, those errors were eliminated with building topology within the permissible limit of threshold already assigned. In extreme cases as already explained such gaps or overlaps were assigned at the margin of free sheets falling in river or other un-surveyed areas.

3.6 Superimpose of Municipality/Rural Municipality Level Seamless Cadastral Dataset on Land Use Zoning Map

Spatial analysis of land use zoning map and cadastral dataset was carried out by overlaying Municipality/Rural Municipality level land use zoning map on cadastral datasets of the same area and level using spatial analysis function in GIS environment. This was possible since all datasets were on the same geo-reference frame. During overlay process, caution was taken to maintain different topology functions viz.

- Topology function must not overlap
- Topology function must not intersect
- Topology function must not contained

3.7 Linking Attribute of Land Use Zoning and Present Land Use with Cadastral Parcel

Land use zoning map is linked with seamless cadastral datasets by the process of querying in the attribute table of Municipality/Rural Municipality level cadastral datasets and land use zoning class datasets. Geographic objects in a vector map were linked 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 use of this system is that it allows placement of thematically distinct but topologically related objects on a single map. Further, the table can be linked to subsequent layers.

CHAPTER 4: CHARACTERISTICS OF THE SUPERIMPOSE OF CADASTRAL DATA

4.1 Cadastral Parcel Superimpose on Present Land Use

A total of 21575 parcels were recorded in the Myagang Rural Municipality with seven present land use classes except industrial, mine & mineral and undersigned other land use classes. The most prevalent land use category is agriculture with 19529 parcels corresponding to 2689 ha (95.36%) area. Similarly, the public use area comprises of 734 parcels with 65 ha (2.30%) area followed by residential area with 54 ha (1.91%) having 1110 parcels and riverine & lake area with 7 ha (0.25%). The commercial area comprises of 95 parcels with area of 3 ha (0.09%).

Table 4.1: Cadastral Parcels with respect to present land use

Land use	Total Parcel	AREA_H	Percentage
Agriculture	19529	2688.64	95.36
Public Use	734	64.97	2.30
Residential	1110	53.93	1.91
Riverine & Lake	82	7.02	0.25
Commercial	95	2.62	0.09
Forest	16	1.74	0.06
Cultural & Archeological	9	0.65	0.02
Total	**21575**	**2819.58**	**100.00**

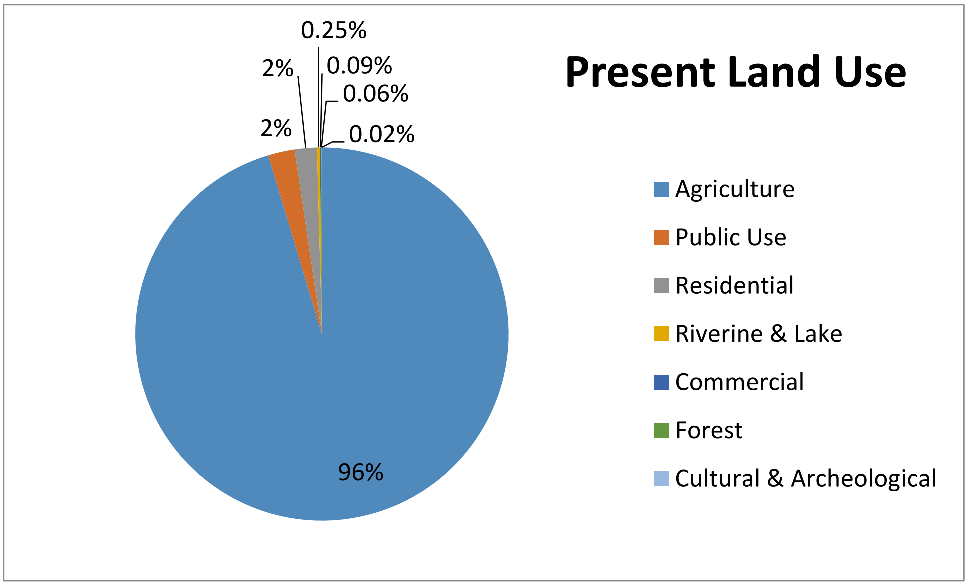

Figure 4.1: Parcel area under various present land use types

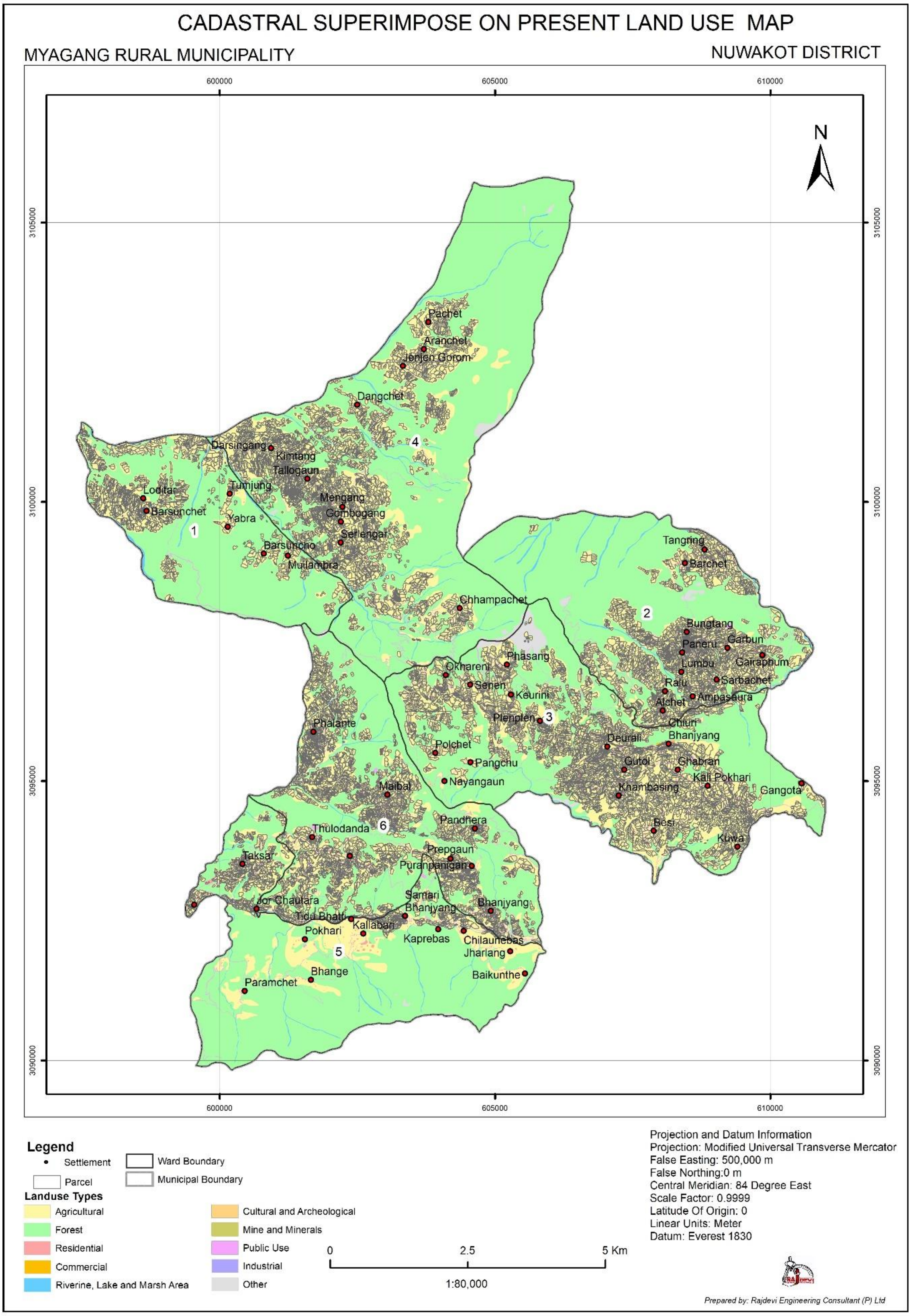

Figure 4.2: Cadastral parcels superimposed on present land use

4.2 Cadastral Parcel Superimpose on Land Use Zoning

Table 4.2 shows the characteristics of cadastral parcels superimposition on land use zoning for the Myagang Rural Municipality of Nuwakot District of Nepal. The land use zoning shows a restructuring on the existing land use. In the cadastral area of the Municipality/Rural Municipality, out of the designated 10 classes, zoning for eight present land use classes occurred except mine & mineral and undersigned other land use classes. Agriculture land parcels area is reduced from 2689 ha to 2672 ha whereas agriculture land parcels is reduced from 19529 to 19345 land parcels. The significant change in the existing agriculture land use land parcels allocation has converted into residential, commercial, industrial and public service land use classes. The distribution of cadastral parcel in land use zoning classes is shown in Table4.2

Table 4.2: Cadastral parcels with respect to land use zoning

Landuse	Total Parcel	AREA_H	Percentage
Agriculture	19345	2671.64	94.75
Public Use	866	79.32	2.81
Residential	1154	55.54	1.97
Riverine & Lake	82	7.02	0.25
Commercial	100	2.81	0.10
Forest	14	1.71	0.06
Industrial	5	0.89	0.03
Cultural & Archeological	9	0.65	0.02
Total	**21575**	**2819.58**	**100.00**

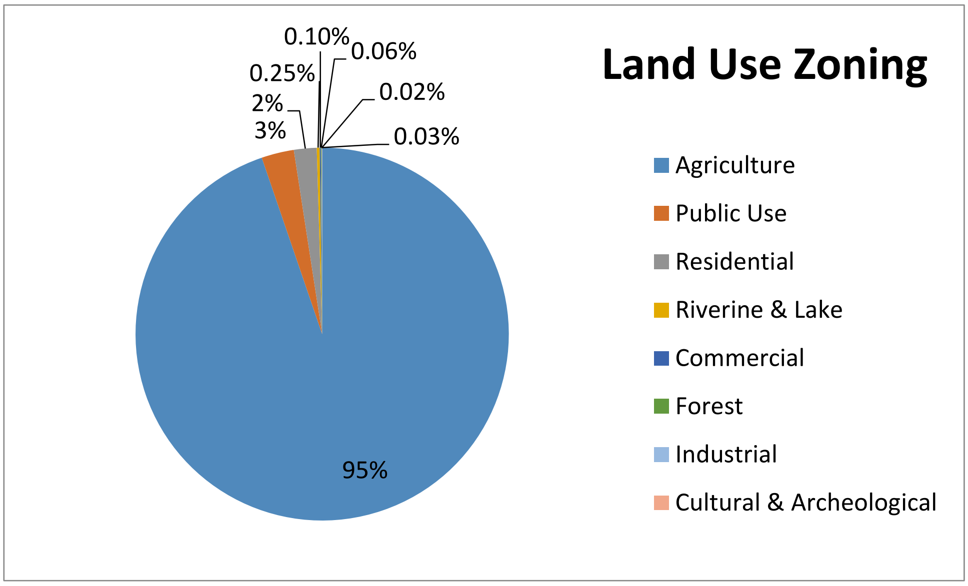

Figure 4.3: Area of cadastral parcels under various land use zones

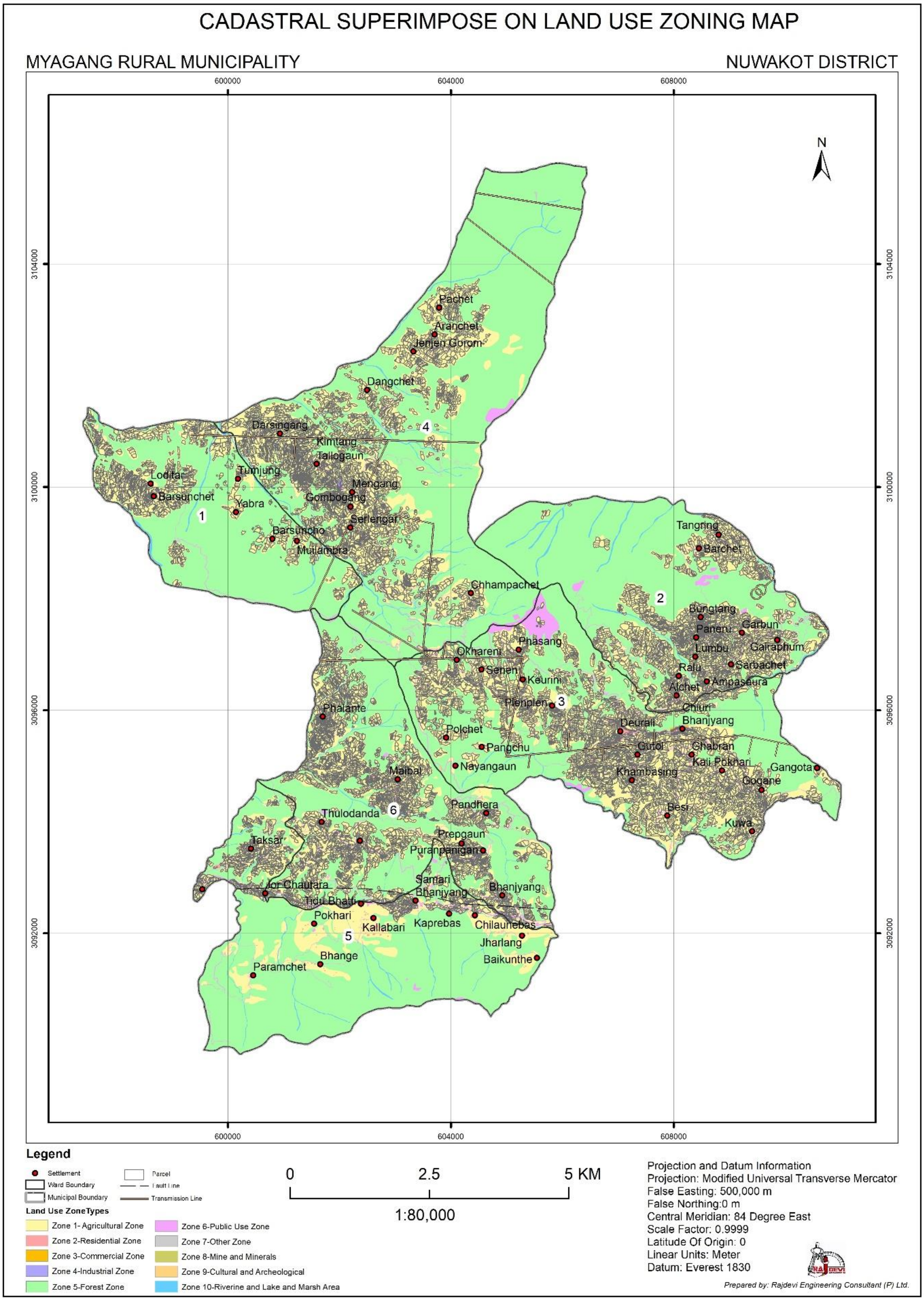

Figure 4.4: Cadastral parcels superimposed on land use zone map

Out of the total 2820 ha of land parcel, currently 2802 ha remains constant. A total of 18 ha of the agricultural parcels have been converted 2 ha to Residential, 14 ha area into Public service land use class. The new characteristics of the Municipality/Rural Municipality is now more homogeneously structured, and looks to be restructured with sufficient allocation for commercial use, preserving in the same time the parcels and areas under public use (Table 4.3).

Table 4.3: Parcel characteristics of present land use and land use zoning superimposition

Land use/Zoning	Total Parcel	AREA_H	Percentage
AGR/AGR	19345	2671.64	94.75
PUB/PUB	734	64.97	2.30
RES/RES	1095	53.28	1.89
AGR/PUB	114	13.65	0.48
HYD/HYD	82	7.02	0.25
COM/COM	94	2.60	0.09
AGR/RES	59	2.26	0.08
FOR/FOR	14	1.71	0.06
AGR/IND	5	0.89	0.03
RES/PUB	15	0.65	0.02
CULARCH/CULARCH	9	0.65	0.02
AGR/COM	6	0.21	0.01
FOR/PUB	2	0.03	0.001
COM/PUB	1	0.01	0.0005
Total	**21575**	**2819.58**	**100.00**

CHAPTER5: CONCLUSIONS

5.1 Conclusions

Due to discrepancies in the administrative area attributes during the cadastral survey and present time, one of the initial problems was the identification of appropriate cadastral map sheets. Appropriate documentation of cadastral map sheets is also lacking. In addition to this, cadastral survey has yet to be done for the areas like forest, river basins etc. The situations of land might be changed considerably at present that at the time of cadastral survey and those changes have not been accommodated in the cadastral system. Another situation is the study area cadastral surveying and mapping has not been integrated with national geodetic control network which led to a tremendous effort in geo-referencing and integration with the available satellite image data and present land use zoning dataset. It's important to minimize the errors overlaying satellite image and digital cadastral data.

5.2 Recommendations

The following are some of the recommendations drawn from the present study that could be helpful in future:

- There is the need of appropriate documentation of administrative area attributes during the cadastral survey and present time.
- Cadastral survey has yet to be done for the areas like forest, river basins etc. The situations of land are changed considerably at present than that at the time of cadastral survey and those changes have not been accommodated in the cadastral system.
- Another cadastral surveying and mapping need to be integrated with national geodetic control network.

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PROFILE

Preparation of Profile Report
Myagang Rural Municipality of Nuwakot District

This document is the output of the consulting services entitled **Preparation of Rural Municipality/Local unit level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Rural Municipality/Local unit Profile for Land use zoning and Superimpose of Cadastral Layers) **maps, database and reports**, awarded to **Rajdevi Engineering Consultant (P) Ltd.** by Government of Nepal, Ministry of Land Management, Co-Operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division(TSLUMD) in Fiscal Year 2077-078. This package (08) includes, twelve local units of Nuwakot district (Belkotgadhi, Bidur, Tarkeshwar municipalities and Dupcheshwor, Kakani, Kispang, Likhu, Myagang, Panchakanya, Suryagadhi and Tadi rural municipality), five local units of Lalitpur district (Lalitpur, Mahalaxmi municipalities and Bagmati, Konjyosom and Mahankal rural municipality), four local units of Bhaktapur district (Bhaktapur, Changunarayan, Madhyapur-Thimi and Suryabinayak municipality) and ten local units of Kathmandu district (Budhanilkantha, Chandragiri, Dakshinkali, Gokarneshwor, Kageswori Manohara, Kathmandu, Kirtipur, Nagarjun, Tarakeswor and Tokha municipality) and this report covers **Myagang Rural Municipality.**

The area coverage of Local unit of this package used and analyzed for different purpose under the scope of work of this consulting service are computed from cadastral maps provided by DOLIA Office, Government of Nepal, Ministry of Land Management, Cooperatives and Poverty Alleviation of Nepal. Therefore, the area of Local unit may match to the area computed from Topographic Digital Database provided by the Survey Department of Nepal.

ACKNOWLEDGEMENT

The **Rajdevi Engineering Consultant Pvt. Ltd**. is highly obliged to Government of Nepal, Ministry of Land Management, Co-operatives and Poverty Alleviation, Topographical Survey and Land Use Management Division (TSLUMD), for awarding the project **Preparation of Rural Municipality/Municipality Level Land Resource Maps** (Present Land Use Map, Soil Map, Land Capability Map, Risk Layer Map, Land Use Zoning Map and Cadastral Layer Superimpose and Rural Municipality/Municipality Profile)**, database and reports, Package 08 of Kathmandu, Bhaktapur, Lalitpur and Nuwakot district**. The consultant and the team members would like to extend special thanks to **Mr. Prakash Joshi**, Director General of Survey Department, **Ms. Karuna KC** (Deputy Director General) for the positive supports during the project period. Similarly, the consultant and the team members would also like to highly acknowledge the overall supports of **Mr. Prakash Dulal** (Survey Officer) for their supports during the project period.

The consultant and team members would like to thank **Mr. Aasha Tamang**(Chairman) and **Mr. Pawan Kumar Pyakurel**(Chief Administrative Officer) the local people, members of the different political parties and staffs of the Rural Municipality and local institutions of **Myagang Rural Municipality of Nuwakot District** for providing their valuable time to the study team in discussing different aspects of the project. Without their support this work could not have been completed.

Similarly, the consultant is highly obliged to Mr. Vijay Thakur for his sincere field work and mapping of forestry within the Rural Municipality/Municipality under study. In the same way, Mr. Hom Jyoti Adkhikari (Environmentalist), Mr. Rajan Pudasaini (Geologist), Mr. AwadhNarainYadav (Agriculture Expert) and Mr. Ashim Ratna Bajracharya (Land Use Planner) worked diligently in their own specialized area. Special thanks go to soil scientists Dr. Shree Chandra Shah together with the team of soil sample collector (Surendra Prasad Yadav) for their tedious and untiring tasks at the field. Thanks are due to Mr. Kamal Sah and Mr. Mohan Prasad Gautam for their excellent job as Remote Sensing and GIS experts. Similarly, the inputs of Mr. Gokarna Prasad Gyawali in collecting the socio-economic information from the concerned Rural Municipality/Municipality and preparing Rural Municipality/Municipality profiles are highly appreciable. Support staffs Mr. Devanand Chaudhary worked diligently in different capacities to make the project work successful. The consultant would like to thank all the team members as well as Team leader **Dr. Shobha Shrestha,** for the successful completion of the project work as per the ToR and the Specification, 2019.

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CHAPTER 1: AN OVERVIEW OF THE MYAGANG RURAL MUNICIPALITY

1.1 Naming and Origin of the Rural Municipality

Myagang Rural Municipality is one of the major Rural Municipality of Nuwakot district, in the Bagmati zone, Bagmati province of Nepal. People started to settle here from ancient period. According to the local old aged people, the name of this Rural Municipality was kept from the name of Myagang which means archery hill in Tamang language i.e. mya means arrow and gang means hill which attributes historical, religious and cultural importance. Myagang Rural Municipality is situated in the central part of the Nuwakot district.

It is situated in the central-west part of the district. The total area of the municipality is 97.83 km^2 (9783.49 ha) and comprises 6 administrative wards. The project area boundary was readjusted during restructuring of local bodies in 2073 BS by annexing five former Village Development Committees (VDCs) namely, Barsunchet, Kimtang, Deurali, Bumtang and Samari. Geographical extension of the Local unit ranges from 84^0 59' 26'' to 85^0 17'16'' East longitude and 27^0 55'25'' to 28^0 04'02'' North latitude. It is bordered by Bidur Municipality and Kispang rural municipality in the east, Dhading district in the West, and North, and Bidur municipality and Tarkeshwor rural municipality in the south. The north western part is dominated by higher elevation topography and while central and southern part has gentle slope. The altitude of the municipality ranges from 205 m to 3071 m from the mean sea level. Climate is variable due to altitude variation and ranges from sub-tropical to temperate types. Most of the higher hill slope area is covered by forest whereas lower slopes and valley floor is dominated by agricultural land and settlements. Kintang Khola,Thopal Khola, Samari Khola etc. are major rivers flowing through the project area.

1.2 Location

The Rural Municipality occupies 97.83 square km. stretching long from east to west. It borders Bidur Municipality and Kispang Rural Municipality in the east, Dhading District in west and North and Bidur Municipality and Tarkeshwor Rural Municipality in the South. This Rural Municipality is around 25 kilometers away from the Bidur, Nuwakot and is well connected to the road network.

The total population of the municipality as per the census 2011 is 13,484 comprising 6,064 male population and 7,420 female population with 3,390 households. An average household size is 3.97 which is lower than the national average household size i.e. 4.88 (CBS, 2074). However, the population growth rate is negative with -1.17 % which is largely due to out-migration. Population is not evenly distributed and varies by wards due to controlling factors such as slope, infrastructure and availability of agricultural lands etc. The population density is 138 persons per Km^2.

This area is inhabited by different castes and ethnic groups. Among them, Tamang is dominant with 85 percent followed by Kami occupying 5 of the total population. The total literacy rate of population of 5 years and above, is 54.02 percent of which male literacy constitute 61.73 percent and female literacy constitute 47.79 percent. People of the project area are engaged in various economic activities for their living and around 70 percent of the total population is engaged in agriculture.

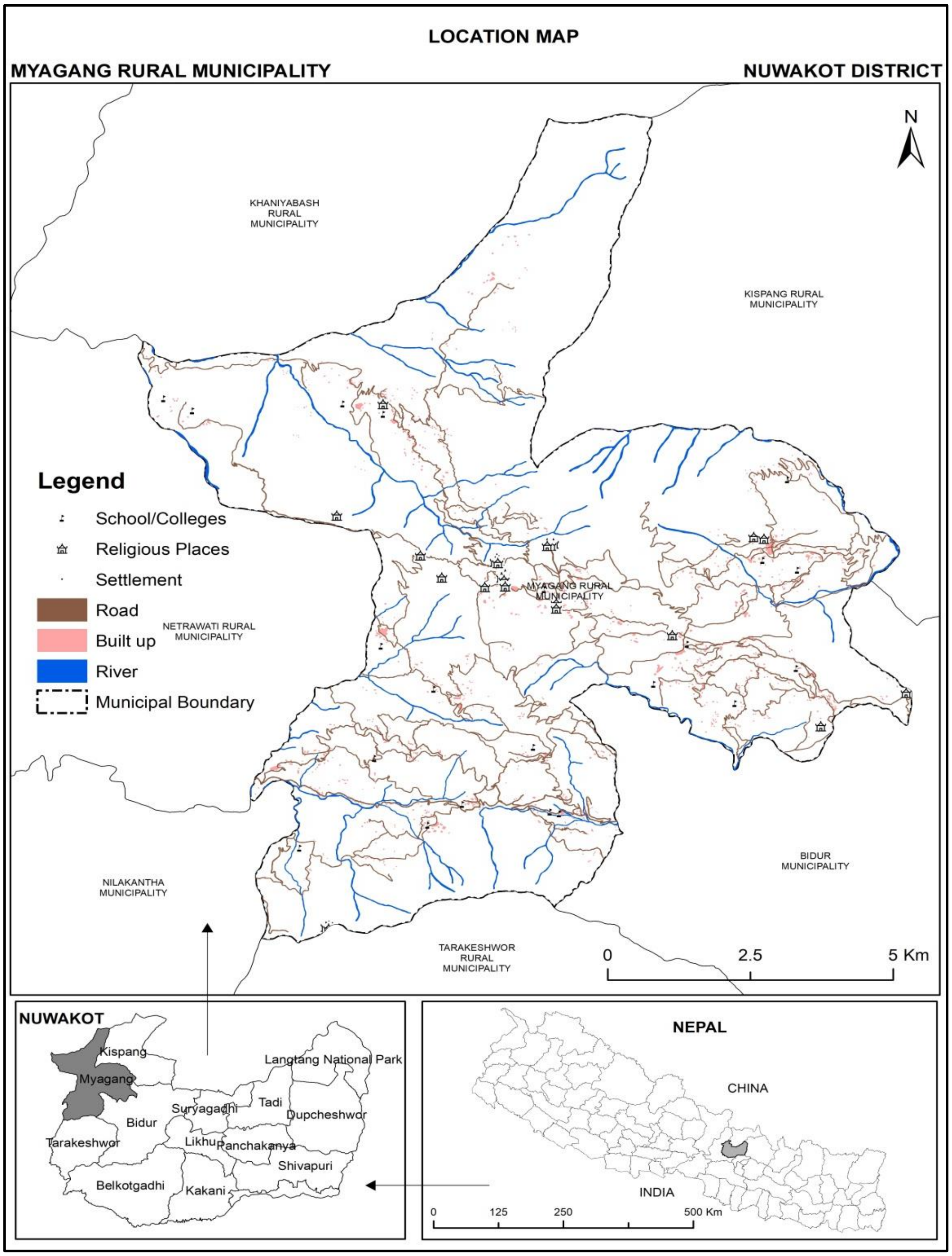


Figure 1.1: Location Map of Myagang Rural Municipality

1.3 Settlements and Administrative Units

Myagang Rural Municipality is a large village situated in the mid-part of the Nuwakot district of Bagmati province. The Rural Municipality consists of 6 wards and covering an area of 97.83 km2. However, all the wards of the Rural Municipality vary in an area and population size. Ward number three has the largest population size with 1005 households and ward number one has the smallest population size of with 118 households. Major settlements of the city are presented in Table 1.1.

Table 1.1: Settlements of Myagang Rural Municipality

Ward No.	Major Settlements	Household (CBS 2011)
1	Gumbadada, Basunchet	118
2	Bustang, Thulo Gaun, Barchet, Sarbachet, Parigaun, Ralu, Alchet, Lumbu, Gadirafum, Khampagoyo, Khomelo, Dodo, Sanen, Tetichen	599
3	Chiuri Bhanjyang, Mane Bhanjyang, Gogane, Thulogaun, Rato dada, Plenplen	1005
4	Kimtang, Gunam, Bhyanggaun, Thlangje, Danjel, Manetar, Namangpang	459
5	Samari Bhanjyang, Kallabari, Bhagi Taksar, Bhabrang	546
6	Pokhari, Maibal Mathillo, Bhaibal Taloo, Falot, Padhera, Puranpaani Bhanjyang	661
	Total	3388

Source: CBS, 2011

The wards are not equal in terms of number of households. The total population according to CBS (2068) of this Rural Municipality is 13,479 people residing in 3388 households. The ratio of male to female population is 0.82 and size of house hold is 3.98.

2.1 Physiography

Dhital (2015) classified Nepal Himalaya together with Terai into the longitudinal geological zones from south to north (Gansser, 1964; Fuchs and Frank, 1970; Stöcklin, 1980). This includes Terai and Bhabar zone, Siwaliks and intermontane basins, Lesser Himalaya, Higher Himalaya and Tethys Himalaya respectively. The main geological sub-divisions are Terai or Active Himalayan foreland basin, Siwaliks (Sub-Himalaya), Lesser Himalaya (Lesser Himalayan Sequence), Higher Himalaya (Greater Himalayan Crystalline Complex) and Tethys Himalaya which are also referred as the major sub-divisions by Yin (2006) of the North Indian Sequence (Brookfield, 1993).

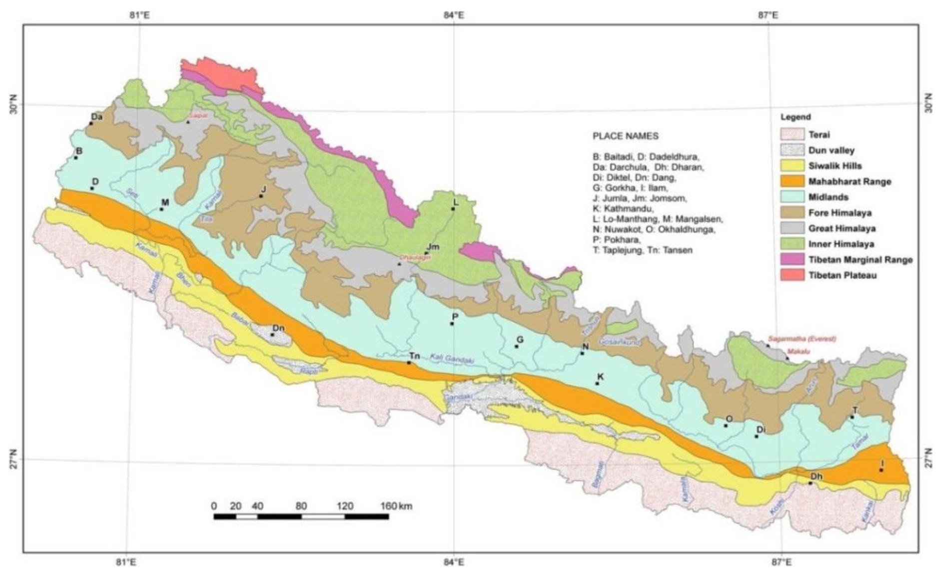


Figure 2.1: Physiographic divisions of Nepal Himalaya (*Source,* Dhital, 2015, Modified from Hagen, 1969).

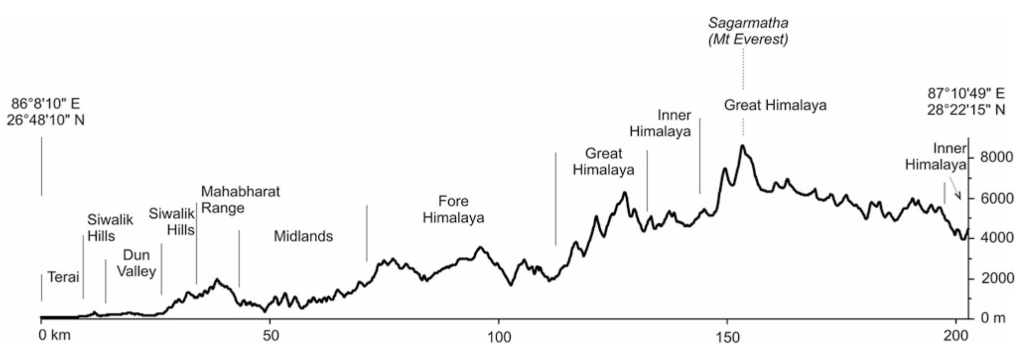


Figure 2.2: Profile of the Nepal Himalaya through east Nepal and position of physiographic regions (Dhital, 2015).

Based on these studies, Dhital (2015) has proposed geological divisions into the following six transverse physiographic regions incorporating watersheds of the major river systems as

- Mahakali-Seti region
- Karnali-Bheri region
- Gandaki region
- Bagmati-Gosainkund region
- Koshi region
- Arun-Tamar region

2.2 Geomorphology

The study area is located in the Midland region of Lesser Himalaya inside the Bagmati Province in the hills of the Gandaki River Basin and represented with the presence of nine hills. It is represented with different climatic zones such as upper tropical, subtropical, temperate, subalpine, alpine and nival with the elevation ranged from the lowest 300 m up to the highest more than 5,000 m. Amidst, half of the land is occupied with subtropical zone. The Trishuli River one of the major rivers of Saptagandaki passes through mid-part of Nuwakot. The study area is hence comprised of moderate to steep hill slopes, river valleys, terrace deposits, forests and cultivated lands. The formation of soil in this region is due to deep weathering of metamorphic rocks together with current and ancient river deposits formed as terraces. The river valley is also fed with red soil deposits on the foothills obtained due to local damming of river due to ancient geological events in the form of lacustrine deposits. The agro-economics are generally formed on river terraces and along the gently dipping slopes of colluvial and residual soils respectively.

Dendritic drainage pattern is formed around the Nuwakot District fed by the Trishuli River, the Betrawati River and Tadi Khola. The Trishuli River flows from north to south while the Tadi Khola flows from northeast to south where confluence of both rivers meet at Devighat. The Betrawati River runs from northeast to southwest and made conjunction with the Trishuli River at Betrawati Bazar. Proceeding the Salankhu Khola flows from northwest to southeast and intersct with the Trishuli River around 1 km north of Betrawati Bazar. On the other hand, the Mailung Khola flows from northwest to southeast and meet with the Trishuli River at Mailung Bazar. As a consequence, the drainage patterns are controlled by geological distribution and quite responsible to form river terraces, lacustrine deposits during damming of rivers and mixed alluvial and colluvial soils suitable for agricultural purpose in the area.

2.3 Geology

The Myagang Rural Municipality is located in the Lesser Himalayan rocks of the Bagmati-Gosainkund region which is comprised of a relatively wide portion of the Great Midland Antiform in the inner zone between Nuwakot and Dhunche. The Lesser Himalayan rocks are differentiated into two complexes named as Nawakot Complex and Kathmandu Complex (Stöcklin and Bhattarai, 1977 and Stöcklin, 1980). The Kathmandu Complex is overlain on the Nawakot Complex and differentiated each other by the Mahabharat Thrust (MT). The study area is comprised of Proterozoic Era rock sequences representing phyllite, amphibolite, metasandstone and schist. Two different types of geological formations and units of different geological time represent the entire municipality with the coverage of 9783.49ha area. Lithostratigraphy of the municipality represents Ranimatta Formation (Rm) and Ulleri Formation (Ul) of Dailekh Sub Group of Midland Group. The brief characteristics of each geological formation are described in the following sub-sections in detail.

Ranimatta Formation (Rm)

The Ranimatta Formation (Rm) in the Myagang Rural Municipality belongs to Dailekh Sub Group of Midland Group. It is composed of grey greenish grey gritty phyllites grilstones with conglomerates with white massive quartzites in the upper parts. Basic intrusions are noted.Robang is a member of Ranimatta Formation which consists of white quartzites intercalated with phyllites. The areal coverage of the formation in the area is 9518.37ha.

Ulleri Formation (Ul)

The Ulleri Formation (Ul) in the MyagangRural Municipality belongs to the formation of augen gneisses, muscovite biotite gneisses and feldspathic schists. The areal coverage of the formation in the area is 265.12ha.

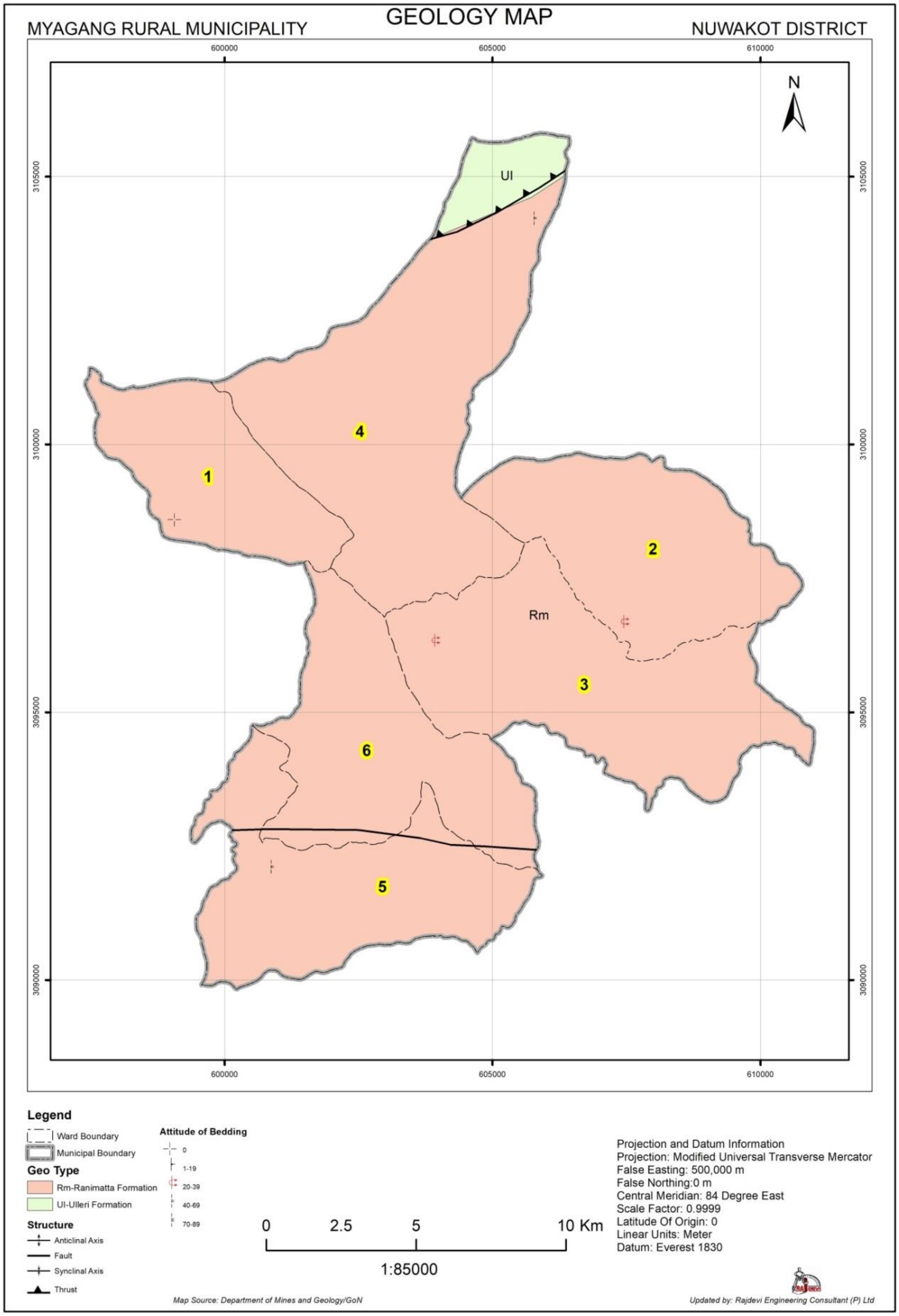


Figure 2.3: Geology map of Project area

2.4 Drainage

There are many rivers flowing in the project area. There are also other small streams and rivulets flowing from the project area which includes Sarakhu khola, Chhap khola, Bhanjyang khola, etc. (Figure 2.4). These rivers are very shallow in winter but during rainy season, they are extremely big. Due to rain, water from streams, canals and other rivulets mixed to these rivers and sometimes it inundates massive alluvial soil and sand as well. They are also the source of irrigation water to major crops.

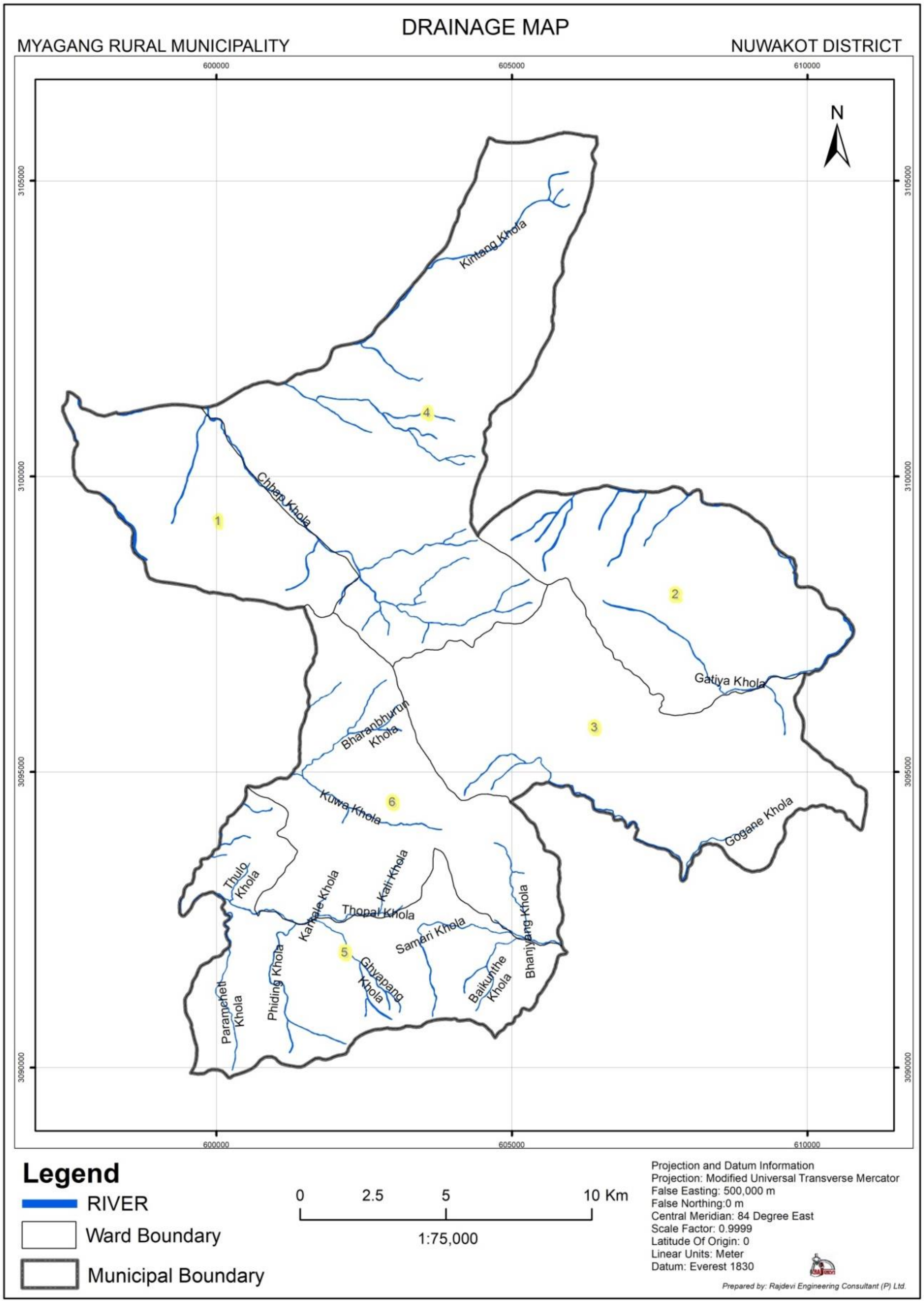


Figure 2.4: Drainage Network map of Project area

2.5 Terrain

2.5.1 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 impacts vegetation type. From the slope map it could be revealed that Myagang Rural municipality has large ranges of slope. It is almost sloppy and most of the area has more or less similar variation in slope. However, the slope ranged from moderate to very highly steep slope (5% to more than 30%) as shown in the map below.

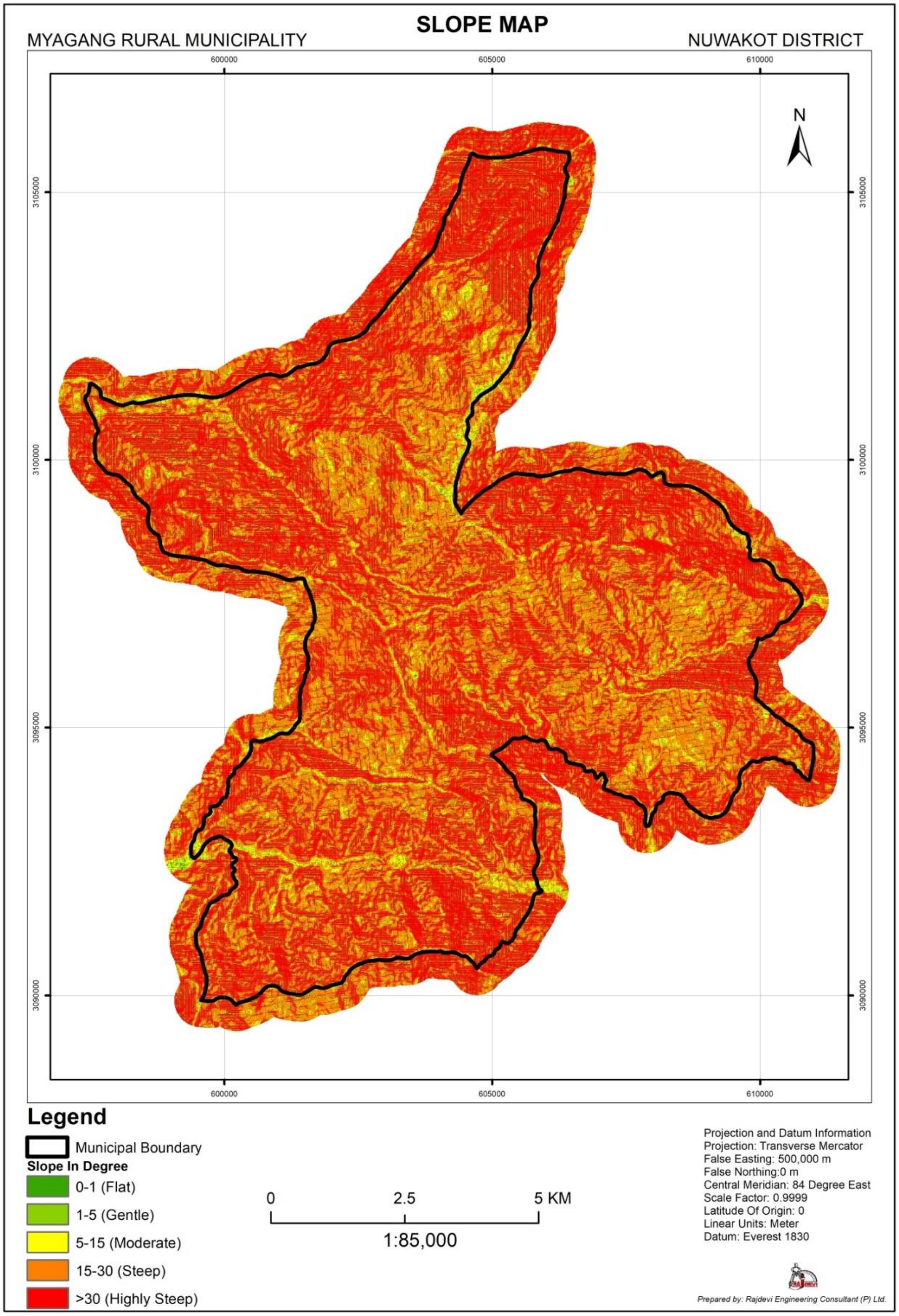


Figure 2.5: Slope Map of the Myagang Rural municipality

2.5.2 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 Myagang Rural municipality ranges from as high as 722 m to 3202 m AMSL as shown in the Figure 2.6.

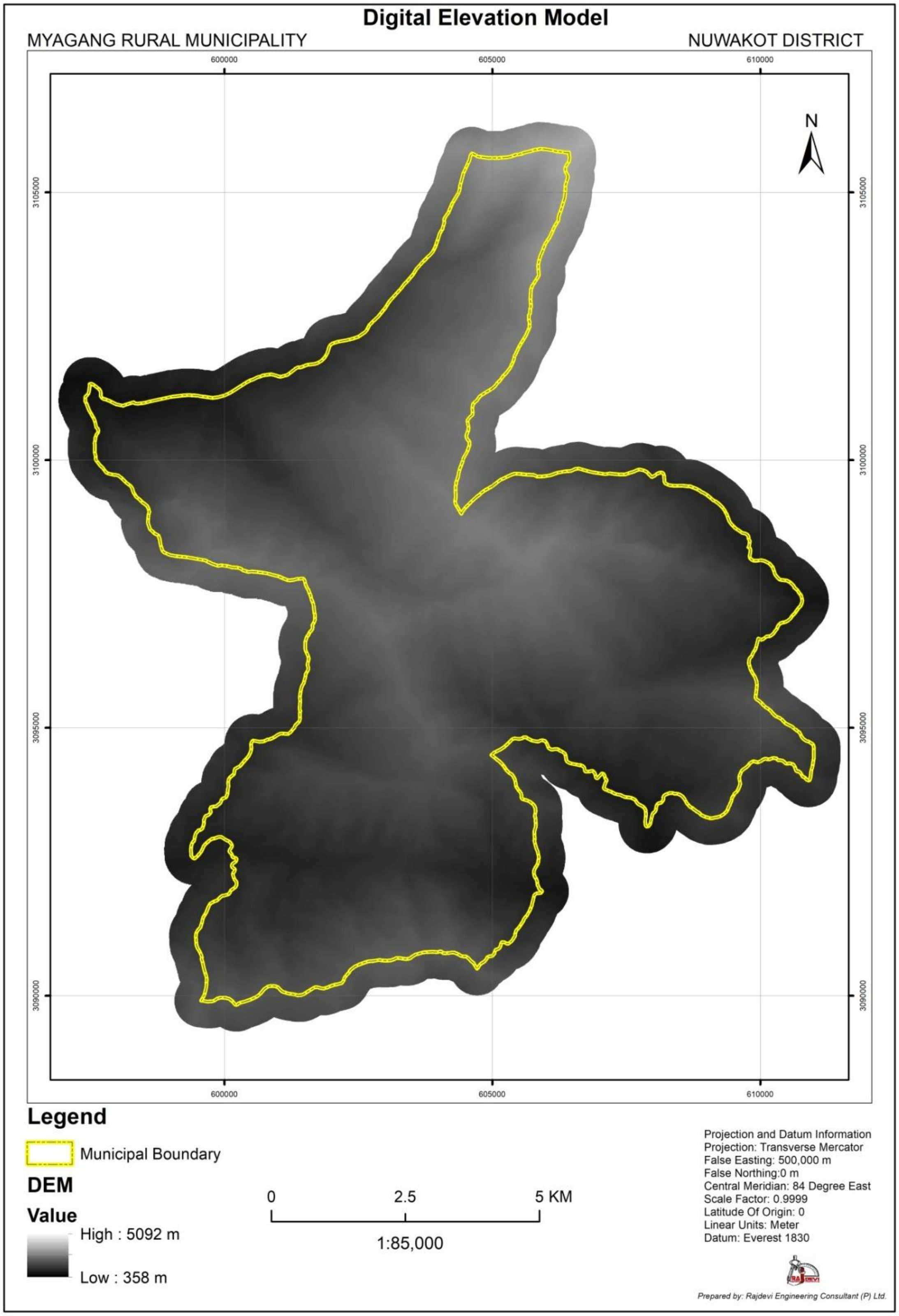


Figure 2.6: DEM Map of Myagang Rural municipality

2.6 Climate Data

Soils tend to show a strong geographical correlation with climate. Sunlight 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, like other local units of hill, is warm temperate. This climate has three distinct seasons. Dry summer season begins in the month of March when the sun starts to move northward from the equator. It lasts till the middle of May when mean minimum temperature reaches up to 16.34^0Celsius (Table 2.1) and mean maximum temperature is nearly 29.62^0 C (Table 2.2). Rainy season starts from the month of May last and ends in September. The amount of rainfall that occurred in this season is about 1295mm (Table 2.3) whereas the mean annual precipitation is only 129 mm. Roughly speaking winter season begins in the month of November 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 2.7 below reveal the maximum and minimum monthly average temperature (2010-2019). Slightly higher temperature is observed in the month of June and it remains active till September. However, the maximum temperature exceeds 28 degrees from April and reached till 30 degrees in June and there is slight decrease in average maximum temperature from October. Extreme cold starts from October last and last till first week of April. The area is less than 7degree Celsius for 3 months and it also experience freezing cold from November last till February. There is about 9 to 15 degree mean difference in daily maximum and minimum temperature as shown in Tables 2.1 and 2.2 and Figure 2.8.

Table 2.1: Minimum Temperature in ^{0}C (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	3.1	4.8	10.9	13.9	16.8	19.5	20.6	20.6	19.2	14.9	9.9	2.9	13.09
2011	2.4	5.3	8.8	11.9	16.2	19	20.5	20	19.1	14.2	9.5	4.1	12.58
2012	2.7	5.2	8.4	13	16	20.1	20.6	20.2	19	12.7	6.5	4	12.37
2013	1.6	6.1	10.1	12.4	17.1	20.1	20.4	20.2	18.9	15.9	7.7	4.8	12.94
2014	3.9	5.6	9.1	11.9	16.4	20.1	20.9	20.6	19	13.7	10.1	4.8	13.01
2015	4.4	7	9.9	12.6	16.6	19.7	19.8	20.1	18.9	13.7	9.5	4.3	13.04
2016	4	6.3	10.3	14.2	16.2	19.5	20.4	20.1	19.3	15.5	8.5	5.8	13.34
2017	3.2	6.8	9.4	13.4	16	19.6	20.4	20.4	19.3	15.4	9	5.4	13.19
2018	3.2	7	10.1	13.2	16.3	19.3	20.7	20.2	19.2	12.4	7.8	4.3	12.81
2019	3.6	6.1	8.4	13.8	15.8	19.3	20.3	20.6	19.1	14.9	11	4.5	13.12
TOTAL	**32.1**	**60.2**	**95.4**	**130.3**	**163.4**	**196.2**	**204.6**	**203**	**191**	**143.3**	**89.5**	**44.9**	**129.49**
Av	**3.21**	**6.02**	**9.54**	**13.03**	**16.34**	**19.62**	**20.46**	**20.3**	**19.1**	**14.33**	**8.95**	**4.49**	**12.95**

Source: Department of Hydrology and Meteorology

Table 2.2: Maximum Temperature in^{0}C (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	22.3	23.2	29.2	31.9	30.3	31.1	29.5	29.2	28.6	28	24.8	20.8	27.41
2011	19.6	23.8	27	28.7	28.9	29.4	28.6	29.5	28.4	28.1	22.4	18.9	26.11
2012	17.5	22.8	26.6	28.7	31.4	31.2	28.8	29.5	29.4	27.3	22.5	19.3	26.25
2013	18.9	23.8	28.1	29.3	30	30	29.4	29.6	29.8	26.6	22.6	18.8	26.41
2014	18.6	20.9	25.8	29.6	29.7	30.5	29.6	29.3	28.4	26.5	21.9	20.1	25.91
2015	20.2	22.2	24.7	26.4	30.6	31.4	29.5	29.1	29.4	27.2	23.6	18.8	26.09
2016	18.3	23.4	27	31.2	28.9	29.2	28.1	30	27.9	27.4	23.5	20.8	26.31
2017	19.3	23.7	24.1	28.2	28.2	29.9	29.3	29.2	29.7	28	23.6	20.8	26.17
2018	18.5	22.8	26.8	26.2	27.6	29.4	29.5	28.8	29.4	26.3	22.7	18.7	25.56
2019	18.1	20.8	25.1	27.3	30.6	30.7	28.8	30.5	27.4	26.5	23.7	18.1	25.63
TOTAL	**191.3**	**227.4**	**264.4**	**287.5**	**296.2**	**302.8**	**291.1**	**294.7**	**288.4**	**271.9**	**231.3**	**195.1**	**261.84**
AV	**19.13**	**22.74**	**26.44**	**28.75**	**29.62**	**30.28**	**29.11**	**29.47**	**28.84**	**27.19**	**23.13**	**19.51**	**26.18**

Source: Department of Hydrology and Meteorology

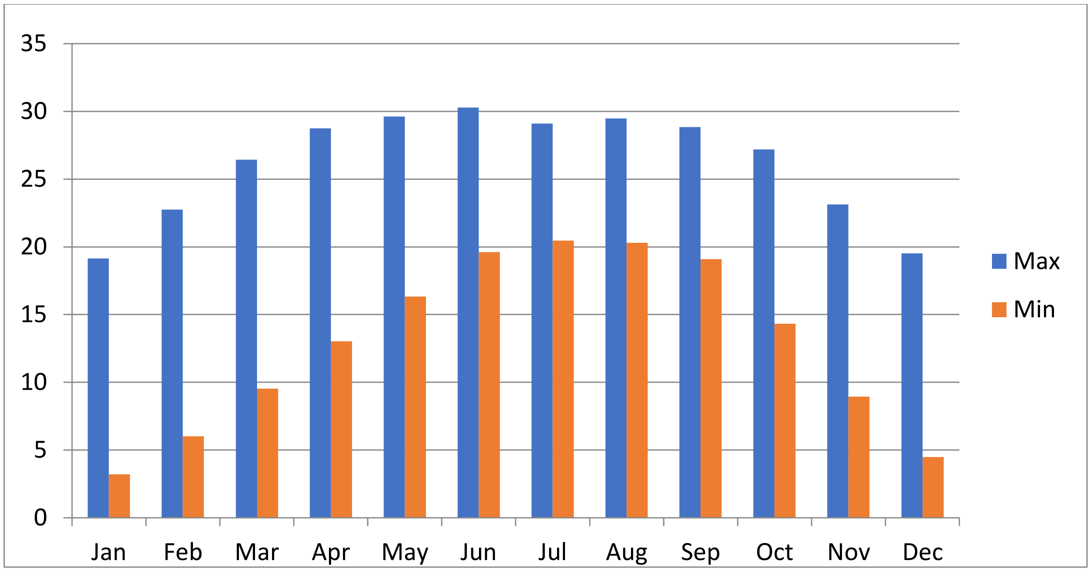


Figure 2.7: Maximum and Minimum Monthly Average Temperature (2010-2019)

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. In ploughed soils, with rainfall the clods are broken down to smaller particles. The physical structure of the soil changes with rainfall. Even chemical properties are enhanced. The concentration of N or acid in rainwater influences the chemical properties of soil. Biological properties are also enhanced with soil moisture. Thus rainfall or annual precipitation affects soil physical, chemical and biological properties of soil. There is no any definite trend of raining. It rains all over the year and sometimes it remains dry for long time. Rainfall most occurs in July and August. Maximum raining is recorded in the month of July and August reaching only 78 and 81 mm in average respectively. Due to the effect of climate change, these days there is erratic rainfall and drought. 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 2.8.

Table 2.3: Average Rainfall (in mm) (Kathmandu, 2010-2019)

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	1.9	23.3	35.7	45.3	148	141.7	354.9	486.3	217.1	24.5	0	0	123.23
2011	6.2	54.9	16.4	56.8	167.4	306	437.8	265.4	318	13	12.9	0	137.90
2012	17.8	41.8	15.6	80.1	42.2	149.2	452.3	289.6	362.2	13.2	0.7	0	122.06
2013	11.5	45.4	27.3	44.5	278.6	299.1	428.5	451.4	217.3	95.7	0	0	158.28
2014	4.2	26.7	58.7	6	153.5	165.8	461.9	294.5	279.4	91.2	0	36.7	131.55
2015	3.4	35.2	98.7	51	155.9	125.6	470.6	452	189.4	67.6	0	0	137.45
2016	0.4	25.3	6.3	11	92.3	370.2	477.8	126.8	281.7	91	0	0	123.57
2017	13.3	0.5	135	75.7	127.4	120.6	282.2	360.6	98.5	63.9	1.5	0.1	106.61
2018	6.1	1.5	27.7	148.8	154.7	240	408.9	402.8	126.6	11.9	0	0	127.42
2019	19.1	85.2	37.4	102.8	55.1	126.4	485.4	226.5	358	0	0	33.4	127.44
Total	**83.9**	**339.8**	**458.8**	**622**	**1375.1**	**2044.6**	**4260.3**	**3355.9**	**2448.2**	**472**	**15.1**	**70.2**	**1295.49**
Mean	**8.39**	**33.98**	**45.88**	**62.2**	**137.51**	**204.46**	**426.03**	**335.59**	**244.82**	**47.2**	**1.51**	**7.02**	**129.55**

Source: Department of Hydrology and Meteorology

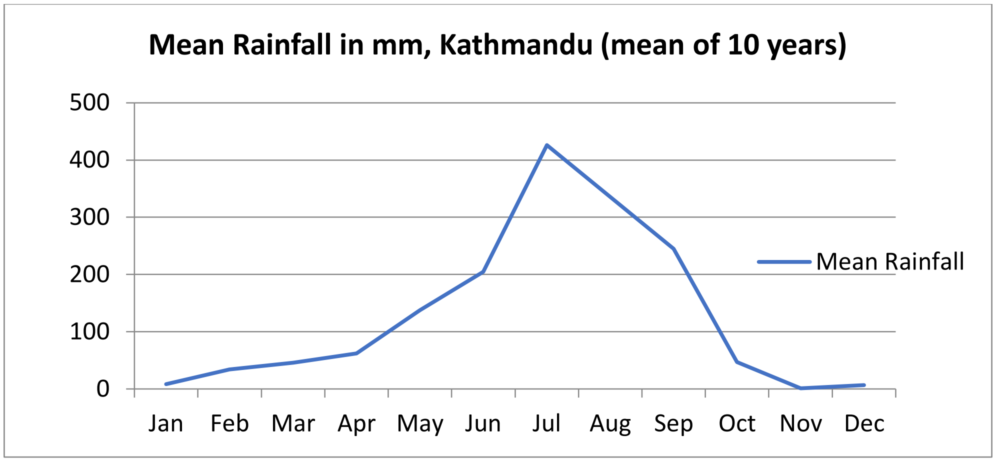


Figure 2.8: Mean monthly rainfall (2010-2019)

2.7 Forest and Biodiversity

This Rural Municipality lies between 84^0 59' 26'' E to 85^0 17'16'' E and 27^0 55'25'' N to 28^0 04'02'' N having an area of 9783.49 ha out of which 2622.97 ha is community forest area. The elevation range is 688 to 3188m. The elevation difference is 2500m.There are total 24 CFs. This Rural Municipality is surrounded by Dhading in the north, Tarkeshwar Napa, Bidur Napa in the south, Kispang Rural Municipality and Bidur Napa in the east and Dhading district in the west.

In this Rural Municipality ward no 1 (1 CF), 2(6 CF), 3 (4 CF),4(1 CF), 5(5 CF), 6(7 CF) have community forests only. At level 1 the forest type is natural and plantation i.e. mix..Climatic vegetation is Subtropical, Temperate and Sub alpine. Cover type is broad leaved, conifers and Bushes. Species types are Uttis, Sal, Katus, Chilaune, Sallo, khotesallo, Banjh, Gurans, Dhupi, Kafal, Jamun Nigalo etc. Crown cover density is sparse 40-70%. Forests are in mature class. All forests are community forests ownership category. , Fire, landslides, and erosion are the risks. Slope is steep i.e. more than 45%. Somewhere moderate steep also.

Major Species: are Uttis, Sal, Katus, Chilaune, Sallo, khote sallo, Banjh, Gurans, Dhupi, Kafal, Jamun Nigalo, Salla, Botdhangero, Pate sallaetc

NTFP: Amrisho, Ritha, Amala, Tejpat, Kurilo, Burans, Dhupi, Kafal. Harro, Barro, Chiraito, Timur, Majitho, Nagbeli, Lokta, Pakhanved, etc

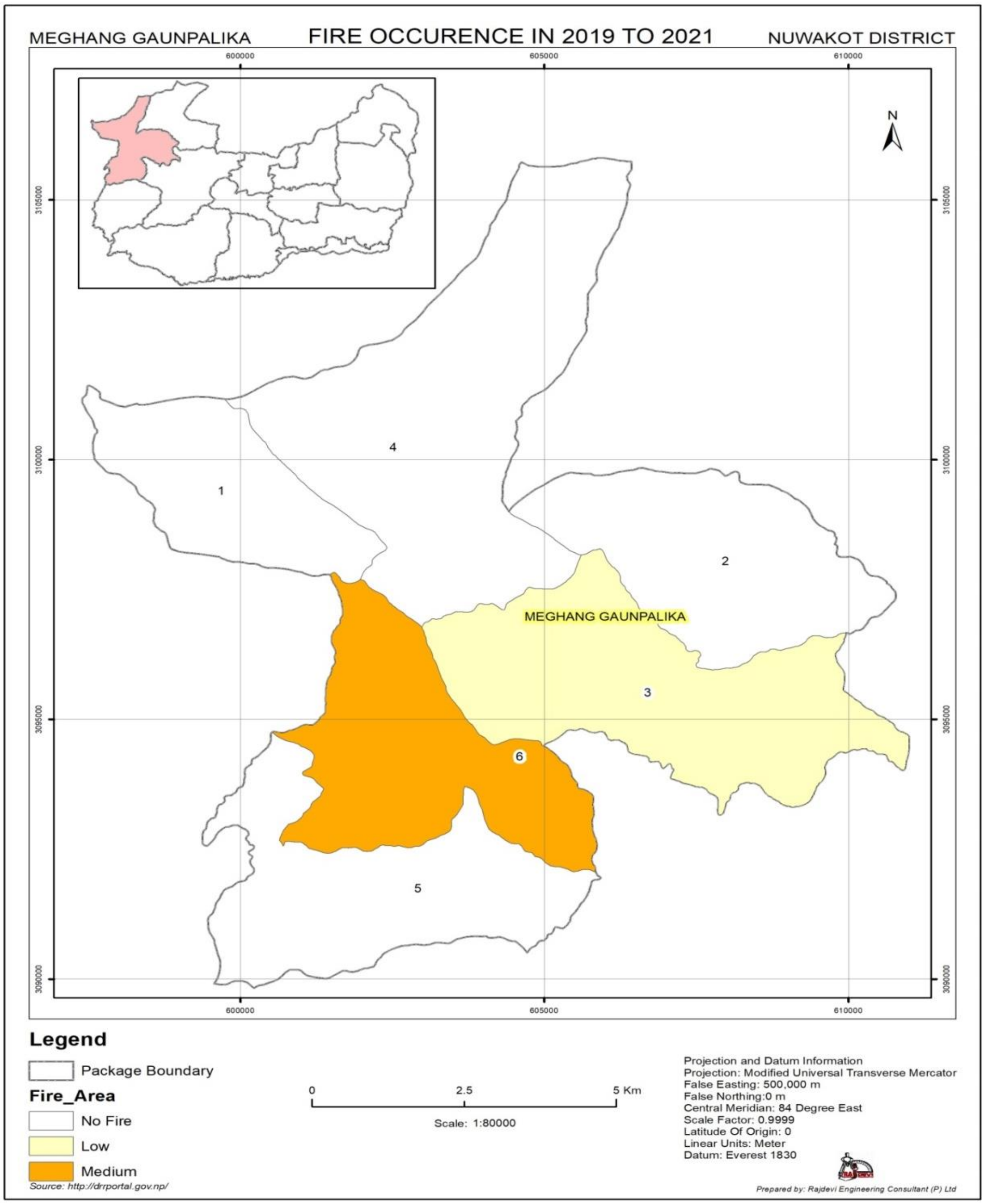
Biodiversity: Mrig, Bagh, Syal, Bandel, Jungali biralo, Charibagh, Ratuwa, Ghoral, Kasturi mrig, Bhalu, Shalak, Chhparo, Sarp, Chituwa, etc. Biodiversity is in increasing trend.

Fire:

The fire occurrence was found in ward no. 3 and 6 during 2019 and 2020 years. The fire table is given below.

S.No.	District	VDC/Municipality	Ward No.	Incident Place	Incident Date	Incident
1	Nuwakot	Myagong Rural Municipality	6	Bhanjyang	5/11/2019	Fire
2	Nuwakot	Myagong Rural Municipality	6	Pokhari	1/30/2020	Fire
3	Nuwakot	Myagong Rural Municipality	3	Deuraly	4/20/2020	Fire

Source: MOHA Gov. Nepal Drr fire portal.



The fire occurrence was found low in ward no 3 and medium in ward No. 6.

2.8 Natural Hazards and Environment

The spatial distribution patterns of settlements in Myagang Rural Municipality mostly consist of scattered arrangement in the form of agricultural village areas and clustered settlements in market areas. Settlements in Pangjyu and Naya Basti (Ward no. 3) lie adjacent to forests. The inhabitants of the Rural Municipality are managing natural resources mostly as community forest in which plants such as Sal (*Shorea robusta*), Chilaune (*Schimaa wallichii*), Siris (*Alibizia spp*), Mauwa (Engelhardia spicata) and Uttis (*Alnus nepalensis*) and Gobresalla and wild animals such as Chari Bagh (Leopard cat),Chitu wa (Common Leopard), Dhedu (Langur Monkey), Porcupine (*Hystrix Indica*), Fyauro(Fox), G horal, Kharayo, Squirrel (*Fuinambulas palmaurum*), Mal samproo (Yellow throated marten; *Martes flavigula*), Jackal (*Canis aureus*), Barking deer (*Muntiacus munjak*), Rhesus Monkey (*Macaca mulata*), Cat (Felis chaus) are found. Human wildlife conflict is also commonly observed in the Rural Municipality. Out of the 9755 ha of total land, forest covers 6166 ha of land constituting 63.2% of the total land of the Rural Municipality.

Rural population in the Rural Municipality generates mostly organic waste which is used to prepare organic manure. Burning of solid waste is also observed in the Rural Municipality. In environmental and health perspective, burning of waste is not desirable and should be replaced with more appropriate method. Such method includes 4 R principles: Reduce, Reuse, Recycle, and Recover. The final reduced amount of the waste after applying 4R principle should be disposed in environmentally friendly manner in appropriate waste disposal location.

The Rural Municipality offers infrastructure and facilities related to transportation, education, health service, electricity, water and sanitation. Despite the richness in natural resources, use of traditional methods of agriculture in the Rural Municipality has resulted in under exploitation of natural resources. Even the agriculture lacks irrigation and fertilized land due to which farmers are unable to get enough production.

Due to the fragile geological condition, occasional but prolonged and high-intensity rainfall, and various anthropogenic factors, Myagang Rural Municipality has a high risk of landslide and flooding. The presence of numerous gullies and resulting erosion is mainly taking place in south facing hill slopes. Further, the construction of the rural road has also caused the occurrence of landslides. The presence of a number of landslides and bank erosion sites within the Rural Municipality has increased the probability of water induced disaster in the area.

Flood, landslide, fire, and thunderbolt are the major hazards that the Rural Municipality is exposed to. There are multiple incidents associated with these hazards affecting a number of households and destroying property. Previously, settlements in Kimtang (Ward no. 4), Deuri (Ward no. 3) had been displaced due to landslide event.

Farmers of the Rural Municipality use organic as well as inorganic fertilizers such as DAP, Urea and pesticides. Due to the lack of proper awareness, the incorrect application of such chemicals negatively affects agricultural practice as well as soil productivity. As the majority of land consisted of agricultural land, water runoff, a non-point source of pollution, carries these chemicals from agricultural fields into the local water sources. Besides, illegal fishing by using pesticides in streams is polluting streams. The government and other concerned stakeholders should focus to timely provide technical knowledge on adopting good agriculture practices.

The problem of such indirect source of pollution has been further exacerbated for direct source of pollution, i.e., the practice of solid and liquid waste disposal directly by the local businesses, although of small scale, as well as individuals to the water sources without any treatment especially in conglomerated settlements along the roads. Air pollution is caused by fugitive dust from vehicles movements particularly over unpaved roads and grounds, and some constructions activities. Gas emissions come from household cooking, open burning, and moving vehicles. Emissions from these sources are scattered/spread apart both in terms of locations and timing.

Besides, there is a lack of segregation of medical infectious waste produced by local health centers (Barsunchet Health Post, Bungtang Health Post, Deurali Health Post, Kingang Health Post, Samari Health Post and Thap Samari Health Post) from domestic, non-infectious waste. This practice can be hazardous or potentially harmful to the community because when medical wastes are mixed with domestic wastes, the combined wastes also become infectious as there is the presence of dangerous chemicals, pharmaceuticals in medical wastes. The practice of burning solid waste has been observed in these health care facilities.

CHAPTER 3: SOILS AND LAND CHARACTERISTICS

3.1 Land System and Soil Characteristics

3.1.1 Land System

Land system is the theoretical unit of land that is classified mainly with the consideration of bio-physical factors. Land after their classification, they are brought to the economic use. LRMP (1986) has classified land under the land system into seventeen major land system types ranging from the land next to river water body of Tarai to the mountain top. Of the total land system classes, Tarai is divided into 3 classes, Siwalik region into 5 classes, Middle mountain region into 3 classes, High mountain into 3 classes and High Himalaya into 2 classes. The land system classes, respective sub-divisions and description are presented in Table 3.1.

Table 3.1: Land system classes

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
3a	Alluvial fan complex, upper piedmont(erosional), very gentle slopes
3b	Alluvial fan complex, upper piedmont(erosional), gentle slopes
3c	Alluvial fan complex, upper piedmont(erosional), undulating
3d	Alluvial fan complex, upper piedmont(erosional), highly dissected
7	Moderately to steeply sloping hilly and mountainous terrain
8	Steeply to very steeply sloping hilly and mountainous terrain
9a	Alluvial plains and fans(depositional), river channel
9b	Alluvial plains and fans(depositional), alluvial plains
9c	Alluvial plains and fans(depositional), alluvial fans
10a	Ancient lake and river Terrace called Tars (Erosion), non dissected
10b	Ancient lake and river Terrace called Tars (Erosion), dissected
11	Moderately to steeply sloping mountainous terrain
12	Steeply to very steeply sloping mountainous terrain
13a	Alluvial plains and fans, active alluvial plains
13b	Alluvial plains and fans, recent alluvial plain
13c	Alluvial plains and fans, fans
13d	Alluvial plains and fans, ancient alluvial terraces
14a	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, moderate to steep slopes
14b	Past glaciated mountainous terrain below upper altitudinal limit ofarable agriculture, very steep slopes (>30)

Land Units	Descriptions
15a	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, moderate to steep slopes
15b	Past glaciated mountainous terrain above upper altitudinal limit of arable agriculture, very steep slopes
16a	Alluvial,ColluvialandMorainal Depositional surfaces, glacio-alluvial plains
16b	Alluvial,ColluvialandMorainal Depositional surfaces, morainal deposits
16c	Alluvial,ColluvialandMorainal Depositional surfaces, alluvial colluvial fans
16d	Alluvial,ColluvialandMorainal Depositional surfaces, colluvial gans
17a	Steeply to very steeply sloping mountainous terrain, shallow till or colluviums over bedrock
17b	Steeply to very steeply sloping mountainous terrain, rock headwalls

Source: LRMP, 1986

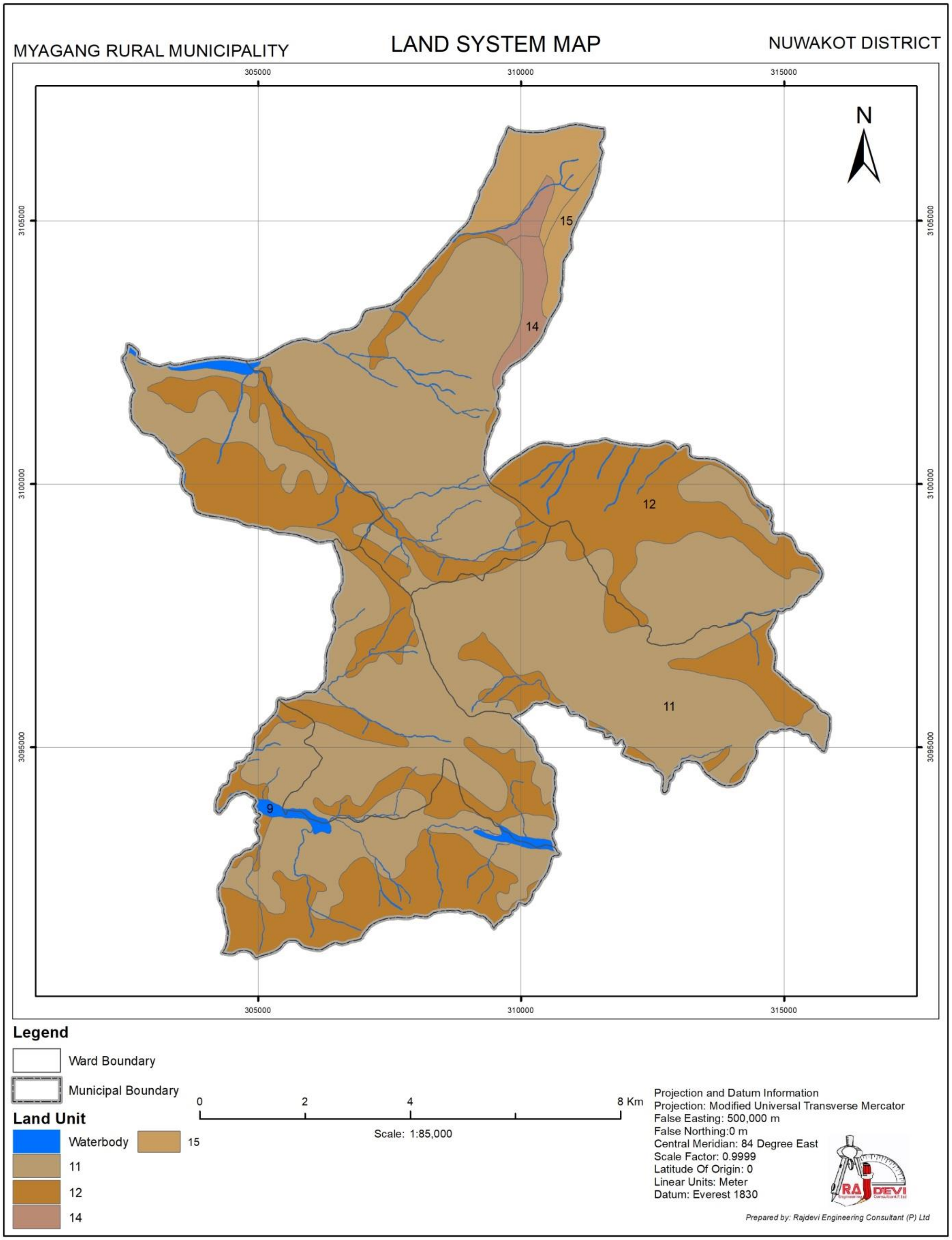


Figure 3.1: Land System Map of Myagang Rural Municipality

3.1.2 Soil Characteristics

Soils of Project area of Nuwakot district 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 Project area.

Table 3.2: Soil Taxonomy Classification of Project area

Order	Sub-order	Great Group	Sub Great Group	Area (Ha)	Percentage
ALFISOLS	USTALFS	HAPLUSTALFS	LITHIC HAPLUSTALFS	10.03	0.10
			TYPIC HAPLUSTALFS	1133.82	11.59
INCEPTISOLS	ANTHREPTS	HAPLANTHREPTS	TYPIC HAPLANTHREPTS	4435.16	45.33
	AQUEPTS	HAPLAQUEPTS	MERIC HAPLAQUEPTS	118.42	1.21
	OCHREPTS	DYSTOCHREPTS	TYPIC DYSTOCHREPTS	943.27	9.64
	UMBREPTS	HAPLUMBREPTS	LITHIC HAPLUMBREPTS	152.24	1.56
			TYPIC HAPLUMBREPTS	2879.09	29.43
Water body				111.45	1.14
Total				**9783.49**	**100.00**

In general, only Inceptisols and Alfisols were found in Project area along with five sub-orders, five great soil groups and seven sub-groups of two orders from the soil survey investigation in Project area of Nuwakot District. Inceptisols is most extensively found in Project area. These types of soils are found in the entire country and covers extensive areas of land. Inceptisols are comparatively older and used for cultivation quite for some time.

Anthrepts, Aquepts, Umbrepts and Ochrepts are the major sub orders found within Inceptisols. Among the greatgroups of Inceptisol, this Municipality has Dystrochrepts, Haplaquepts, Haplanthrepts and Haplumbrepts. In alfisols, only Ustalfs sub orders were found and Haplustalfs great group are available. Typic haplustalfs and Lithic haplustalfs were the sub great group observed during the study.

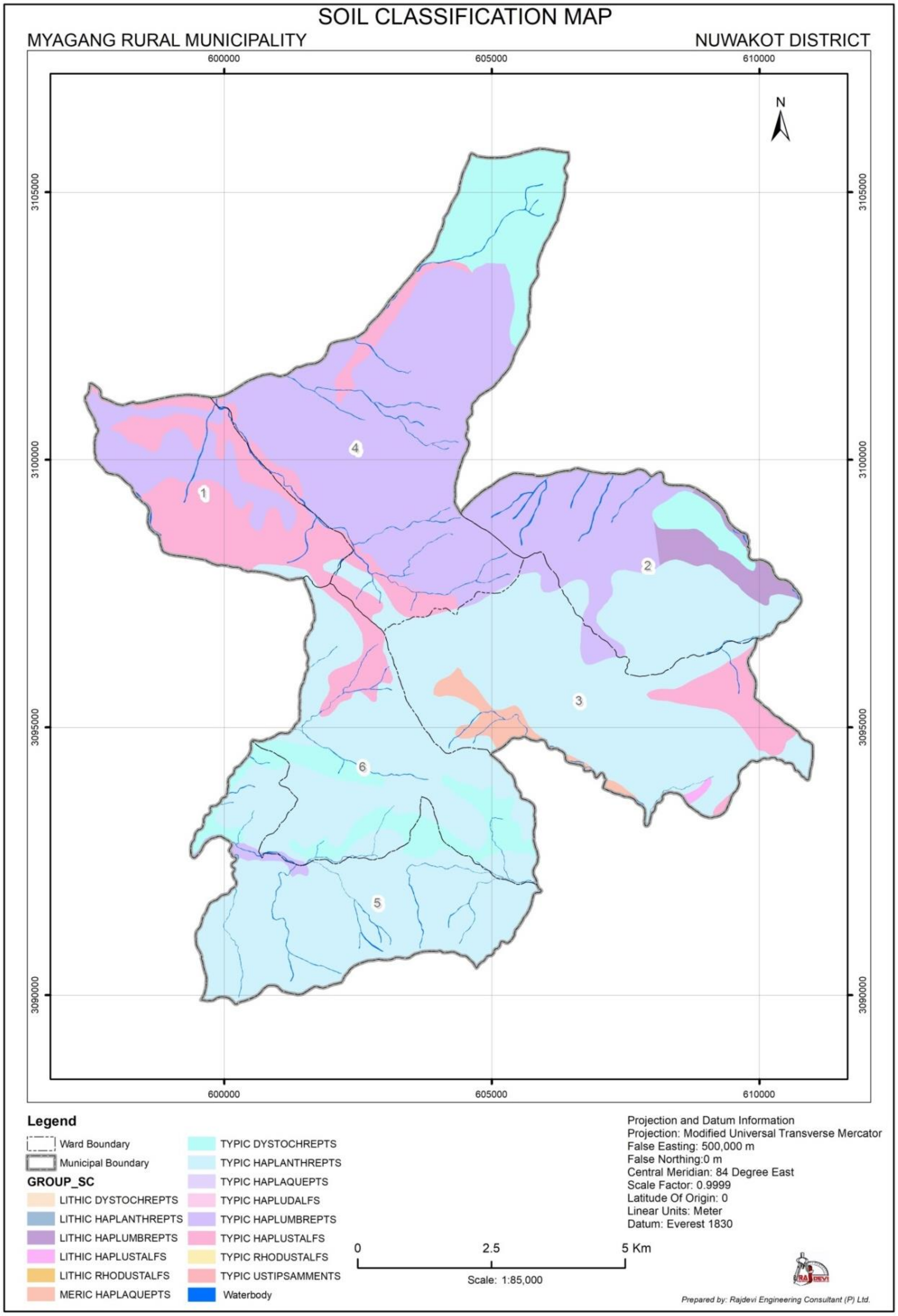


Figure 3.2: Soil map of Project area

3.2 Land Capability

The capability classification in Myagang Rural 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 3.3 and Figure 3.3). Land capability symbol is indicated by Class, its climate is denoted by A/B/C. The climate of the hilly region is humid/perhumid region indicated by h/p. Most of the land area in this municipality has gentle slope to steep slope and ununiformly distributed. Having good soil properties but many limitations including soil depth (moderate depth) this land is classified as Class III, V and VI. Altogether 11 different land capability classes were observed in the study area. Class V land is dominating and it is almost 89% and Class III occupies 4% while class VI occupies 7% of the total area. The total area of Myagang Rural Municipality is 9783.5 ha and out of which forest covers 55%, Agricultural land occupies 41%, residential area covers 0.73%, public use occupies 1.6% area of the Municipality as shown in table 4.0. Other areas are present in least amount. Commercial area occupies 0.03%, riverine, lake and marsh area occupies 1.2%, Cultural and archeological area occupies 0.01% and other area occupies 0.64% of the total area of the Municipality. Land which is not used for agriculture is not assigned the capability class (Table 3.3).

Table 3.3: Land use and Land Capability Classes

S.N.	Description	Area (Ha)	Percentage
1	Agricultural	4014.51	41.03
2	Commercial	3.24	0.03
3	Cultural And Archeological	0.86	0.01
4	Forest	5357.17	54.76
5	Industrial	0.06	0.001
6	Other	62.93	0.64
7	Public Use	156.10	1.60
8	Residential	71.35	0.73
9	Riverine, Lake And Marsh Area	117.29	1.20
	Total	**9783.49**	**100.00**

The total land of Myagang Rural Municipality is 9783.5 ha. This Municipality has 11 different land capability classes as described below.

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 IIIAh/2: This type of land covers only 34.35 ha of the total land of project area and it covers an area comprising 0.35%. This type of land is moderately suitable for diversified crops.

Class IIIAh/5: This type of land covers only 235.5 ha of the total land of Myagang Rural Municipality and it covers little area comprising 2.41%. This type of land is non-arable due to seasonal inundation.

Class IIIAh/6: This type of land covers only 111.45 ha of the total land of Myagang Rural Municipality and it covers little area comprising 1.14%. This type of land is non-arable due to complex topography.

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 VAh/1Rtd: This type of land covers 109 ha of the total land of Myagang Rural Municipality and it covers area comprising 1.12%. This type of land is highly suitable for diversified crops and rice but has topographic and drainage deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/1t: This type of land covers 3105.99 ha of the total land of Myagang Rural Municipality and it covers area comprising 31.75%. This type of land is highly suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/2t: This type of land covers 1514.79 ha of the total land of Myagang Rural Municipality and it covers area comprising 15.48%. This type of land is moderately suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAp/1t: This type of land covers 118.4 ha of the total land of Myagang Rural Municipality and it covers area comprising 1.21%. This type of land is highly suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/1te: This type of land covers 24.35 ha of the total land of Myagang Rural Municipality and it covers area comprising 0.25%. This type of land is highly suitable for diversified crops but has topographic and erosion deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VAh/2t: This type of land covers 3772.3 ha of the total land of Myagang Rural Municipality and it covers area comprising 38.56%. This type of land is moderately suitable for diversified crops but has topographic deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

Class VBp/1t: This type of land covers 53.75 ha of the total land of Myagang Rural Municipality and it covers area comprising 0.55%. This type of land is highly suitable for diversified crops but has topographic and erosion deficiency. Since it falls in class V, it restricts its use for agriculture and forestry.

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 VIAh/2t: This type of land covers 703.25 ha of the total land of Myagang Rural Municipality and it covers area comprising 7.19%. This type of land is moderately suitable for diversified crops but has topographic deficiency with shallow soil depth and steep slopes.

The laboratory analysis of soil of this Municipality would be more helpful in making decision of the soil producing capacity. The soil reaction of Project area varies from 4.5 to 7.29 ranging from very highly acidic to neutral. Mean soil reaction of the area is 5.3 that fall under the category of strongly acidic, which is fairly suitable for most of the crops. Almost all soils of Project area were within the strongly acidic range that is fairly suitable for most local crops. The soil pH being moderately acidic, macro and micronutrients will be in available form. Vegetables and most food crops can be grown in such type of soil but with adequate care. However, for commercial farming and gaining higher productivity, liming should be done in most areas with proper care.

The organic matter content of the soil ranged from 0.17 to 10.93%. Mean organic matter content of the sampled soil is 4% which falls under the category of medium. Most of the soils of Project area are under the category of medium organic matter content. However, there are places with critically very low organic matter content in the area. 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 local unit ranged from 0.01 to 0.55% which falls under the category of very low to very high. Mean N content of the soil is 0.2%, which is high 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 medium and high category. Care should be taken to grow crops with ample incorporation of organic manure in this area in order to obtain higher crop yield. Available phosphorus of the soils, in general falls within wide range and depending upon the soil types, it ranges from 7.73 to 19.33 kg/ha that falls in the category of very low to low. Mean Phosphorus content of the soil is only 12.8 kg/ha which is low and there may be problem of phosphorus in the soils of the study area in near future. But the amount of available potassium in the soils of Project area is low to high which ranged from 107 to 294 kg/ha. The mean value of the available potassium in the soil is 199 kg/ha which falls under the category of medium. Most of the soils contain high amount of available K. Most soil parameters of Project area were found to be in low range and soil pH seems to be critical for crop production. However, management efforts should be carried out in soils where critical situation appears. Soil nutrients and pH should be well managed in this area.

Majority of the soils of study area are sandy loam, loam and silty loam. Sandy loam type of soil is dominating in the study area. Based on the soil analysis report, it could be concluded that the soils of Project area is good enough for cultivating food and vegetable crops at the moment because of good soil type but all nutrients are scarce in the soil. It is recommended to apply higher amount of fertilizer as they are in low range along with liming.

In a nutshell, Myagang Rural Municipality possesses eleven different land capability classes with the following properties as described in Table 3.4.

Table 3.4: Land Capability Classes

S.N.	Land capability classes	Area (Ha)	Percentage	Description
1	IIIAh/2	34.35	0.35	Subtropical, humid, moderately suitable for diversified crops
2	IIIAh/5	235.50	2.41	Subtropical, humid, non arable due to seasonal inundation
3	IIIAh/6	111.45	1.14	Subtropical, humid, non arable due to complex topography
4	VAh/1Rtd	109.32	1.12	Subtropical, humid, highly suitable for diversified crops and rice but has topography and drainage deficiency with restrictions to forestry and agriculture
5	VAh/1t	3105.99	31.75	Subtropical, humid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
6	VAh/2t	1514.79	15.48	Subtropical, humid, moderately suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
7	VAp/1t	118.42	1.21	Subtropical, perhumid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
8	VAp/1te	24.35	0.25	Subtropical, perhumid, highly suitable for diversified crops but has topography and erosion deficiency with restrictions to forestry and agriculture
9	VAp/2t	3772.30	38.56	Subtropical, perhumid, moderately suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture

10	VBp/1t	53.75	0.55	Warm temperate, perhumid, highly suitable for diversified crops but has topography deficiency with restrictions to forestry and agriculture
11	VIAh/2t	703.25	7.19	Subtropical, humid, moderately suitable for diversified crops but has topography deficiency with shallow soil depth and steep slopes
	Total	9783.49	100.00	

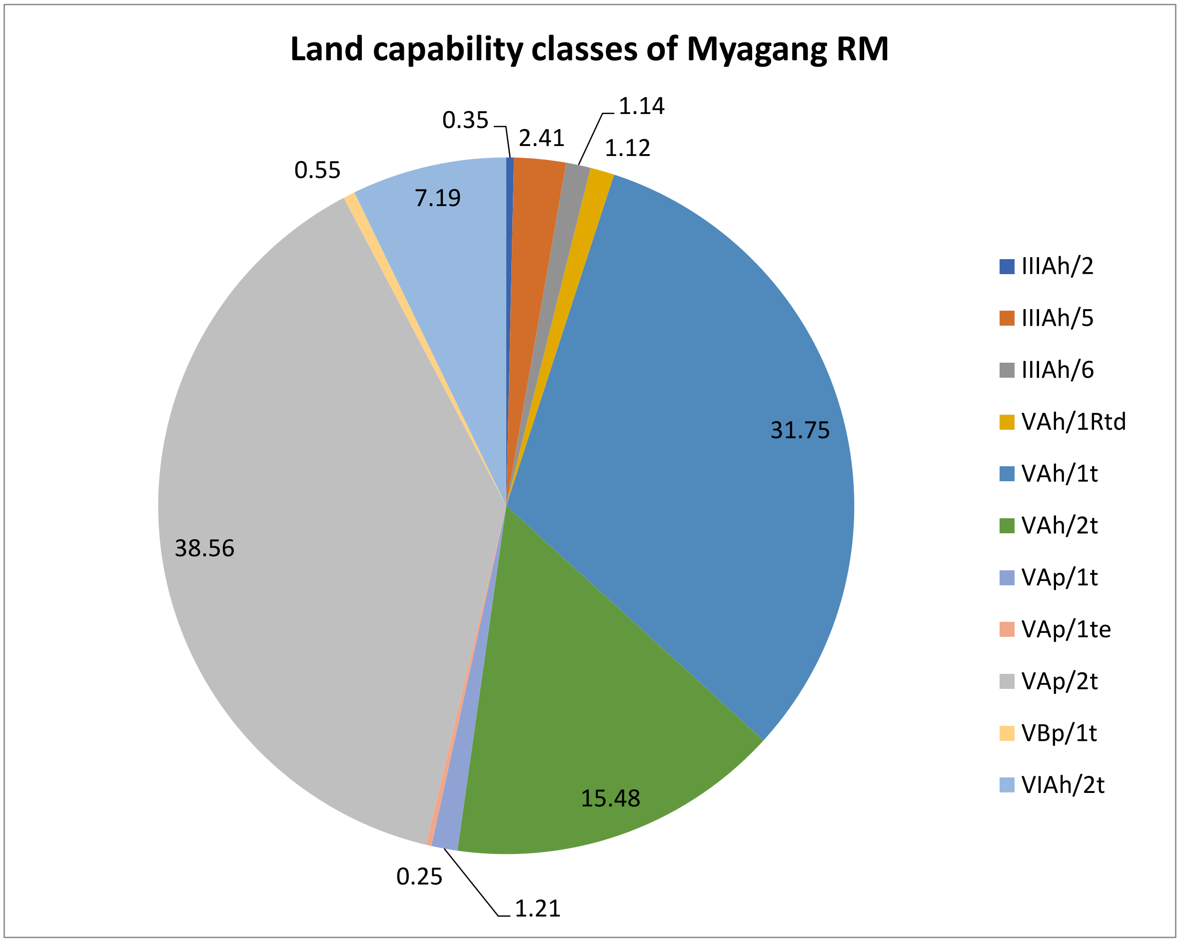


Figure 3.3: Land Capability Classes distribution of Myagang Rural Municipality

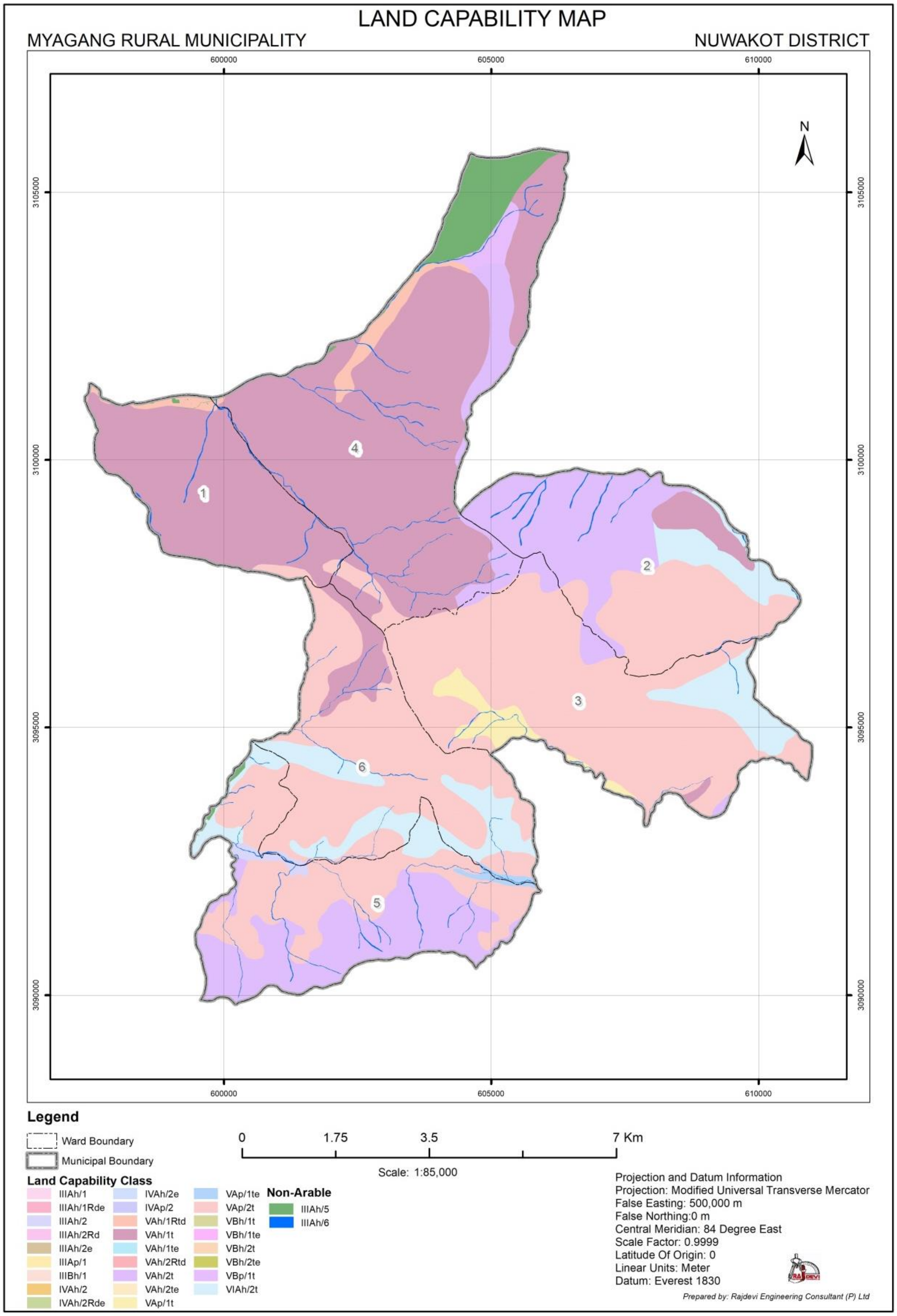


Figure 3.4: Land Capability Map of Myagang Rural Municipality

3.3 Present Land Use

The general land use pattern of project area exhibits nine major land use classes at level 1 identified by Land Use Act, 2076BS. The current classification is based on the National Level Specification for the Preparation of Rural Municipality/Local unit level Land Resource Maps, database and Reports, 2019 which identifies ten landuse classes at level 1. As characteristics of most of the Hill region, the largest share is of agriculture and forest. Forest is dominant land use covering more than 54 percent of the total project area. Agriculture occupies second place with more than 41 percent coverage of the total area which is followed by public use class comprising 1.6 percent. Residential use covers 0.73 percent. Besides residential use, commercial, industrial, cultural and archaeological and other use also occupies less than a percent of the total area. Riverine, lake and marsh covers 1.2 percent of the total area. The percentage share of each land use class at level 1 is shown in Table 3.5.

Table 3.5: Level 1 Land use hierarchy and area distribution

SN	Description	Area (Ha)	Percentage
1	Forest	5357.17	54.76
2	Agricultural	4014.51	41.03
3	Public Use	156.10	1.60
4	Riverine, Lake And Marsh Area	117.29	1.20
5	Residential	71.35	0.73
6	Other	62.93	0.64
7	Commercial	3.24	0.03
8	Cultural And Archeological	0.86	0.01
9	Industrial	0.06	0.001
	Total	**9783.49**	**100.00**

The project area covers more than 9783 hectares, among which forest covers more than 5357 hectares and agriculture use covers 4014 hectares. It is followed by public use area with 156-hectare area. Residential area covers 71 hectares. Riverine, lake and marsh area covers 117 hectares whereas industrial, and cultural and archaeological use occupies less than 1 hectare of total project area. Others category however, shares more than 62 hectares which comprises grazing, barren and landslide areas. Distribution of level 1 land use classes are shown in Figure 3.5 and Figure 3.6.

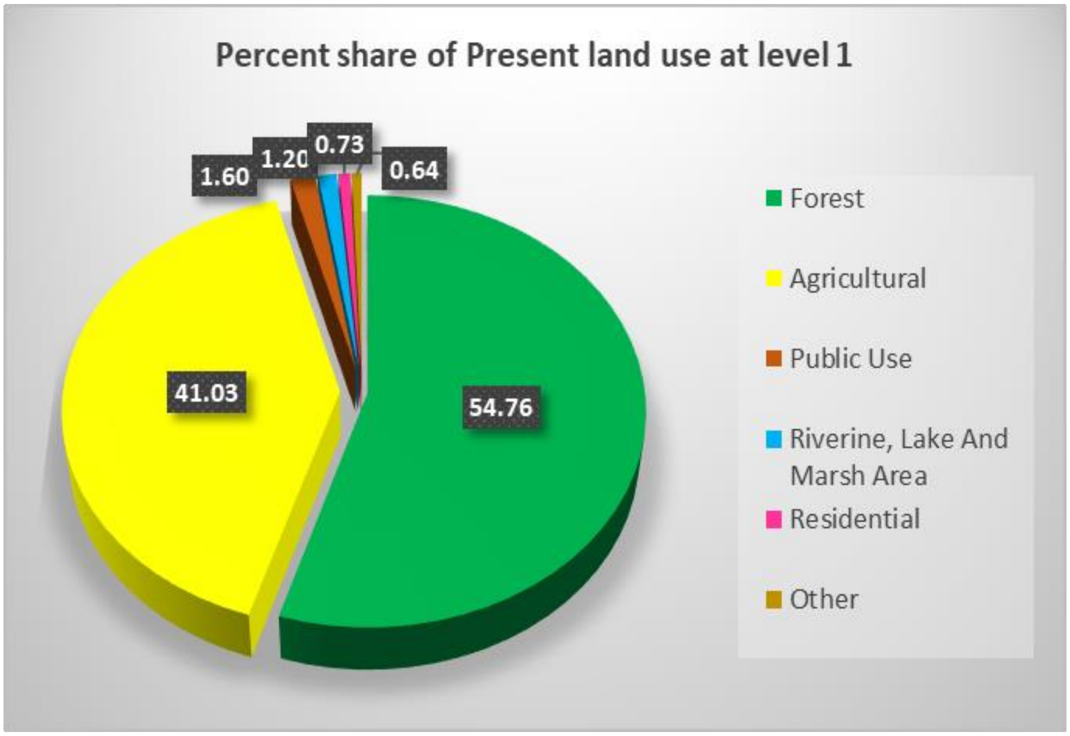


Figure 3.5: Distribution of present land use classes at level 1

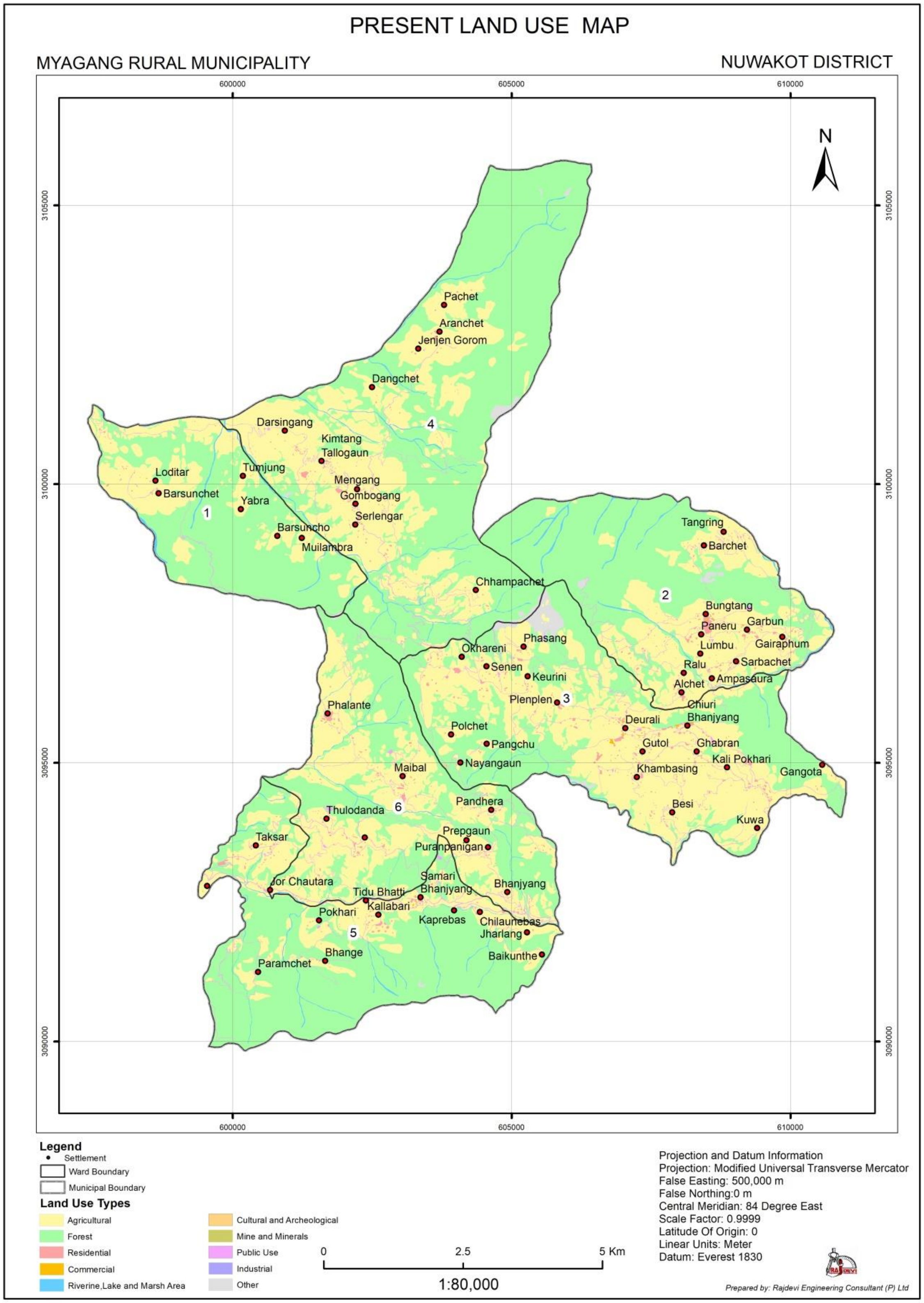


Figure 3.6: Present Land Use Map of Myagang Rural Municipality

3.4 Agriculture Pattern

Agricultural land use refers to areas which have been used for the production of agricultural products such as cereals, cash crops, orchards etc. Variation in distribution of agricultural land use is found due to variation in physiographic components, topography and cultural practices over the project area. Agriculture area of the project area lies under only hill cultivation at land use hierarchy level 2. At the hierarchical classification level 3, agricultural land use pattern is categorized as level terrace, level terraces upland cultivation, sloping terrace and sloping upland. More than 62 percent agriculture practices are carried out on level terraces and around 37 percent is carried out on sloping terraces. Whereas at level 4 classification, 37 % is under upland sloping terraces, and 34% is under level terrace Pakho land. More than 28% is under level terrace khet land cultivation. Table 3.6 and Figure 3.7 presents the distribution of agriculture land use at level 4.

Table 3.6: Agricultural Land Use Classification at Level 4

S.N	Description	Area (Ha)	Percentage
1	Level Terraces Khet Land Cultivation-Tk	1127.10	28.08
2	Level Terraces Upland/Pakho Land Cultivation-Tp	1399.48	34.86
3	Slopping Upland/ Pakho Land Cultivation-Cp	1487.93	37.06
	Total	**4014.51**	**100.00**

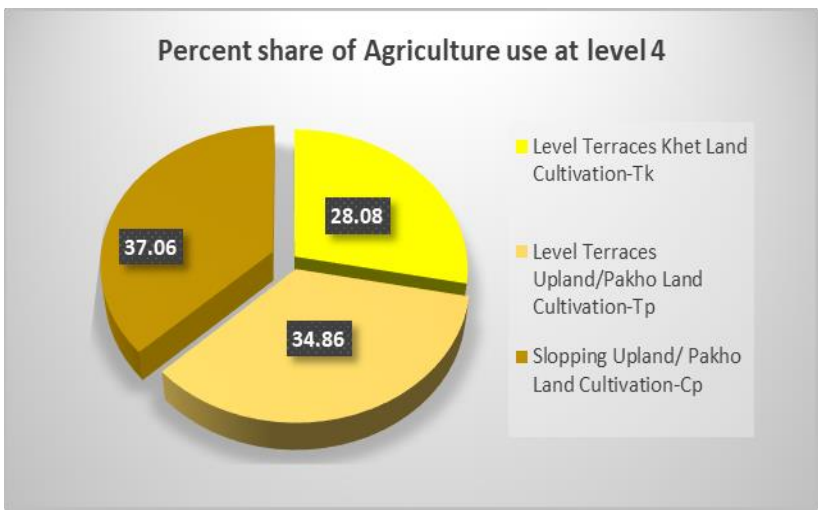


Figure 3.7: Distribution of Agriculture land use class at level 4

Regarding the cropping pattern (i.e. land use hierarchical classification level 5) dominant is food crops with maize-millet- rice-wheat and vegetables combination. Highest percent share is of maize-millet cropping pattern with more than 18 percent area. Shrubs from the non-forest area covers nearly 17 percent whereas rice-maize- vegetables combination covers 11 percent. Different combination of food crops with potato and vegetable area also found. Other combination comprises 3 percent. Cropping pattern under level 5 hierarchies is detailed in Table 4.3. No specific high value crops are found though some off-season farming is in practice.

Table 3.7: Agricultural Land Use Classification at Level 5

S.N	Description	Area (Ha)	Percentage
1	Maize-Millet-m7	757.67	18.87
2	Shrub from non-forest area-s3	701.14	17.47
3	Rice-Maize-Vegetable-r12	463.51	11.55
4	Cardamom-c2	460.05	11.46
5	Maize-Wheat-m5	399.56	9.95
6	Rice-Potato-r8	298.72	7.44
7	Maize-Potato-m8	220.21	5.49
8	Barley-Buck Wheat-b1	171.10	4.26
9	Rice-Wheat-r2	129.65	3.23
10	Barren Cultivable land-b5	126.57	3.15
11	Rice-Wheat-Maize-r15	57.78	1.44
12	Rice-Oilseed-r4	55.77	1.39
13	Rice-Maize-r10	41.50	1.03
14	Others	131.28	3.27
	Total	**4014.511**	**100**

3.5 Land Use Zones

Land use zones and sub-zones are identified based on the integrated analysis of multi-criteria analysis and expert evaluation. The methodological framework as outlined in Figure 3.1 is adopted and GIS analysis is performed at different levels beside expert opinion and qualitative analysis for land use zoning. The Land Use Zones identified in the project area and detailed sub-zones covered by each land use zone is summarized in Table 3.8 and Table 3.9. Similarly, percentage share of identified land use zones and area coverage is summarized in Figure 3.8 and geographical distribution of land use zones are shown in Figure 3.9.

Table 3.8: Land use Zones at Classification level 1

S.N	Land use Zone	Area Ha	% of Total
1	Forest	5351.63	54.70
2	Agriculture	3988.22	40.76
3	Public use	244.14	2.50
4	Riverine Lake and Marsh	117.13	1.20
5	Residential	74.72	0.76
6	Commercial	3.39	0.03
7	Other	2.30	0.02
8	Industry	1.14	0.01
9	Cultural and Archaeological	0.82	0.01
Total		**9783.49**	**100.00**

Highest percent of the project area is covered by forest zone comprising 54percent of the total area. It is followed by agriculture zone with more than 40 percent coverage. Public use is the third largest zone sharing 2.5percent. Higher coverage of public use zone is due to inclusion of right of way of roads defined by national and local authorities such as Department of Roads and municipalities/ rural municipalities. Riverine lake and marsh zone comprises 1.2 percent of spatial coverage. Residential zone is the fifth highest coverage but with less than1 percent share. All other land use zones comprise less than 1 percent of the total area. Limited commercial area mostly is along major road network and local market centers scattered in different locations providing different levels of trading and business services. Land use zone and percent share of each class is shown in Figure 3.8 and geographical distribution is depicted in Figure 3.9.

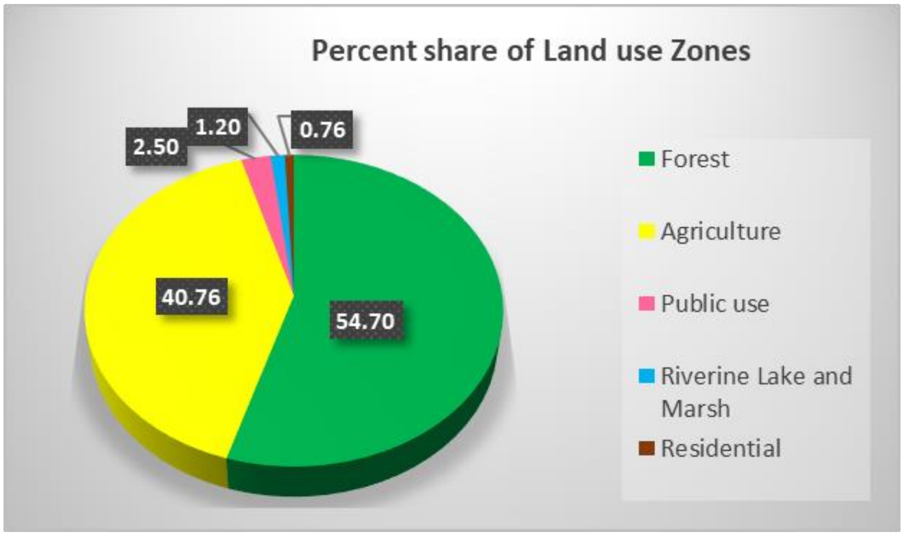


Figure 3.8: Percentage share of Land Use Zones

There are 20 different land use sub zone in the project area, identified based land use classification level 1. Among those identified sub-zones, agriculture use includes 5 sub-zones, public useincludes4 sub-zones, commercial, industrial, forest and residential zone each includes 2 sub-zones and cultural & archaeological, other use zone, and riverine, lake& marsh, zone includes 1 sub-zone category. The area coverage and percent share of each sub-zone is detailed in Table 3.9. Noteworthy among these sub zones beside existing forest are, business area, potential area for industrial use, potential residential zone, agro-forestry, cash crop production and, areas under transportation sub zones.

Table 3.9: Land use Sub-zones area coverage

Zone	Sub zone	Area Ha	% Area
Agriculture	1A-Cereal Crop Production area	2233.83	56.01
	1B-Cash crop area	499.26	12.52
	1C-Horticultural area	15.13	0.38
	1D-Animal husbandry area	1.11	0.03
	1E-Fish Farming area	0.00	0.00
	1F-Agro forestry area	1238.94	31.06
	1G-Other Agricultural area	0.00	0.00
	Sub Total	**3988.27**	**100.00**
Residential	2A-Existing Residential Zone	70.27	94.05
	2B-Potential area for residential zone	4.45	5.95
	Sub Total	**74.72**	**100.00**
Commercial	3A-Governmental Service areas	0.66	19.69
	3B-Business area	2.69	80.27
	Sub Total	**3.35**	**99.96**

Industrial	4A-Areas under industrial use	0.06	4.88
	4B-Potential area for industrial use	1.08	95.05
	Sub Total	**1.14**	**99.92**
Forest	5A-Existing Forest	5349.68	99.96
	5B-Potential area for forest including barren lands, wet lands etc.	1.96	0.04
	Sub Total	**5351.63**	**100.00**
Public Use	6A-Areas under roads, railways, bus parks, airport and landfill site etc.	180.59	73.97
	6C-Recreational, Picnic spots, playground etc.	2.20	0.90
	6E-Health/Education/Security/Utilities, fire station, telephone / electricity areas etc.	2.71	1.11
	6F-Grazing land	58.63	24.02
	6G-Government Institutional Area	0.01	0.01
	6H-Open Area	0.00	0.00
	Sub Total	**244.14**	**100.00**
Other Use	7Ot-Other areas (e.g. landslide areas)	2.30	100.00
	Sub Total	**2.30**	**100.00**
Mines and Minerals	8A-Existing Mine and Mineral Area	0.00	0.00
	8B-Potential Mine and Minerals Area	0.00	0.00
	Sub Total	**0.00**	**0.00**
Cultural and Archeological	9A-Existing Cultural and Archaeological Areas	0.82	100.00
	9B-Potential Cultural and Archaeological Areas		
	Sub Total	**0.82**	**100.000**
Riverine, Lake and Marsh Area	10A-Existing Riverine, Lake & Marsh Area	117.13	100.00
	10B-Potential Riverine, Lake & Marsh Area		
	Sub Total	**117.13**	**100.00**
	Total Area	**235.90**	

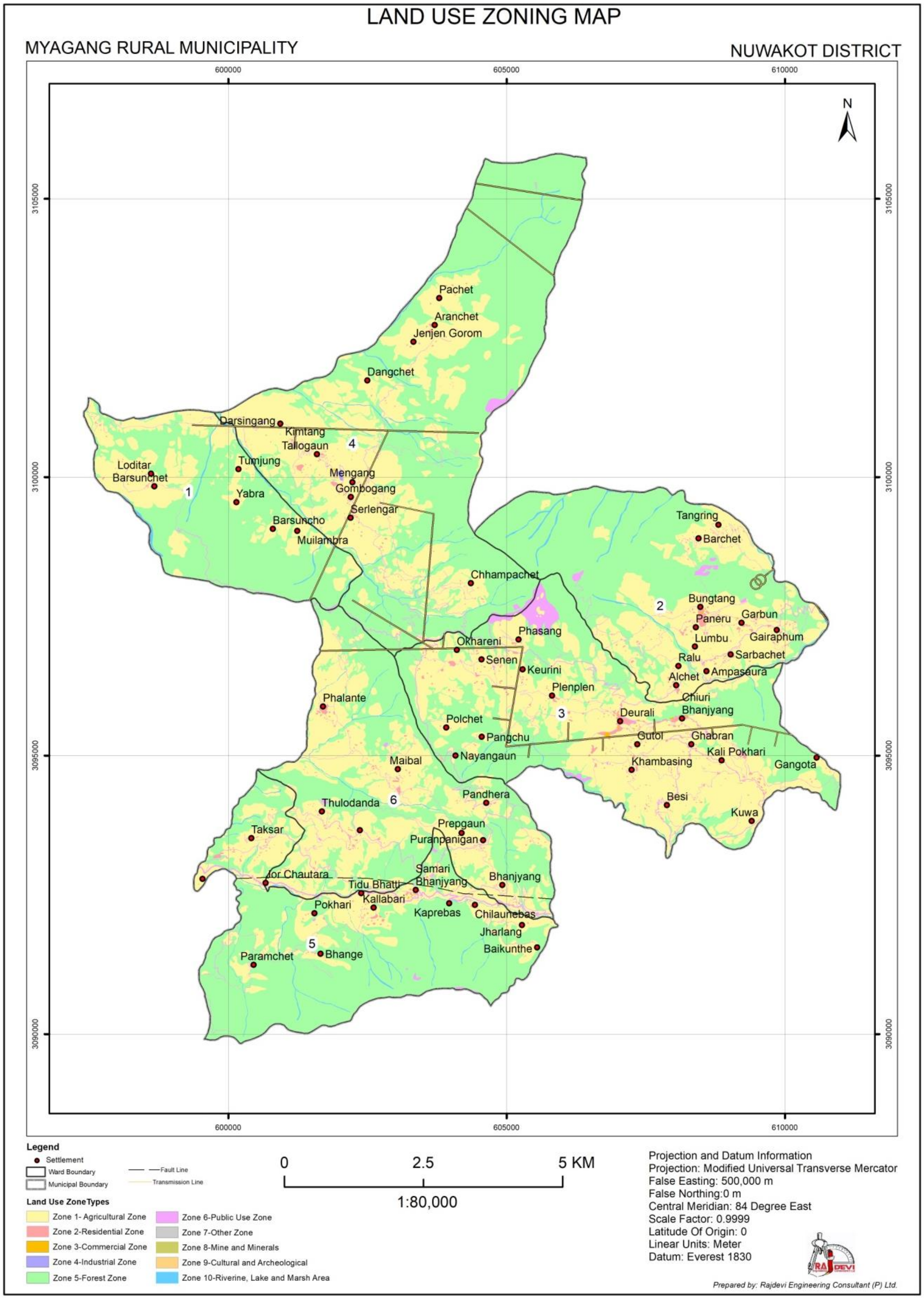


Figure 3.9: Land use Zone Map of the project area

Discussion

The project area is one of the remote regions of Nuwakot district. Characteristics to remote rural region, it has forest as a dominant land use zone, followed agriculture and then public use zone. Residential and commercial area coverage is relatively low.

Clustered traditional settlements are characteristics. Potential residential zone allocation is centered on considerations like adjacency to existing residential area, low arability of soil and land capability, proximity to road network and lower slopes. Land with marginal capability for agriculture production adjoining to existing residential and commercial area is allocated for potential residential area at most possible.

The agricultural area coverage decreased while zoning. The main reason behind this decrease is that existing growth is taking place in agriculture land because no other land use is available for urban expansion.

The average annual population growth rate of the project area is negative with -1.17 percent, which is low as compared to national growth rate of 1.35 and district growth rate of -0.39(CBS, 2014). It has been observed that there are very few new residential growths. The rate of outmigration is higher than internal migration; therefore, relatively very low growth can be seen in the residential zone.

The commercial area coverage is very limited covering only 0.03 percent of the total area and hence, there is limited economic and commercial activities. The markets are mostly related to retailing, and small wholesaling. The foreseeable commercial economy is limited and agro- based activities.

The project area has very small household level agro-processing and natural resource based (such as NTFP) processing units. There is potential of NTFP and medicinal and herbal processing products.

Combination of food crops and vegetables is the agricultural practices. Cardamom and Tea is the major cash crop beside some off-season farming practice. Cash crop farming is potential towards western part. Hence very highly suitable area for diversified crop is allocated for cash crop. Regarding major agriculture product, potato is dominant with off-season vegetables and medicinal plants.

Cash crop and agro-forestry are two major sub-zones identified in the area as potential agriculture diversification. This could be a very appropriate solution as better food supply to tourist services and to raise income level of the people and shift from subsistence to commercial activity. This will also help maintain the greenery. Besides, area under right of way of the river/stream is assigned as agro-forestry which can increase the greenery and can be used as green belts.

3.6 Cadastral Data

3.6.1 Cadastral Land Parcel based on Land Use

A total of 21575 parcels were recorded in the Myagang Rural Municipality with seven present land use classes except industrial, mine & mineral and undersigned other land use classes. The most prevalent land use category is agriculture with 19529 parcels corresponding to 2689 ha (95.36%) area. Similarly, the public use area comprises of 734 parcels with 65 ha (2.30%) area followed by residential area with 54 ha (1.91%) having 1110 parcels and riverine & lake area with 7 ha (0.25%). The commercial area comprises of 95 parcels with area of 3 ha (0.09%).

Table 3.10: Cadastral Parcels with respect to present land use

Land use	Total Parcel	AREA_H	Percentage
Agriculture	19529	2688.64	95.36
Public Use	734	64.97	2.30
Residential	1110	53.93	1.91
Riverine & Lake	82	7.02	0.25
Commercial	95	2.62	0.09
Forest	16	1.74	0.06
Cultural & Archeological	9	0.65	0.02
Total	**21575**	**2819.58**	**100.00**

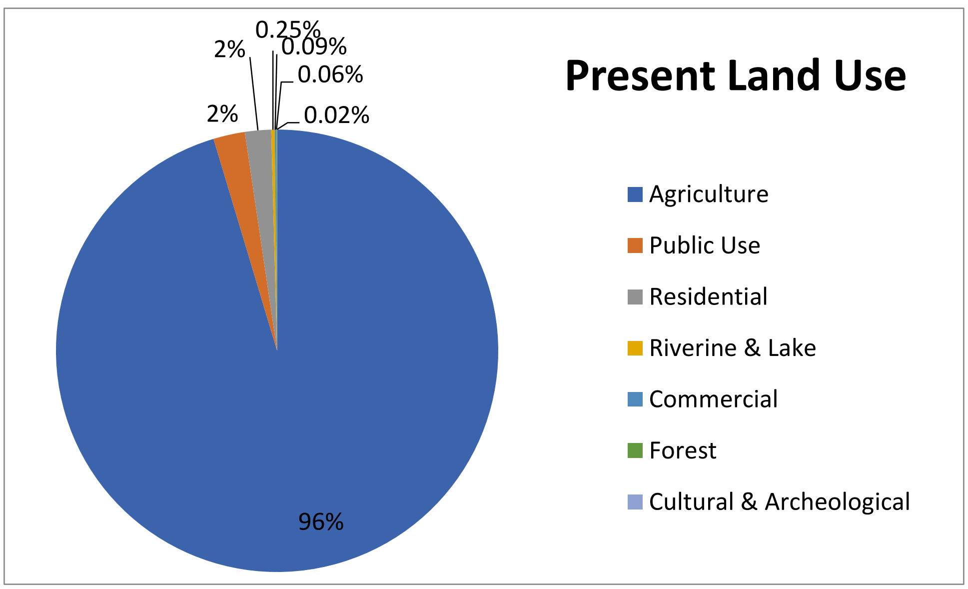


Figure 3.10: Parcel area under various present land use types

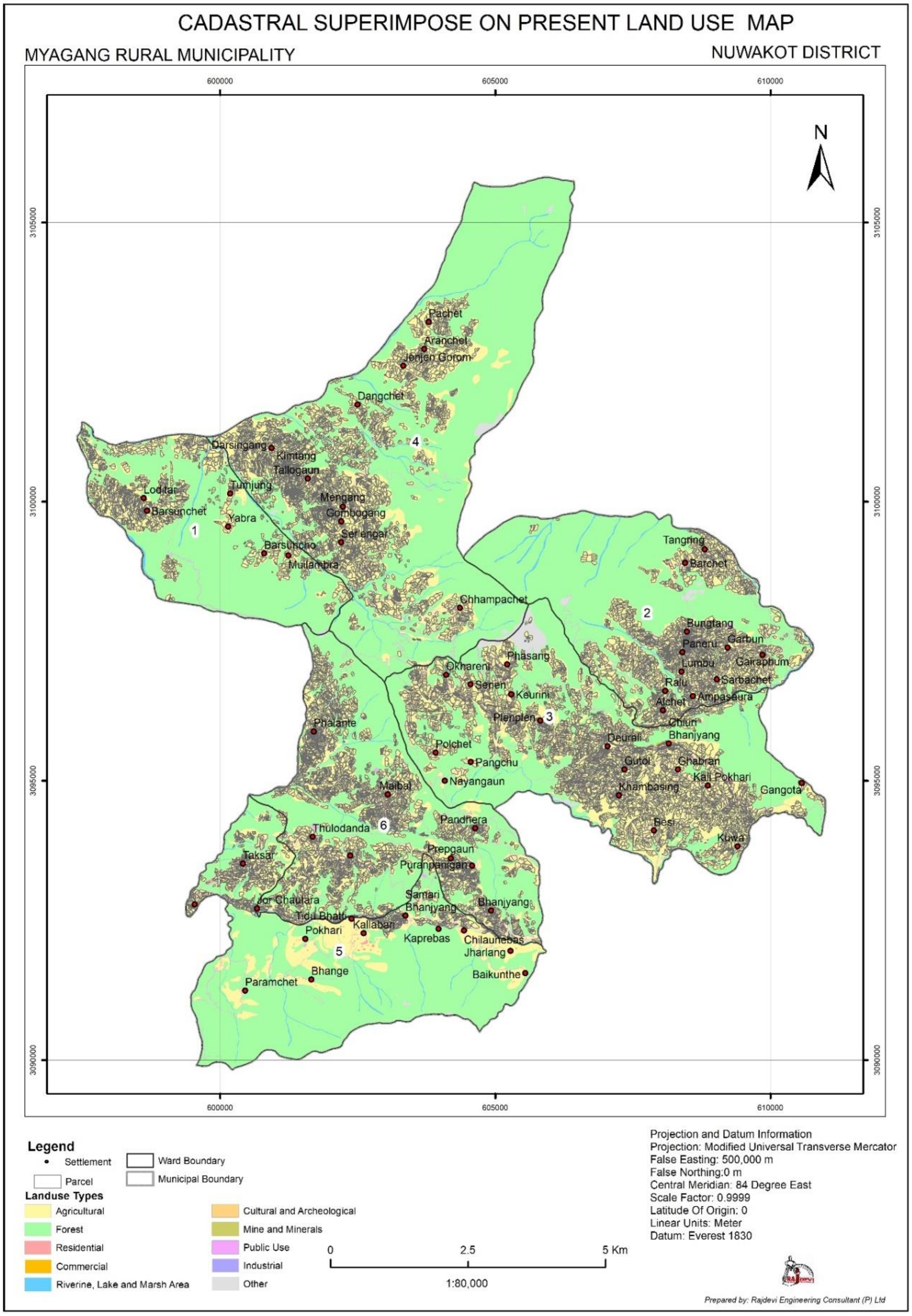


Figure 3.11: Cadastral parcels superimposed on present land use

3.6.2 Cadastral Land Parcel Based on Land Use Zoning

Table 3.11 shows the characteristics of cadastral parcels superimposition on land use zoning for the Myagang Rural Municipality of Nuwakot District of Nepal. The land use zoning shows a restructuring on the existing land use. In the cadastral area of the Municipality/Rural Municipality, out of the designated 10 classes, zoning for eight present land use classes occurred except mine & mineral and undersigned other land use classes. Agriculture land parcels area is reduced from 2689 ha to 2672 ha whereas agriculture land parcels is reduced from 19529 to 19345 land parcels. The significant change in the existing agriculture land use land parcels allocation has converted into residential, commercial, industrial and public service land use classes. The distribution of cadastral parcel in land use zoning classes is shown in Table 3.11

Table 3.11: Cadastral parcels with respect to land use zoning

Landuse	Total Parcel	AREA_H	Percentage
Agriculture	19345	2671.64	94.75
Public Use	866	79.32	2.81
Residential	1154	55.54	1.97
Riverine & Lake	82	7.02	0.25
Commercial	100	2.81	0.10
Forest	14	1.71	0.06
Industrial	5	0.89	0.03
Cultural & Archeological	9	0.65	0.02
Total	**21575**	**2819.58**	**100.00**

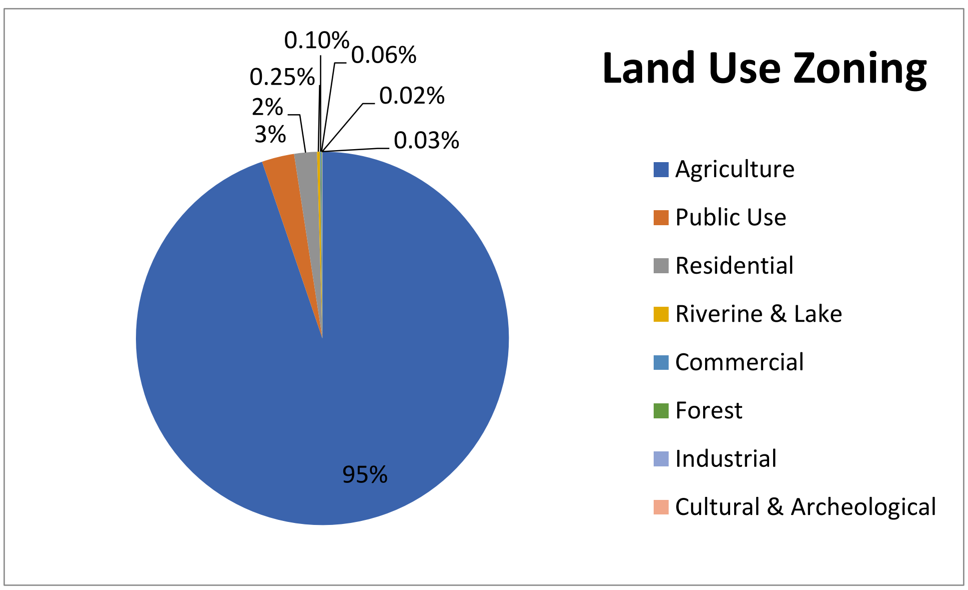


Figure 3.12: Area of cadastral parcels under various land use zones

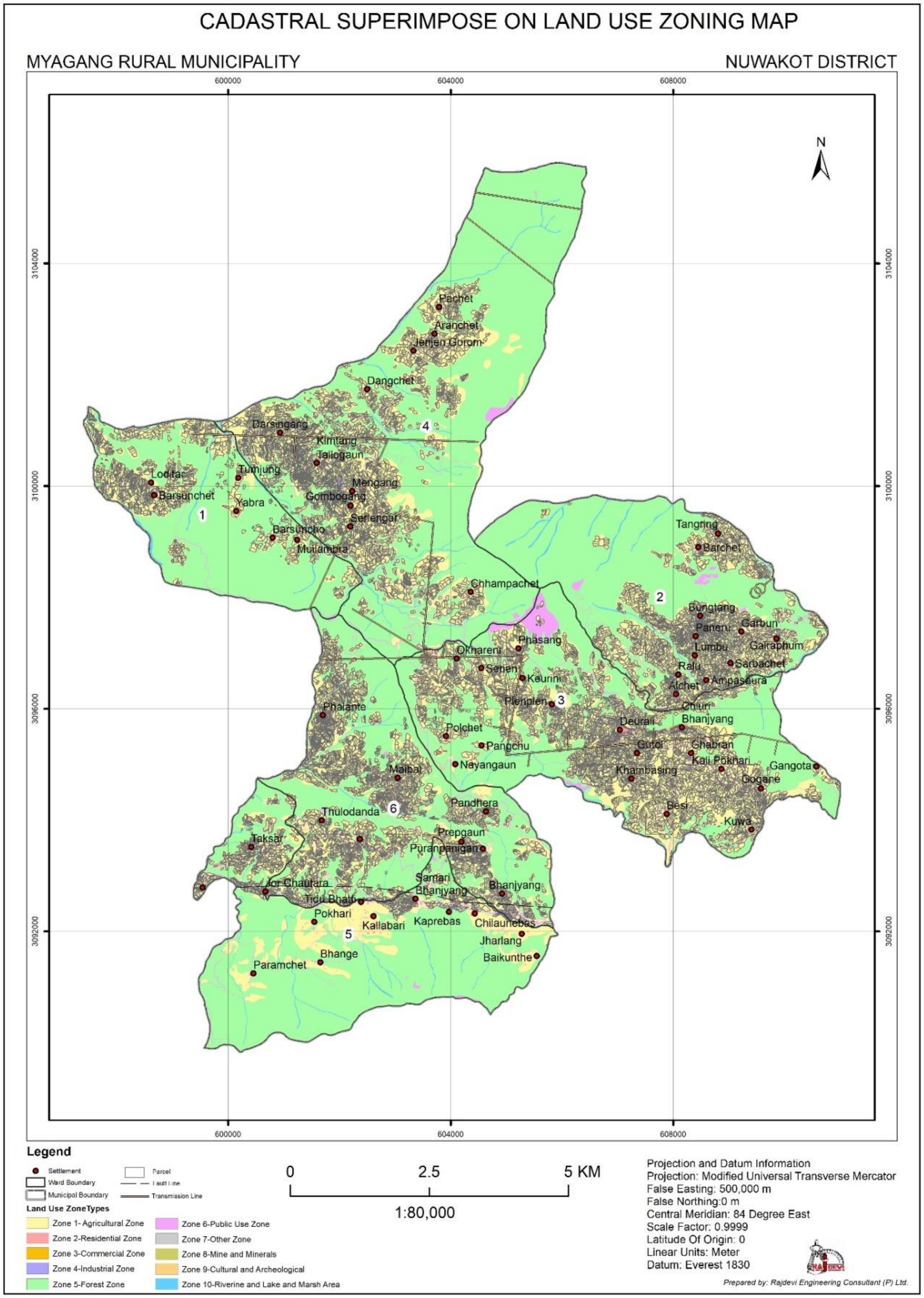


Figure 3.13: Cadastral parcels superimposed on land use zone map

Out of the total 2820 ha of land parcel, currently 2802 ha remains constant. A total of 18 ha of the agricultural parcels have been converted 2 ha to Residential, 14 ha area into Public service land use class. The new characteristics of the Municipality/Rural Municipality is now more homogeneously structured, and looks to be restructured with sufficient allocation for commercial use, preserving in the same time the parcels and areas under public use (Table 3.12).

Table 3.12: Parcel characteristics of present land use and land use zoning superimposition

Land use/Zoning	Total Parcel	AREA_H	Percentage
AGR/AGR	19345	2671.64	94.75
PUB/PUB	734	64.97	2.30
RES/RES	1095	53.28	1.89
AGR/PUB	114	13.65	0.48
HYD/HYD	82	7.02	0.25
COM/COM	94	2.60	0.09
AGR/RES	59	2.26	0.08
FOR/FOR	14	1.71	0.06
AGR/IND	5	0.89	0.03
RES/PUB	15	0.65	0.02
CULARCH/CULARCH	9	0.65	0.02
AGR/COM	6	0.21	0.01
FOR/PUB	2	0.03	0.001
COM/PUB	1	0.01	0.0005
Total	**21575**	**2819.58**	**100.00**

CHAPTER 4: SOCIO-ECONOMIC SETTINGS

4.1 Social Settings

The formation of society by the combination of various social components including geographic structure, mode of production and socio-cultural variables is called as social settings. It is an effort has been made to reveal social condition of this Rural Municipality in terms of population distribution, density, caste/ethnicity, religion and literacy.

4.1.1 Population distribution and density

Population distribution is the major component of the Rural Municipality which is affected by both the geographical factors as well as socio-economic factors. The population in this Rural Municipality is uneven by wards. Some wards have dense population, some wards have moderate and some wards have low population distribution because of different geographical location, physical conditions as well as socio-economic conditions. The total population of this Rural Municipality is 13749 of which male population accounts for 6059 and female population is 7420. Ward number three has the highest population with 1005 whereas ward number one has lowest population with 118. There is uneven distribution of population by wards. Ward-wise population distribution is shown in Table 4.1.

Table 4:1 Sex and Ward-wise Population of the Rural Municipality

Ward No.	Men	Women	Total	Household
1	181	245	426	118
2	921	1196	2117	599
3	1632	2024	3656	1005
4	917	1059	1976	459
5	1127	1366	2493	546
6	1281	1530	2811	661
Total	6059	7420	13749	3388

Source: CBS, 2011.

Female population is larger than male population in the Rural Municipality. The population density of this Rural Municipality is 140 Km2. and average size of house hold is 3.98.

4.1.2 Population by castes/ethnicity

Myagang Rural Municipality is a multi-ethnic and multi-lingual city which has various types of caste and ethnic groups. Caste and ethnic composition are very important factor of society which determines the social cohesion and the organizational basis in a society. A major caste and ethnic group play a dominant role in organizing and decision making in the community. This is a general statement, although it may not always be true. Myagang Rural Municipality is inhabited by different castes and ethnic groups. More than 25 caste and ethnic groups are inhabited in the Rural Municipality. Tamang has the highest population of the

Rural Municipality and their population is more than 83 percent. Similarly, Kami, Brahman, Magar, Ghale, etc. are other major caste/ethnic groups in the Rural Municipality. Distribution of population by caste / ethnicity is given in table 4.2.

Table 4.2: Population by Caste/ Ethnicity

Caste/ethnicity	Number	Percentage
Tamang	11286	83.73
Kami	700	5.19
Brahmin-hill	483	3.58
Ghale	145	2.37
Newar	320	1.30
Magar	175	1.08
Others	370	2.75
Total	13479	100.00

Source: CBS 2011

Although, Tamang and Kami has the largest populations but there are other various types of caste and ethnic groups.

4.1.3 Population by religion

Religion is a set of belief about the cause, nature and purpose of the universe, especially when considered as the creation of a super human agency or agencies, usually involving devotional and ritual observances and often containing a moral code governing the conduct of human affairs. People of this Rural Municipality mainly follow the Buddhist and Hindu religion. Majority of the population follows the Buddhist religion. More than 84 percent people follow Buddhist religion and about 16 percent follow the Buddhism and there are more other religious group in the Rural Municipality which has low population.

4.1.4 Literacy status

In every community, education is one of the fundamental forces to the social restructuring. The degree of education in a community indicates the standard of living. It is also an instrument of change. The literary status is between male and female of 5 years and above age groups varies greatly around 10 percent in this Rural Municipality. More than 75 percent people are literate in the Rural Municipality.

Table 4.3: Literacy status

Sex	Population who are			No Literacy
	Can read & write	Can read only	Can't read & write	
Male	3397	152	-	1951
Female	3256	222	-	3320
Total	**6653**	**374**	**-**	**5271**

Source: CBS 2011.

The above table presents data on the literacy rate by sex of the Rural Municipality. The total literacy rate of the Rural Municipality is 75.01%. Overall literacy rate of the country (for population aged 5 years and above) has increased from 54.1 percent in 2001 to 65.9 percent in 2011. Male literacy rate is 75.1% compared to female literacy rate of 57.4%. The highest literacy rate is reported in Nuwakot district (86.3 %) and lowest in Humla (47.8%). But in Myagang Rural Municipality, both male and female literacy rate is very low than the district.

4.2 Economic Settings

The nature of the distribution of economic resources is the determinant components of the economic status of the people. The people of this Rural Municipality have more than one source of income. Some members of such families are employed in government offices, corporations and Foreign Employment. The households who have some kind of agricultural production particularly vegetables are found benefited from local market. But those households with small landholding size or without land are facing the life of dearth and destitution. They are deprived of opportunities of higher education, jobs in government offices, corporations and foreign employment. They are not in the position to start their own business and enterprises. Some of the economic resources in the Rural Municipality are described in the following topics.

4.2.1 Agriculture

Trade and industrial activities are the predominant economic activity of the people of Myagang Rural Municipality area. Out of total area 60% land is use for agriculture purposes. Paddy, wheat and maize are the main cereal crops grown in the Rural Municipality. The farmers of this area grow lentil, rapeseed, potato and varieties of seasonal and off-season vegetables. Lentil and rapeseed are considered as high value crops. Surface irrigation facility is not developed well in the Rural Municipality. Thus, agriculture of a large portion of the Rural Municipality area either depends on irrigation by Local River like or seasonal rain.

4.2.1.1 Food Production

Paddy is the main food crop grown in the Myagang Rural Municipality. Paddy is grown twice or thrice a year in irrigated areas while it is grown once in the rain-fed areas. Most of the cultivable land is used for the production of paddy. The first crop of paddy (early paddy) harvested in the month of Shrawan-Bhadra (September-October). The next crop of paddy grown in spring season is called ‘Chaite’ paddy. Varieties of paddy are grown in this area. These include *Sona Mansuli, BG1442, Rajendra 1 and swarnaswa 1* under main paddy. For early paddy and spring paddy *Chaite 2* and *Chaite 6 and Hardinath1* are famous among farmers. Majority of the farmer grow Sona Mansuli in this Rural Municipality due to good taste and its demand in the market is also high. The yield of paddy significantly varies by area and season. Yield of early paddy is highest (3.50 MT per ha) as compared to others. The yield varies significantly from minimum 2 MT/ha to maximum 4 MT/ha depending on the irrigation and nutrient condition of the field.

Wheat is another important food crop grown in the Rural Municipality. The average yield of wheat is 2.0 MT/ha. Maize is the other food crop grown in the Rural Municipality. Main maize i.e., monsoon maize covers more area than winter maize. Spring maize is not significantly grown in this Rural Municipality. Farmers are attracted to use Hybrid seeds of maize giving higher yield. Yield of maize significantly varies from minimum 2MT/ha to maximum 4MT/ha depending on the season, irrigation and nutrient condition of the field. Pulses and other cereals are also grown in this Rural Municipality but within small area. Beside paddy, maize and wheat, other crops are also grown in the Rural Municipality. Among others, lentil is the major crop grown in the Rural Municipality. It is grown as single crop as well as mixed crop with rapeseed.

4.2.1.2 Production of High value crop

Like food crops vegetables are grown in the Myagang Rural Municipality. Vegetables are grown mainly in summer, winter and spring season. Vegetables like gourd species, squash, okra and beans are grown in summer season. Cauliflower, cabbage, tomato, radish, eggplant and spinach are grown in winter season and cucumber and squash are grown in spring season. One season crop grown in another season is called off season crop. The area covered by vegetables is limited in the Rural Municipality. Area under all season and off-season vegetables is estimated to approximately 37.05 ha and the production is estimated to 400 MT. The average yield of vegetables is approximately 16 MT/ha. Potato is one of the important crops grown in the Rural Municipality. The average yield of potato is 8MT/ha.

In Myagang Rural Municipality, the other high value crops grown are rapeseed, pulses specifically lentil. Most of the farmers grow rapeseed in this area. Mostly local variety of rapeseeds and pulses are grown in this area. Improved varieties of these crops are also available in the market. Rapeseed is grown single well as mixed crop with lentil. The mixed crop is grown as inter-crop in the paddy field too. The area under rapeseed is estimated to 60 ha and the total production is estimated to 46 MT in the Rural Municipality. The average yield is estimated to 1.0 MT/ha.

4.2.1.3 Livestock Farming

Livestock is an important component of the farming system and it has been remained as an integral part of the agriculture in the Rural Municipality. Both crop farming and livestock are practiced as an integrated farming system in the Rural Municipality. Cow, buffalo, pig and goat are the main animals raised in the Rural Municipality. Cows and buffaloes are raised for both milk and manure purposes. In this Rural Municipality, buffalo number is high as compared to cow. Similarly, Goats number is high as compared to cow and buffalo. Both stall feeding and grazing is commonly practiced in the Rural Municipality. Local breed of goat is common in the Rural Municipality.

4.2.1.4 Poultry and Fish Farming

Poultry farming is being done in most of the wards of the Rural Municipality. Small and marginal farmers are keeping little number of poultry birds. Some farmers are also keeping ostrich and pigeons for meat purpose. Fish farming is also being done in 15 ponds in some of the wards of the Myagang Rural Municipality in personal efforts.

4.3 Employment/Occupation

Major employment of the people residing in this Rural Municipality is agriculture/livestock followed by small trade/business. More than 88 percent people engaged in agricultural & livestock, 2 percent engaged in industry and trades related workers. Similarly, more than 3 percent depend on labour and daily wages and 5 percent involved in foreign employment. The occupational status of Myagang Rural Municipality is given in Table 4.4.

Table 4.4: Main Occupation/Employment of Rural Municipality

S.N.	Occupation	No. of households	Percentage
1	Agriculture and Animal husbandry	2981	88
2	Industry and trade	68	2
3	Labour and daily wage	102	3
4	Foreign Employment	169	5
5	Job/Pension	68	2
	Total	**3388**	**100**

Source: Field visit 2021

4.4 Industry

There are several manufacturing industries, metal crafting, furniture, poultry firm in the Rural Municipality. Nuwakot is mostly a village area and an upcoming link city for the nearby tourist spots. The economy of this Rural Municipality centers on trade, services and agriculture. All kinds of traders, farmers and entrepreneurs sell goods and vegetables directly to the retail & wholesale customers in busy market setup. According to the Rural Municipality visit 2076, it has following industries:

Table 4.5: Industries

S.N.	Types of industries	Numbers
1	Furniture	13
2	Grinding Mills	14
4	Poultry firm	8
5	Tea garden	1
	Total	**36**

Source: Field study, 2021

In addition to this, there are other small-scale industries like dairy, aayurvedic medicines etc. The number of such types of industries is very large so, cannot mentioned here.

4.5 Remittances

Foreign employment is the major source of remittance. About 169 young people are migrated abroad in search of employment. In an average, they earn about thirty million rupees per year. People usually go to Malaysia, Dubai and India for foreign employment.

4.6 Sources of Income

Income sources are the major components of economy. There are different types of sources of income in this Rural Municipality. About 88 percent income comes from agricultural/livestock followed by labour and daily wage workers, service and foreign employment in this Rural Municipality. The status of sources of income is shown in table 4.6.

Table 4.6: Sources of Income

S.N.	Occupation	No. of households	Percentage
1	Agriculture and Animal husbandry	2981	88
2	Industry and trade	68	2
3	Labour and daily wage	102	3
4	Foreign Employment	169	5
5	Job/Pension	68	2
	Total	3388	100

Source: Field Visit 2021

4.7 Potential income Opportunities

People can use land for commercial farming. The land can be used for industries, commercial grain farming, commercial vegetable, fruits farming. Fish and poultry farming is another better option for income. People can do in large scale to meet the increasing demand for fish, chickens in Rural Municipality. But there are no such types of initiation and youth are waiting for visa for foreign employment.

CHAPTER 5: INFRASTRUCTURE AND SERVICES

Infrastructure is the major indicator of the development. Under this section, infrastructure and services including road, electricity, health facility, communication, etc. have been discussed.

5.1 Road

Myagang Rural Municipality is located in the central region of the Nuwakot district. It is connected to other parts of the districts by various roads. All the wards are connected by graveled and earthen roads. There is 285 earthen road in the Rural Municipality. Similarly, there is no brick paved, earthen and graveled road in the Rural Municipality.

5.2 Health

Health is the main components of development. Generally, health facility is good in this Rural Municipality. There are 6 health post 4 birthing centers, 3 private clinic and 4 medicine clinic in the Rural Municipality which provides health facilities to local people. People have to go Myagang Rural Municipality and Bidur, Nuwakot for serious illness.

5.3 Drinking water

Major source of drinking water in Myagang Rural Municipality is piped water. Majority of the people i.e., more than 93 percent uses piped water. More than 4 percent people use spout water. The source of drinking water of the households is given in Table 5.2.

Table 5.2: Sources of Drinking Water

S.N.	Sources of Drinking Water	No. of Household	Percentage
1	Tap water	3139	93.34
2	Spout	162	4.82
3	Uncovered well	34	1.01
4	River stream	13	0.39
5	Covered well	8	0.24
6	Other source	7	0.21
	Total	3388	100

Source: CBS 2011

But the CBS data indicates the different types of sources of drinking water. There is no household who have the tube well or hand pipes user. Similarly, more than 1 percent of households use uncovered well as a source of drinking water.

5.4 Electricity

More than 90 percent households of the Rural Municipality are using electricity. People are using electricity for various purposes like lighting, cooking, heating and also for their small industries. Similarly, 8.75 percent people use kerosene and some people also use other sources of energy for household purpose.

Table 5.3: Sources of energy

S.N.	Sources of energy	No. of household	Percentage
1	Electricity	3033	90.24
2	Kerosene	294	8.75
4	Solar	7	0.80
5	Others	4	0.21
Total		**3388**	**100**

Source: CBS 2011

5.5 Educational Institutions

Myagang Rural Municipality is very near to the Bidur, Nuwakot and Kathmandu. So, there are 6 higher secondary school and 6 basic schools in Rural Municipality. Other educational institutions are given in table.

Table 5.4: Educational institutions

S.N.	Level of educational institutions	Number of students
1	Beginner	267
2	Primary	2723
3	Lower secondary	1584
4	Secondary	818
5	SLC	405
6	Intermediate	235
7	Graduate	49
8	Postgraduate	14
9	Others	3
10	Non-formal	695

Source: CBS, 2011

Usually, students go to others educational institutions for further education in various parts of the Kathmandu valley like Engineering, medicine, agriculture and foreign countries.

5.6 Financial Institutions

There are 19 registered cooperatives and 2 banks in Myagang Rural Municipality. There are no other financial institutions like micro finance in the Rural Municipality. Some people also depend on local money lender for money and other financial needs.

CHAPTER 6: HERITAGE, CULTURE AND TOURISM

6.1 Heritage

There are a number of temples of religious importance in this Rural Municipality. Hindu people perform worship in these temples regularly. During religious ceremonies and festivals people flock the temples to perform worship. There are various temples in the Rural Municipality like, Bindukesari Mahadev, Kali Pokhari, Bolde Pokheri, Tudi Pokhari and Kungargang Bouddha stupa. Buddhist people celebrate Buddha purnima by offering prayers and exchange greeting with friends and relatives. There are several hundu temple, Buddhist temple, Bihar and Stupa as well as other historical places in this Rural Municipality.

6.2 Culture

There are different castes and ethnic groups living in the Rural Municipality. These different castes and ethnic groups have their own customs and traditions. Generally, people following different religions have different cultures. Hindus are the dominant religious group living here. They have their own rites and rituals. They observe different festivals like Dashain, Tihar, Teej, Krishnastami, Raksha Bandhan, Maghe Sankranti and so on. Buddhist people celebrate Buddha purnima and other people celebrates their rituals in religious places. The people of this Rural Municipality following different religions have their own customs and traditions.

6.3 Tourism

There is prospect of development of tourism industry in this Rural Municipality. Nepal has different climates depending on topography and altitude. Therefore, external tourists from different countries as well as internal tourist from different parts of Nepal can choose the climate, they like most. This Rural Municipality has different caste and ethnic groups and having their own culture. Tourists can enjoy cultural varieties. People of this Rural Municipality regard guests as gods. They are courteous and hospitable to the tourists. There are various historic and touristic places in the Rural Municipality like Shergang Cave, Nakur Danda, Kurgang Chaitya, Bindukesar Mahadev, Bolde Pokhari, Tude Pokhari, Chargandanda Cave, Kali Pokhari etc.

CHAPTER 7: RISK IN THE STUDY AREA AND SAFE AREAS OF SETTLEMENT

7.1 Flood Risk

A total of 10.69 ha areas in the project area (0.11% of the total area) are at risk of different flood levels due to 100-year return period flood. Out of this flood risk area 10.04 ha of agriculture land followed by 0.38 ha of forest and the rest of other land uses are likely to be inundated due to 100-year return period flood at different depths. Out of the total flood risk area, 5.03 ha is likely to be flooded with high level depth (more than 1.5 m), 3.12 ha with medium level (0.5 m to 1.5 m) and the rest 2.54 ha with Low level (less than 0.5 m). The land use-wise inundated area is shown in Table 7.1 and flood risk map of the project area is presented in Figure 7.1. Gairihaun and Jharlang are likely to be at risk of 100-year return period flood.

Table 7.1: Land use-wise inundated area in the project area

Landuse Type	High (Ha)	Medium (Ha)	Low (Ha)	Total Risk Area (Ha)	No Risk Area (Ha)	Total Area
Agriculture	4.98	2.98	2.07	10.04	4004.48	4014.51
Commercial	0.00	0.00	0.00	0.00	3.24	3.24
Cultural and Archeology	0.00	0.00	0.00	0.00	0.86	0.86
Forest	0.04	0.06	0.28	0.38	5356.78	5357.17
Minerals	0.00	0.00	0.00	0.00	0.06	0.06
Other	0.00	0.00	0.00	0.00	62.93	62.93
Public	0.00	0.05	0.18	0.24	155.86	156.10
Residential	0.01	0.02	0.004	0.04	71.31	71.35
Hydrology	0.00	0.00	0.00	0.00	117.29	117.29
Total Area (Ha)	**5.03**	**3.12**	**2.54**	**10.69**	**9772.79**	**9783.49**

This report presents a systematic approach in the preparation of hazard, and risk maps with the application of steady flow models and GIS. The result acquired through the analysis reveals the fact that highest area of 5.03 ha of the total flood prone area will be flooded with high level followed by 3.12 ha by medium level and 2.54 ha by low level due to 100-year return period flood.

The assessment of the flood area indicates that vulnerable area lying in flood plain area, need immediate action to take against flood such as river training or embankment or levee construction to protect the given area from further degradation due to flood. Settlements along or nearby lower reaches of Trishuli River, Tadi River, Thopal Khola, Koshi Khola, Chandrawati Khola, etc. specially Panchmure, Dandagaun, Dhansar, Tadipul, Besithok, Kashitar, Panchkhale, Chanaute, Khalte, Gairigaun, Ratmatetar, Kalchedi, Rajwodargaun, Kolputar, Bhalayotar, Kolputar, Majhi Biruwatar, Dandakateri, Biruwatar, Mahabir, Betrawati, Karmetar, Sole Najar, Dandathok, Uparkhutteltol, Agitar, Chhipitar, Akkare Bajar, Bhainse, Chanautetar, Angutar, Distiltyank. Bejal, Rimaghat, Pandegaun, Trishuli Bajar, Dhunge Bajar, Bandre, Pokharithok, Gauribesi, Devighat Koloni, Mandredhunga, Gairitar, Bhorletar, Buwanibesi, Tukanahiti, Majhitar, Devighat, Phirkep Devighat, Kumaltar, Trishuli Koloni, Majhigaun, Baguwa Bajar, Dhade, Ajingare, Anptar, Bhendiswanra, Salle, Kaphle, Dhuseni, Bhyangle, Tulasidanda, Jagatedanda, Jamune, Chyampeswanra, Ranibar, Chaughada, Gankar Bagaincha, Doban Pati, Bachchhala, Sheradil, Thansinphat, Dobate, Amilbote, Dude Bagincha, Pattabari, Gurudanda, Dhikure Bajar, Ladbu, Lavaletar, Chaukhuda, Dumrigaun, Malakot, Gairihaun, Jharlang, Simara, Shreretar Anpraha, Kanle, Mishraphant, Rautal, Anpdanda, Kanelthok, Birtathok, Suntaletar, Chhabise, Athbise, Dumre, Phedibesi, Machha Pokhari, Bakhre, Kutunje, Sano Borle, Barabote, Satbise, Barhabise, Kharaniphant, Budenphant, Bahunbesi Anpra, Darshantar, Dhodbesi, Tarubesi, Birtaphat, Majhitar, Pimaltar etc. villages/settlement are more prone to floods as revealed by the study. The people in such areas are at risk of flood hazard and so, these people need to be shifted from these areas to the safer areas without the risk of being flooded and other risks.

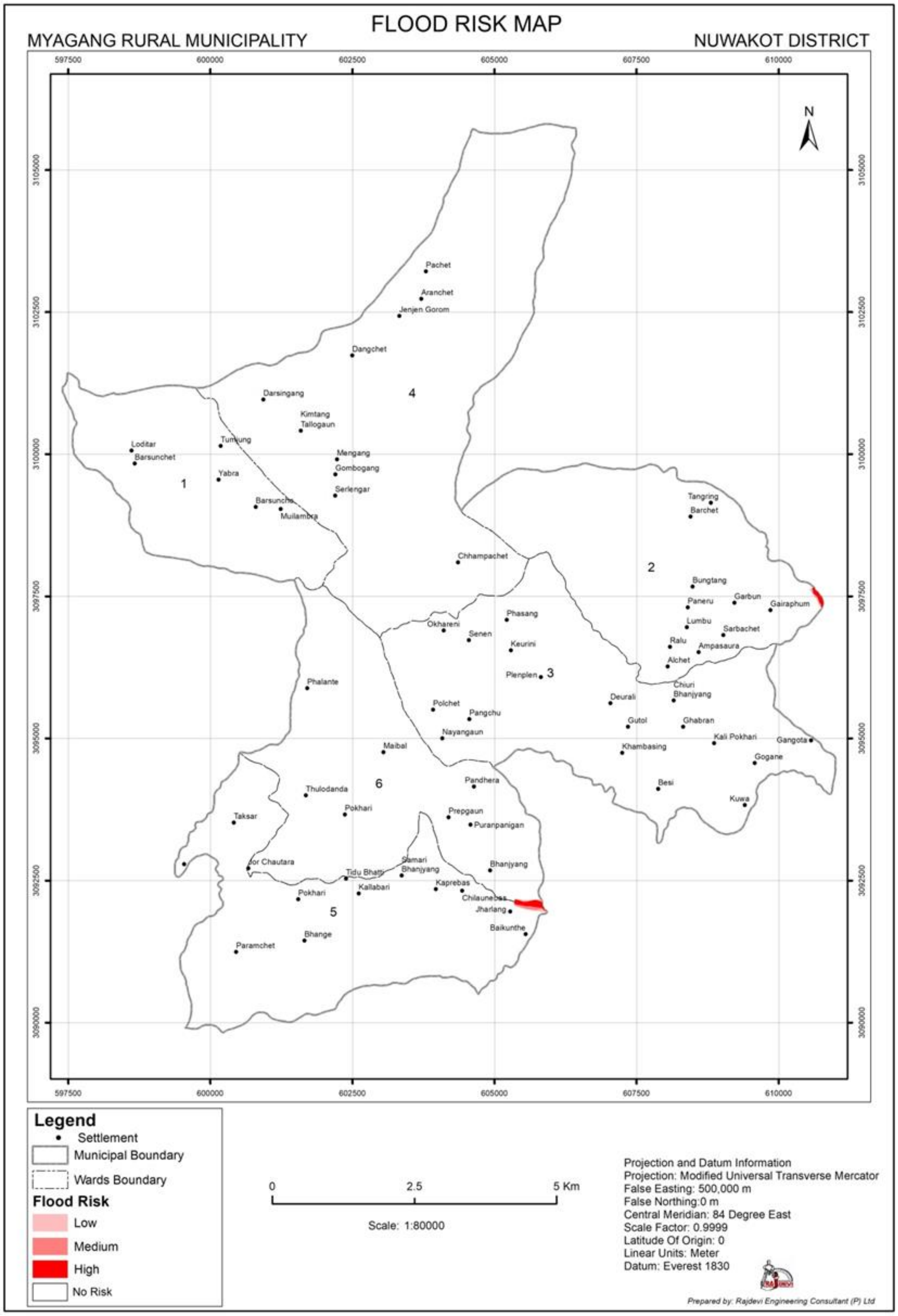


Figure 7.1: Distribution of flood risk area

7.2 Fire Risk

The risk in the area is fire risk spreading in summer. A fuel station within major settlement area has increased the risk of fire. Further, many of the households store inflammable cooking fuel material inside which increases spreading of fire over the settlement. So proper security measures need to be identified and implemented. Fire risk around fuel stations are the potential area of fire hazard.

Transmission lines are the other potential sources to cause disaster. The transmission line passes through the project area. Therefore, new residential should not be proposed within a buffer distance of 30m, 15m, 9m and 3m from a transmission line of 132, KV, 66 KV and 33 KV respectively.

Besides, larger forest cover is potential to forest fire during dry summer. The fire occurrence was found in ward no 3 and 6 with fire frequency of 4 during 2019/20 and 2021 is listed in Table 7.2 and Figure 7.2.

Table 7.2: Fire hazard incidents in project area

S.N.	Ward No.	Incident Place	Incident Date	Incident
1	6	Bhanjyang	5/11/2019	Fire
2	6	Pokhari	1/30/2020	Fire
3	3	Deuraly	4/20/2020	Fire
4	6	Bhanjyang	5/11/2019	Fire

Source: MOHA/DRR Nepal portal

It is reported that number of families were affected due to fire in different wards. The fire in the forest was not estimated. The fire took place in different, workshops, electric pole, households etc.

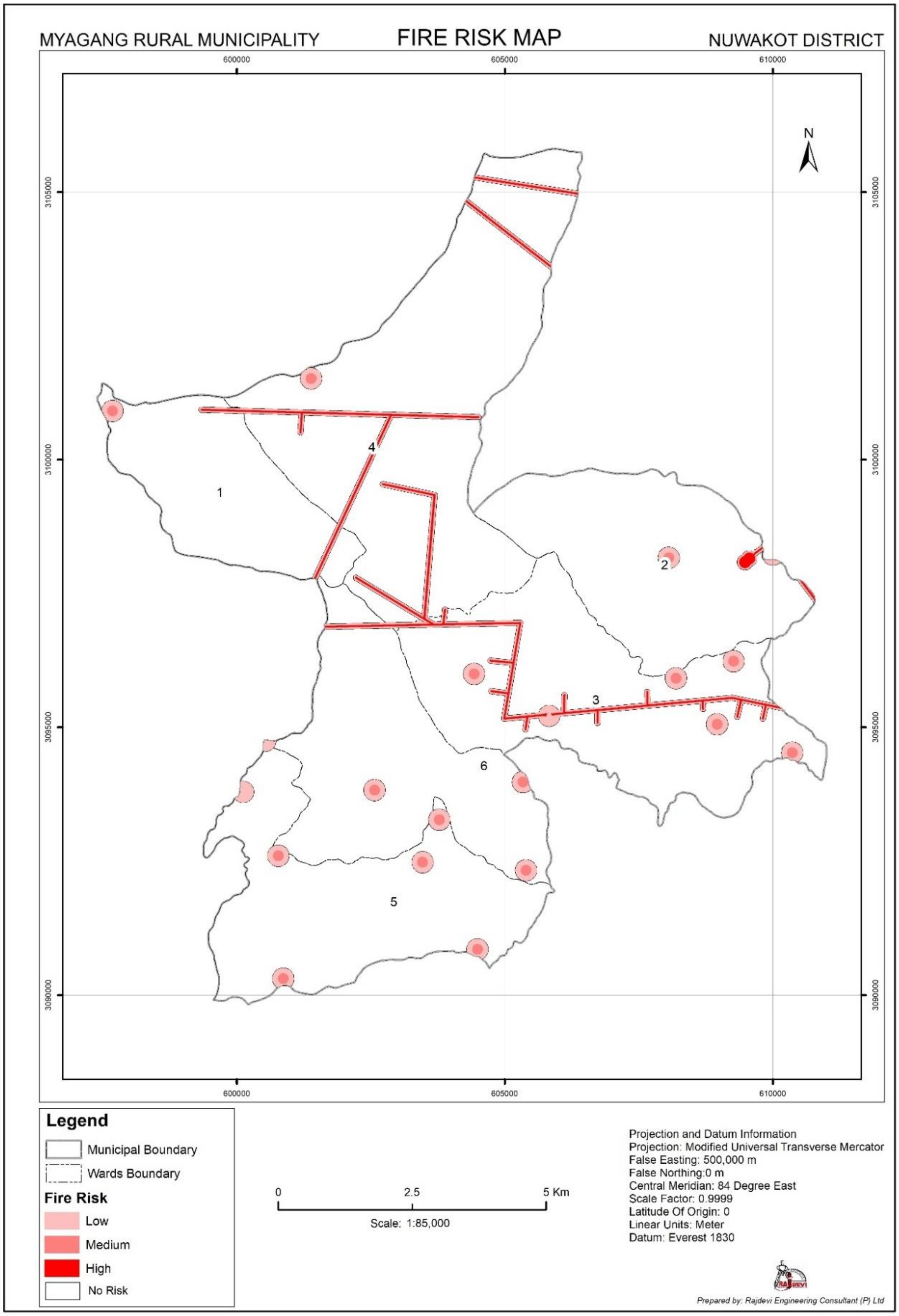


Figure 7.2: Fire Risk Map of Project area

7.3 Landslide Risk

The landslide mapping of Package 08 is carried out using the susceptibility methodology outlined under the methodology chapter by using overlay analysis in the GIS environment. Landslide susceptibility is relatively high covering more than 38 percent of the total area through the forest coverage in the project area is relatively high with 55 percent area under forest. Table 7.3 details the area under different landslide susceptibility classes. Out of the total susceptible area, more than 83 percent area is under high landslide susceptibility class covering 3110 hectares which are lower as compared to other susceptibility classes. More than 16 percent area is under moderate susceptibility to landslide occurrence and 0.18 percent area is under low susceptibility. The central of the project area has higher landslide susceptibility due to higher slopes, western and south western part has moderate to low vulnerability to landslides. Southern parts of the project area are not susceptible due to lower slopes and valley floors.

Table 7.3: Percent share of Landslide susceptible area

S.N	Susceptibility class	Area Ha	Percentage
1	High	3110.94	83.16
2	Moderate	623.16	16.66
3	Low	6.66	0.18
	Total susceptible area	3740.76	38.24
	Total Area	9783.49	

The percent share of high landslide susceptibility class is higher because of characteristic steep slopes despite higher forest cover and human interferences like agriculture, settlement. Overall, landslide vulnerability is high in the project area. Settlement and road infrastructure distribution are dispersed all over the project area and hence landslide vulnerability of settlement and infrastructure is also variable. The percent share of different levels of landslide susceptibility and spatial distribution is presented in Figure 7.3 and Figure 7.4 respectively.

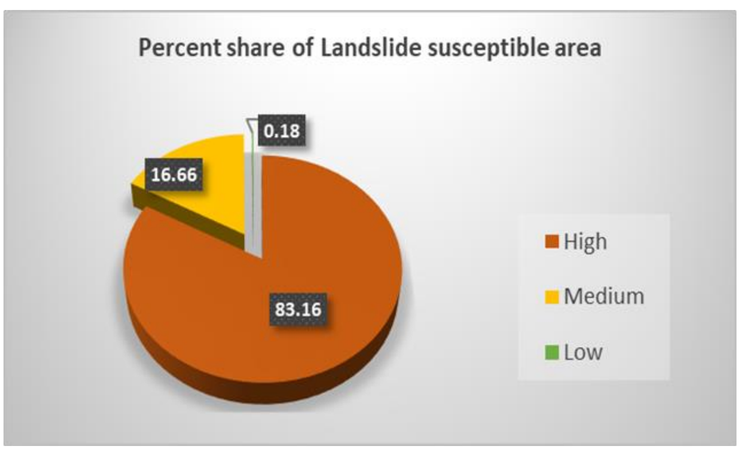


Figure 7.3: Distribution of landslide susceptible area

Landslide susceptibility zoning is based on assumption of continuous landslide density in space. Hence while land use planning and zoning, factors which minimizes landslide risks could be excluded such as in flat area and dense forest cover and slopes of up to 15 degrees. Similarly, in identified landslide susceptible area of varying degree, potential landslides may be of varying likelihood of occurrence based on management practices and protection measures in the area. Agriculture practices in the sloppy area, moderate forest cover and moderate to steep slopes is characteristic of the project area. Hence, conservation, management strategies and protection measures should be implemented for agriculture practices, settlement and infrastructure development.

The assessment of landslide susceptibility based on Multi criteria analysis in GIS environment indicate that there is a close relationship between slope, land cover land use and geology and landslide susceptibility. Beside, infrastructure construction mostly road construction in higher slope area with weak geology is another major factor along roadside landslide occurrence. A study by DWIDP in 2003 also reported that transport infrastructure in Nepal is heavily affected by landslide incidences every year. A field survey conducted in 2003 in arterial routes of Nepal, it was found that small- to medium-scale roadside landslides very often occur as partial landslips within existing large-scale landslides in the area. Therefore, better planning of newer transportation routes, and safe land-use planning, it is very important to understand the distribution pattern of large-scale landslides so as to mitigate the risk. Rapidly increasing construction of infrastructure, such as roads, irrigation canals, and dams without due consideration of natural hazards is contributing to triggering of landslides and debris flows (Thapa, 2015).

Landslide record reveals that road and human settlement slopes are more vulnerable to landslides than ordinary natural slopes. This suggests that there is significant influence of human intervention, particularly in terms of road slope cutting, land development, agricultural practices, etc., on the occurrence of landslides and related failures in Nepal (McAdoo et. al., 2018). Nepal hazard risk assessment report 2011 states Slope, lithology, soil moisture, and precipitation are controlling factors for landslide hazard, while earthquake and rainfall are triggering factors. The report also highlights the paucity of data on the importance of earthquake triggered vs precipitation triggered in terms of fatalities may not be easily available. High severity zone areas are relatively governed by specific lithology condition and slope degree. Based on analysis, more than 20 % of geographical areas are prone to high landslides triggered by high intensity rainfall. Landslides typically occur in hilly areas and primarily affects the road sector. At the national scale, the damage caused by landslides is negligible in comparison to that caused by earthquakes, floods and droughts. These three disasters (earthquakes, floods and droughts) impact large geographical areas, covering almost all parts of the topography of Nepal.

An approach is required to integrate hazard maps developed by different organizations at suitable scale and used for disaster resilient development. The hazard risk map of particular area should be revised from time to time after major, extreme precipitation, and earthquake and major development infrastructure which may have affected.

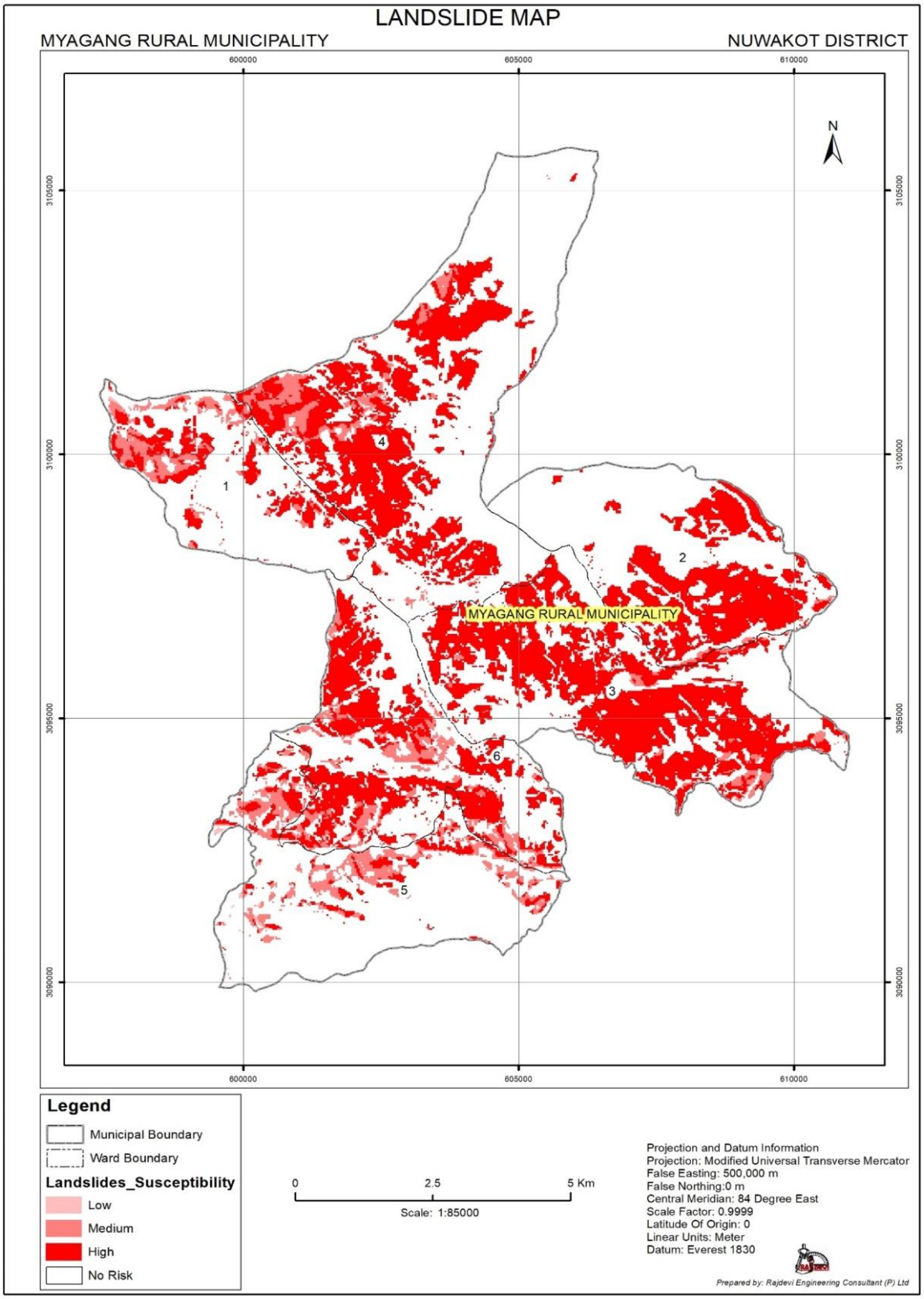


Figure 7.4: Landslide Risk map of the project area

7.4 Seismic Risk

The project area covers maximum acceleration of 350 gal based on Seismic Hazard Map of Nepal (Pandey et al., 2002). The seismic hazard map revealed by Parajuli et al., 2012 determines that the project area covers the Seismic Zone 2 of the Nepal Himalaya. Therefore, the basic horizontal seismic coefficient is calculated for both given reduction factors of 0.50 and 0.65 and averaged ones. Table 7.4 below shows the estimated effective design seismic coefficient is approximately 0.2053 for the averaged reduction factor and the coefficient is ranged between 0.1786 and 0.2321 respectively.

Table 7.4. Estimation of Effective Design Seismic Coefficient.

Maximum Acceleration (gal)	Reduction Factor (R)	Effective Design Seismic Coefficient (A_{eff})
350	0.5	0.1786
	0.65	0.2321
	0.575 (averaged)	0.2053

The project area lies in the seismic zone which is low seismic hazard area (Figure 7.5) and is vulnerable in terms of less seismic activities in comparison to other parts of Nepal. No major fault line lies near the project area. However, a due consideration is required before planning the large scale projects like hydropower development, tunnel construction, reservoir development, highway construction, large irrigation projects and landslide mitigation techniques. That’s why geotechnical considerations are the must before starting any kind of development activities in the area.

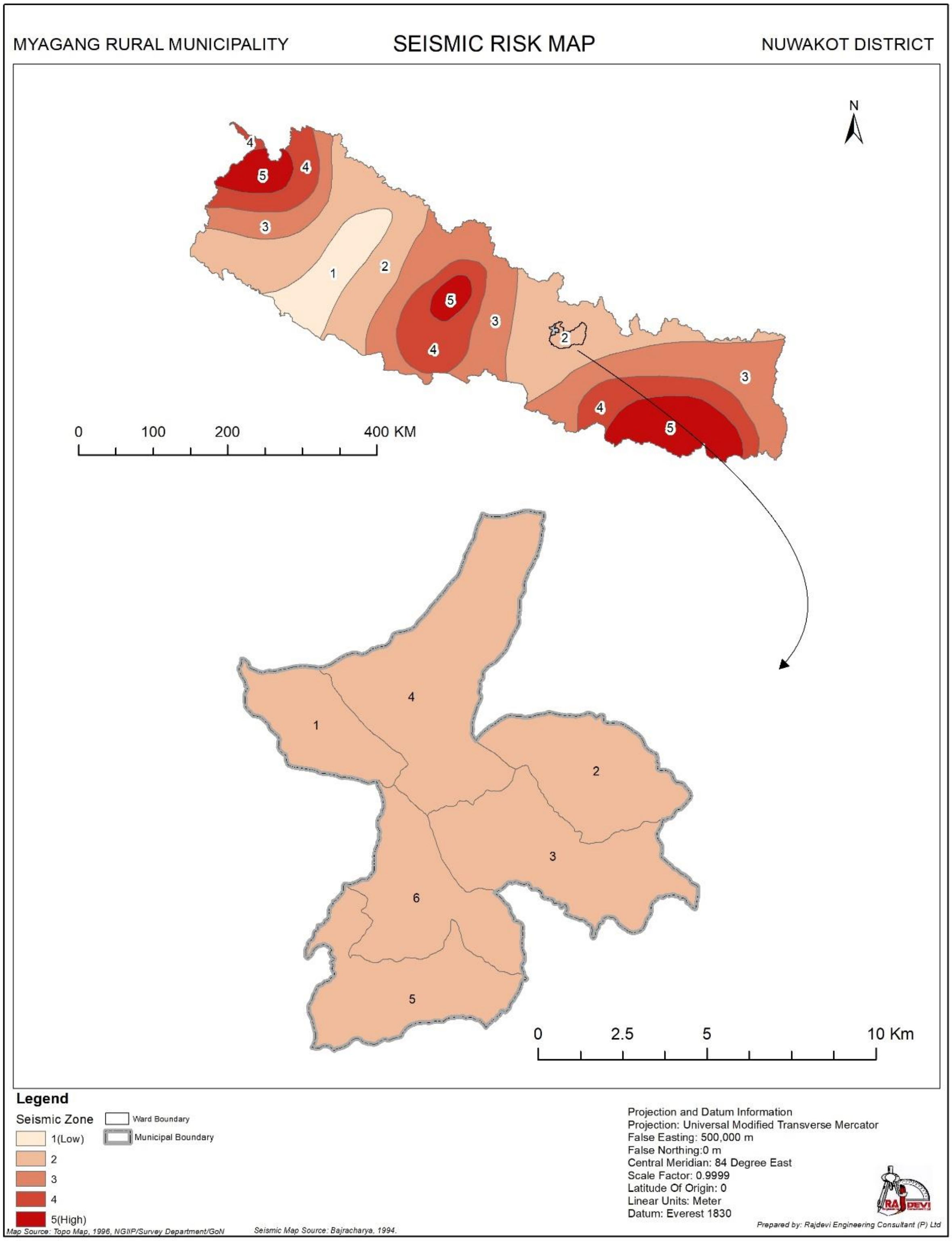


Figure 7.5: Seismic Risk Map of the project area

7.5 Industrial Risk

According to the Focus Group Discussion (FGD), field visits, and literature review it has been found out that there are several small-scale, medium and large-scale industries operating within the project area. Multinational companies and those related to cold drinks, beverage, and automobile have been set up there. Small scale businesses operating with the Municipality include, dairy industries, tailors, retail shops, furniture, readymade cloth shops, hotel, stationery and book shop, fruit & vegetable shops, jeweler shops, mobile phone shops, agro- veterinary, liquor shops, private clinics, tea shops, mill, computer center, hardware shops, fresh house, motor garage, photo studio, and kitchen utensil shops. Besides there are multiple health institutes in the municipality including hospitals, clinics and pharmacists. Project area does not have any system for collecting and managing medical waste or any other type of special waste separately so the hazardous medical waste from these establishments is dumped along with regular municipal waste.

Hospital wastes (general waste and hazardous wastes) are mixed to municipal solid waste stream despite the government regulation, requiring every hospital to properly dispose of waste (The Solid Waste Management Act 2011, states: “the responsibility for processing and management of hazardous waste, medical waste, chemical waste under the prescribed standards shall rest with the person or institution that has generated the solid waste”).

In the project area, the practice of discharging industrial waste and other waste directly into the drains are creating a nuisance to the surroundings and health risks to the public and workers. Residential areas and the neighboring areas are affected from unwanted bad odor smell of the waste water. Such waste water contains various types of untreated organic and inorganic toxic materials that leads to the formation of various toxic gases such as hydrogen sulphide, Sulphur dioxide, etc. and also will be the favorable place for the survival of insects and rodents like mosquito and others. Such polluted environment causes the risks of spreading water-borne diseases including malaria, dengue fever, etc. in the local as well as neighboring areas.

According to the Industrial Statistics of 2076/2077 by Ministry of Industry, Commerce, and Supplies, the total number of registered Industries in Nepal was 8,247 out of which 3,638 were registered within the Nuwakot district (where Project area is located) up to the fiscal year 2076/2077. In Project area itself, the number of industries is found to be 45 in numbers. Due to the presence of the small, medium, and large-scale industries, Project area has high risk related to the industries.

The risks from the industries in Project area are high in nature, for long-term duration and high in magnitude. As stated above, the majority of the industries generate effluents and solid wastes that need to be disposed in an environmentally acceptable manner.

Project area considers the municipal waste as only the waste generated from households. The large-scale commercial businesses and factories those generate waste in huge quantities are not included as the source of municipal waste and they are supposed to manage their waste in their own. Hospitals and industrial wastes are also not included in municipal waste generators. However, the practice of self-managing the generated waste by large scale businesses and industries remains only in theory so far. Therefore, segregation of general waste, hazardous waste of industries, and hazardous medical wastes of healthcare institutions need to be seriously and immediately considered. Appropriate regulatory measures need to be strictly enforced by the government.

In concurrence with the regulatory requirements, the industries need to adopt a sustainable approach to the waste management. The effluents generated by agro-based industries are biodegradable and non-toxic and treated by physical, chemical and biological processes. With the application of appropriate technologies, it is possible to minimize the pollution and also to recover the water and other useful materials from the waste streams.

The best way to reduce the industrial risk would be a land use planning and zoning. Industries need to abide by the environmental rules and regulations and other statutory provisions of the Government of Nepal. The discharges from the industries need to meet the requirements of quality standards as set up by the Government of Nepal. To assure the public and concerned stakeholders about the minimization of industrial risk, the Government of Nepal needs to initiate an effective monitoring system and its thorough implementation.

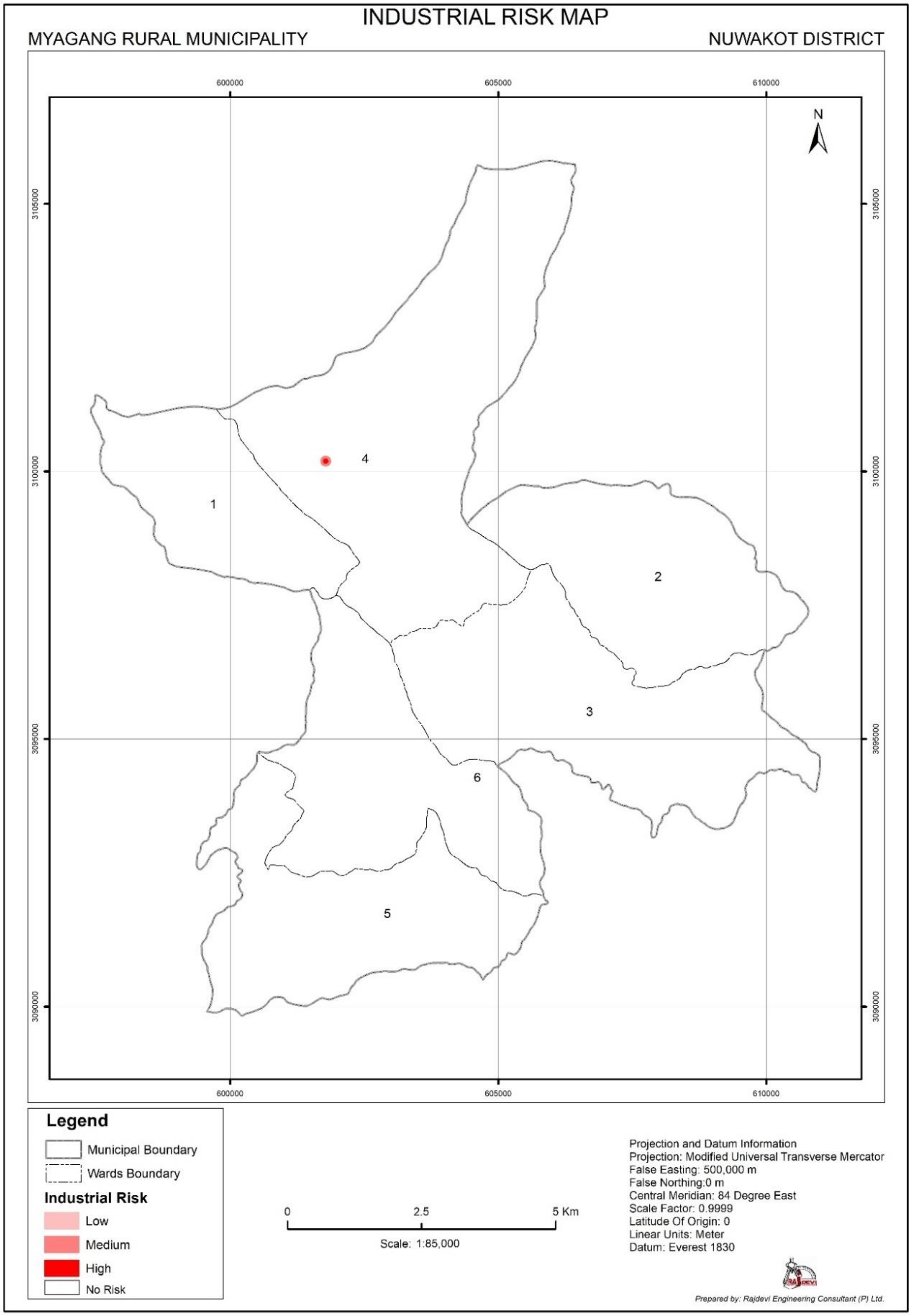


Figure 7.6: Industrial Risk Map of the project area

7.6 Soil Erosion Susceptibility Risk

The project area is composed of varying landforms, topography, slope, landuse and soil. The soil erosion susceptibility is high covering more than 41 percent of the total area. Table 7.5 details the area under different soil erosion susceptibility class. Among total soil erosion susceptible area, more than 16 percent area is under high susceptibility class covering 675 hectares while 45 percent area has moderate susceptibility. Area with low susceptibility constitute 37.8 percent. The north-western part of the project area is vulnerable to soil erosion as compared to other parts of the project area.

Table 7.5: Distribution of soil erosion in the project area

S.N	Soil Erosion	Area Ha	Percentage
1	High	675.54	16.61
2	Medium	1850.94	45.51
3	Low	1540.89	37.88
	Total Susceptible area	4067.37	41.57
	Total area	9783.49	

The percent share of each susceptibility class is presented in Figure 7.7. Of the total susceptible area, maximum percent is shared by medium susceptibility class whereas high susceptibility class shares lowest percent coverage. Distribution of soil erosion susceptible area in the project area is presented in Figure 7.8.

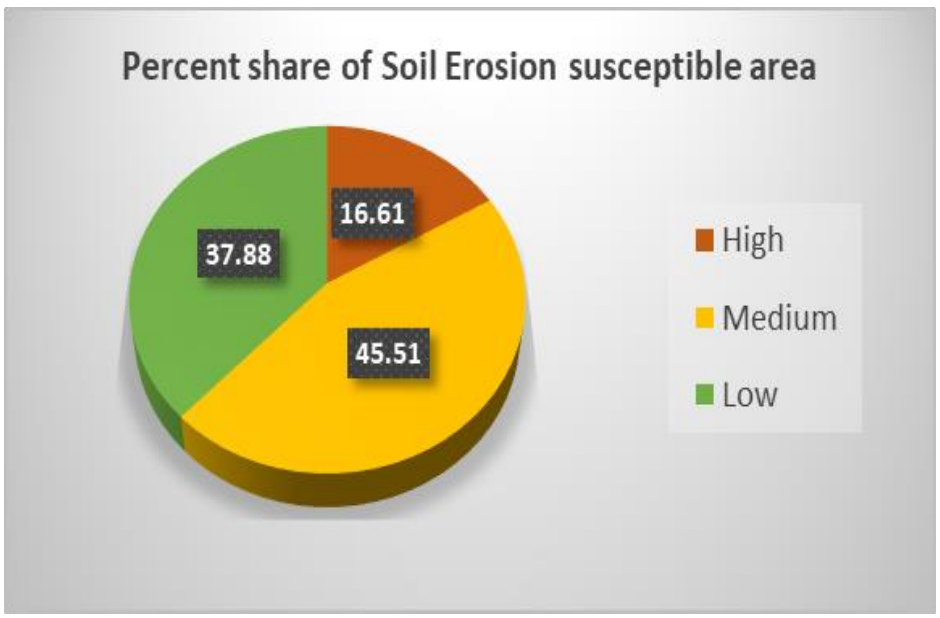


Figure 7.7: Percent share of soil erosion susceptibility in the project area

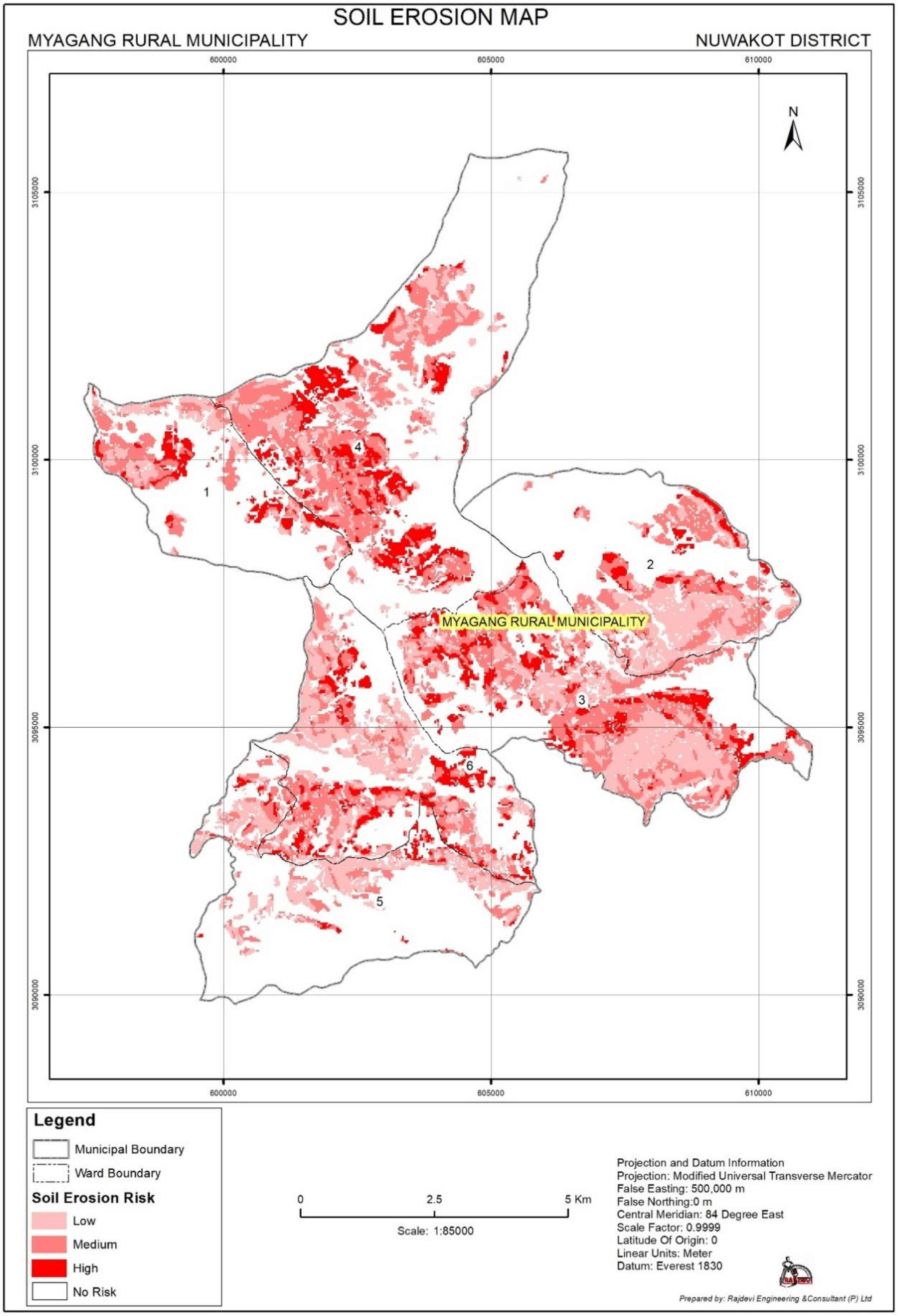


Figure 7.8: Soil erosion map of the project area

Number of studies has shown that various factors have various level of effect on soil erodibility and it is obvious because, plot level or field level studies doesn't represent the general erosion process of whole local administrative unit. A single local administrative unit covers range of geological, topographical, agro-ecological and soil conditions as well as different management practices (Gurebiyaw, Addis, & Teklay, 2018). The application of computer based tools like GIS and Remote sensing and statistical techniques help identify area of soil erosion susceptibility with integrating spatial data and processes and management activities on erosion. Universal Soil Loss Equation (USLE) and revised (RUSLE) is the most extensively used empirical soil erosion model. However, this model requires rainfall and runoff erosivity data which in Nepalese context is very difficult to estimate due to low coverage of rainfall stations particularly in the hill and mountain region.

Human activities such as changing pattern of land use, intensive farming, excessive fertilizer use damage the soil and land. Housing development activities, infrastructure construction such as road need heavy earthworks, cuts resulting change and loss of soil and if not enough attention is paid to rainwater flow management and maintenance will in long run results soil erosion. Different cropping systems produces different rate of soil erodibility (Kunwar, Bergsma & Shrestha, 2016). A selection of the cultivation system that reduces erosion most effectively could be suggested based on soil erosion susceptibility assessment.

7.7 Other Risk

There is no other risk in this rural municipality

REFERENCE

CBS (2011). *National Population and Housing Report, 2011*. Kathmandu: Central Bureau of Statistics.

RM (2076). *Myagang Rural Municipality Profile.* Nuwakot: Myagang Rural Municipality Office of Municipal Executive, Nuwakot Bagmati Provience

APPENDIX

Appendix 1: Rural Municipality Photos

Photo 1: Rural Municipality Office Building

Photo 2: Myagang Pokhari

Photo 3: Gumba of Myagang

Photo 4: Cultivation area of Myagang Rural Municipality

Appendix 2: Rural Municipality Letter

म्याग्दे गाउँपालिका

गाउँ कार्यपालिकाको कार्यालय

म्यागङ गाउँपालिका गाउँ कार्यपालिकाको कार्यालय देउराली, नुवाकोट बागमती प्रदेश

पत्र संख्या: ०७७/७८
चलानी नं ११५१

मिति : २०७७/१०/२२

बिषय : जानकारी सम्बन्धमा ।

श्री भूमि व्यबस्था ,सहकारी तथा गरिबी निवारण मन्त्रालय
नापी बिभाग ,
स्थलरुप नापी तथा भू-उपयोग व्यबस्थापन महाशाखा

उपर्युक्त सम्बन्धमा तहाा कार्यालयको च नं १६८ मिति २०७७/१०/०८ को पत्रानुसार तहाँ कार्यालयको चालु आ.ब २०७७/७८को स्विकृत बार्षिक कार्यक्रम अनुसार यस म्यागङ गाँउपालिका मा खटिएका **pacage no-TSLUMD/CS/QCBS/8/077/78** मा **Rajdevi engineering consulant pvt.ltd,shankhmul, ktm** बाट खटिनु भएका श्री हिक्मत जंग शाह लाई यस कार्यालयको तर्फबाट आबश्यक सहयोग गरिएको ब्यहोरा अनुरोध छ

पवन कुमार प्याकुरेल
प्रमुख प्रशासकीय अधिकृत

पवन कुमार प्याकुरेल
प्रमुख प्रशासकीय अधिकृत

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