Government of Nepal
Ministry of Land Management Co-operatives and Poverty Alleviation

Survey Department

Topographical Survey and Land Use Management Division

Minbhawan, Kathmandu
Nepal

FINAL REPORT

on

Preparation of Gaunpalika/Nagarpalika Level Land Resource Maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map, Gaunpalika/Nagarpalika Profile for Land Use Zoning and Superimpose of Cadastral Layers) Maps, Database and Reports

PACKAGE NO:
TSLUMD/CS/QCBS/01/19/2075/076



Name of the Gaunpalika/Nagarpalika:

Masta Gaunpalika
of
Bajhang District

Poush, 2076

Submitted by:

ADMC Engineering Pvt. Ltd.

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ACKNOWLEDGEMENTS

This project report entitled *"Preparation of Nagarpalika/Gaupalika Level Land Resource Maps (Present Land Use Map, Soil Map, Land Capability Map, Risk Layers, Land Use Zoning Map, Nagarpalika/Gaupalika Profile and Superimpose of Cadastral Layers) of Masta Gaunpalika"* is an outcome of the agreement between the Topographical Survey and Land Use Management Division, Ministry of Land Management, Cooperatives and Poverty Alleviation and ADMC Engineering Pvt. Ltd.

ADMC Engineering Pvt Ltd. would like to acknowledge the contributions made by TSLUMD Management to this project particularly by providing necessary images, maps and documents required for carrying out field survey and preparation of land resource maps. We express our sincere gratitude to Director General, Mr. Prakash Joshi, Deputy Director General, Mrs. Karuna K.C., Chief Survey Officer, Mr. Ramesh Gyawali for entrusting us for the task. We are thankful to Survey Officer Mr. Sumeer Koirala and Mr. Prakash Dulal for their continuous technical and administrative support during various stages of this study. Similarly, we are thankful to Account Officer Mr. Dipak Adhikari for his support. We would also like to express our thanks to all other technical staffs and entire TSLUMD team for their support and cooperation during the course of the project which was crucial for successful completion of this task.

We are highly thankful to Gaunpalika Chairmen Mr. Karna Bahadur Kathayat, Vice-Chairman Mrs. Bhagwati Bohara, Ward Chairman, Administrative Officer Mr. Amar Bahadur Jethara, staffs of the Gaunpalika and other participants in first sharing meeting and draft report presentation for their kind co-operation and valuable feedback to the study. We also thankful them for co-operating and providing data and other supports to study team members in different times during the study period.

This report would have never come to this shape without arduous efforts of the study team. We would like to express our sincere thanks to Dr. Gopi Krishna Pandey, Team Leader (Package 19) and his entire team Mr. Binod Kumar Gupta (Soil Scientist); Mr. Ashok Kumar Mallik (Agriculture Expert); Mr. Thakur Prasad Tripathi (Senior Surveyor); Mr. Suman S Bhattarai (Natural Resource Manager); Mr. Amleshwor Singh (Forestry Expert); Mrs. Rita Rai, Mr. Kiran Thapa and Mr. Niroj Lage (GIS Expert); Mr. Lokraj Khanal and Mr. Sandeep Adhikari (Remote Sensing Expert); Mrs. Leena Koirala (Land Use Planner); Mr. Subesh Ghimire and Mrs. Srijana Tripathi (Geologist); Mr. Damodar Bhakta Shrestha and Mr. Narayan Prasad Gautam (Hydrologist); Mr. Keshab Raj Khanal, Dr. Dhyanendra Bdr. Rai, Dr. Narayan Prasad Paudel, Mr. Bishal Gyawali and Mr. Basanta Acharya (Socio-Economist); Mr. Ramyatan Mandal, Mr. Shiva Yadav and Mr. Tara Baral (Soil Sample Collector), Mrs. Anita Sharan, Mr. Kamal Rawal and Mr. Nirajan Giri (Field Enumerator); Mr. Agam Sharan Jung Rana, Mr. Lokraj Pandey and Mr. Hemanta Roshiyar (GPS Operator); Mrs. Bindira Shrestha (Digitization Operator) for their significant contribution to the project. Also Mr. Bikash Shrestha, Mr. Sunil Tripathi, Mr. Rojen Shrestha, Miss Bhawana Khadka and Miss Smriti Chaudhary deserve thanks for their assistance in GIS/RS data analysis, field data collection, Report Compilation and Map preparation. We would also like to record the hard works of field enumerators who spent several days in the field for this project.

We are also thankful to Mrs. Dibya Laxmi Bajracharya, the Chief of Agricultural Research Centre and K.B. Shahi from AASTHA Scientific Research Service Pvt. Ltd. for facilitating the task of soil testing and for her prompt services in delivering the soil test reports to the company.

Many difficult hours were poured into this report to make it what it is now and we realize that there is enough room for improvement. However, we are confident that this report will be useful both in its range and extent, not only to TSLUMD in its planning for future, but also for all the map/data users at large.

ADMC Engineering Pvt. Ltd.

Team of Expert

Expert Code	Name of Expert	Position
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K-2	Mr. Binod Kumar Gupta	Soil Scientist
K-3	Mr. Ashok Kumar Mallik	Agriculture Expert
K-4	Mr. Thakur Prasad Tripathi	Senior Surveyor
K-5	Dr. Suman S Bhattarai	Natural Resource Manager/Environmentalist
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K-16	Mr. Ramyatan Mandal	Soil Sample Collector

Executive Summary

Land is one of the most important natural resources in Nepal and land related official documents are perhaps the oldest legal natural resource management documents in the country. Identifying and promoting areas suitable for agriculture, settlement, defense posts, forest and frontier areas remained integral part of state mechanism from historical times. Over the years, with growth of population and expansion of state infrastructure the multifaceted use of land began to be realized more and more and all these components together have exerted pressure on existing land resource in the country. As a result, with a vision to achieve sustainable social, economic and environmental development through optimum use of land resources the government of Nepal implemented National Land Use Policy (NLUP) 2072 and Land Use Act 2076 BS. The NLUP aimed at classifying land according to its structure, capability, suitability and the necessity and bring to its utilization accordingly. For its implementation, Topographical Survey and Land Use Management Division (TSLUMD), under the Department of Survey, Ministry of Land Management, Cooperatives and Poverty Alleviation, has carried out activities at Gaunpalika (Rural Municipality) and Nagarpalika (Municipality) level by organizing the Gaunpalika/Nagarpalika into packages and each package consists of a set of several adjoining Gaunpalika/nagarpalika in a district. Before the promulgation of the present constitution in 2072BS, such study packages used to consists of VDCs/municipalities. This report presents the findings of land situation and its zoning of Masta Gaunpalika of Bajhang district within Package 19 (2076/077). The Masta Gaunpalika consists of 3 previous VDCs namely Kotdewal, Masta, Bhatekhola and Rilu.

The main objectives of this study are to: i) prepare Gaunpalika level land use map, soil map, land capability map, land use zoning map, land hazard map, cadastral layer superimposition map; and ii) prepare socio-economic profile document of the Gaunpalika.

Multiple sources of data have been utilized. The main sources of map data are satellite imagery (Zy (ziyuan- 3-01/02 China first high resolution steorescopic mapping satellite image), topographic maps, and digitized cadastral maps made available by TSLUMD. Necessary field verification was done. After satellite data acquisition, the process of map data generation include digital elevation model (DEM) generation, control point establishment differential global positioning system (DGPS), ortho-rectification and geo-referencing, pan sharpening, radiometric and spectral correction, digitization topology correction and database generation. Maps have been produced at 1:10,000 scales. Extensive fieldwork and consultations with local stakeholders in the Gaunpalika have been carried out for soil mapping, hazards mapping, Gaunpalika profile preparation and for proposed land use zoning. Importantly, it was presented the study package objectives to Gaunpalika before starting the work and engaged during the work and also presented the draft final report at Gaunpalika and have taken their inputs.

Masta Gaunpalika covers an area of 109.05 km^2. There is a famous temple of Masta Kul Dewata in ward number three which is worshipped with devotedly by the common people of Bajhang. This Kul Dewata is very popular in this area including surrounding districts. Before reconstruction of state by constitution 2073, one of the of VDC name was Masta in Bajhang district which is related with Masta Kul Dewata. The total population and households of the Gaunpalika is 17909 and 2798 respectively. Out of the total population, percent 47.66 are males and 52.34 percent are female. The average household size is 6.4. Masta Gaunpalika is predominated by Brahmin and Kshetri which are included under caste group. Nearly 81 percent people are belonged to this group. The second largest group is Dalit community which. Kami, Damai and Sarki are main Dalit castes in this category in Masta. The other group i.e. Janajati that has sis population with only one household.

Based on present land use map prepared as part of this study Out of total 10905.18-hectare land, 63.4% area is covered by forest, 30.9% area is covered by agriculture followed by Riverine and lake area which covers 1.1% area of the Gaunpalika. Public services cover about 0.4% and Residential covers 0.6% of the total area. However, Commercial, Mine and Minerals, Cultural and archeological & Industrial sectors cover small portion which are noticed below 0.01% of total area. Respectively, Other Land use area covers less than 3.6% of total area in this Gaunpalika. Whereas significant Mine & Minerals and Industrial land use distribution were not found in this gaunpalika. While preparing land use map some land use categories like residential, commercial buildings and road were found difficult to delineate in the given spatial resolution of the image. However, it was resolved with the help of field data and secondary data and images.

Soil analysis follows USDA Soil classification scheme. Based on this, LRMP in the 1980s identified seven categories of soils at order level and 21 at sub-order level. The seven order level categories included entisols, inceptisols, spodosols, mollisols, alfisols, ultisols, and aridisols. Considering the river sediments and landform, the entire Gaunpalika has been represented with 9a, 13b, 13d, 14a, 14b and 15b land units. A total 35 pit was surveyed in this Gaunpalika. Landform of the Gaunpalika is primarily dominated by steeply to very steeply sloping mountainous terrain. Based on land type/unit, soil survey revealed that the entire Gaunpalika is comprised of 6 land units in which 26.5% of the area falls under moderately to steeply sloping mountainous terrain 30.8% of area falls under very steep slopes and 41% of the area falls under steeply to very steeply sloping mountainous terrain. The soil taxonomy classification categories in the Gaunpalika suggest that inceptisols covers 92.2 % followed by entisols with 7 percent. The acidic soil has noticed in the major part of the palika and some area are acidic that suggest the need of application of krishi chun. The soil nutrients of the palika is good except in some pocket areas nutrient values like potassium, phosphorus, nitrogen and organic matter are seen low where application of phosphorus, potash and urea is recommended at specificied amount.

Identification of land capability classes is based on multi-criteria evaluation that includes biophysical, soil fertility and erosion susceptibility parameters on the one hand and climatic, topographic and drainage/wetness parameters on the other hand. The smallest mapping unit for delineation of land capability categories is 0.25 hectare.

Land Capability of Masta Gaunpalika was conducted on the basis of the soil properties, terrain slope, erosion and drainage characteristics. Majority of land (51.4%) consists of land capability class IIIAh/2, 46.9% land has IVCh/5 class and 0.9% land has Non-Arable Land class. There are few limitations in land capability class III for the forest development for fodder, fuel wood, or timber production. It also consists of suitable arable agriculture for diversified crops but terrace farming is compulsory to control erosion. 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. The available steep to very steep slopping land can be utilized for grazing purpose and fodder grass production so that livestock product can be increased. For the benefit at the local level, a detail analysis is presented showing the best suitable cereal crops, cash crops, horticulture, vegetables by elevation zones of the Gaunpalika.

Hazard risk situation in the Gaunpalika has been analyzed. Five types of risks namely flood, landslide, fire, seismic (earthquake) and industrial hazards are analyzed and mapped. The study area holds major risk of landslide along road and steep slope area. The multicriteria based landslide hazard map shows major hazard prone area in the central part of the Gaunpalika which is mainly contributed by the presence of steep slopes, weak geological condition and degraded forest areas and also close to MCT relative to the MBT line. Flood risk has analysed using HECRAS with different return period. The high flood risk area is along the River and its tributaries especially in the agricultural areas which is under high threat from the flood and inundation. Seismicity analysis shows low seismic activities in the study area but the area lies in the Central Seismic Gap of the Himalaya and its impact should be taken seriously as there are also epicentre from the past earthquakes are falling in the study area. There is significant risk of forest fire mostly in dry season and it is because the major portion of the area is covered with forest. The flood risk may trigger by potential Glacier Lake Out Burst Flood (GLoF) so that detail investigation of potentially dangerous glacier lakes in the upper catchment of the existing river networks is important.

Proposed land use zoning is based on National Land Use Policy 2072 and Land Use Act 2076 which specifies 10 zones that include i) agricultural, ii) residential, iii) commercial, iv) industrial, v) forest, vi) public uses, vii) other zone, viii) mine and minerals, ix) cultural and archeological, and x) riverine and lake area. The proposed land use zoning are based on multi-criteria analysis, extensive field visits; hazards risk analysis, expert opinions, land use and settlement expansion over the last 10-15 years, population growth and its projection, migration and state of infrastructure development. Three main considerations for proposed land use zoning are: i) meeting the increasing demand for land to accommodate the increasing population due to population growth, migration and urbanization, ii) regulating and controlling land use changes in areas designated as agriculture zone, and iii) protecting and preserving areas that are environmentally sensitive. Out of the 10 categories, it has proposed seven zones in which mines and mineral, and 'other' zone are not found suitable although mines and mineral locations are reported by local people. While preparing land use zone, a minimum transition has been proposed based on the policy guideline and practical need so that land can be best utilized in a sustainable way and also ensure comparative advantages. The main land use transition is from agriculture to residential, agricultural to commercial and agriculture to public use. While forest land use zone is intact. Finally, cadastral layers have been overlaid on the proposed land use zones presented. The cadastral superimpose shows the need of accurate and up-to-date cadastral map. The present superimpose maps need wider local consultation and the prepared maps are to be used as an important reference.

The socio-economic profile of Gaunpalika has prepared based on the provided guideline and the database which can be an important asset to the Gaunpalika for its planning effort. While engaging with the Gaunpalika representatives during the study period and presentations of the report a few import suggestions have been provided. They find the study important and show their willingness in its implementation. However, at the same time it has also reported the need of detail technical and human resource support, and community awareness about the proposed new system of land management at local level.

कार्यकारी सारांश

भूमि नेपालको एउटा महत्वपूर्ण प्राकृतिक स्रोत हो । भूमि सम्बन्धि दस्तावेज नेपालको सबैभन्दा पुरानो कानुनी दस्तावेज हो । ऐतिहासिक कालखण्डमा पनि विभिन्न प्रयोजनका लागि उपयुक्त जमिनको पहिचान गर्ने र सोहि बमोजिमको उपयोगको लागि प्रोत्साहन गर्ने नीति राज्यको रहेको पाइन्छ । समयक्रम संगै जनसंख्यामा वृद्धि हुदै गयो । बसाई-सराई, सहरीकरण तथा विकास निर्माणका विभिन्न पूर्वाधारहरु बन्ने क्रमसंगै जमिनको उपयोगमा चाप बढ्न थाल्यो । परिणामस्वरुप नेपाल सरकारले दिगो आर्थिक, सामाजिक तथा वातावरणीय विकास गर्ने दुरदृष्टि लिएर राष्ट्रिय भू -उपयोग नीति २०७२ तथा भू - उपयोग ऐन २०७६ ल्यायो । राष्ट्रिय भू - उपयोग नीति २०७२ ले भुमिलाई मुख्यत, यसको संरक्षण (structure), क्षमता (capability), उपयुक्तता (suitability) तथा आवश्यकता अनुसार विभाजन गर्ने र सोहि बमोजिम उपयोग गर्ने उदेश्य लिएको छ । यी उदेश्य हासिल गर्न नेपाल सरकार भूमि- व्यवस्थापन, सहकारी तथा गरिबी निवारण मन्त्रालय नापी विभाग, स्थलरूप नापी तथा भू- उपयोग व्यवस्थापन महाशाखा अन्तर्गत यो कार्यक्रम संचालन गरि यस सम्बन्धि विभिन्न क्रियाकलाप गाउँपलिका/ नगरपालिका स्तरमा गर्दै आइरहेको छ । यो कार्यक्रम संचालन गर्न जिल्लाका विभिन्न गाउँपलिका/ नगरपालिकालाई समावेस गरि प्याकेज बनाइएको छ जसमा एक आपसमा जोडिएका गा.पा./ न.पा. लाई मिलाईएको छ । नेपालको संविधान २०७२ लागु हुनु अघि यस्ता हरेक प्याकेजमा गा.वि.स./ न.पा. समावेस गर्ने गरिन्थ्यो । यस प्रतिवेदनमा बझांग जिल्ला मष्टा गाउँपालिकाको तल उल्लेखित अध्ययनका उद्देस्यहरुसंग सम्बन्धित बिषयवस्तुहरुको अध्ययन/ विश्लेषणबाट प्राप्त परिणामलाई प्रस्तुत गरिएको छ । यो प्रतिवेदनले प्याकेज नं.१९ अन्तर्गत बझांग जिल्ला मष्टा गाउँपालिकालाई समेटेको छ । यो पालिका पहिलेका चारवटा गा.वि.स - कोटदेवल, मष्टा, भातेखोला र रीलु गाभिएर बनेको हो ।

यस अध्ययनका मुख्य उद्देस्यहरुमा क) गाउँपालिकाको भू-उपयोग नक्सा, माटो नक्सा, भुमि क्षमता नक्सा, जोखिमका नक्सा, भुमिको क्षेत्र वर्गीकरण नक्सा, कित्तानापी नक्साको super-impose गर्ने, तथा ख) गाउँ पालिकाको सामाजिक आर्थिक पार्स्वचित्र तयार पार्ने रहेका छन् ।

यस अध्ययनका लागि विभिन्न डाटाहरु प्रयोग गरिएका छन् । मुख्यत: चिनियाँ भू-उपग्रह zy-3(Zi-Yiua3) बाट खिचिएका तस्बिरहरु, स्थलगत नक्सा र विभागबाट उपलब्ध भएका कित्तानापीका नक्साहरु छन् । भू-उपग्रह नक्सालाई विभिन्न प्रक्रिया जस्तै orthorectification र geo-referencing गर्नका लागि फिल्ड मा DGPS सर्भे तथा अध्ययन क्षेत्रको DEM तयार गरि सो तस्बिरलाई accurate बनाइएको छ । प्राप्त नक्सालाई digitisation प्रविधि मार्फत, विभाग द्वारा भू-उपयोगको नीति र भू-ऐनलाई आधार मानेर बनाइएको National Landuse Mapping specification मा, रहेर डाटाबेस तयारी तथा नक्सांकन गरिएको छ । सो नक्सांकन कार्य १:१०,००० माननापमा गरिएको छ र शुद्धताको चेकजाँचका लागि फिल्डमा स्थानीय श्रोत व्यक्ति र आवस्यक सूचना तथ्यांक मार्फत निश्चित गरिएको छ । यसका साथै

गाउँपालिकाको पदाधिकारीहरु र सरोकारवाला निकायहरु माझ तयार पारिएका नक्सा र डाटाको प्रस्तुतीकरण गरि सल्लाह र सुझाव लिने कार्य पनि भएको छ ।

मष्टा गा.पा.ले १०९.०५ वर्ग कि.मि क्षेत्र ओगटेको छ । यस गा.पा.को कुल जनसंख्या १७,९०९ र कुल घर संख्या २,७९८ रहेको छ । कुल जनसंख्याको ५२.३४% महिला र ४७.६६% पुरुष रहेका छन् । ब्राह्मण/ क्षेत्री, कामी/ दमाई/ सार्की र ठकुरी यस गा.पा.का प्रमुख जातिहरु हुन् । ब्राह्मण/ क्षेत्रीको जनसंख्या उल्लेख्य रुपमा ८१ प्रतिशत रहेको छ भने दलित - कामि/ दमाई/ सार्कीको दोस्रो ठुलो जनसंख्या रहेको छ । जनजातिको जम्मा एक घरधुरी संख्या रहेको छ ।

पालिकाको वर्तमान भू-उपयोगको अवस्था हेर्दा कुल क्षेत्रफलको ३०.९ प्रतिशत कृषि, ६३.४ प्रतिशत वन, ०.४ प्रतिशत सार्वजनिक सेवा, ०.६ प्रतिशत आवासीय, १.१ प्रतिशत खोला-नाला, ताल-तलैया सिमसार र ३.६ प्रतिशत अन्य क्षेत्रले ढाकेको देखिन्छ । व्यावसायिक क्षेत्र, सांस्कृतिक र पुरातात्विक क्षेत्र, खानी तथा खनिज क्षेत्र तथा औद्योगिक क्षेत्रको प्रतिशत अत्यन्त न्यून रहेको छ ।

अन्तरराष्ट्रिय स्तरमा मान्यता प्राप्त USDA Soil Classification Scheme का आधारमा यस गा.पा.को माटोको विश्लेषण गरिएको छ । सो कार्यका लागि १९८० को दशकमा तयार पारिएका विभिन्न नक्साहरु, भू-उपग्रहिय तस्बिर र माटोका नक्साहरुलाई आधार मानी माटो परिक्षणका लागि उपयुक्त स्थान छनोट गरिएको र संकलन गरिएको माटो प्रयोगशालामा परिक्षण गरि माटोका विभिन्न गुण तथा क्षमताको अध्ययन गरिएको छ । जम्मा ३५ ठाउँबाट नमुना परिक्षणको लागि माटो संकलन गरिएको छ । प्राप्त तथ्यांकलाई विश्लेषण गर्दा यस गा.पा.मा ९२.२ प्रतिशत inceptisols र ७ प्रतिशत entisols प्रकारका माटो पाइन्छ । यसैगरि कुल क्षेत्रफलको २६.५ प्रतिशत मध्य देखि भिरालो प्रकृतिको, ३०.८ प्रतिशत अति उच्च भिरालो प्रकृतिको जमिन र ४१ प्रतिशत भिरालो देखि अति उच्च भिरालो प्रकृतिको जमिन यस गा.पा.मा देखिन्छ । गा.पा.को उत्तरपूर्वी क्षेत्रको माटोमा अम्लियपना देखिएको हुनाले कृषि चुनको प्रयोग गर्न उपयुक्त देखिन्छ भने पालिकाको अधिकांश क्षेत्रमा नाईट्रोजन, पोटासियम र जैविक तत्व उच्च देखि मध्यम स्तरमा रहेका छन् । फोस्फोरसको मात्रा भने यस गा.पा.मा अलि कम देखिएको छ ।

माटोको विश्लेषण र नक्सांकनमा आधारित यस गा.पा. को भू-क्षमता नक्सा पनि तयार पारिएको छ । जस अनुसार कुल ७ भू-क्षमता वर्ग मध्ये वर्ग ३ मा अधिकांश ५१.४ प्रतिशत, वर्ग ४ मा ४६.९ प्रतिशत रहेको देखिन्छ भने ०.९ प्रतिशत कृषिका लागि अयोग्य क्षेत्र भएको पाइन्छ । वर्ग ३ का जमिन मध्ये देखि उच्च भिरालो रहेको र उचित व्यवस्थापन गरेको खण्डमा विभिन्न वालीका लागि उपयुक्त देखिन्छ भने वर्ग ४ मा जमिन, वन तथा वनजन्य उपभोग्य वस्तुका लागि प्रयोगमा ल्याउन उपयुक्त देखिन्छ । यस प्रतिवेदन भित्र गाउँपालिकाका लागि उपयुक्त नगदेवाली, अन्नवाली र फलफुल खेति उचाईका आधारमा सिफारिस गरिएको छ ।

यसैगरि भू-उपयोग नीति तथा ऐनले जोखिमयुक्त क्षेत्रमा बसोबासलाई निरुत्साहित गर्ने उद्देश्यले त्यस्ता क्षेत्रको नक्सांकन गर्ने कार्य पनि महत्व दिइएको छ । यस गा.पा.मा देखिएका वाढी, पहिरो, वन डढेलो, भूकम्प र अन्य प्रकोपहरुको अध्ययन, विश्लेषण तथा नक्सांकन गरिएको छ । पहिरोको जोखिमको अध्ययन multi-criteriaका आधारमा गरिएको छ । भिरालो जमिनको ढाल, कमजोर भौगर्भिक अवस्था तथा जमिनको दरार, वन विनाश भएका क्षेत्रहरुमा पहिरोको जोखिम बढी रहेको पाइएको छ । वाढी जोखिमको विश्लेषण विभिन्न पुनरावृत्ति हुने समय(return period) का आधारमा गरिएको छ । बाढीका धेरै जोखिम रहेका क्षेत्रहरुमा सेती नदि किनारको क्षेत्र र देउरा रहेका छन् । भूकम्पको जोखिमका हिसाबले समग्र जिल्ला जोखिम क्षेत्र भित्र पर्दैन तर पश्चिम नेपालमा seismic gap लामो रहेकाले यसलाई उच्च सतर्कताका रुपमा लिनु पर्दछ । यस पालिकाका केहि ठाउंहरुमा हिउँदमा डढेलोको जोखिम देखिन्छ । यस गा.पा.को तल्लो भेगमा बग्ने सेती नदिको आसपासमा रहेको देउरा बजार क्षेत्रलाई बाढीको जोखिम रहेकोले सो क्षेत्रमा जोखिम न्युनिकरणका उपायहरु अपनाउन पर्ने देखिन्छ । बाटो निर्माण कार्य गर्दा हुनसक्ने भू-क्षय र पहिरोको जोखिमलाई पनि मध्यनजर गर्नुपर्ने देखिन्छ । बाढीको जोखिम विश्लेषण गर्दा सेती नदीको उपल्लो भागमा रहेका हिमतालहरुको बिष्फोटन हुने सम्भावना र यसको प्रभावबारे थप अध्ययन गर्नुपर्ने देखिन्छ ।

भूमिको समुचित उपयोग र प्रभावकारी व्यवस्थापन गर्दै अधिकतम र दिगो लाभ हासिल गर्ने उद्धेस्यले प्रस्तावना गरिएको भू-उपयोग ऐनका आधारमा यस गा.पा.को भू-उपयोग क्षेत्रहरुलाई विभिन्न क्षेत्रमा वर्गिकरण गरिएको छ । भू-उपयोग नीति २०७२ र भू-उपयोग ऐन २०७६ मा निर्दिष्ट गरिएका १० वटा क्षेत्रहरु (क. कृषि क्षेत्र, ख. आवासीय क्षेत्र, ग. व्यवसायिक क्षेत्र, घ. औद्योगिक क्षेत्र, ङ. खानि तथा खनिज क्षेत्र, च. वन क्षेत्र, छ. नदि खोला तथा सिमसार क्षेत्र, ज. सार्वजनिक उपयोगको क्षेत्र, झ. सांस्कृतिक तथा पुरातात्विक महत्वका क्षेत्र र ञ. नेपाल सरकारबाट आवस्यकता अनुसार तोकिएका क्षेत्र) मध्ये "खनिज तथा खानि क्षेत्र" तथा "अन्य क्षेत्र" बाहेक आठ वटा भू-उपयोगका क्षेत्रहरु प्रस्ताब गरिएको छ । यी क्षेत्रहरुको वर्गीकरण गर्दा भूमिको वस्तुस्थिति, जनसंख्या वृद्धिदर, खाद्य तथा आवासको आवस्यकता, आर्थिक विकास तथा पूर्वाधार निर्माणका लागि भूमिको माग लगायतका विषयलाई आधार लिइएको छ । वर्तमान भू-उपयोग र प्रस्तावित भू-उपयोग क्षेत्र हेर्दा कृषिबाट आवास, व्यवसायिक तथा सार्वजनिक उपयोगको क्षेत्रमा केहि जमिन स्थानान्तरण भएको छ । वन क्षेत्र खासै घटेको छैन । प्रस्तावित भू-उपयोगको क्षेत्र वर्गीकरण नक्सामा कित्तानापी नक्सालाई super-impose गरि विश्लेषण गर्दा सामान्यत super-impose भएको पाइन्छ । यस्तो super-impose गर्नको लागि सहि र अध्यावधिक कित्तानापी नक्साको आवस्यकता रहेको छ । यसका अलावा कित्ता नापी नक्सामा काम गर्दा स्थानीय समुदाय/ सरकार संग बिस्तृत रुपमा सहकार्य/ परामर्श गर्नु पर्ने हुँदा प्राप्त super-impose mapलाई सन्दर्भ सामग्रीका रुपमा लिन उपयुक्त देखिन्छ ।

यस प्रतिवेदनको अन्तिम खण्डमा यस मष्टा गा.पा.को पार्श्वचित्र (profile) समावेश गरिएको छ । यसमा गा.पा.को सामाजिक, आर्थिक, वातावरणीय, भौगोलिक, जोखिमयुक्त क्षेत्र तथा अन्य बिषय वस्तुलाई समेटिएको छ । उल्लेखित विषयवस्तुलाई समेटेर आगामी दिनमा विकास निर्माणका योजना तयार गर्न सहयोगी भूमिका निर्वाह गर्ने उद्धेस्यले यो प्रतिवेदन पेश गरिएको छ जुन पालिकाका विभिन्न विकास निर्माणका काम तथा योजना बनाउन उपयोगी हुनेछन । यस अध्ययनको क्रममा गाउँपालिकाका पदाधिकारी तथा अन्य व्यक्तिहरु संग भएका प्रस्तुतीकरण तथा छलफलबाट विभिन्न सकारात्मक सुझावहरु प्राप्त भएका छन् । पालिकाले यस अध्ययनलाई महत्वपूर्ण दस्तावेजका रुपमा लिदै यसलाई लागु गर्ने प्रतिबद्धता जनाएको छ । साथसाथै पालिका संग यस सम्बन्धि प्राबिधिक तथा अन्य जनशक्तिको अभाव, यसलाई आवस्यक पर्ने पूर्वाधार नभएको तथा यो लागु गर्नु पूर्व व्यापक रुपमा जनसमुदाय संग छलफल गर्नुपर्ने आवस्यकता पनि औल्याएको छ ।

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A. General Background

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List of Abbreviation

Abbreviation	**Full Form**
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DNA	Data Not Available
DOLIA	Department of Land Information and Archive
DTM	Digital Terrain Model
ERDAS	Earth Resources Data Analysis System
FAO	Food and Agricultural Organization
GCPs	Ground Control Points
GDP	Gross domestic Product
GIS	Geographic Information system
GoN	Government of Nepal
GPS	Global Positioning System
Ha	Area in hectare
HQs	Headquarters
IHS	Intensity Hue Saturation
ISRIC	International Soil Reference and Information Centre
IUSS	The International Union of Soil Sciences
KII	Key Informants Interview
Km	Kilometer
LC	Land Cover
LP	Land Policy
LRMP	Land Reform Mapping Project
LU	Land use
LULC	Land use and the land cover
LUTs	Land Utilization Types
m	Meter
MCA	Multi-Criteria Analysis
mm	Millimeter
MMU	Minimum Mapping Unit

MoLMCPA	Ministry of Land Management, Cooperatives and Poverty Alleviation
MoLRM	Ministry of Land Reform and Management
MSS	Multi Spectral Scanner
MUTM	Modified Universal Transverse Mercator
NDVI	Normalized Difference Vegetation Index
NGOs	Non-Governmental Organizations
NLUP	National Land Use Project
OM	Organic Matter
PAN	Panchromatic
PCA	Principal Component Analysis
PH	Power of Hydrogen
RGB	Red Green Blue
RMSE	Root Mean Square Error
RPC	Rational polynomial coefficient
RS	Remote Sensing
RSM	Rigorous sensor Model
Sil	Silty Loam
SL	Sandy Loam
ToR	Terms of Reference
TSLUMD	Topographical Survey and Land Use Management Division
UNESCO	United Nation Educational, Scientific and Cultural Organization
USA	United States of America
USDA	United States Department of Agriculture & Soil Conservation
UTM	Universal Transverse Mercator
GaPa/NaPa	Gaunpalika/Nagarpalika
VHRS	Very High Resolution Satellite
WGS84	World Geodetic System 84
WRB	World Reference Base
WRBS	World Reference Base for Soil Resources

1. Background

Land use planning is the systematic assessment of the land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the land use options (FAO, 1993). Land is the only natural resource that is at the centre of all economic activities. The land use/ land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. In the context of rapidly growing human population, the demand for land for agriculture, grazing, wildlife, tourism, and urban development, is conflicting and greater than it is available.

About 60% of the active populations of Nepal depend upon the agriculture and related activities like forestry and pasture. These activities constitute about 97% of the total land use area. Since the country is producing insufficient food, the demand for arable land is increasing. In addition, the problem has become much severe due to increased land demand for urbanization, industrial uses, infrastructures and forestry and pasture. The forces that would change their availability like climate change and natural disaster; and need to preserve the land quality and availability for the future generation is challenging task. Therefore, land use planning is required to best utilize the limited land resources based on inherent qualities. This will address the issues of food security, land degradation, forest and wild life protection, hazard mitigation, and physical development. 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 polices and national planning efforts. The Ninth and Tenth Five Year plans (2002/03 - 2006/07) of Nepal highlighted on the formulation and implementation of land use policy to discourage to use arable land for non-agricultural purposes. Comprehensive local level (Gaunpalika/Nagarpalika level) land use planning has been felt necessary by the Government of Nepal to address the issues of food security, land degradation, forest and wild life protection, hazard mitigation, and physical development. In this scale of land use planning, basic information of the current land use, soil characteristics, land capability, land system, land use zoning, and cadastral maps as well as that of people and service is required. In the Tenth Five Year Plan, implementation of land use program was included. So, the Topographical Survey and Land Use Management Division (TSLUMD) initiated its work to update existing land resources maps, to prepare land zoning data and to prepare profile of district level and to create land use data, to prepare land zoning data, to prepare profile for Nagarpalika/Gaunpalika level and to superimpose cadastral map. This project of selected Nagarpalika/Gaunpalika of Bajhang district is a part of the series of functions to achieve the objectives of the TSLUMD. Analysis and interpolations of high resolution satellite images supported with field observations for the soil data and other related details for the preparation of the Nagarpalika/Gaunpalika level existing land use maps, soil maps, land capability maps, land use zoning maps in large scale using Remote Sensing and Geographic Information System techniques is the present state of art to execute the project. This spatial information is intended to provide valuable insight to the land resources planners, urban/infrastructure planners, environmentalists, foresters, scientific researchers as well as local Nagarpalika/Gaunpalika authority and other agencies to implement effective land use plans.

The Topographical Survey and Land Use Management Division, (hereinafter referred as 'TSLUMD') under the Ministry of Land Management, Cooperatives and Poverty Alleviation, Government of Nepal offered the task to prepare Nagarpalika/Gaunpalika level present land use maps, soil maps, land capability maps, land use zoning maps, land hazard maps, Cadastral Superimpose and profile, and databases and reports for the Package 19 having 3 Gaunpalika (Masta, Talkot and Saipal) of Bajhang District to ADMC Engineering Pvt. Ltd.

2. Objectives

The broad objective of Topographical Survey and Land Use Management Division (TSLUMD), Package 19, (2075/76 fiscal year) is to prepare (Nagarpalika/Gaunpalika) 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 of Bajhang district of Nepal. In order to fulfill the broad objective, the present study aims to prepare a present land use map of Masta Gaunpalika based on high resolution satellite image ZY (Ziyuan-3) and detailed field survey. Therefore, the main objective of the study is:

a) Preparation of Nagarpalika/Gaunpalika level present land use maps,

b) Preparation of Nagarpalika/Gaunpalika level soil maps,

c) Preparation of Nagarpalika/Gaunpalika level land systems maps,

d) Preparation of Nagarpalika/Gaunpalika level land capability maps,

e) Preparation of Nagarpalika/Gaunpalika level land use zoning maps,

f) Preparation of Nagarpalika/Gaunpalika profile for land use zoning,

g) Superimposition of Cadastral layers with land use zoning maps and

h) Preparation of Land Hazard Mapping for land use zoning.

Details of each of the task are described in respective chapters.

3. Project Area

The project area under this working package consists 3 Gaunpalika (Masta, Talkot and Saipal).

S.No	Name	Area (Ha.)
1	Masta Gaunpalika	10905.18
2	Talkot Gaunpalika	33469.65
3	Saipal Gaunpalika	146484.55

Location map of the Masta Gaunpalika in Bajhang district given below in Figure 1.

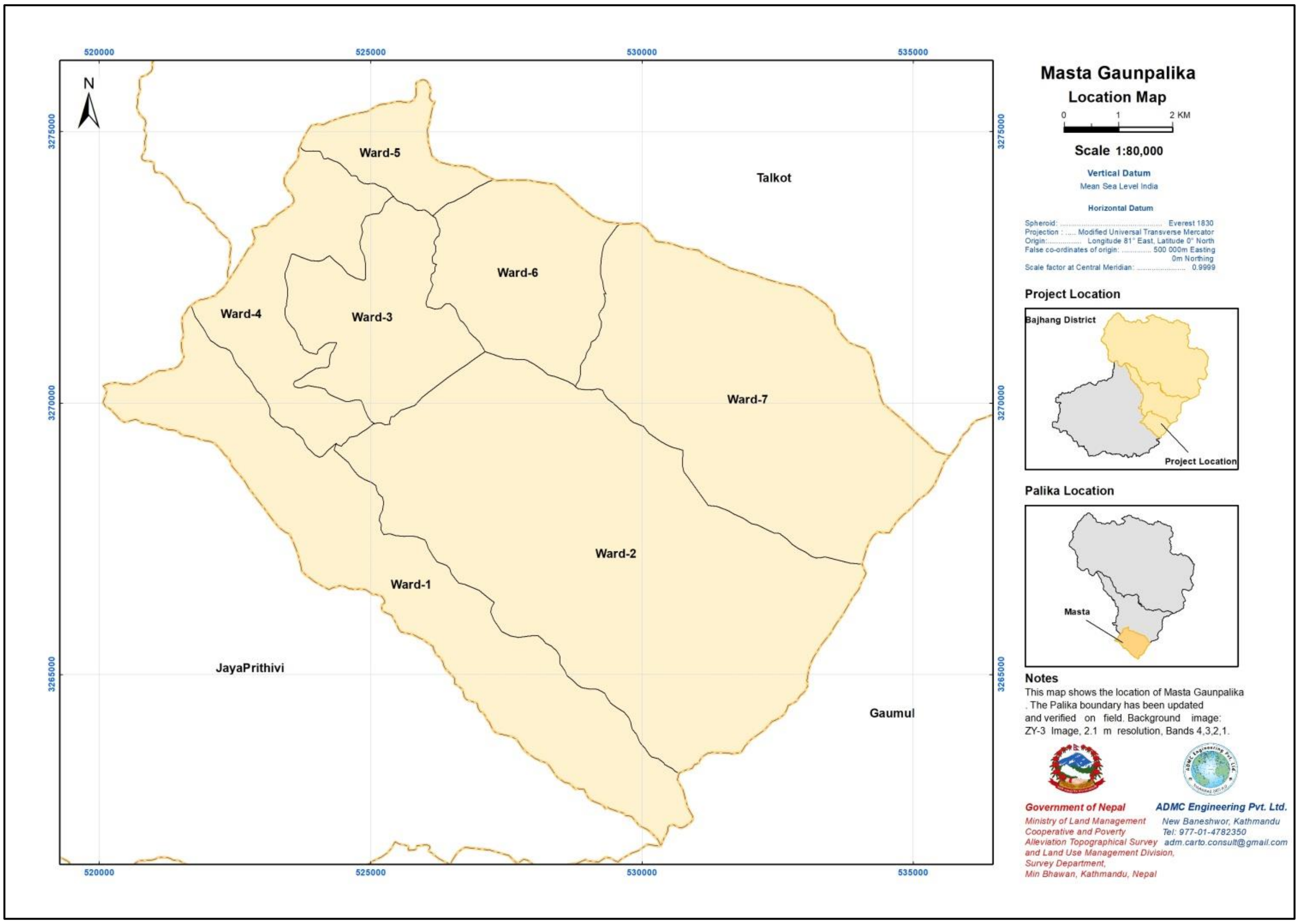

Figure 1: Location Map of Masta Gaunpalika in Bajhang District

B. Present Land Use

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Chapter -1
INTRODUCTION

1.1 Background and Rationale

Background: Land is the only natural resource that is at the center of all economic activities. An inventory of land, skillfully classified according to various economic uses, has been an important database for governments, planners and policy makers for a long time. At the country level, these databases are being produced using available resources and reflecting local needs. Studies have shown that there remain only few landscapes on the Earth that is still in their natural state. Due to anthropogenic activities, the earth surface is being significantly altered in some manner and man's presence on the Earth and his use of land has had a profound effect upon the natural environment thus resulting into an observable pattern in the land use/land cover over time.

Land Cover (LC) is defined as the observed bio/physical cover of the earth's surface (Gregorio & Jansen, 2005). It refers to the type of feature present in the land (but not limited to the land because, the dispute about whether it covers the water area or not is normalized by scientific community, who accept, in practice, water area also under land cover) (FAO, 2005). Land use (LU) relates to the human activity or economic function in a specific piece of land. LU demonstrates the economic activities of an area. It can also be considered as to reflect the degree of human activities directly related to land and making use of its resources or having an impact. LC can describe in terms of biophysical component of a particular area where as LU is a functional unit of the LC. Many of the LU operations lead to the change in LC, which is the consequence of interactions between the natural environment and the human activities. Land use and the land cover (LULC) are the complex mixture of natural and anthropogenic influences and is the composition and characteristics of land surface elements (Cihlar, 2000). Land is a scarce and precious resource and knowledge of the land use/cover has become increasingly important for the national planning.

Land is one of the most important natural resources of the earth. Conducting developing activities of a nation is not possible without adequate information on many complex interrelated aspects of its activities, particularly land, in order to make appropriate or effective decision by using land in sustainable manner. If a nation cannot make effective decision on particular land, the use may turn into misuse/overuse, which finally results in degradation and deterioration of land. Thus, for the sustainable land resource management is required to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wet lands, and loss of fish and wildlife habitat (Anderson, Hardy, Roach, & Witmer, 1976).

Sustainable land resource management requires a systematic approach towards land utilization planning, land use zonation and assessment of land performance when used for specific purpose (Joshi, 2007). Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels. Its other application includes residential-industrial-commercial site selection, population estimation, tax assessment, development of zoning regulation etc. (Anderson, Hardy, Roach, & Witmer, 1976).

Rationale: The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use / land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change thus providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority.

Viewing the Earth from space is now crucial to the understanding of the influence of man's activities on his natural resource base over time. In situations of rapid and often unrecorded land use change, observations of the earth from space provide objective information of human utilization of the landscape. Over the past years, data from Earth sensing satellites has become vital in mapping the Earth's features and infrastructures, managing natural resources and studying environmental change.

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

Therefore, attempt has been undertaken to map out the present status of land use in Gaunpalika/Nagarpalika level for the whole country by the Topographical Survey and Land Use Management Division (TSLUMD).

Land is one of the important and precious natural resources of the earth surface. The demands for arable land, grazing, forestry, wild-life, tourism and urban development are greater than the land resources available. Hence, land–use planning for making the best use of the limited land resources is inevitable. 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, 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. However, Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (**LRMP**, 1983/84). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the **National Land Use Project** (**NLUP**) in 2057/058 fiscal year to generate the necessary data bases on the land resources of the country.

In the first phase, the National Land Use Project of Nepal had initiated several projects at district level and prepared **Land Resource Maps and Database** at 1:50,000 scale for the whole Nepal. It had also prepared same kinds of maps and database for Kirtipur, Lekhnath, Madhyapur Thimi and Bhaktapur Nagarpalika at larger scales. Finally, NLUP was mandated to prepare land resource maps of Gaunpalika/Nagarpalika of Nepal for local level planning through outsourcing modality. Up to 2068/069 fiscal years, NLUP has completed preparation of land resource maps and database for all VDCs of Chitawan district and Nawalparasi Districts and one VDC each for Kavre (*Panchkhal VDC*) and Tanahun (*Anbu Khaireni VDC*) District as well. These digital data base includes VDC level present land use, soil, land capability, land use zoning, cadastral layers and VDC profile with bio-physical and socio – economic data base.

Previously, on 16th Baisakh 2012, the Government of Nepal approved the **National Land Use Policy, 2069**. It is intended to manage land use according to land use zoning policy of the government of Nepal and outlined six zones such as **Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area**. The policy has defined the respective zones as per the land characteristics, capability and requirement of the lands. Further, for the effective implementation of land use zones in the country, the National Land Use Policy, 2069 has clearly directed for an institutional set up of **Land Use Council** at the top to the **District level** and **Gaunpalika/Nagarpalika level** at the bottom. It has added further importance to the NLUP projects on preparation of Gaunpalika/ Nagarpalika level maps and database.

During the course of implementation some updating and refinement has felt in NLUP 2069. As a result, GON came up with **National Landuse Policy, 2072** (2015 AD). This Policy has designated eleven land use catagories for present land use mapping or land use zoning task. Later on, Landuse act 2076 has integrated Excavation Area into Mines and Minerals area. So, It came up with 10 different catagories. Following list exhibits the corresponding codes used for each of the classes and the class itself.

1. AGR Agriculture
2. FOR Forest
3. RES Residential
4. COM Commercial
5. IND Industrial
6. PUB Public Service
7. MIN Mine and Minerals
8. CULARCH Cultural and Archeological
9. HYD Riverine, Lake and Marsh Area
10. OTH Other

Following TSLUMD 2076, the Topographical Survey and Land Use Management Division (TSLUMD) has awarded the project entitled Package 19: Preparation of Gaunpalika/Nagarpalika level land resources maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map and Gaunpalika/Nagarpalika profile for Land Use Zoning Map and Superimpose of Cadastral Layers), Data Base and Reports of 3 Gaunpalika of Bajhang District to our consultancy for fiscal year 2076/077. The Package 19 covers 3 Gaunpalika (Saipal, Talkot and Masta). Total no of wards in Saipal Gaunpalika is 5 wards, Talkot Gaunpalika is 7 wards and Masta Gaunpalika is 7 wards.

The rationale for the preparation of Gaunpalika/Nagarpalika level land use maps by TSLUMD are:

- Classify land into agricultural area, residential area, commercial area, industrial area, forest area, public use area and other lands as per the policy of the government of Nepal;
- Identification of residential area to provide basic facilities conveniently;
- Classification of agricultural land into maximum comparatively advantageous sub areas on the basis of land characteristics;
- Conservation of the natural resources including forest, shrub, wet lands, hazard prone areas, rivers and rivulets.

1.2 Objective of the Study

The broad objective of **Topographical Survey and Land Use Management Division (TSLUMD),** Package 19, (2076/077 fiscal year) is to prepare of Gaunpalika/Nagarpalika 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. Package 19 covers 3 Gaunpalika (Saipal, Talkot and Masta) of Bajhang. In order to fulfill the broad objective, the present study aims to prepare a present land use map of Masta Gaunpalika based on enhanced high-resolution satellite images originally provided by the TSLUMD office and detailed field survey. Therefore, the main objective of the study is:

i) To prepare Present Land Use Maps, GIS Database and Reports for the Masta Gaunpalika at 1:10,000 scales.

Scope:

In order to achieve the above-mentioned objectives, the scope of this study includes;

- Perform ortho-rectification of the given satellite image.
- Prepare present Land cover/land use maps in different hierarchical levels for the selected Gaunpalika/Nagarpalika.
- Design appropriate GIS database logically.
- Discuss the accuracy, reliability and consistencies of data.
- Prepare reports describing methodology, existing land use pattern and model of GIS data base.

1.3 Study Area

Masta Gaunpalika is an important urban center in Bajhang district and it lies in Sudur Pashchim province in Nepal. Geographically, Masta is located at 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude. This Rural Municipality consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Municipality to the west, Bajura district to the south and Talkot Rural Municipality to the north. The total area of the Gaunpalika is 109.05 km². The total population of this Gaunpalika is 17909, of which male population accounts for 8537 and female population is 9372. However, all the wards vary in area and population size. Total number of households in the Gaunpalika is 2798.

This Gaunpalika is inhabited by different caste and ethnic groups. However, Masta Rural Municipality is predominated by Brahmin and Kshetri which are included under caste group. Nearly 81 percent people are belonged to this group. The second largest group is Dalit community where Kami, Damai and Sarki are main Dalit castes in this category in Masta. The other group i.e. Janajati that has sis population with only one household.

Economic condition of the people of this Gaunpalika largely depends on agriculture. Land is main source of income and capital accumulation and also the major source of employment. Economic condition of the people having large landholding size is better than the others.

The location map of the study area has been shown in **Figure 1.1**

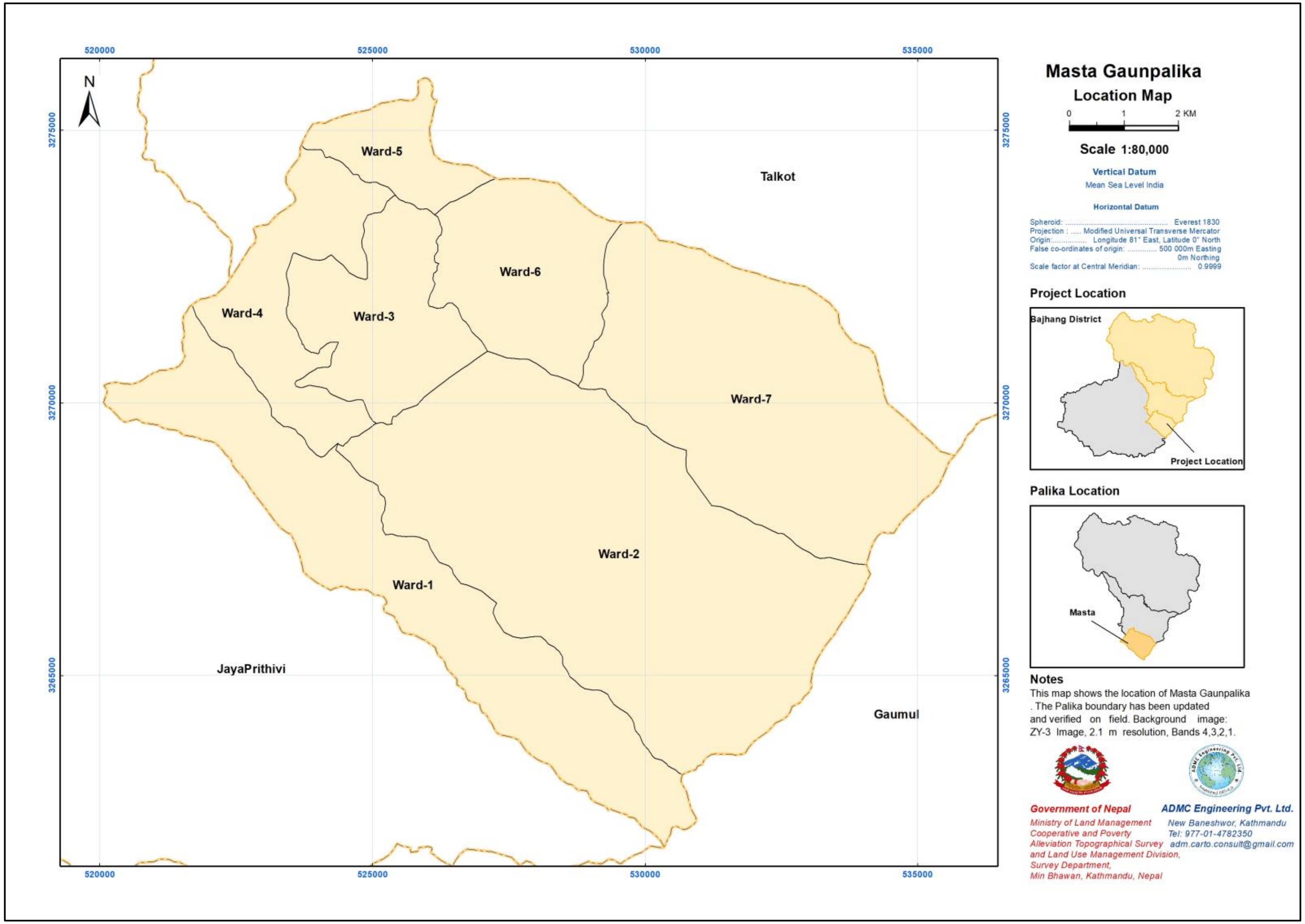


Figure1.1: Location Map of Masta Gaunpalika

Chapter – 2
CONCEPTUAL BASIS OF LAND USE CLASSIFICATION

2.1 Classification System and Criteria

In almost any classification process, it is rare to find the clearly defined classes that one would like. In determining land cover, it would seem simple to draw the line between land and water until one considers such problems as seasonally wet areas, tidal fiats, or marshes with various kinds of plant cover. Decisions that may seem arbitrary must be made at times, but if the descriptions of categories are complete and guidelines are explained, the inventory process can be repeated. The classification system must allow for the inclusion of all parts of the area under study and should also provide a unit of reference for each land use and land cover type (James R. Anderson et el 1976).

There is no one ideal classification of land use and land cover, and it is unlikely that one could ever be developed. There are different perspectives in the classification process, and the process itself tends to be subjective, even when an objective numerical approach is used. There is, in fact, no logical reason to expect that one detailed inventory should be adequate for more than a short time, since land use and land cover patterns change in keeping with demands for natural resources. Each classification is made to suit the needs of the user, and few users will be satisfied with an inventory that does not meet most of their needs. In attempting to develop a classification system for use with remote sensing techniques that will provide a framework to satisfy the needs of the majority of users, certain guidelines of criteria for evaluation must first be established. We have taken the reference of the recently formulated land use policy as guidelines of classification and fit into the model supplied by TSLUMD.

Land use land cover of an area is largely depending on different factors such as terrain, lithology, soil type, climate, rainfall pattern, socio-cultural practices, relative location etc. land use classification is necessary for the preparation of land use zonation and or for the optimum utilization of a particular land. Classification is an abstract representation of the situation in the field using well-defined diagnostic criteria: the classifiers. It can be defined as: "the ordering or arrangement of objects into groups or sets on the basis of their relationships” (Sokal, 1974). A classification describes the systematic framework with the names of the classes and the criteria used to distinguish them, and the relationship between classes. Classification thus requires the definition of class boundaries, which should be clear, precise, possibly quantitative, and based upon objective criteria (Gregorio & Jansen, 2005).

A classification should be:

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

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

Classification system can be a priori or posteriori. In a priori classification system classes are pre-arranged. The use of such a classification assumes that all possible classes can be derived, independent of scale and tools used, from the system. It is the most effective way to produce standardization of classification results among user communities. Posteriori classification system is based upon definition of classes after clustering the field samples that are collected. Since this system depends on the specific area described and is adapted to local conditions, it is unable to define standardized classes.

A land use and land cover classification system which can effectively employ orbital and high-resolution remote sensing image should meet the following criteria (Anderson, Hardy, Roach, & Witmer, 1976). The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensing image should be at least 85 percent.

I. The accuracy of interpretation for the several categories should be approximately equal.
II. Repeatable or repetitive results should be obtainable from one interpreter or another and from one time of sensing or another.
III. The classification system should be applicable to extensive areas.
IV. The categorization should permit vegetation and other types of land cover to be used as surrogate for activity.
V. The classification system should be suitable for use with remote sensing image obtained at different times of the year.
VI. Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensing image should be possible.
VII. Aggregation of categories must be possible.
VIII. Comparison with future land use data should be possible.
IX. Multiple uses of land should be recognized when possible.

For land use and land cover data needed for planning and management purposes, the accuracy of interpretation at the generalized first and second levels is satisfactory when the interpreter makes the correct interpretation 85 to 90 percent of the time. For regulation of land use activities or for tax assessment purposes, for example, greater accuracy usually will be required. Greater accuracy generally will be attained only at much higher cost.

2.2 Land Use Hierarchy and Description

Land use practice in any region of the country is governed by physiography, lithology/soil climatic conditions, settlement pattern, cultural practices and socio-economic factors. To incorporate diverse land use at the Gaunpalika/Nagarpalika level, comprehensive model should be adopted while making land use inventory. Hierarchical classification system has been recommended in TOR provided by the Topographical Survey and Land Use Management Division **(TSLUMD),** Under Ministry of Land management, Cooperatives and Poverty Alleviation **(MOLCPA-Nepal),** Minbhawan, Kathmandu. This system provides a great flexibility in terms of application through its hierarchical structure. Priori classification system with land use categories as specified in the specification provided by TSLUMD has been adopted. This ensures the standardization among the classification result. National Land Use Policy 2072 provides the nomenclature of the Land Use classes. The level 1 categories of the land use distribution are: - **Agricultural area, Forest area, Residential area, Commercial area, Industrial area, Public Service area, Mine and Minerals area, Cultural and Archeological area, River-Lake & Marsh area, Others area (Grazing/ Pasture lands).**

2.2.1 Agricultural Land Use

Agricultural land is defined broadly as land used primarily for production of food and fiber. The areas those have been used for agricultural production such as cereals, cash crops, orchards, and so on. Use of land for different agricultural production differs due to physical (e.g. climatic condition, topography, soil) and social/cultural believes of the particular region. LRMP has broadly categorized cultivated land based on physiography of Nepal, namely Tarai, Hill, Mountain and Valley cultivation. The Tarai cultivation is further sub divided into Wet land, Dry land and Mix land cultivation. The Mountain cultivation is further divided into Level terraces, Upland cultivation and Sloppy upland. Similarly, Valley cultivation is divided into Level terraces, Khet land cultivation, Level terraces, Upland/pakho cultivation, Valley slope upland cultivation and Valley riverbeds lower foot slope alluvial fans cultivation (alluvial riverbed fans). The Wetland cultivation is further divided into Low khet land cultivation and Upper khet land cultivation-tari khet. Different cropping pattern is presented in level five, whereas cropping intensity is also presented in subsequent chapter. TSLUMD has provided hierarchy of agricultural land for this study **(Table 2.1).**

Table 2.1: Hierarchy of Agricultural Land Use

<table>
<tr><th rowspan="2">Level 1</th><th rowspan="2">Level 2</th><th rowspan="2">Level 3</th><th rowspan="2">Level 4</th><th>Level 5 Cropping Pattern</th><th>Level 6 Cropping Intensity</th></tr>
<tr><th>Monsoon- Winter-Dry season</th><th></th></tr>
<tr><td rowspan="3">Agricultural Land Use</td><td rowspan="3">Tarai Cultivation</td><td>• Wet Land Cultivation</td><td>• Low Khet Land Cultivation
(Poorly drained with High bond)
• Upper Khet Land Cultivation-TariKhet
(Intermediate land between wet and dry land with well drain soil bonds are lower)</td><td rowspan="3">As indicated below the table</td><td rowspan="3">Intense (75%-100% cultivated)
Medium (50%-75% cultivated)
Light (25%-50% cultivated)</td></tr>
<tr><td>• Dry Land Cultivation
(Upland pakho/ Bhith land Cultivation, Drained, smallest bond height)</td><td>Unclassified</td></tr>
<tr><td>• Mixed Land Cultivation
Diyara land cultivation
(Commonly found near River where River have change the course)</td><td>Unclassified</td></tr>
</table>

Level 1	Level 2	Level 3	Level 4	Level 5 Cropping Pattern Monsoon- Winter-Dry season	Level 6 Cropping Intensity
	Hill Cultivation	**Level Terraces**	• **Level Terraces Khet Land Cultivation** (level khet land with small bond) • **Level Terraces Upland/Pakho Land Cultivation** (level upland with no bond)		
		Slopping Terraces	• **Slopping Upland/ Pakho Land Cultivation** (cultivated on natural slopes		
	Mountain cultivation	• **Level Terraces Upland Cultivation** • **Sloppy Upland**	Unclassified		
	Valley Cultivation	• **Level Terraces Khet Land Cultivation** (Level khet land with small bond) • **Level Terraces Upland/Pakho Cultivation** (Level upland with small bond)	Unclassified	As listed at the end of the table.	Light-1 Medium-2 Intense-3
		• **Valley slope upland/Pakho cultivation** (Cultivated on natural slopes)	Unclassified		

Level 1	Level 2	Level 3	Level 4	Level 5 Cropping Pattern	Level 6 Cropping Intensity
				Monsoon- Winter-Dry season	
		• **Valley Riverbeds (Lower footslope) Alluvial Fans Cultivation** (alluvial riverbed fans)			

Level 5 for Agricultural Landuse (including cropping pattern)

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 Residential Land Use

Residential areas are the built-up areas used for housing purposes. Area of sparse residential land use such as farmstead will also be included in this category. This includes annex buildings like cow sheds, garage and farm house etc. This also includes features such as lawn area, well, private path, vegetable farm close to the house etc. The area delineated as residential area by government should also be categorized in this class. Based on density of houses, the residential area is further divided into three categories; dense (> 70%), moderate (40-70%) and sparse (<40%). Similarly, it is also divided in terms of origin of the settlement; old area, newly developed area (unplanned) and planned area such as colony type, parcels plotting area and housing complex etc. Table 2.2 shows the hierarchy of residential land use.

Table 2.2: Hierarchy of Residential Land Use

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

2.2.3 Commercial Land Use

Commercial areas are those used predominantly for the sale of goods and services. It consists of the main building, supporting structure and area that serve for commercial purpose. They are often abutted by, residential, agricultural, or other contrasting uses which help define them. It includes shopping centers, hotels, guest houses, shops, private schools, health centers, radio station, petrol pumps etc. Commercial areas are further classified into service areas and business areas. The service areas include public services whereas Business area includes market area where exchange of goods and services occur. Commercial strip are situated along the highway and access route to the highway in this Gaunpalika/Nagarpalika. Table 2.3 shows the hierarchy of commercial land use.

Table 2.3: Hierarchy of Commercial Land Use

Level1	Level2	Level3	Level4
Commercial	Service Areas	Government Service Area(G)	Designated Name
	Business Areas	Market Area with specific categories like Market (M) Hotel (H) Recreation(R) Utility(U) Storage(T) Service (S)	

Commercial Level4

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
	Night Club - n1	Other storage - x3

Hotel Subcategory (H)

Hotel - h1
Guest House -g1
Fast-food -f1
Restaurant - r1
Bar - b1
Travel Agency - t1
Other hotel - o1

Hotel Subcategory (H)
Hotel - h1
Guest House -g1
Fast-food -f1
Restaurant - r1
Bar - b1
Travel Agency - t1
Other hotel - o1

Storage Subcategory (T)
Storage house/ area - s3
Consultancy service area - c4
Business house - b4

Gaming Hall - g2
Gambling Hall - l1
Exhibition Centre - e1
Gym House - m2
Other Entertaing area - x2

Services Subcategory (S)
Bank/Money Exchange - b3
Private Post office - p1
Private Communication Area - c3
Broadcast Studio - d3
Private School Area - e2
Private Health Service Area - h3
Petrol Pump - m3
Radio Station - r3
Service centre - s2
TV Station - t3
Other Service - o3

Government Service Area Subcategory(G)
Agriculture Office - ag
CBS - b5
Civil Aviation - ca
Communication - cm
Court - co
Cultural Office - cu
District Administration office - a1
Doildar - do
Education - en
Electricity office - eo
Forestry office - f2
Health office - h5
Irrigation office - i1
Land Transaction Office -lt
Local Development office - l2
Mining and Geology - mg
Other - o5
Petroleum - pm
Post Office - po
Road Office - r4
Soil Conservation - sc

2.2.4 Industrial Land Use

Industrial areas are the areas where production of goods occurs. It includes a wide array of land uses from light manufacturing to heavy manufacturing plants. It includes area covered by land, house and shed that are used as workshop or processing and manufacturing industry. It consists of factories such as textile, food, brick, timber, vehicle, brewery etc. It is further sub-divided into small scale industry including cottage industry, medium scale industry and large-scale industry. Table 2.4 shows the hierarchy of industrial land use.

Table 2.4: Hierarchy of Industrial Land Use

Level1	Level2	Level3	Level4
Industrial	Small Scale Industry(S) Medium Scale Industry(M) Large Scale Industry(L) Special Economic Zone(E) Industrial Estate(I) Other Industrial Category(O)		Designated Name

2.2.5 Forest Land Use

Area covered by vegetation completely or partially and which does not fall under above mentioned category is forest. It consists of area covered by forest, shrub and grazing land/grassland. It is an area with natural or planted trees along with shrubs and grass where the dominant species are trees of various kinds. The forest land are subdivided into level 2 sub types as per the climatic vegetation zone such as tropical (<1000 m), subtropical (1000-2000/2100m), temperate (2000/2100-3000/3100), sub-alpine (3000/3100-4000/4100) and alpine (4000/4100-4500). Similarly, the forest land is further subdivided into level 3 categories by cover type as hardwood, coniferous and mixed. On the basis of crown density, forest is classified as dense, sparse, degraded types. Similarly, according to the forest ownership category or use right, it is classified as private, protected, government managed, community, leasehold, collaborative and religious. The hierarchy of forest land use is shown in **Table 2.5.**

Table 2.5: Hierarchy of Forest Land Use

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

Level 4 for forest landuse

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

Shrub or bushes has multiple stems and are usually about 5-6m in height. A large number of plants can be either shrubs or trees depending on their growing conditions. Shrubs are generally found in the gardens, narrow gullies, along the river bank as well as on bare unattended land during rainy season. Shrubs are not categorized into lower levels.

2.2.6 Public Services Land Use

Public services are those services which cannot exclude any person from using it under certain terms of condition. Land used for School, College, Hostel, Parks, Airport, Road, Stadium, Picnic spot, and other public service activities are categorized in this class. Public service is further classified on the basis of their functional use into Educational, Security Services, Transportation Infrastructure, Health Service, Recreational facility, Institution and Open Area. School, Colleges and Universities are placed in Educational class. Police station and Fire station are categorized in Security services. Transportation Infrastructure includes Road, Trail, Airport, Bus Park, Railway, Ropeway, etc. Hospital, Health Post, Polyclinic etc are included under Health services. Recreational facility includes Park, Picnic spot, Open Spaces, Stadium, Playground etc. Institutional service includes Government and Public institutions. The hierarchy of public services is presented in Table 2.6

Table 2.6: Hierarchy of Public Service Land use

Level 1	Level 2	Level 3	Level 4
Public Services	Educational	As explained at the end of the table	Designated Name
	Security Services		
	Transportation Infrastructure		
	Health Service		
	Recreational Facility		
	Institution		
	Open Area		
	Utility Service Area		
	Other public Use Area		

Public Use Level 3

Sub-Category Transportation- T

Highway - h2

Feeder Road - f2

District Road - d3

Local Road - i1

Other Road - o5

Bus park - b1

Airport - a2

Railway - r2

Car Park - c4

Port - p3

Pavement - v1

Cart Track - t3

Other Transportation - x1

Bridge - g3

Sub-Category Education- E

Primary - p5

Secondary - s2

Campus - c5

University - u2

Other educational area- o6

Sub-Category Health - H

Hospital - h3

Sub-Category Institutional- I

Private Institution - r3

Public Intuition - p6

NGO - n2

INGO - i4

Other intuitional- o8

Sub-Category Recreational- F

Public Theatre- c8

Drama House - d4

Stadium - s3

Playground - g4

Open space - o9

Other - x2

Zoo - z1

Rest-point-Chautari- r4

Museum - m1

Sub-Category Security Service- S

Police Station - p8

Military Area - m2

Armed Force - a3

Other Security- o10

Nursing Home - n1

Health Centre - c7

Pharmacy - f3

Polyclinic - i2

Other - o7

Snowy Mountain- sm1

2.2.7 Mine and Minerals Area Land Use

The mine and mineral area land use include areas having metallic minerals, non-metallic minerals, gemstones, construction minerals (materials), fuel minerals, decorative and dimension stones and other minerals. The hierarchy of mine and mineral area land use is given below in Table 2.7.

Table 2.7: Hierarchy of Mine and Minerals Land use

LEVEL1	LEVEL2	LEVEL3	LEVEL4	LEVEL5
Mine and Minerals	Metallic Minerals	**Mine_minerals_Construction (Materials) sub_Category (CNSM)**	Licensed	Not Operated So Far
	Nonmetallic Minerals	Sands	Not-Licensed	Currently under Operation
	Gemstones	Cobbles	Reserved	Closed
	Construction Minerals (Materials)	Flaggy quartzite	Banned	Other Operation Status
	Fuel Minerals	Limestone		
	Decorative and Dimension Stones	Pebbles		
	Other Minerals	Quartzite		
		River boulders		
		Schist		
		Slates		
		Other Construction Minerals		
		Mine_minerals_ Decorative and Dimension_sub_Category (DCDEM)		
		Basalt		

		Coloured sandstone		
		Granites		
		Marble		
		Quartzites		
		Other Decorative and Dimension Minerals		
		Mine_minerals_Fuel_Sub_category(FUEL)		
		Coal		
		Hot springs		
		Methane		
		Petroleum		
		Other Fuel Minerals		
		Natural Gas		
		Mine_minerals_GEM_Sub_category(GM)		
		Aquamarine		
		Beryl		
		Garnets		
		Gem		
		Kyanites		
		Quartz crystals		
		Ruby		
		Sapphire		
		Tourmaline		
		Other Gemstone Minerals		
		Mine_minerals_non_metallic_category(NM)		
		Clay		
		Dolomite		
		Limestone		
		Magnesite		
		Mica		
		Phosphorite		
		Quartz		
		Silica sand		

		Talc		
		Other Non-Metallic		
		Phyllite		
		Mine_minerals_Metallic_Sub_category(MTL)		
		Iron		
		Copper		
		Zinc		
		Lead		
		Cobalt		
		Nickel		
		Gold		
		Silver		
		Tin		
		Tungsten		
		Molybdenum		
		Uranium		
		Lithium		
		Lepidolite (Mica)		
		Tantalum		
		Bismuth		
		Arsenic		
		Cadmium		
		Chromium		
		Mercury		
		Titanium		
		Other Metallic Minerals		

2.2.8 Cultural and Archaeological Land Use

The Cultural and Archaeological land use include heritage site, durbar square, gadh, archaeological site, cultural site, fort, temple, stupa/monastery, mosque, church, bahal, patis, bihar and other. The hierarchy of Cultural and Archaeological land use is presented in Table 2.8.

Table 2.8: Hierarchy of Cultural and Archaeological Land use

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

2.2.9 Riverine, Lake and Marsh Area

The Riverine, Lake and Marsh Area land use include ponds, lakes, canals, glaciers, snow area, wetlands, rivers, spout, wells, kulo, sand and other hydrological area. The hierarchy of Riverine, Lake and Marsh land use is shown in Table 2.9

Table 2.9: Hierarchy of Riverine, Lake and Marsh 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)

2.2.10 Others Land Use

Other land use include types of land that does not belong to the above mentioned categories. Such type of lands are: grass land and its various forms. Grass land is further divided into tropical (<1000m), sub-tropical (1000-2000/2100m), temperate (2000/2100-3000/3100 m), sub-alpine (3000/3100-4000/4100m) and alpine (4000/4100-4500m) categories. Table 2.11 presents the hierarchy of other land uses as per Land Use Policy 2072.

Table 2.10: Hierarchy of Other Land use

Level 1	Level 2	Level 3	Level 4
Others	**Grazing Land-G**	***Climatic Vegetation Zone***	
		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

There are many different sources of information on existing land use and land cover and on changes that are occurring. Local planning agencies make use of detailed information generated during ground surveys involving enumeration and observation. Interpretation of large-scale aerial photographs also has been used widely. In some cases, supplementary information is inferred on the basis of utility hookups, building permits, and similar information. Major problems are present in the application and interpretation of the existing data. These include changes in definitions of categories and data collection methods by source agencies, incomplete data coverage, varying data age, and employment of incompatible classification systems. In addition, it is nearly impossible to aggregate the available data because of the differing classification systems used (James R. Anderson et el 2001).

The primary data source used for the land use classification in this project is 2.1m resolution Panchromatic ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 satellite imagery fused with the 4 band multi-spectral image of 5.1-meter spatial resolution of the same. Various other vector, raster and imagery data sets were used as ancillary data, which enhanced interpretation and classification of land use classes. This chapter describes, in brief, the sources and characteristics of various datasets used for the study.

Both types of data, primary and secondary, were used for the present land analysis. Maps and their related information of Land utilization, Land Capability, Land System, and Topographical Map prepared by Survey Department, Government of Nepal in different years were used as secondary information. Above maps and their reports was gathered and analyzed before interpretation of satellite imagery and field visit. ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 satellite images (MSS and pan bands) dated on 26th November 2016, 24th December 2016, 12th January 2017, 6th December 2017, 11th January 2018 and 23rd January 2018 of the project area was used for this project. Primary data (e.g., land use types, cropping pattern, and forest types/management) was collected during the field work through observation and discussion with locals using the formatted questionnaires and maps. All data and information obtained from secondary sources related to this theme (land use) were verified during the field work. Major data sources used for this study are as follows.

ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Satellite Imagery:

The ZY-3 (Ziyuan-3, 'Resource-3') series represents China's first high resolution, stereoscopic mapping satellites for civilian use. The second satellite is managed by the Satellite Surveying and Mapping Application Center (SASMAC). The imaging payload consists of a three-line camera array and a multispectral imager.

The three-line panchromatic camera array to acquire stereoscopic imagery consists of three telescopic cameras with one oriented to the nadir and the other two each offset by 22° forward and backward in-flight direction. The stereo mapping camera of ZY-3 has a resolution of 2.1 m for the nadir camera, and 2.6 m for the offset cameras. Swath width is 51 km. The multispectral imager for environmental and vegetation monitoring consists of a three-mirror telescope and a cooled detector system sensitive to four wavelength bands to capture full-color imagery as well as near-infrared data. The ground resolution of this system is 5.8 m.
First satellite, ZY-3 01, was launched in January 2012 on a CZ-4B rocket and ZY-3 02 reached orbit in May 2016. The ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 image was obtained

from Topographical Survey and Land Use Management Division Survey Department, (TSLUMD), Min Bhawan, Kathmandu. Some of the scene of satellite images provided had some cloud coverage in which information have been derived using additional satellite images provided by the client, primary and secondary data. A sensor characteristic of ZY-3-01 and ZY-3-02 is described in Table 3.1

Image Resolution Information

Bands	**Wavelength**	**Spatial resolution**
Nadir Scene panchromatic	500-800 nm	2.1 m
Blue	450-520 nm	5.8 m
Green	520-590 nm	
Red	630-690 nm	
Infrared	770-890 nm	
Cloud Cover	Less than 10%	

Table 3.1: Specification of ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Image

Package 19	
Product ID:	**zy301a_033328_083150_20180109130208_01_sec_0001_1801159331**
Image Manufacturer:	CAST (spacecraft), CIOMP (payload)
Operator:	Ministry of Land and Resources of the People's Republic of China
Image (sensor Name):	ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02
Processing Level:	Standard Geometrically Corrected
Cloud cover:	6 in the study area
Image Type:	PAN/MSL
Resolution	Spatial Pan- 2.1 m and MSL: 5.8m, Spectral: 4 bands
Date of Acquisition:	2018-01-15 13:01:59
Buffering:	Well cross the boundary of the project study area
Sensor Type:	Satellite

Product ID:	**zy302a_013184_082151_20181014133426_01_sec_0004_1811077510**
Image Manufacturer:	CAST (spacecraft), CIOMP (payload)
Operator:	Ministry of Land and Resources of the People's Republic of China
Image (sensor Name):	ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02
Processing Level:	Standard Geometrically Corrected
Cloud cover:	6 in the study area
Image Type:	PAN/MSL
Resolution	Spatial Pan- 2.1 m and MSL: 5.8m, Spectral: 4 bands
Date of Acquisition:	2018-10-14 13:34:26
Buffering:	Well cross the boundary of the project study area

Sensor Type:	Satellite

Product ID:	**zy302a_013108_083151_20181009133557_01_sec_0004_1811098388**
Image Manufacturer:	CAST (spacecraft), CIOMP (payload)
Operator:	Ministry of Land and Resources of the People's Republic of China
Image (sensor Name):	ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02
Processing Level:	Standard Geometrically Corrected
Cloud cover:	8 in the study area
Image Type:	PAN/MSL
Resolution	Spatial Pan- 2.1 m and MSL: 5.8m, Spectral: 4 bands
Date of Acquisition:	2018-10-09 13:35:57
Buffering:	Well cross the boundary of the project study area
Sensor Type:	Satellite

The ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 image used in the study area are shown in Figure 3.1.

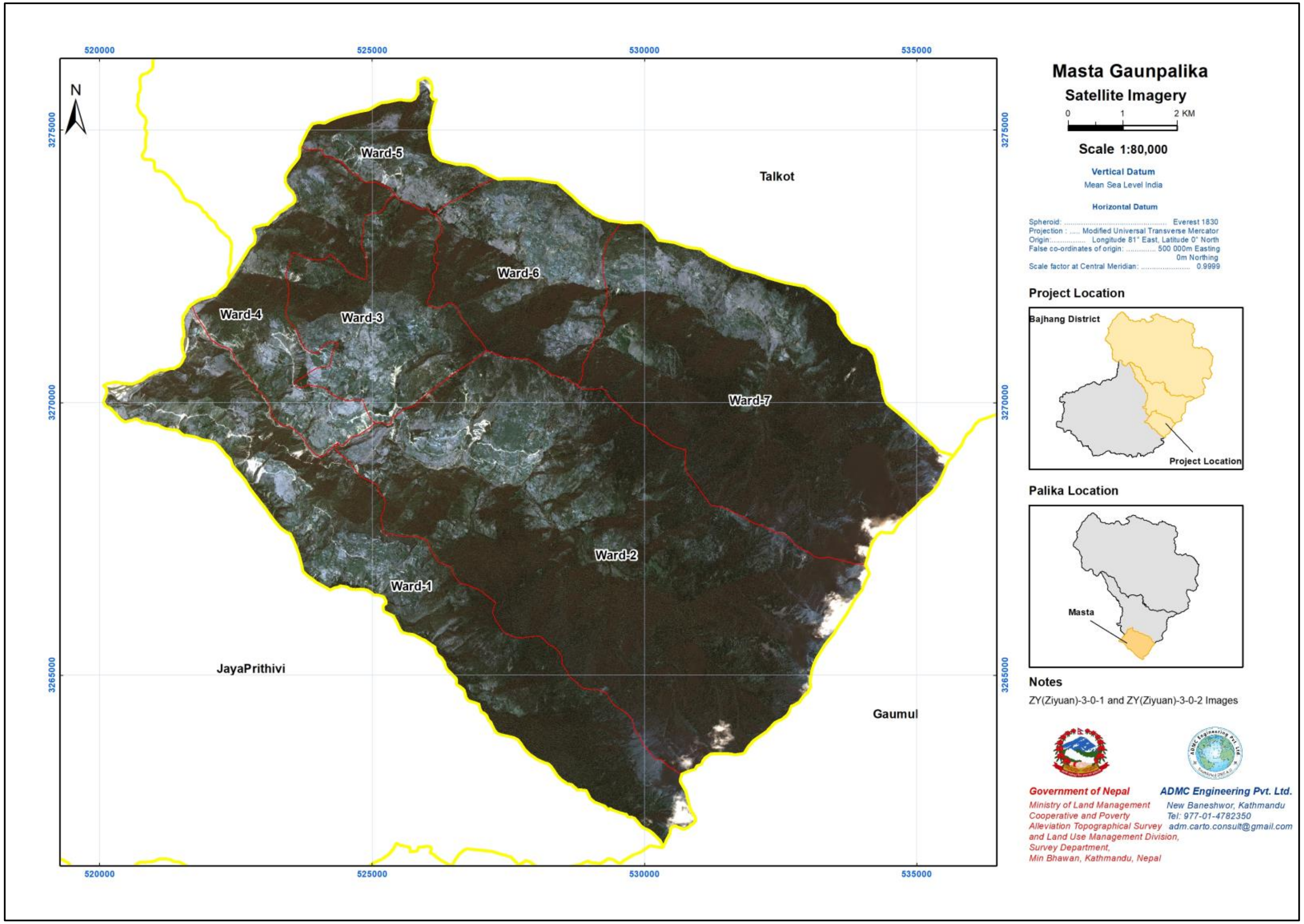
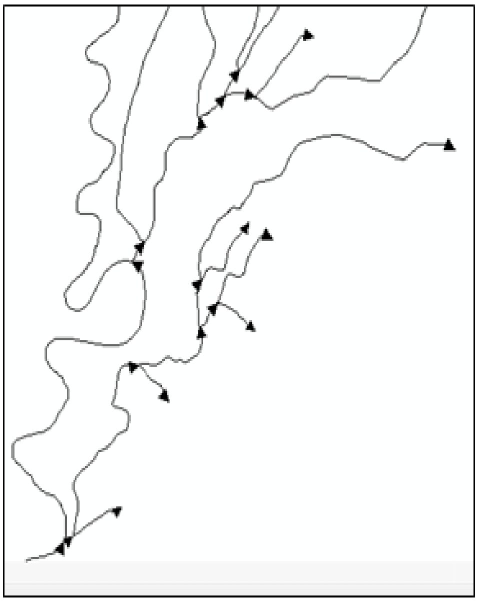


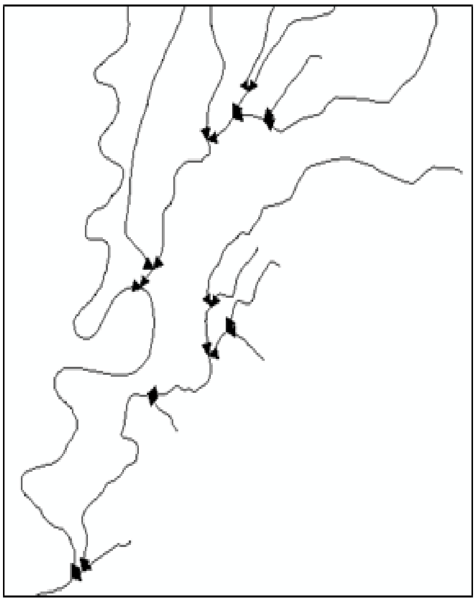
Figure 3.1: ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Images of the Study Area

Topographical Map: The Topographical base maps collected from TSLUMD as bellow: Map Sheet No. 2981 10, 2981 05 and 2981 06 in the scale of 1: 50000 bearing supplementary contour of interval 10m and in some areas even 5m. These maps are published in 1996 and are compiled from 1: 50000 scale aerial photography of December, 1990 and field verification done in December, 1991. Both hard copy and soft copy covering the project Nagarpalika/Gaunpalika and its surrounding 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, Nagarpalika/Gaunpalika boundary, location name, etc. and additional data for GIS based analysis.

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



Topologically erroneous survey data



Topologically rectified survey data during the project task

Digital Elevation Model has been prepared from the spot height and contour data of Topographic map of Department of Survey. However, an intensive task was required to be performed for correcting the hydrographic data as the given river line data do not match with the geographic behavior. The DEM was created in ArcGIS using topo to raster feature tool. The DEM was used to derive information such as slope, aspect, relief intensity surface etc. for performing different terrain analysis. Hillshading is the process of adding light and dark areas or shading to a map to highlight the location of hills or mountains. Hillshading uses light and dark areas to highlight where sunlight would hit and where shadows would form in the presence of hills and mountains.

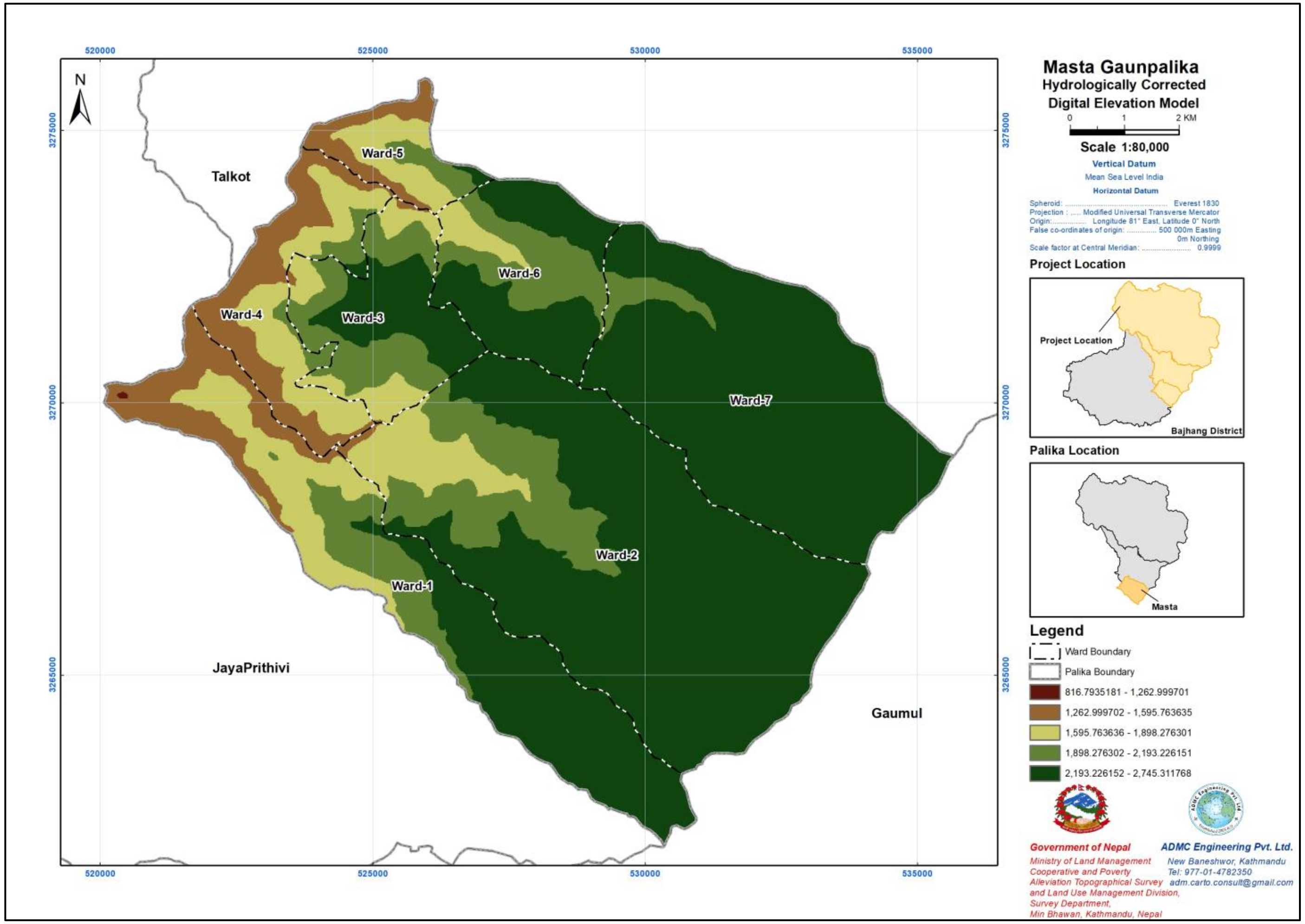


Figure 3.2: Hydrologically corrected DEM for Masta Gaunpalika of Bajhang District

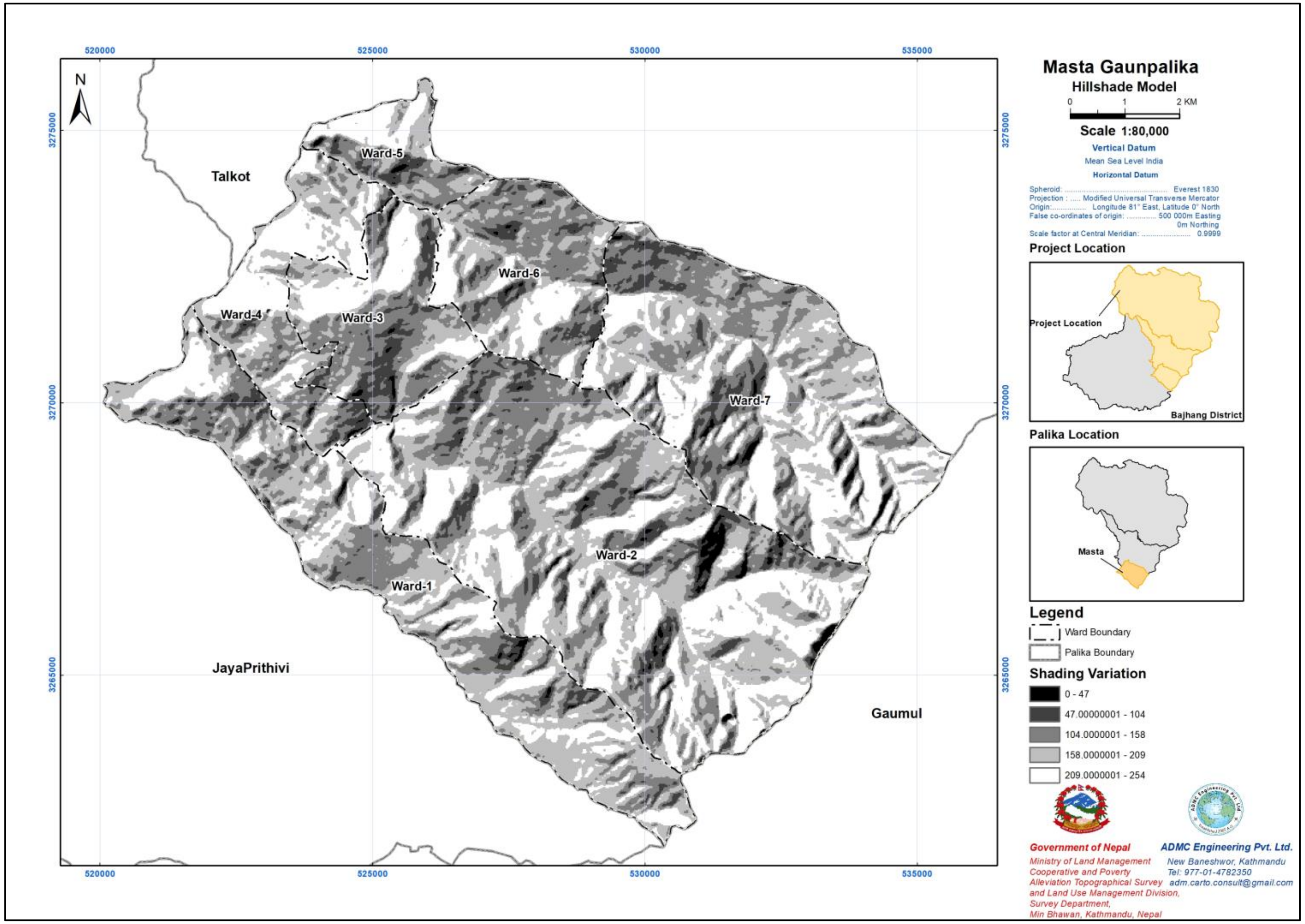


Figure 3.3: Hillshade Model for Masta Gaunpalika of Bajhang District

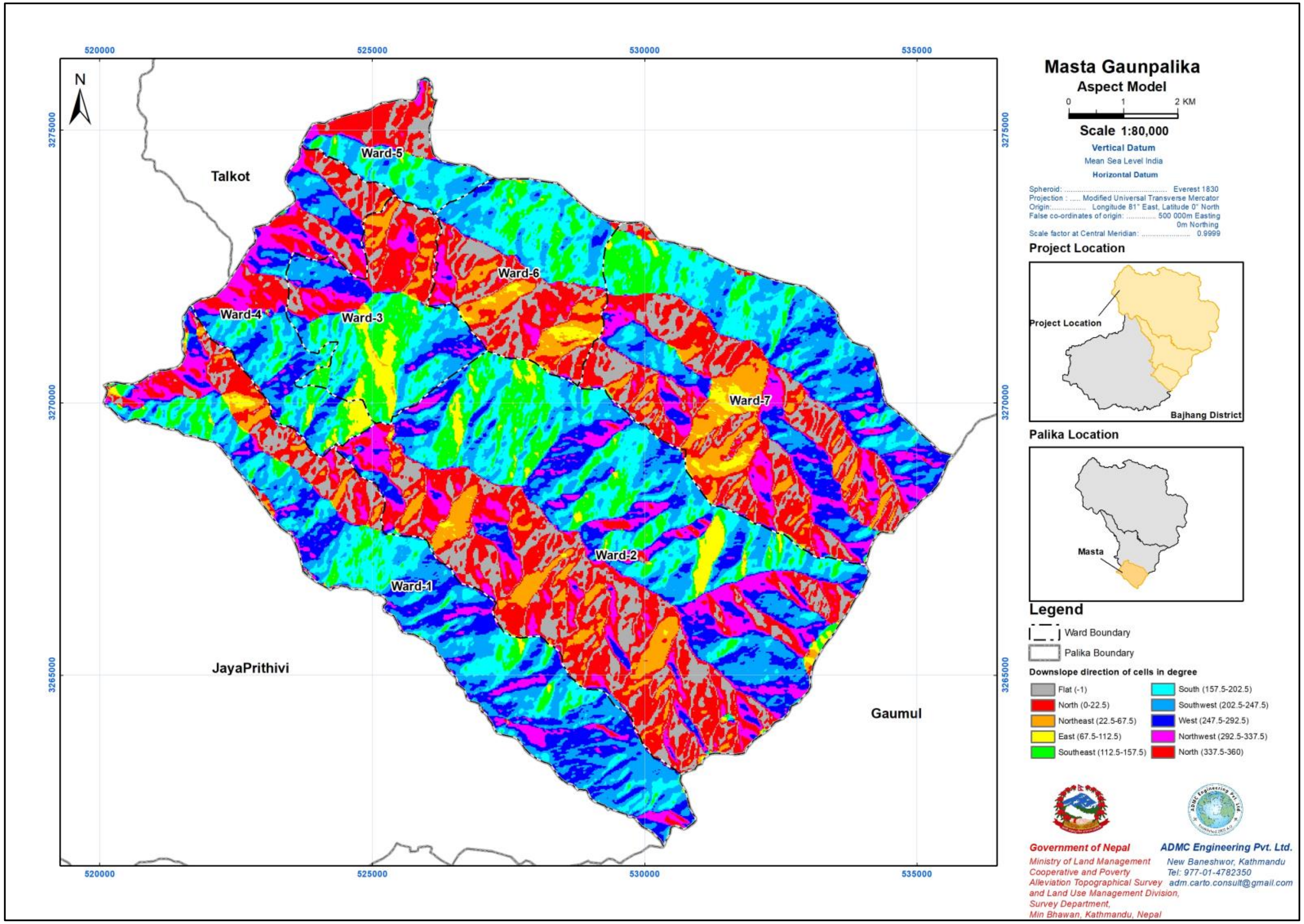


Figure 3.3: Aspect Model for Masta Gaunpalika of Bajhang District

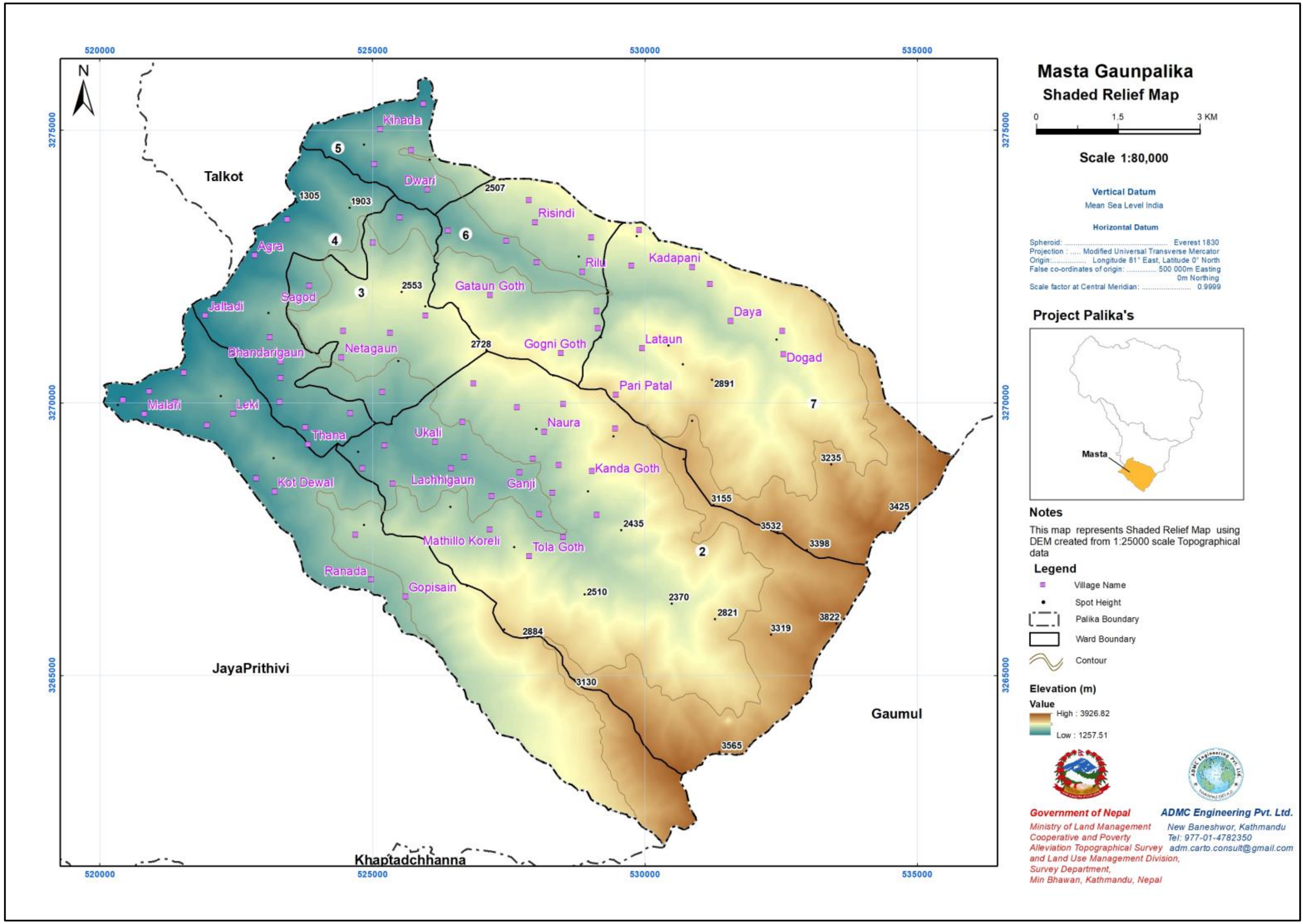


Figure 3.4: DEM map of Masta Gaunpalika

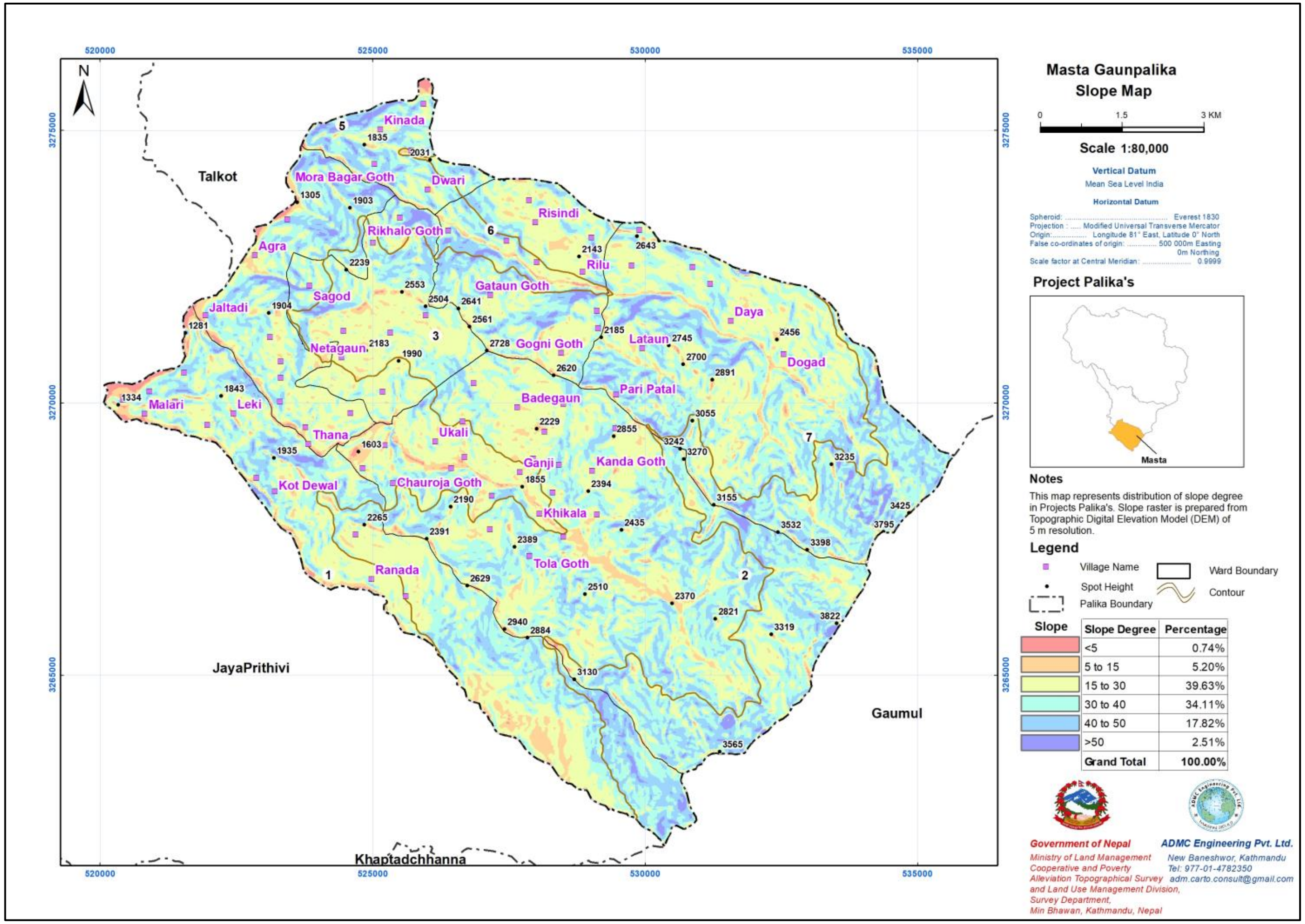


Figure 3.5: Slope map of Masta Gaunpalika

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

Land Use Policy 2072: Land Use Policy (2072) was the main basis for the classification of the land use categories. The policy was reviewed. The major land use categories ascribed by the policy were adopted in classifying the existing land use of the study area.

Key Informants Interview (KII): KII conducted interviewing selected individuals for their knowledge and experience in land use, forests (species and management) and cropping pattern and their related issues. Interviews were qualitative, in-depth, and semi-structured. The interviews were guided by a checklist of topics/issues or open-ended questions.

Formal and Informal Consultation, Discussion and Observation: Formal/informal discussion with Gaunpalika/Nagarpalika members, local stakeholders and people of different backgrounds and social identities was conducted to identify key actors and agents of the project and to explore the underlying socioeconomic, cultural and bio-physical situation that have shaped the optimum utilization of resources and land use practices. Observation was made for confirm the land use pattern and their practices.

Ground Control Point: Differential global positioning system (DGPS) survey was carried out for the collection of ground control points (GCPs) including check points. The DGPS survey for this package was carried out during the month of January 2018. The works includes establishment of 11 Ground control points (GCPs) in the project area with an observation time of at least one hour in all the points and 12 hours in one main GCP on the vicinity of the project area. The DGPS stations were established on the locations identifiable in the ZY(Ziyuan -3) imagery as well as on the ground well distributed covering entire study area and ranges of elevation.Three sets of Geomax Zenith 35 Pro Series were used in which one is used as base station and the remaining were used for collection of ground control points as rover station. DGPS readings were later processed using post processing software (Geomax Geo-Office) to get adjusted co-ordinates of GPS points. Then, these adjusted co-ordinates were transformed into national co-ordinate system. The co-ordinate list of GCPs used in the study is shown in Table 3.2. The distribution of GCPs location overlay on ZY (Ziyuan -3) imagery is shown in Figure 3.6.

Specification adopted according to the Landuse act 2076, For the establishment of Control points with Differential Global Positioning System (DGPS); we have followed the following features accordingly. In order to assure the accuracy of the Ortho-rectification, Differential Global Positioning System (DGPS) should be carried out as;

a) Ground Control Points (GCPs) should be well distributed over the area of interest
b) GCPs should be well defined which could easily be identified on the ground as well as in the image
c) Location of GCPs should represent the range of elevation
d) GCP should be connected to National Geodetic Control Networks
e) Additional GCPs should be established as check points
f) Error in the check points should not exceed three times the accuracy of DGPS

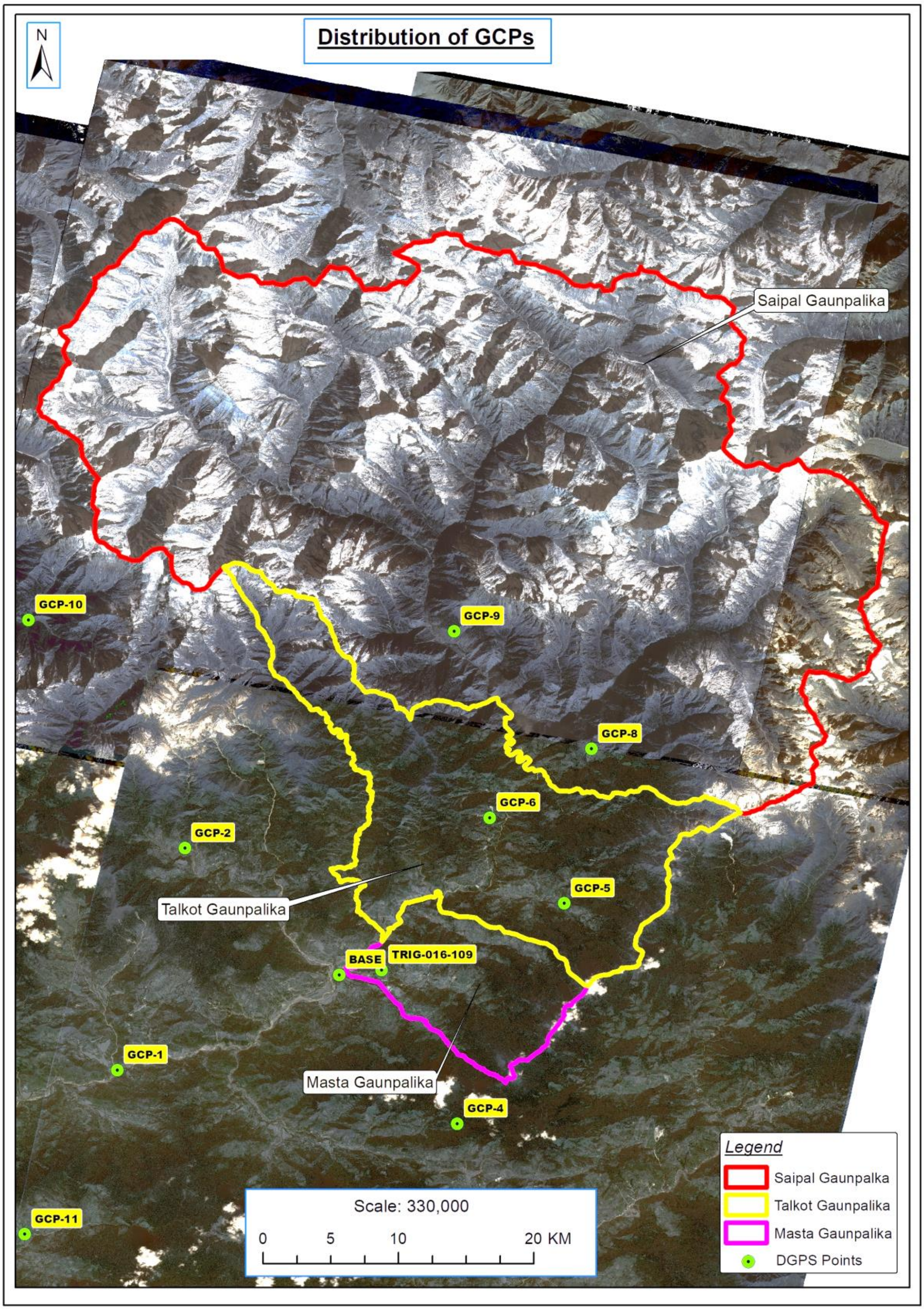


Figure 3.6 Distribution of GCPs locations on Imagery

Table 3.2: Coordinate list of GCPs

Point ID	Easting (MUTM81)	Northing (MUTM81)	Orthometric Height	Posn. + Hgt. Qlty	Remarks
TRIG-016-109	**522204.4624**	**3270137.5341**	**1843.3689**	**0.0018**	
BASE	**519463.0200**	**3269775.0560**	**1299.2810**	**0.0000**	
GCP-1	505176.7752	3262740.8851	1013.7362	0.0028	
GCP-2	509511.4272	3279106.0262	2286.9034	0.0006	
GCP-4	527100.2332	3258811.1284	2325.7857	0.0003	
GCP-5	533945.6237	3275085.1999	1939.9331	0.0006	
GCP-6	529130.3677	3281383.0870	2001.4347	0.0010	
GCP-8	535666.9224	3286482.2981	2635.2819	0.0007	
GCP-9	526805.7640	3295125.4870	2749.1325	0.0013	
GCP-10	499458.2851	3295938.4545	2751.9589	0.0092	
GCP-11	499209.8771	3250638.0423	1560.3186	0.0103	
GCP-12	502623.2328	3244091.4838	2021.5016	0.0013	

3.2 Methods Adopted

The specific approaches and methods adopted to generate the Gaunpalika/Nagarpalika level land use map of the project Gaunpalika/Nagarpalika area is explained briefly with the flow diagram in **Figure 3.7.**

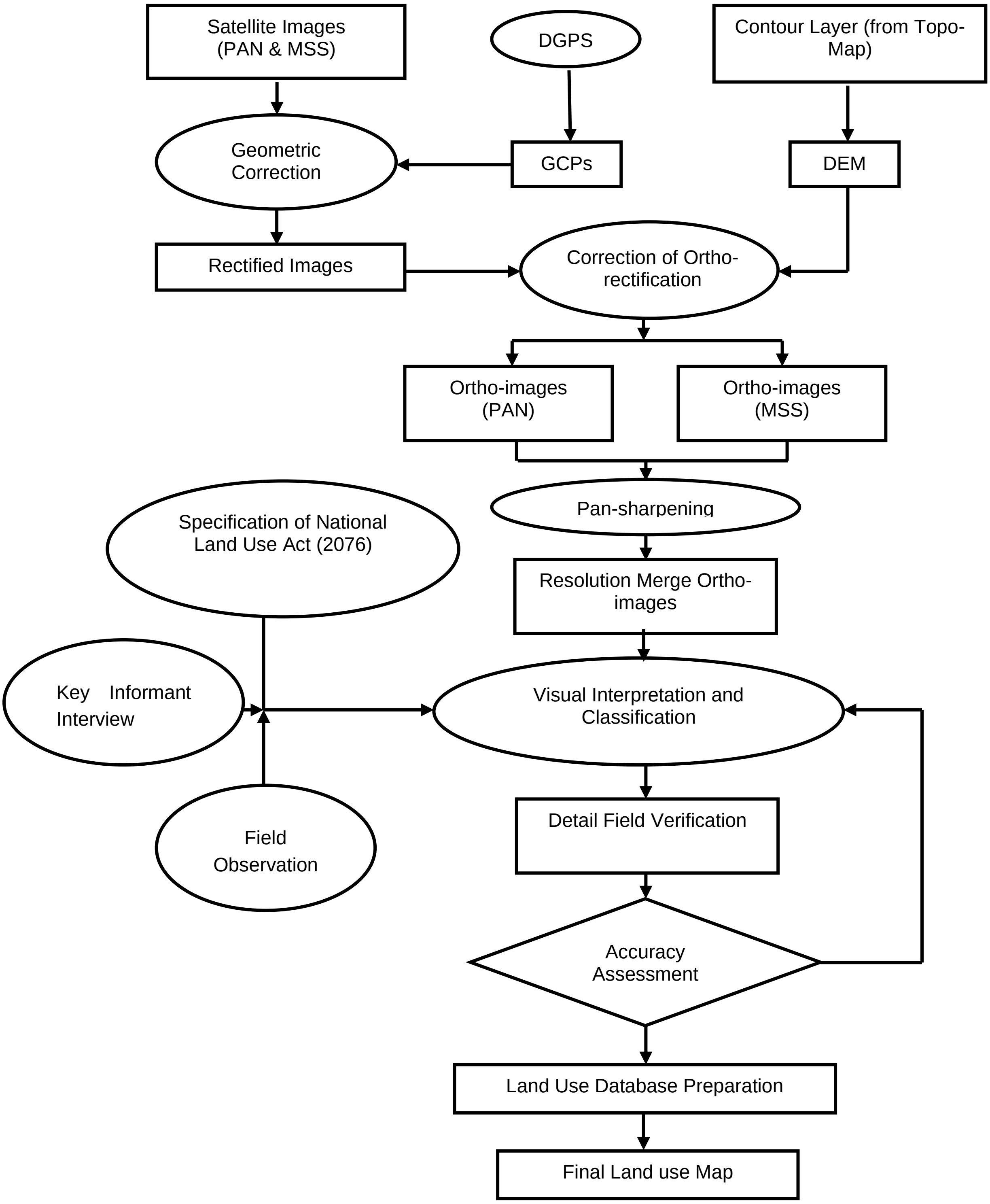


Figure 3.7 Schematic Work Flow Diagrams

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

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

3.2.1 Ortho-rectification of Satellite Images

Radiometric Correction

Rectification of the imagery consists of the Geometrical, radiometric aspects. Firstly, the images are radiometrically corrected in which basically we focus in the sun angle correction and haze correction. However, we could not ascertain about the Skylight correction from the very beginning as it can be only said after the observation of the actual dataset and other acquisition parameters (date and time of day of the observation, type of the satellite imagery itself etc.) After the application of radiometric correction, we apply the geometric correction of the satellite imagery where it is geo-referenced and re-sampled. The process was conducted in the ERDAS Imagine software. Part of the originally supplied imagery has been shown as follows.

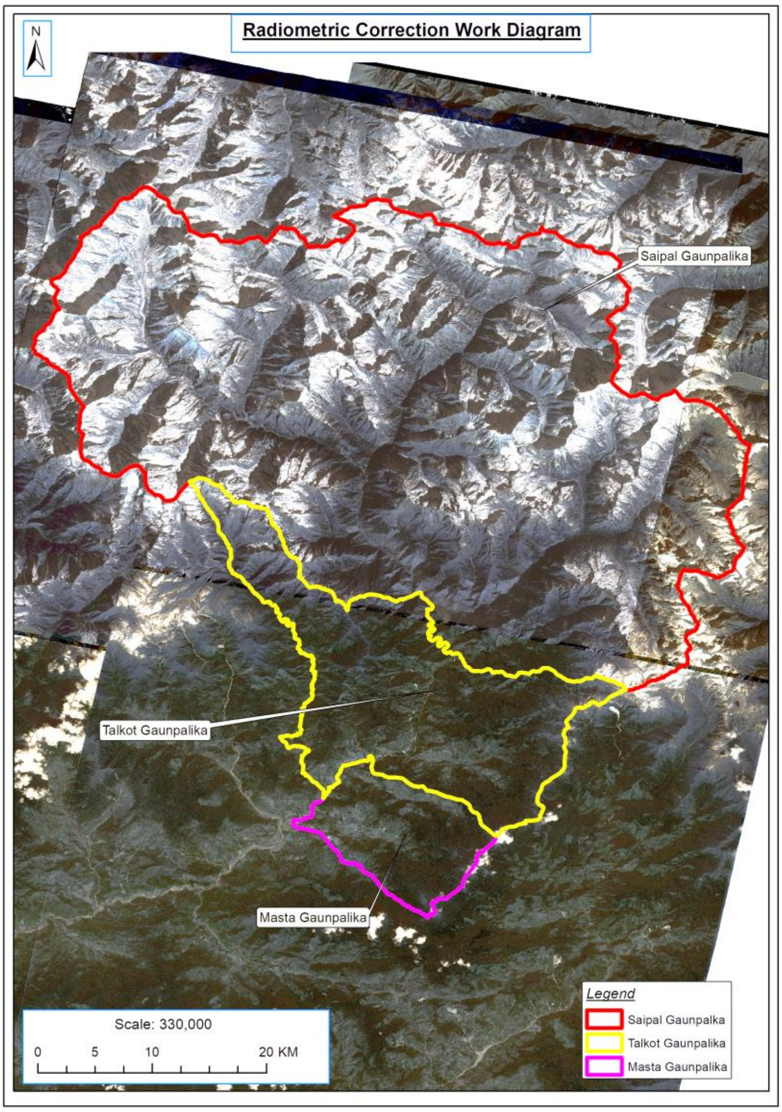


Figure 3.8 Radiometric Correction Work Diagram

Ortho-Rectification

For an image taken with very high-resolution satellite (VHRS) with push broom sensor in which each image line is taken at a different instance of time, i.e. each scan line has its own perspective projection model. On satellite board, there is GPS receivers which are used for determining satellite ephemeris, i.e. camera position with respect to time. Star trackers and gyros on board measure the camera attitude angle (roll, pitch and yaw) as a function of time (Grodecki and Gene, 2003). The sensor camera position and attitude angle most essential to geo-rectification of VHRS optical images. Geometric corrections include correcting for geometric distortions due to sensor-earth geometry variations, and conversion of the data to real world (Tempfli, Bakker, & Kar, 2001). Geometric correction was done to compensate for errors caused by variation in altitude, velocity of sensor platform, rotation of the earth and earth curvature etc.

For the geometric correction of optical images, there are two mathematical approaches commonly used. The first is rigorous sensor model (RSM) which is parametric based on satellite orbital parameters; is used in direct geo-referencing techniques which describes physically the image generation process from the focal plane location of an instrument pixel to an earth surface location in terms of earth coordinate system i.e. this model is established relationship between the point on the image and the correspondent point on the ground (Kaveh and Mazlan, 2011) using model as;

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = kM_aM_b\left[\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} - m\begin{bmatrix} \mathbf{0} \\ \mathbf{0} \\ f \end{bmatrix} - \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix}\right] \quad (3.1)$$

The second is rational polynomial functions (RPFs) which are non–parametric or generic or universal sensor models which provide a standardized and easy to use mathematical model to map object coordinates to image column and row values of the original image. Exterior and interior orientation can be implicitly encoded in the form of RPFs using third order polynomials for numerator and denominator. The universal sensor model provides the transformation of object space coordinates to image space coordinates, which is available in standard format for a lot of remote sensing satellite systems (Reinartz.P.et al, 2010) and each of the RPFs for a row and column is given by the ratio of two polynomials of third order with normalized ground coordinate (λ, Φ and h) with 20 coefficients. The advance form of RPF is the rational polynomial co-efficient (RPC) which has universally 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.

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

$$row = a_0 + a_1 \,.\, rpc_r + a_2 \,.\, rpc_c$$

$$col = b_0 + b_1 \,.\, rpc_r + b_2 \,.\, rpc_c \quad (3.2)$$

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 images (Lehner et al., 2005).

Ortho-rectified images are the most popular product from high spatial resolution satellite sensors and digital image for the accurate representation of the earth planimetric features or objects as a map (Toutin, 2004). So, it is a map like geometric properties i.e. orthogonal projection with earth reference terrestrial (geographic) coordinate system which preserves the shape of the earth surface and makes the distance measurements possible across the entire image accurately. It is used for the measurements and analysis where a high positional accuracy is required. Nowadays, it is possible to represent the earth surface accurately by DEM, which is useful for environmental planning; monitoring and decision support system and plays an important role in impact of environment and the associated human, cultural, and physical landscape.

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 causes 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 and re-sampling process is used for computing the new geometric and radiometric properties of the image of each location after ortho-rectification (Schenk, 1999). Without performing ortho-rectification, the scale of the photograph/image is not constant and uniform over the entire scene as well there is not possibility of accurate measurements of distance and direction. 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. These distortions is eliminated or reduced by ortho-rectification using high quality DEM, but only DEM is not sufficient to eliminate the effect of elevated objects and occlusion caused by it completely.

The present project used geometric correction of satellite 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 of central meridian 81^0 E is as following:

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 81^0 E, Latitude 0^0 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 minimum and maximum residual errors are shown in Appendix-2. The ortho-rectification process has been presented below:

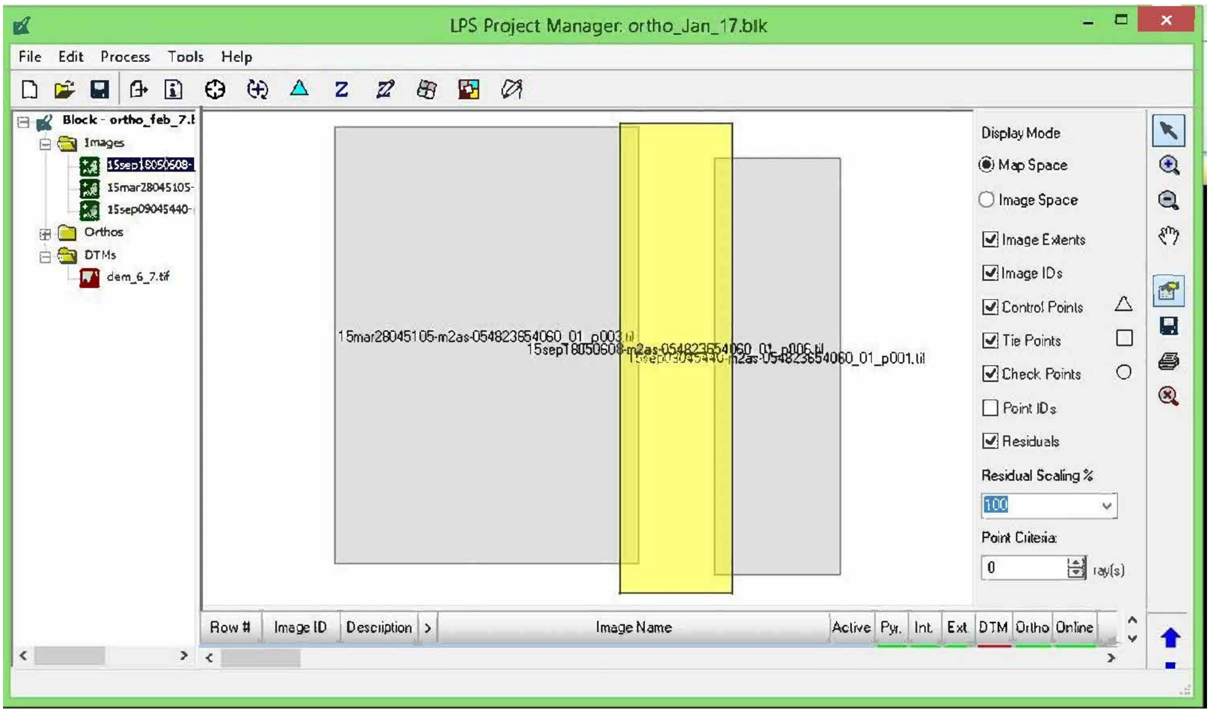


Figure 3.9 Ortho-rectification work diagram

Visualization of different Color Composite

Enhancing of the spatial resolution was carried out by fusioning the multi-spectral images among themselves (i.e. generating color composite). In this way, Intensity of panchromatic image is utilized to get the better detail view. As the date and time of the acquisition of these two sets of satellite imagery do not vary that much, we also conducted the image fusion. The process is conducted in the ERDAS Imagine software.

Application of Filters

The original image consisted of spatial disturbance abundantly. To solve this problem, low pass filter was applied to smoothen the spatial quality of the image.

Cloud Removal

As the image originally given by TSLUMD was of cloud-free, we did not have to carryout any operation for cloud removal.

Pan-sharpening

Pan-sharpening (resolution merge or image fusion) technique has used to create a high-resolution multispectral data set by the fusion process of high-resolution panchromatic data with lower resolution multispectral data. Now-a days in image processing several methods of pan-sharpening are used such as Brovey transform, Multiplicative technique, Principal Component Analysis (PCA), Intensity Hue Saturation (IHS) transform, Wavelet transform, Euler's technique, Gram-Schmidt transform etc. For present project, the pan-sharpening was carried using Brovey transform 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). Pan-sharpening was done using Multiplicative technique to increase presence of the intensity component and involved in urban or suburban studies, city planning, and utilities routing roads and cultural features (which tend toward high reflection) to be pronounced in the image. Pan-sharpening was done using PCA technique for better spatial and spectral resolution. Similarly, it also used IHS transform for stretching the contrast so that it has approximately the same variance and mean as intensity image and substituted the intensity of image for high resolution image. Pan-sharpening was done with Gram-Schmidt transforms that gives more accurate due to it uses the spectral response function to estimate as panchromatic data as look like. Pan-sharpening was done using wavelet transform technique to analyze signal in time domain and frequency domain respectively and the multi-resolution analysis is similar with Human Vision System. Pan-sharpening was done using Euler's technique to preserves the spectral characteristics of the lower spatial resolution multispectral images for single-sensor, multi-sensor, and multi-temporal fusion. The requirement for pan-sharpening is that the both images are registered or rectified with an accuracy of 0.25 pixels; otherwise pan-sharpening images may not give the better results. In this study, pan-sharpening was done with Brovey transform technique. The following figure shows the pan-sharpening process.

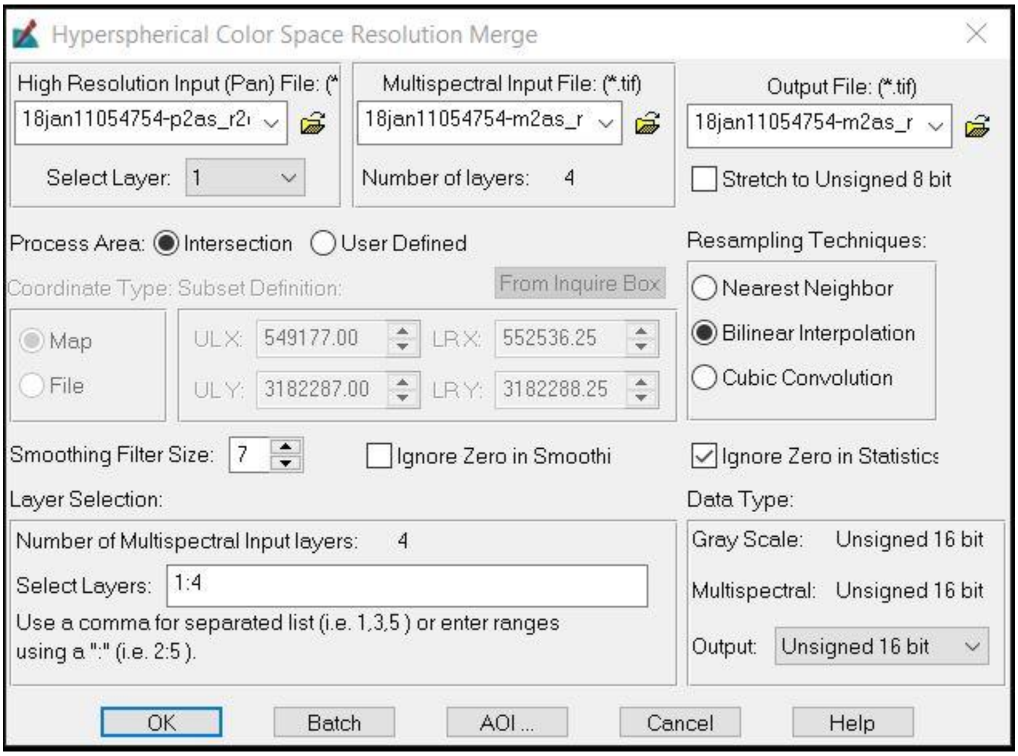


Figure 3.10 Pan sharpening Work Diagrams

3.2.2 Classification

Initially during priliminary analysis and for the purpose of vegetation analysis, classification was mostly used however database have been prepared using digitization and as per the National Land Use specificaton, 2019 provided by the client. Radiometrially and geogmetrically rectified satellite Image was classified using the supervised classification method adopting the maximum likelihood classifier algorithm. Training samples were collected during the field visit, at the time when soil samples were being collected. Samples for the specified thematic classes were fed in the required number to enhance the higher precision of the classified result. The process was conducted using in the ERDAS Imagine software. However, this classification did not render the good result. Theory has already been established in the context of the result of the satellite imagery. Since spectral information based classification renders mixed result, it was found not suitable to directly use as the basis for the land use mapping. Error matrix was generated to see the level of the error in classification. Subjective judgement is always essential over this result. Hence we only applied the classification over the agricultural area to extrac different level of cropping pattern in the field.

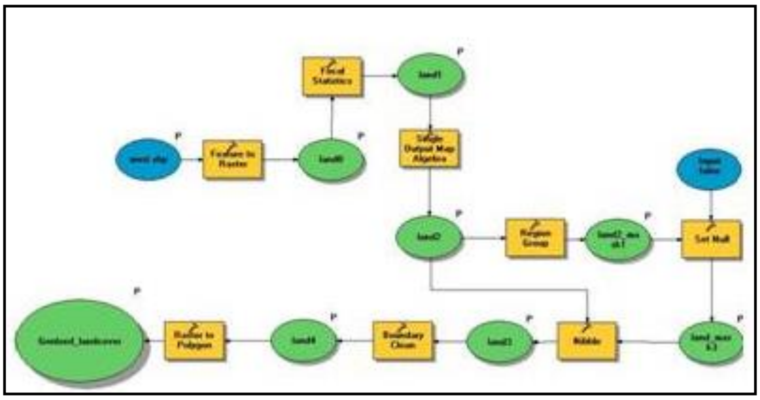
Therefore, multiple image processing techniques were performed to extract the information from the satellite imagery. Subsets of information were extracted from one type of processed product whereas the other subsets were extracted from the other product. Techniques such as Intensity, Hue and Saturation separation, Principal Component Analysis and NDVI calculation were carried out, the product of which were the main inputs for the final classified result.

Later these individual classes were then merged using conditional scripts in ArcGIS Map Algebra into single feature class. Reclassification was also made to merge differently named raster polygon of the same feature types into one. Reclassification was carried out using ArcGIS Spatial Analysis. Samples of the script used are as follows:

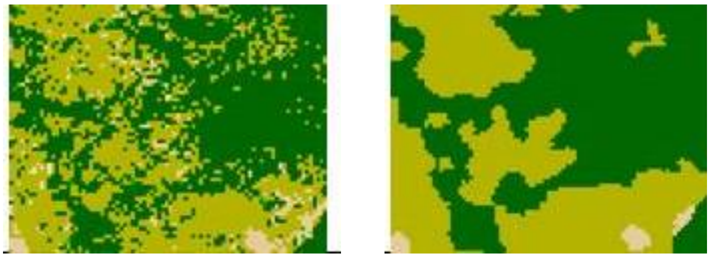
- CON (isnull (class1), (Class2), Class1)
- CON (class2 GE 4, class3, Class4)

Model generation and generalization of the image extracted information

Howsoever and whatsoever techniques are applied to get the classified image, one always acquire speckles in the classified result. Hence, generalisation must be carried out to clean these speckles and disturbance from these raw outputs. A highly complex model was generated using the model builder for this purpose, which is given below:



Result before and after the application of the above model is shown in the following diagram:



Classified Image before and after the application of model

3.2.3 Visual Interpretation

Visual interpretation is the process of identification and classification of land cover classification. This method has been extensively used by digitizing the landuse classes by visual interpretation of the high-resolution satellite images aided by primary data collection by the field, classified images and google images. Most intuitive way to extract information from the satellite imagery is visual image interpretation (Tempfli, Bakker, & Kar, 2001). Visual image interpretation assisted by extensive field visit was used to derive the land use classes from the imagery. The main basis for the land use mapping is the extensive field visit with satellite imagery printed at large scale during field data collection where different ancillary layers such as NDVI, simple ratio, DEM were used in support while performing this task.

Two extremely important issues must be addressed before undertaking task of image interpretation for delineating land use classes. The first is the definition of the criteria to be used to separate the various categories of features occurring in the photographs. For example, in mapping land use the interpreter must fix firmly in mind what specific characteristics determine if an area is residential, commercial, public service or industrial. This was guided by the definition of land use classes defined by Land Use Act (2076). The second important issue in delineation of discrete areal units on photographs 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 for delineating of land use category was 0.25 hectare. However, important and essential features smaller than the MMU were also mapped.

Interpretation elements such as tone, texture, shape, size, pattern, site and association were used for digitizing, editing and assigning land use classes. The size of an object is one of the most distinguishing characteristics and one of the most important elements of image interpretation. Many natural and man-made features on the ground have very unique shapes that can be referenced in photo and image interpretation. For example, Schools and Colleges can be identified by their peculiar L shape.

Tone of the imagery is important while classifying land cover categories. The tonal variation among different land use is a basis for demarcating land use boundary. Each color is caused by the mixture absorbing some wavelengths of light and reflecting others. We may use color-combining techniques to create color composite images. Knowledge of the bands other than the visible range of spectrum increased the quality of the interpretation. For example, Vegetation appears red in standard false color composite. Texture is the characteristic placement and arrangement of repetitions of tones or color in an image. Pattern is the spatial arrangement of objects in the landscape. Site refers to the topographic and geographic location. Some parameters of site are elevation, slope, aspect, type of surface cover, value of the land, adjacency to water etc. We can classify agricultural land into sub classes using these parameters. Association refers to the fact that combination of object makes it possible to infer its function or meaning. School can be identified by using the combination of elements shape and association. Peculiar L- shaped building with associated ground confirms that the object is school.

Vectorization and Coding

The Classified agricultural Raster Polygons were then turned into Vector using the conversion tools. Vector generalisation techniques were carried out to comply with the minimum size of the polygon as specified in the TOR. There was the necessity of assigning codes for the vector output. The database model provided by TSLUMD was then used to load the data so geneated.

3.2.4 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. It is a measurement of the argument between a standard that is assumed to be correct and a classified image of unknown quality. If the image classification corresponds closely with the standard, it is said to be accurate (Bhatt, 2008). Classification is not complete until its accuracy is assessed (Lillesand et al., 2008). There are several methods of evaluating the accuracy assessment. In general, one method is compared the classified image to a reference image and a random set of points are generated for the comparison of the classification result with the true information classes in the reference image. A second method is used to perform accuracy assessment involves using a GPS and again a random set of points are generated over the classified image with ground truth has performed by going into the field at the location of each randomly generated point (Bhatt, 2008). 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.

In this study, validation of classification results were done for the quantification and evaluation of error using confusion matrix (error matrix) which compares the class-by-class based on the training samples with visual interpretation of original images and classification result classes at Level-1. The size of interpretation unit and number of polygons that belong to the unit do not influence the number of points. The total area covered by one legend unit is not taken into account for other legend unit. The confusion matrix was generated based on the comparison between the classified image and the existing ground using GCPs collected from visual interpretation i.e. the matrix depicts the land cover classification categories versus the field observed land cover type. This matrix was an N x N matrix of “classified” and “observed” cells corresponding to N land cover class. 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 agreed with the reference data. Off-diagonal elements in each row present the sample that has been misclassified by the classifier at classification process (Bhatt, 2008). These error matrices were 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).

$$K = \frac{N \sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} (X_{i+} * X_{+i})}{N^2 - \sum_{i=1}^{r} ((X_{i+} * X_{+i}))} \tag{3.3}$$

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 error matrices of classified images 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 accuracies with KIA (kappa statistics) were found 95.38% and 0.93 respectively for the classified objects of the Masta Gaunpalika.

Table 3.3: Summary of Accuracy Assessment

	AGR	FOR	RES	COM	PUB	CULARCH	RIV	Total	Comission Error	User Accuracy
AGR	60		1				1	62	3.225806452	96.77419355
FOR	1	32						33	3.03030303	96.96969697
RES			10					10	0	100
COM			1	3				4	25	75
PUB					6		1	7	14.28571429	85.71428571
CULARCH						3		3	0	100
RIV		1					10	11	9.090909091	90.90909091
Total	61	33	12	3	6	3	12	130		
Omission Error	1.639344	3.030303	16.66667	0	0	0	16.66667		Overall Accuracy	95.38461538
Producers accuracy	98.36066	96.9697	83.33333	100	100	100	83.33333		Kappa	0.93341301

Chapter – 4
PRESENT LAND USE PATTERN IN THE MASTA GAUNPALIKA

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

4.1 Land Use Pattern

General land use of the Masta Gaunpalika at first hierarchical level of classification is provided in Table and Figure below. Out of total 10905.18-hectare land, 63.4% area is covered by forest, 30.9% area is covered by agriculture followed by Riverine, lake and Marsh area which covers 1.1% area of the Gaunpalika. Public services cover about 0.4% and Residential covers 0.6% of the total area. However, Commercial, Mine and Minerals, Cultural and archeological & Industrial sectors cover small portion which are noticed below 0.01% of total area. Respectively, Other Land use area covers less than 3.6% of total area in this Gaunpalika. Whereas significant Mine & Minerals and Industrial land use distribution were not found in this gaunpalika.

Table 4.1: General land use of Masta Gaunpalika

S.No	Landuse Class	Area (sqm)	Area (ha)	Percent
1	Forest	69184718.60	6918.47	63.4
2	Agriculture	33725206.37	3372.52	30.9
3	Other	3875438.03	387.54	3.6
4	Riverine, Lake and Marsh Area	1154027.14	115.40	1.1
5	Residential	669225.09	66.92	0.6
6	Public Service	438306.18	43.83	0.4
7	Commercial	3501.12	0.35	0*
8	Cultural and Archeological	1372.00	0.14	0*
	Grand Total	**109051794.53**	**10905.18**	**100**

*LESS THAN 0.01 PERCENT

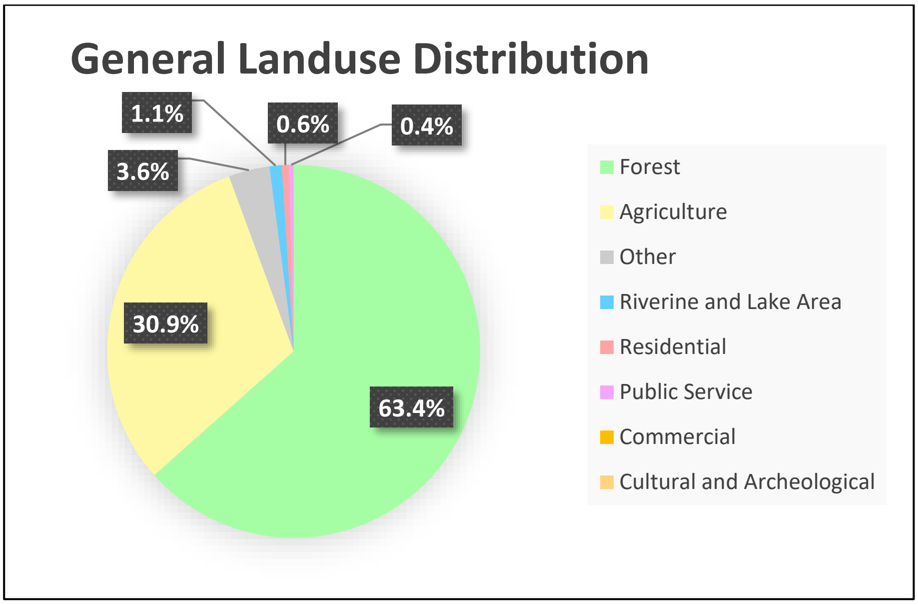


Figure 4.1: General land use of Masta Gaunpalika

Agricultural Land Use: Almost all agricultural land of the Masta Gaunpalika is classified as Hill cultivation based on the physiographic region.

Agriculture level 3 is further divided into Slopping terraces and level terraces cultivation. About 86.2% of level 3 of agriculture are on Slopping terraces cultivation category.

Table 4.2: Agriculture land use level 3

S.No	Agricultural Landuse (Level 3)	Area (sqm)	Area (ha)	Percent
1	Slopping Terraces-C	29084718.13	2908.47	86.2
2	Level Terraces-T	4640488.24	464.05	13.8
	Grand Total	**33725206.37**	**3372.52**	**100**

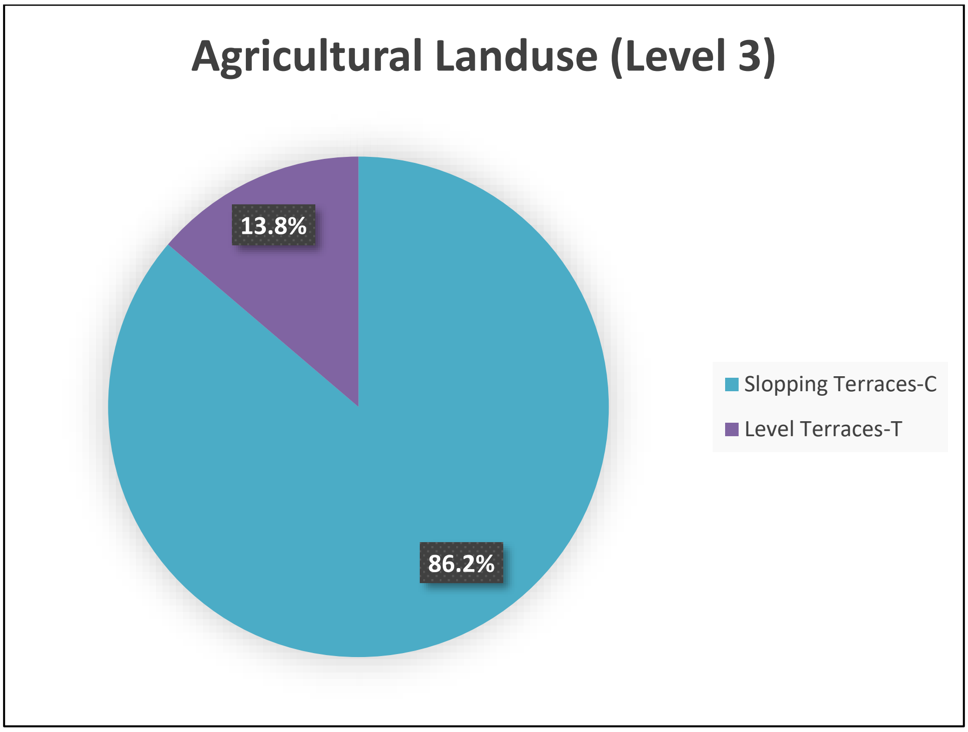


Figure 4.2: Agriculture land use level 3

Table 4.3: Agriculture land use level 4

S.No	Agricultural Landuse (level 4)	Area (sqm)	Area (ha)	Percent
1	Slopping Upland/ Pakho Land Cultivation-Cp	29084718.13	2908.47	86.2
2	Level Terraces Khet Land Cultivation-Tk	3965329.11	396.53	11.8
3	Level Terraces Upland/Pakho Land Cultivation-Tp	675159.13	67.52	2.0
	Grand Total	**33725206.37**	**3372.52**	**100**

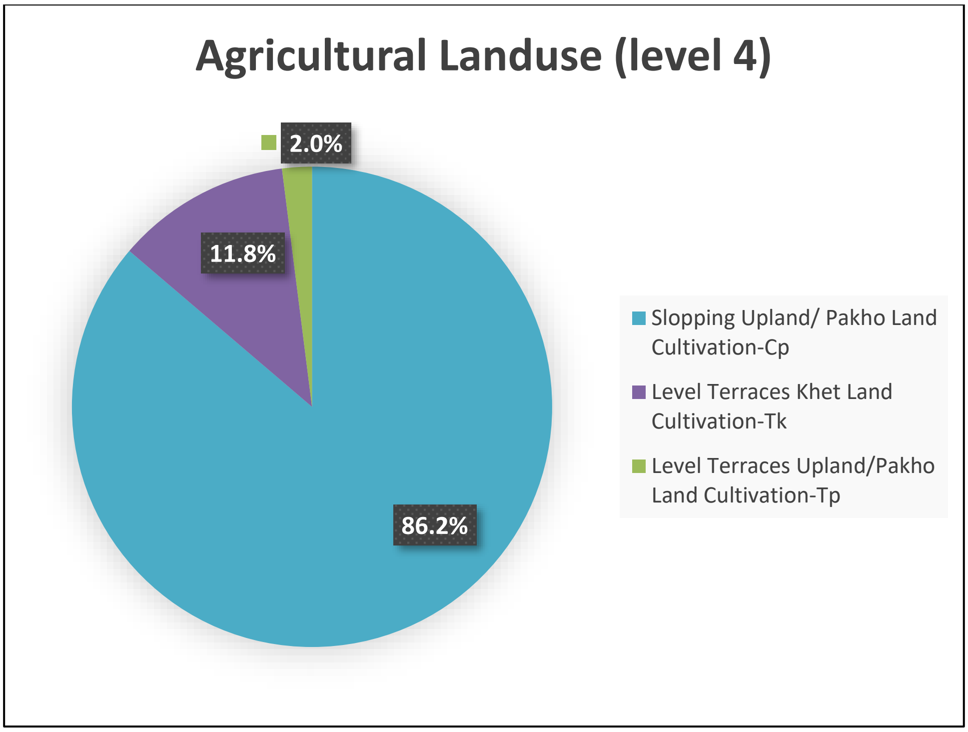


Figure 4.3: Agriculture land use level 4

The cropping pattern of this Gaunpalika varies according to agricultural land types, irrigation and precipitation. The Level Terraces and Slopping Terraces cultivation comprises of crops such as Rice, Wheat, Maize, Millet, fruits, Pulses and vegetables. Rice, Wheat, Maize are the dominant crops. The table below presents the cropping pattern of the Masta Gaunpalika.

Table 4.4: Cropping pattern

S.No	Cropping Pattern	Area (sqm)	Area (ha)	Percent
1	Maize-Millet-m7	7076923.22	707.69	21.0
2	Rice-Wheat-Pulses-r3	6476620.61	647.66	19.2
3	Rice-Wheat-r2	6163271.05	616.33	18.3
4	Maize-Wheat-m5	3820271.31	382.03	11.3
5	Rice-Wheat-Maize-r15	3033890.42	303.39	9.0
6	Rice-Maize-r10	2860376.12	286.04	8.5
7	Shrub from non-forest area-s3	2250665.94	225.07	6.7
8	Barren Cultivable land-b5	916387.73	91.64	2.7
9	Livestock Grazing area-g2	722440.26	72.24	2.1
10	Fruit-Others-f3	401921.43	40.19	1.2
11	Vegetables-Others-v4	2438.28	0.24	0.01
	Grand Total	**33725206.37**	**3372.52**	**100**

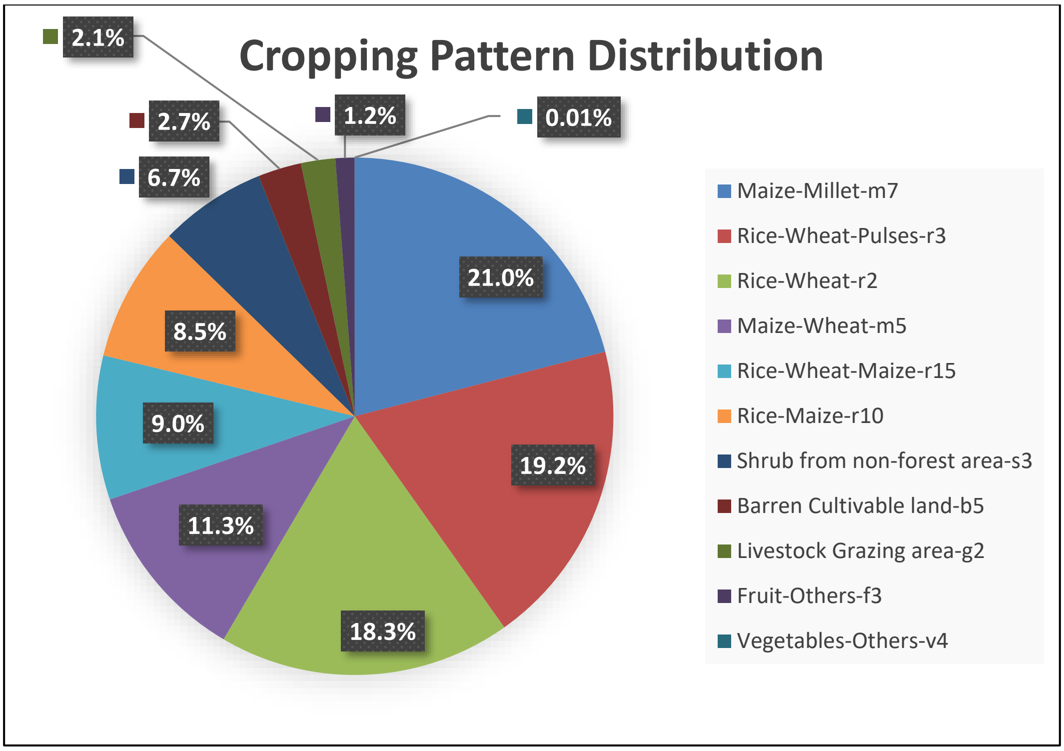


Figure 4.4: Cropping Pattern in Agricultural land

The Gaunpalika witness 85.7% of agricultural land having Medium cropping intensity, 11.3% of arable land of intense cropping intensity and 3% of land as of Light intensity. Although, orchard and pond areas do not directly relate themselves with cropping intensity, these have been included in the table as they also bear some degree of agriculture area related production. The following figure shows the distribution of cropping intensity including orchard-pond.

Table 4.5: Cropping intensity

S.No	Cropping Intensity	Area (sqm)	Area (ha)	Percent
1	Medium-2	28909996.08	2891.00	85.7
2	Intense-3	3819530.58	381.95	11.3
3	Light-1	995679.72	99.57	3.0
	Grand Total	**33725206.37**	**3372.52**	**100**

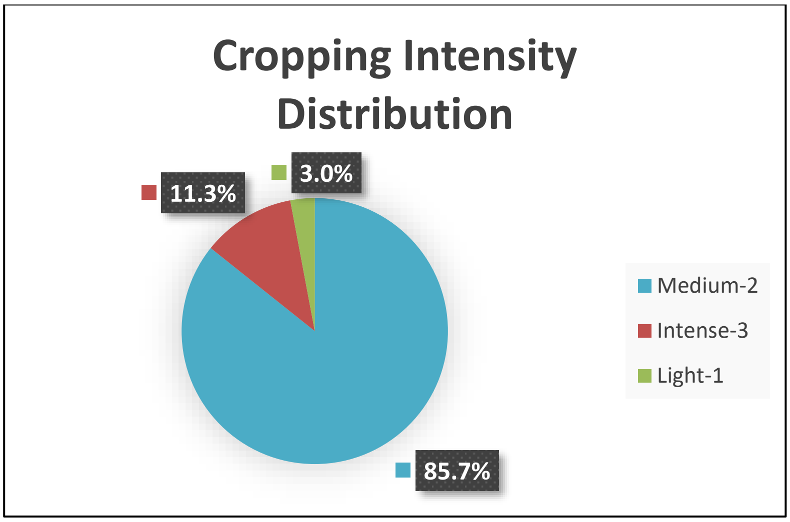


Figure 4.5: Cropping Intensity

Residential Land Use: Masta Gaunpalika has 0.6% residential area. Residential areas of this Gaunpalika is categorized as densely populated, moderately populated and sparsely populated having the majority of the Moderate. The distribution of these categories has been given in the following table.

Table 4.6: Residential Land use level 2

S.No	Residential Landuse (level 2)	Area(sqm)	Area(ha)	Percent
2	Moderately Populated-M	346343.34	34.63	51.8
1	Densely Populated-D	303755.55	30.38	45.4
3	Sparsely Populated-S	19126.21	1.91	2.9
	Grand Total	**669225.10**	**66.92**	**100**

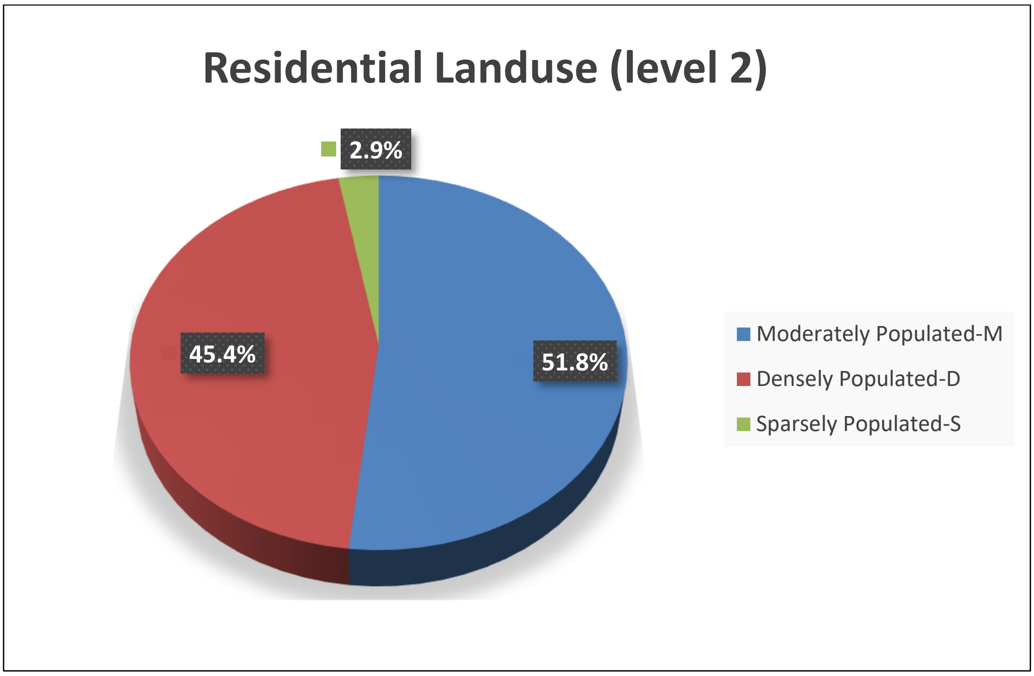


Figure 4.6: Residential Land use level 2

Most of the residential unit of Masta Gaunpalika are old areas i.e. 99.8%. Similarly, 0.2% residential area of the Gaunpalika is newly developed area.

Table 4.7: Residential Land use level 3

S.No	Residential Landuse (level 3)	Area(sqm)	Area(ha)	Percent
1	Old Area-O	667820.32	66.78	99.8
2	Newly Developed Area-N	1404.78	0.14	0.2
	Grand Total	**669225.10**	**66.92**	**100**

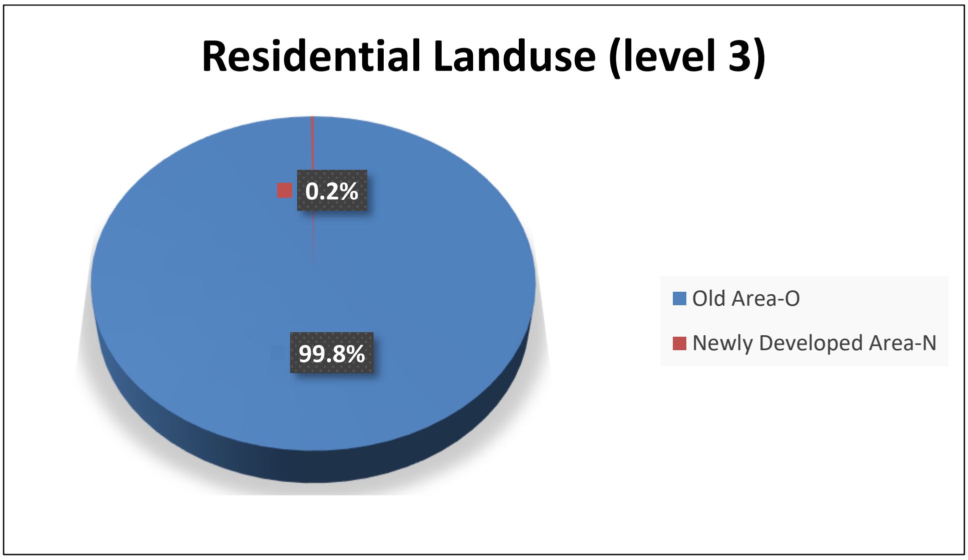


Figure 4.7: Residential level 3 land use

Public Services: Public services which include Educational services such as school, college, recreational facility includes playground, open space, Park etc.,road and trail in transportation Infrastructure and health services. About 94.7% public services areas are of Transportation Infrastructure. The educational service comprises 4.8% of the public service area. Detail of the public services is presented in table and figure below.

Table 4.8: Public services level 2 land use distribution

S.No	Public Services (level 2)	Area(sqm)	Area(ha)	Percent
1	Transportation Infrasturcture (T)	414887.59	41.49	94.7
2	Educational (E)	20844.48	2.08	4.8
3	Health Service (H)	2448.44	0.24	0.6
4	Security Service (S)	125.67	0.01	0.03
	Grand Total	**438306.18**	**43.83**	**100**

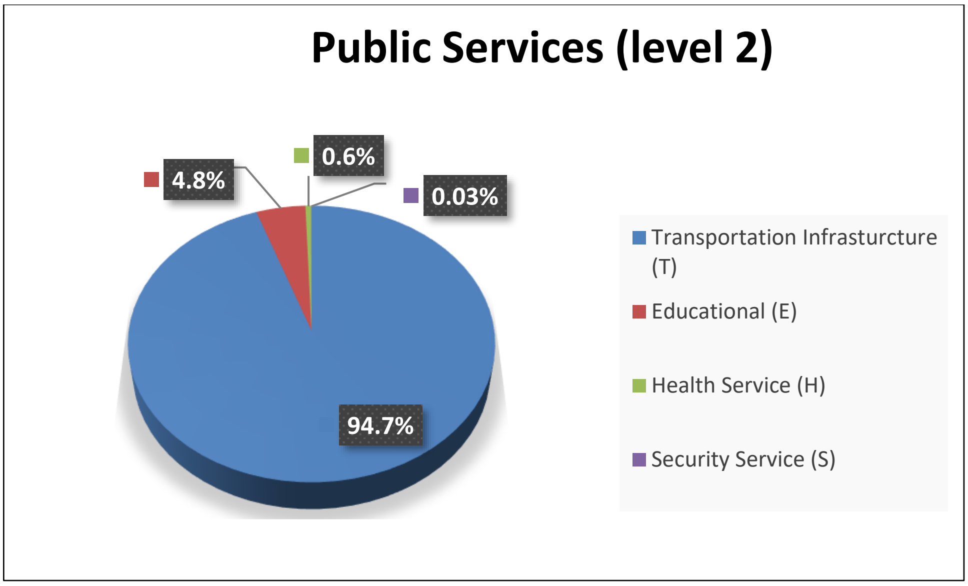


Figure 4.8: Public services level 2 land use distribution

The Public service level 3 has been classified further into Primary school, Health Centre, Police centre, Local Road and So on which has been presented below.

Table 4.9: Public services Level 3 land use distribution

S.No	Public Services (level 3)	Area(sqm)	Area(ha)	Percent
1	Local Road - i1	218865.95	21.89	49.9
2	Other Road - o5	195656.18	19.57	44.6
3	Secondary - s2	10682.69	1.07	2.4
4	Primary - p5	7423.24	0.74	1.7
5	Playground - g4	2738.55	0.27	0.6
6	Health Centre - c7	2448.44	0.24	0.6
7	Bridge - g3	365.47	0.04	0.1
8	Police Station - p8	125.67	0.01	0.03
	Grand Total	**438306.18**	**43.83**	**100**

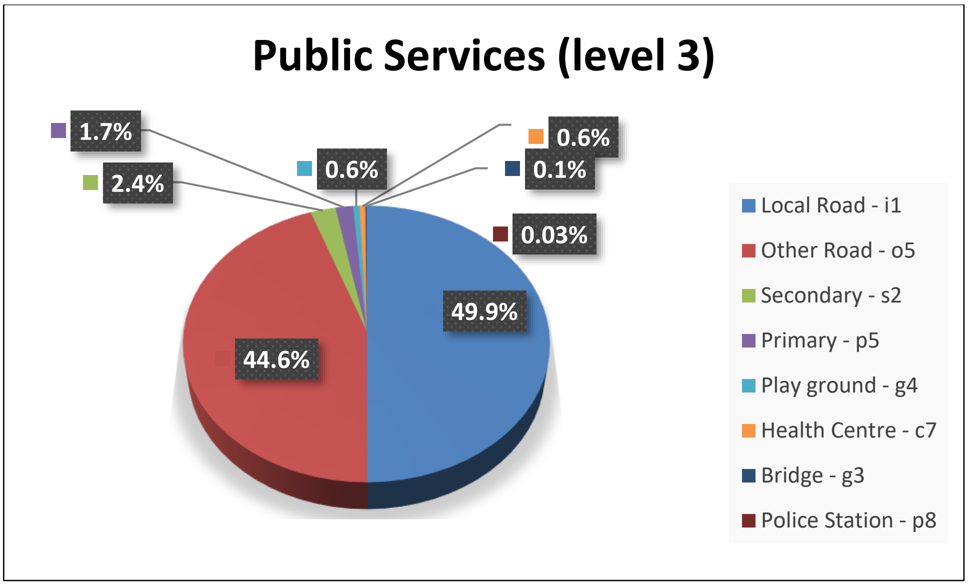


Figure 4.9: Public services level 3 land use distribution

Commercial level 2 is classified as business area and service area in this Gaunpalika.

Table 4.10: Commercial Level 4 land use distribution

S.No	Commercial Landuse (level 4)	Area(sqm)	Area(ha)	Percent
1	Local Development office - l2	2527.32	0.25	72.2
2	Post Office - po	357.96	0.04	10.2
3	Government Service Area SubGategory(G)	297.93	0.03	8.5
4	Bank/Money Exchange - b3	203.59	0.02	5.8
5	Services Subcategory (S)	66.92	0.01	1.9
6	Health office - h5	47.41	0.00	1.4
	Grand Total	**3501.12**	**0.35**	**100**

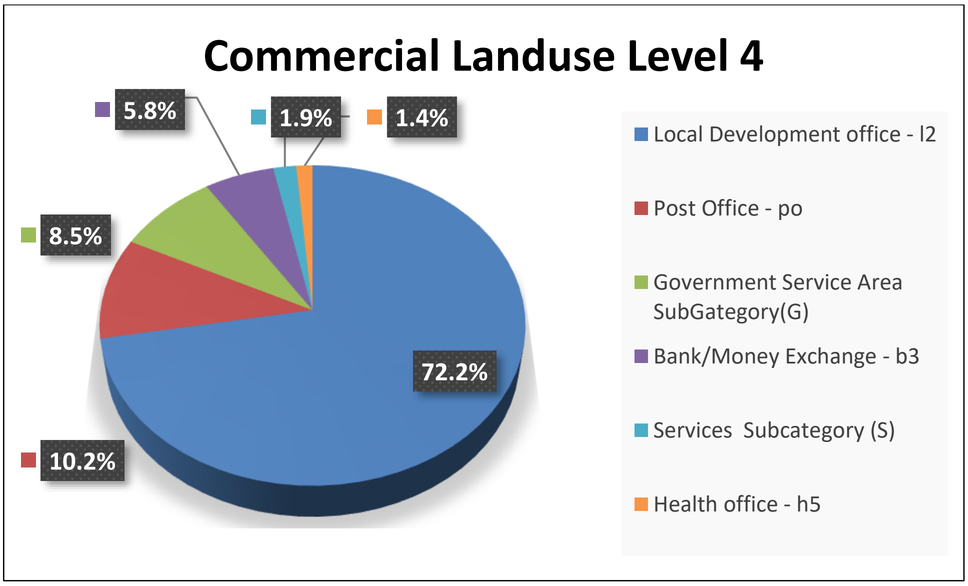


Figure 4.10: Commercial Level 4 distribution

Riverine, lake and marsh area covers 1.1% land of this Gaunpalika out of which 85.3% is River, 14.7% is Sand are categorized under river.

Table 4.11: Riverine, Lake and Marsh Area Level 2 land use distribution

S.No	Riverine, Lake and Marsh Area (Level 2)	Area(sqm)	Area(ha)	Percent
1	River (r)	984498.02	98.45	85.3
2	Sand (d)	169529.14	16.95	14.7
	Grand Total	**1154027.16**	**115.40**	**100**

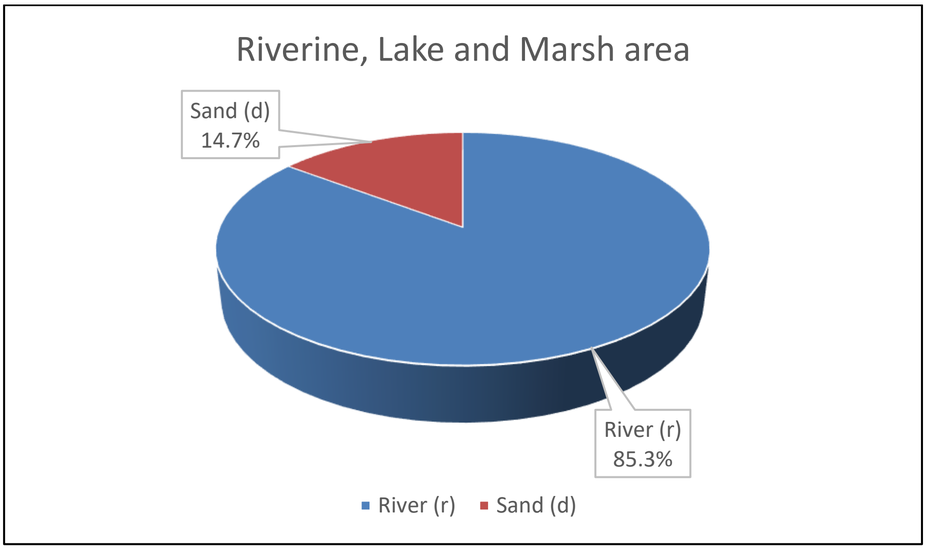


Figure 4.11: Level 2 land use distribution

Forest covers 63.4% land of this Gaunpalika out of which certain percentage of forest is allocated as dense, some degraded and other sparse.

Sub-tropical climatic vegetation zone has Schima wallichii, Castonopsis indica, Alnus nepalensis and Pinus roxburghii as dominant species and Ritha, Tuni and Darim as sparse. Whereas temperate climatic vegetation zone has Loth salla, Thingre salla, Quercus incana-Q. lanuginose Forest (Qq) and Quercus dilata as dominant species and Forest (Qd)Rhododendron Forest (Rh) as dense. And Sub-alpine climatic zone has Cedrus deodara Forest (Cd) as dominant species Cupressus torulosa Forest (Ct), Picea smithiana Forest (Ps) and Abies pindrow Forest (Ap) as dense.

The important NTF of the forest area are Nigalo, Lokta and Allo. Similarly, important medicinal herbs are Guchhichyau, Pakhanbed, Satuwa and others. The dominating timer trees species is pine. Other species composition and distribution of plants are about the same as of the district. The potential forest-based enterprises are Resin (Khoto) collection, Lokta paper industries and allo fibers industries. Road network has connected most of the settlement and having hydropower furniture industries is a potential enterprise.

Table 4.12: Forest Level 2 Land use distribution

S.No	Forest Landuse (Level 2)	Area (sqm)	Area (ha)	Percent
1	Temperate(Tm)	59651097.11	5965.11	86.2
2	Sub-tropical(St)	8530193.94	853.02	12.3
3	Sub-alpine(Sl)	1003427.56	100.34	1.5
	Grand Total	69184718.60	6918.47	100

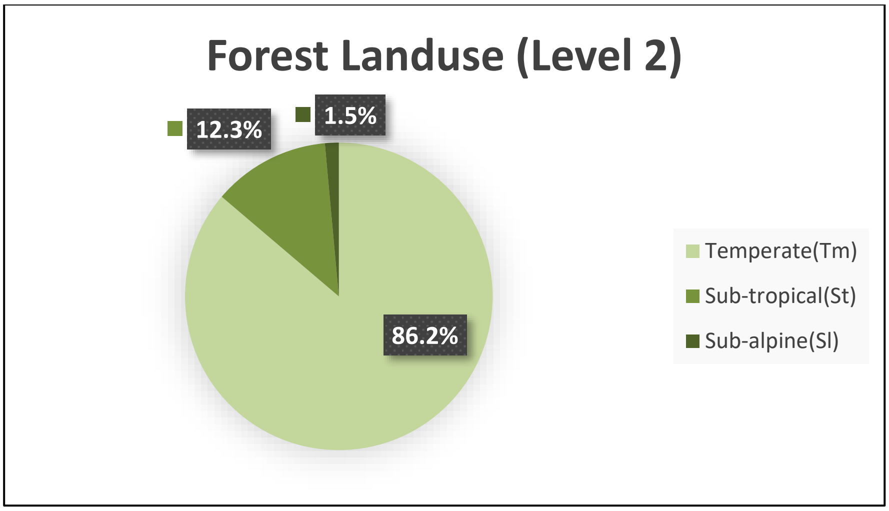


Figure 4.12: Forest Level 2 Land use distribution

Other Landuse covers 3.6% of total area. It includes Grazing land based on climatic vegetation zone. Basically, this Gaunpalika has Sub-tropical, Temperate and Sub-alpine climatic vegetation zone. Other land use class also covers barren uncultivable lands, Rock outcrops, Hazardous zone, Landslide prone area and other unrecognizable lands.

4.2 Land Use GIS Database

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

Table 4.13: Database for present land use

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	FID
SHAPE	Geometry	Geometric Object type	SHAPE
ID	Long	Unique Object ID	ID
LEVEL 1	String	Land Use Class	LEVEL 1
LEVEL 2	String	Land Use Class	LEVEL 2
LEVEL 3	String	Land Use Class	LEVEL 3
LEVEL 4	String	Land Use Class	LEVEL 4
LEVEL 5	String	Land Use Class	LEVEL 5
LEVEL 6	String	Land Use Class	LEVEL 6
LEVEL 7	String	Land Use Class	LEVEL 7
RMP_MP	String	Gaunpalika/Nagarpalika Name	
District	String	District Name	
Remarks	String	Any remarks regarding the feature	
AREA	Double	Area in m2	AREA
AREA_HA	Double	Area in Hectare	AREA_HA
FY	Text	Fiscal Year of Data Preparation	

Chapter – 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The present land use pattern of the Gaunpalika under study is classified using remotely sensed image with the help of ground-based information. The Gaunpalika showed different degree of variability in land use pattern, maximum with forest and minimum on cultural and archeological.

Lack of clear guidelines on the classification system has posed a level of difficulty in assigning the classes of different hierarchy in land use, especially in differentiating forest category. The system does not say in which category the plantation should be kept as neither it belongs to the category of Forest nor is it explicitly on agricultural use. This has posed a degree of ambiguity to assign the proper land use codes.

Hierarchical classification system helped in incorporation of complex land use pattern of this Gaunpalika. Priori classification system used in the study attribute to standardization in the land use result among different Gaunpalika. Visual image interpretation incorporated with extensive field visit and use of ancillary data such as LRMP map, slope map, DEM, NDVI, Google earth was used to generate land use map. For mapping at scale 1:10000 combinations of different levels are used. The accuracy of the results was assessed and overall accuracy was obtained to be 95.38% with Kappa coefficient 0.93.

The land use classes yield better accuracy because the classes are designated manually based on ground knowledge and visual interpretation rather than automatic classification. These land use data and map can be used to formulate land use and other plans for the Gaunpalika/Nagarpalika under study. Further it can also be used for management activities and regulating land use activities in the Gaunpalika.

Out of total 10905.18-hectare land, 63.4% area is covered by forest, 30.9% area is covered by agriculture followed by Riverine, lake and marsh area which covers 1.1% area of the Gaunpalika. Public services cover about 0.4% and Residential covers 0.6% of the total area. However, Commercial, Mine and Minerals, Cultural and archeological & Industrial sectors cover small portion which are noticed below 0.01% of total area. Respectively, Other Land use area covers less than 3.6% of total area in this Gaunpalika. Whereas significant Mine & Minerals and Industrial land use distribution were not found in this gaunpalika.

5.2 Recommendation

Based on the constraints faced on this project following recommendation has been made for future undertaking of similar projects.

- For better result satellite imageries of the study area should be of individual bands. It would be better if there were individual bands supplied which then would be undergone for different image analysis techniques. Further, the study also felt the strong need of real time satellite imageries as problem was faced during field visit because the total change occurred in some of the land use (e.g. farmed land).
- Comprehensive land use database model provided by TSLUMD facilitated in establishing the physical model very much but if proper criteria of defining the land use polygon in an objective sense is provided, then it would further enhance the consistency of the final product.

सारांश

यस अध्ययनका लागि विभिन्न डाटाहरु प्रयोग गरिएका छन् । मुख्यत: चिनियाँ भू-उपग्रह zy-3(Zi-Yiua3) बाट खिचिएका तस्बिरहरु, स्थलगत नक्सा र विभागबाट उपलब्ध भएका कित्तानापीका नक्साहरु छन् । भू-उपग्रह नक्सालाई विभिन्न प्रक्रिया जस्तै orthorectification र geo-referencing गर्नका लागि फिल्ड मा DGPS सर्भे तथा अध्ययन क्षेत्रको DEM तयार गरि सो तस्बिरलाई accurate बनाइएको छ । प्राप्त नक्सालाई digitisation प्रविधि मार्फत, विभाग द्वारा भू-उपयोगको नीति र भू-ऐनलाई आधार मानेर बनाइएको National Landuse Mapping specification मा, रहेर डाटाबेस तयारी तथा नक्सांकन गरिएको छ । सो नक्सांकन कार्य १:१०,००० माननापमा गरिएको छ र शुद्धताको चेकजाँचका लागि फिल्डमा स्थानीय श्रोत व्यक्ति र आवस्यक सूचना तथ्यांक मार्फत निश्चित गरिएको छ । यसका साथै गाउँपालिकाको पदाधिकारीहरु र सरोकारवाला निकायहरु माझ तयार पारिएका नक्सा र डाटाको प्रस्तुतीकरण गरि सल्लाह र सुझाव लिने कार्य पनि भएको छ । यस गा.पा.ले १०९.०५ वर्ग कि.मि क्षेत्र ओगटेको छ । आयातकार रुपमा फैलिएको यस गा.पा.को बिभिन्न भेगबाट स-साना नदि बग्दछन् भने उपल्लो भेगमा अधिकांश उच्च डाँडाहरु भएको पाइन्छ । पालिकाको वर्तमान भू-उपयोगको अवस्था हेर्दा कुल क्षेत्रफल ३०.९ प्रतिशत कृषि, ६३.४ प्रतिशत वन, ०.४ प्रतिशत सार्वजनिक सेवा, ०.६ प्रतिशत आवासीय र १.१ प्रतिशत खोला-नाला, ताल-तलैया र सिमसार क्षेत्रले ढाकेको देखिन्छ । व्यावसायिक क्षेत्र तथा सांस्कृतिक र पुरातात्विक क्षेत्रको प्रतिशत अत्यन्त न्यून रहेको छ ।

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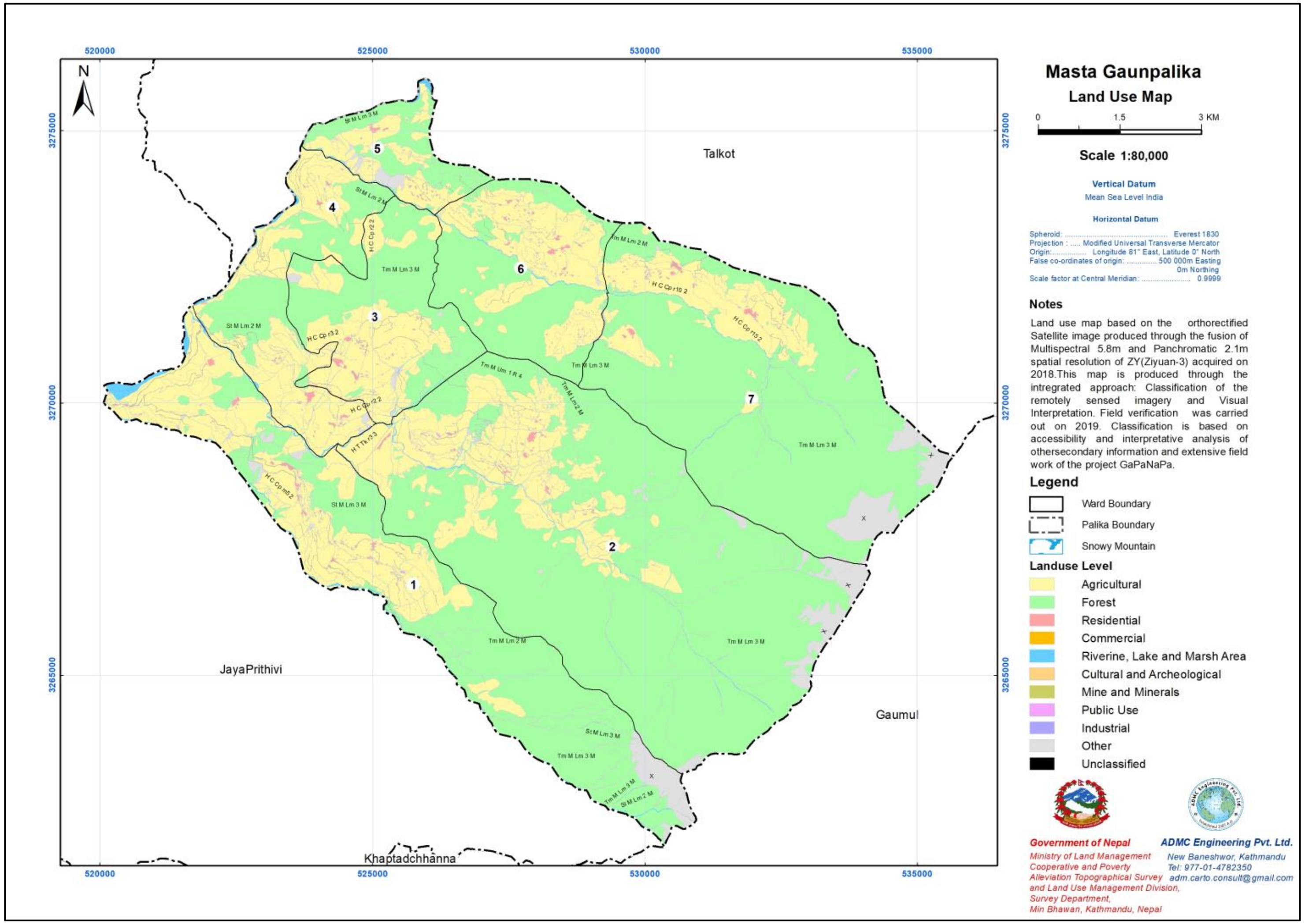
Appendix 1: Land Use Map Masta Gaunpalika, Bajhang



Appendix 2: Root Mean Square Error (RMSE), Assessment of DGPS

Measurement of error between two data sets enable user to compare predicted value and observed or Know value. The smaller an RMSE value, the closer predicted and observed values are. As RMS error is found to be less than 1 meters for our study area.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}}$$

Appendix 3: Accuracy Assessment of Land Use Classification

	AGR	FOR	RES	COM	PUB	CULARCH	RIV	Total	Comission Error	User Accuracy
AGR	60		1				1	62	3.225806452	96.77419355
FOR	1	32						33	3.03030303	96.96969697
RES			10					10	0	100
COM			1	3				4	25	75
PUB					6		1	7	14.28571429	85.71428571
CULARCH						3		3	0	100
RIV		1					10	11	9.090909091	90.90909091
Total	61	33	12	3	6	3	12	130		
Omission Error	1.639344	3.030303	16.66667	0	0	0	16.66667		Overall Accuracy	95.38461538
Producers accuracy	98.36066	96.9697	83.33333	100	100	100	83.33333		Kappa	0.93341301

C. Soil

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CHAPTER - 1

INTRODUCTION

1.1 Background and Rationale

Background: Land use planning has been defined as "The systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses." (Food and Agriculture Organization).

Land use planning is fundamental to the process of natural resource management and ecological sustainable development. It demands an integrated and strategic approach at national, regional and local levels to meet all needs. Land use planning should consider the sustainability, social impact and an assessment of what the land is capable of supporting and sustaining into the future and in the interests of the wider community. The demand on the use of our land to achieve many objectives requires the application of a rigorous process of planning. For example, some areas of land can support a wide range of uses whereas other areas support a small range of uses or certain types of uses. Effective planning involves anticipation and an understanding of land use and land management practices, and the participation by land users, planners, the public and decision makers in the planning process.

Soil surveys most commonly are made for areas that have more than one kind of important land use and for users who have varied interests and needs. These needs may be few and noncomplex in areas of extensive land use where change is not expected, or they may be many and complex in areas of intensive land use where changes are expected. The predictions of soil surveys serve as a basis for judgment about land use and management and provide information about soil resources needed for planning development of new lands or conversion of land to new uses. This is important in planning specific land use and the kind and intensity of land management needed, including those operations that must be combined for satisfactory soil performance. Soil surveys are also useful in helping to locate possible sources of sand, gravel, or fertile topsoil for cultivation. Thus, intended land use and its economic feasibility can be determined with the soil surveys and ultimately by land use planning.

Agriculture is the major sector in the country Nepal, which provides employment to the more than 65 percent of the people, contributing 33 percent in the national GDP. The production of major cereal crops plays an important role in agriculture production. The production of major cereals was reduced by 8 percent (Economic Survey, 2012/13). Low agriculture production is the major problem in Nepalese agriculture posing food security problem in the country. The major cause of low agriculture production is the cultivation of crops and soil management without scientific land resource data. Thus, land resource inventory data is necessary for environment friendly agriculture sustainability.

In this context, the Government of Nepal has recently formulated the 20-year Agriculture Development Strategy emphasizing to increase agriculture production to solve the food and nutritional security problems of the country safeguarding the environment. Also, the National Land Use Policy-2072 has been declared, which is focused to increase the productive capacity of land.

Rationale: Land-use planning can be applied at three broad levels: national, district and local. For local level planning, information regarding the natural resource, socio-economic and demography of that area is necessary for effective planning which gives guideline for selection of land and what activities can be performed, when and who is responsible for those activities. However, Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (LRMP, 1983/84). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the National Land Use Project (NLUP) in 2057/058 fiscal year to generate the necessary data bases on the land resources of the country.

In the first phase, the National Land Use Project of Nepal had initiated several projects at district level and prepared Land Resource Maps and Database at 1:50,000 scale for the whole Nepal. It had also prepared same kinds of maps and database for Kirtipur, Lekhnath, MadhyapurThimi and Bhaktapur Nagarpalika at larger scales. Finally, NLUP was mandated to prepare land resource maps of Village Development Committees of Nepal for local level planning through outsourcing modality.

The National Land Use Policy 2072, has emphasized to manage land use in accordance with the land zoning policy of Government of Nepal which categorizes 10 land zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area, Mine and Minerals, Cultural and Archeological, Riverine and Lake area, and others. The policy has mentioned the land characteristics, capability of each category of land zones. In addition, the policy has pointed to form Land Use Council at the top of district and Nagarpalika/Gaunpalika level at the bottom which also highlighted the importance of preparation of Nagarpalika and Gaunpalika level maps and databases on natural resources.

In this regard, TSLUMD has awarded to conduct the project entitled Package 19: Preparation of Nagarpalika/Gaunpalika level land resources maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map and Nagarpalika/Gaunpalika profile for Land Use Zoning Map and Superimpose of Cadastral Layers), Data Base and Reports of 3 Gaunpalika of Bajhang District to our consultancy for fiscal year 2076/077. The Package 19 covers 3 Gaunpalika (Masta, Saipal and Talkot). Total no of wards in Masta Gaunpalika is 7. Total no. of wards in Saipal Gaunpalika is 5 wards and 7 in Talkot Gaunpalika.

National Landuse Act 2076 has following specification for preparation of soil map:

(a) Soil Mapping Unit delineation:

- Based on purpose and scale of soil survey and mapping at Gaupalika/Nagarpalika level, Soil mapping unit (SMU) has to be identified as a consociation meaning to an area dominated by a soil of a single taxon such as soil family or series. For hardcopy mapping, due to legend space constraints, it is recommended to map order level but the database should be maintained up to series level.
- It further intensifies as a group of geographic mixture of taxon such as association or complexes.
- Soil mapping unit is the smallest area of a map delineated by a single boundary at the scale of 1: 10000.
- These soil mapping units have to be appeared as soil association in which classes are reorganized and located first and then grouped according to land types.

- Actual boundary of soil properties representing a single taxon is difficult to determine because of its hiding below the surface.
- Based on indicators of surface features visible such as topography, vegetation, surface and soil color, boundary of soil mapping unit has to be drawn on map with the consideration of degree of matching between the delineated area and actual soil properties depending upon the surface indicators and associated features.

(b) Soil Survey Methods:

General Traversing, Grid Survey and Free Survey are methods widely used depending upon based on purpose and scale of soil survey. Considering these methods, last two years, Topographic Survey and Land Use Management Division adopted grid survey at interval of 500 meters. Because of more than one pedons had to be collected within the same surface feature/characteristics, in recently completed projects of land use planning with soil survey, Topographic Survey and Land Use Management Division changed the method from grid to free survey with the mandate of mapping at least one hectare. Free method of soil survey along with horizontal and vertical transects is seen very popular adopted in many other countries and also LRMP in Nepal with the consideration of delineation of soil mapping unit. Gaupalika/Nagarpalika level soil survey in the country should recommend adopting such free method of soil survey.

(c) Soil Survey Types:

Based on objective, survey method, scale, type of base map available and the intensity of observation, four major types of soil survey are recognized. They are a) detailed b) reconnaissance c) detailed-reconnaissance and d) semi-detailed. LRMP adopted semi-detailed type of soil survey for district planning at the scale of 1:50000 representing 25 ha of land area by 1sq cm on map that also indicated one frequency observation in 25 ha of land in the proposed soil survey. Detailed type of soil survey has been recommended to adopt for the preparation of Gaupalika/Nagarpalika level soil survey and mapping with the purpose of solving management problems. It contains 1: 10,000 scales and having the frequency of pit defined by the need exhibited by the topography, Land unit, geology, land use and land system.

(d) Approach of Soil Survey:

A 3-tier approach such as image interpretation- landform analysis, field survey-laboratory analysis and cartography-printing were found very popular procedure for detailed soil survey and thus it is recommended for preparation of

Gaupalika/Nagarpalika level soil map**.** The following steps to be undertaken for completing the approach of soil survey:

- A specific legend for generating landforms, land units and land types have to be prepared and then high-resolution image to be visually interpreted.
- These legends further have to be modified during the field survey
- The final delineation of Soil mapping units from high resolution satellite imagery have to be transferred on topographic base map (Topo-sheet) which is basis for field survey at Rural Municipality/Municipality.
- A free survey supporting the purpose and scale of soil survey has to be done for collecting soil pits for digitizing whole Gaupalika/Nagarpalika database.
- Soil excursions have to be undertaken to review, correlate and classify the soils.
- In the laboratory, physical and chemical properties of soil pits such as soil nutrients N, P, K, as well as soil texture, pH, organic matters have to be analyzed with standard methods of examination.
- Based on landform analysis, field survey and correlation laboratory investigation, detailed soil resource maps at Gaupalika/Nagarpalika level at the scale of 1:10,000 will have to be prepared.
- Finally, GIS database and several thematic maps as per need of NLUP will have to be prepared.

(e) Soil Classification

USDA Soil classification scheme (USDA 2003) has to be followed for classification of soil pits from the category of Order to series linking with world Reference Base for Soil resources (FAO 1998). In this concern, LRMP has identified seven categories of soils such as entisols, inceptisols, spodosols, mollisols, alfisols, ultisols, and aridisols at order levels, twenty-one at sub-order 3 of each order. Some of them are aquents, aquepts, orthods, aquolls, aqualfs, udults and so on. Similarly, forty-one categories are identified at great-group level representing 2 of each sub-order and 110 categories at sub-group level.

1.2 Objectives

The objectives of the study are as follows:

1. To prepare map specifications for preparation of Land Resources Maps at the scale of 1:10000
2. To prepare standards for different steps of the preparation of land resources maps
3. To maintain uniformity and to follow the standards and norms for the preparation of land resources maps of specified areas
4. To identify the supplementary data and information necessary for the preparation of profile of the specified area. In order to achieve the objective, the study team shall carryout the following activities:

a. Prepare Geological Maps of the selected Nagarpalika/Gaunpalika at 1:10000 scales.
b. Prepare Land System Maps for the selected Nagarpalika/Gaunpalika at 1:10000 scales.
c. Prepare maps of sample pits covering each land unit/land type of the Nagarpalika/Gaunpalika 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 physical and 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 Nagarpalika/Gaunpalika at 1:10000 scales.
g. Design appropriate GIS database logically for detailed field survey and Lab test analysis data.
h. Discuss the accuracy, reliability and consistencies of data.
i. Prepare reports describing methodology, distribution of different soil types and model of GIS data base.
j. Prepare A4 size Maps of N, P, K, OM, Texture, and pH to attach in the soil reports of the Nagarpalika and Gaunpalika.

1.3 Study area

Masta Gaunpalika is an important urban center in Bajhang district and it lies in Sudur Pashchim province in Nepal. Geographically, Masta is located at 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude. This Rural Municipality consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Municipality to the west, Bajura district to the south and Talkot Rural Municipality to the north. The total area of the Gaunpalika is 109.05 km². The total population of this Gaunpalika is 17909, of which male population accounts for 8537 and female population is 9372. However, all the wards vary in area and population size. Total number of households in the Gaunpalika is 2798.

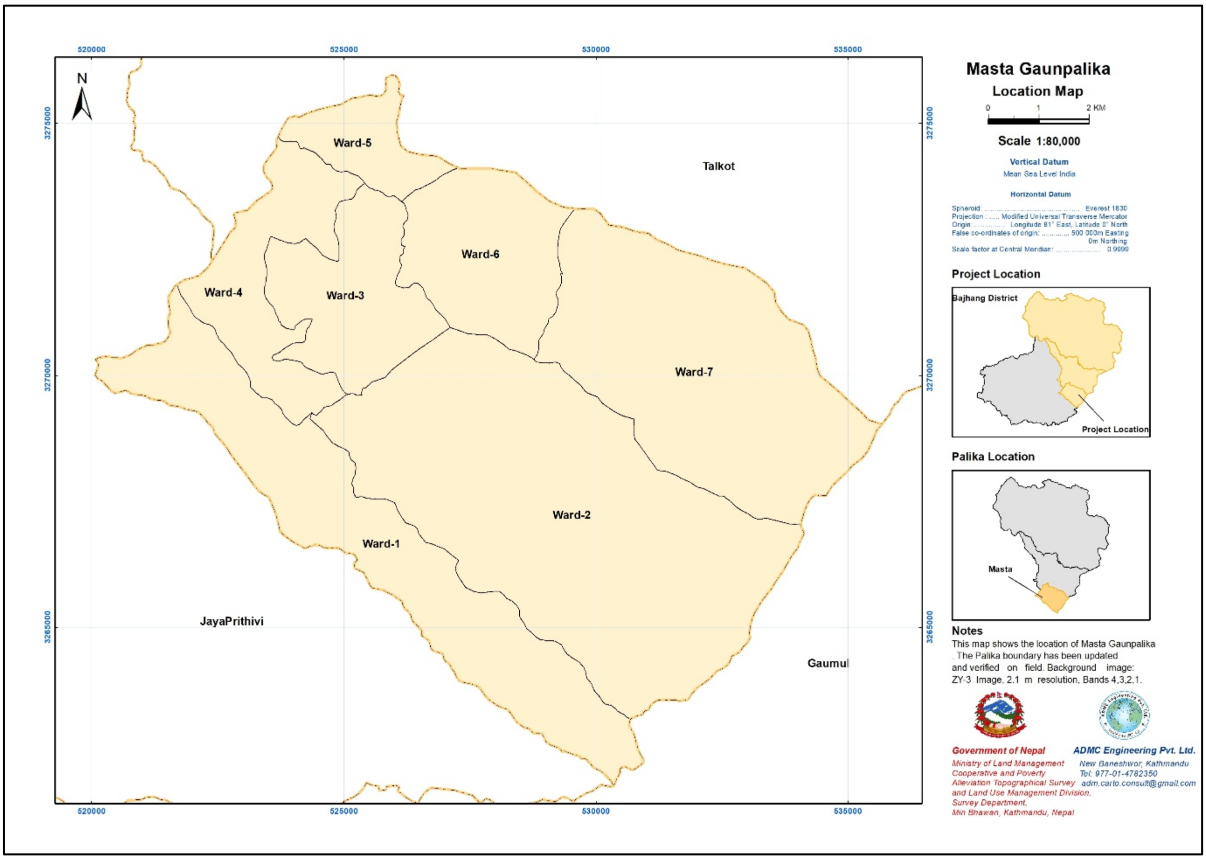

Figure 1.1: Location Map of Masta Gaunpalika of Bajhang District.

CHAPTER - 2

BIO-PHYSICAL CONDITION OF THE STUDY AREA

2.1 Physiographic region

Bajhang is one of the districts located in the Middle Mountain region. Physiography of Nepal has been mainly divided on the basis of river, relief, structure altitude and geographical distribution. Because of such variations, it has resulted in distinct landform and topography. For the sake of convenience, the physiography of Nepal is divided as High Himal, High Mountain, Middle Mountain, Siwalik and Terai from north to south. The Terai is the flat land below 300m elevation formed by alluvial deposition. The Siwalik, Churiya, lies just above Terai. It ranges from 300-900-meter elevation in general. It is formed with conglomerates.

The middle mountain or the mahabharat extends widely just immediately after the siwalik. It lies between 900 to 3000 meters' elevation. It has sprus, hills, river basins and valley, the Arun Vallley, Kathmandu Valley, Pokhara Valley, Tumlingtar, Rumjatar, and Salyantar lie in this belt. The high mountain also has steep and dissected landforms. The High Himals is in the northernmost part where hundreds of mountain peaks are found.

2.2 Elevation

The elevation is an important topographic element affecting the soil formation. Elevation influences the soil formation by affecting the type of vegetation and soil type along with the climatic factors. The Elevation of the Masta Gaunpalika ranges from 1257.51 m. to 3926.82 m.

2.3 Slope

Slope influences the soil formation controlling soil erosion and water movement in the soil along with the other soil forming factors and affecting the soil characteristics. To delineate the soil boundary, slope is used as the physiographic variation. Besides this, slope of the project area was used as the basic tool for the demarcation of landform, land types and land units. The slope of this Gaunpalika ranges from 0^0 to 77.25^0.

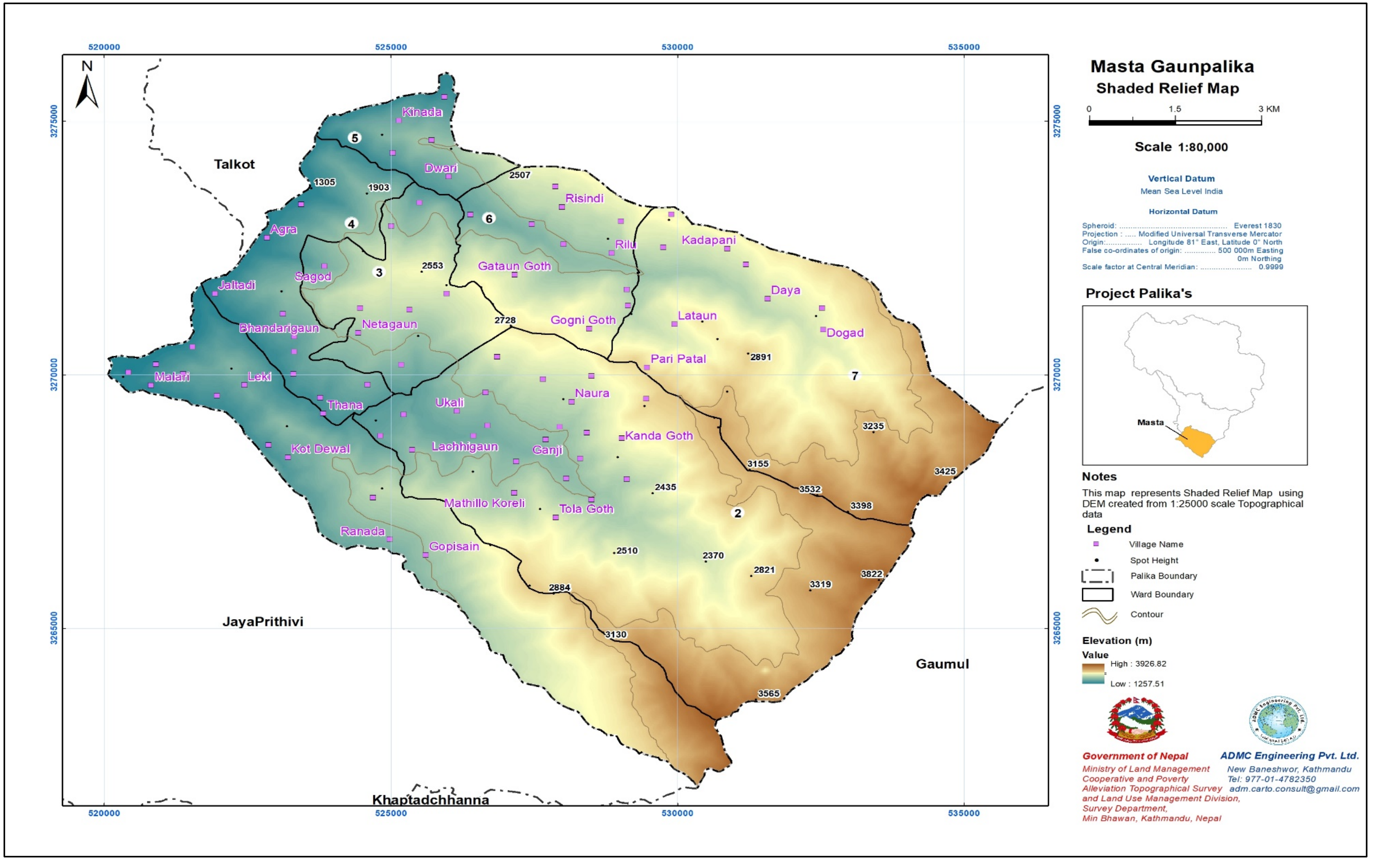

Figure 2.1: Elevation Map of Masta Gaunpalika

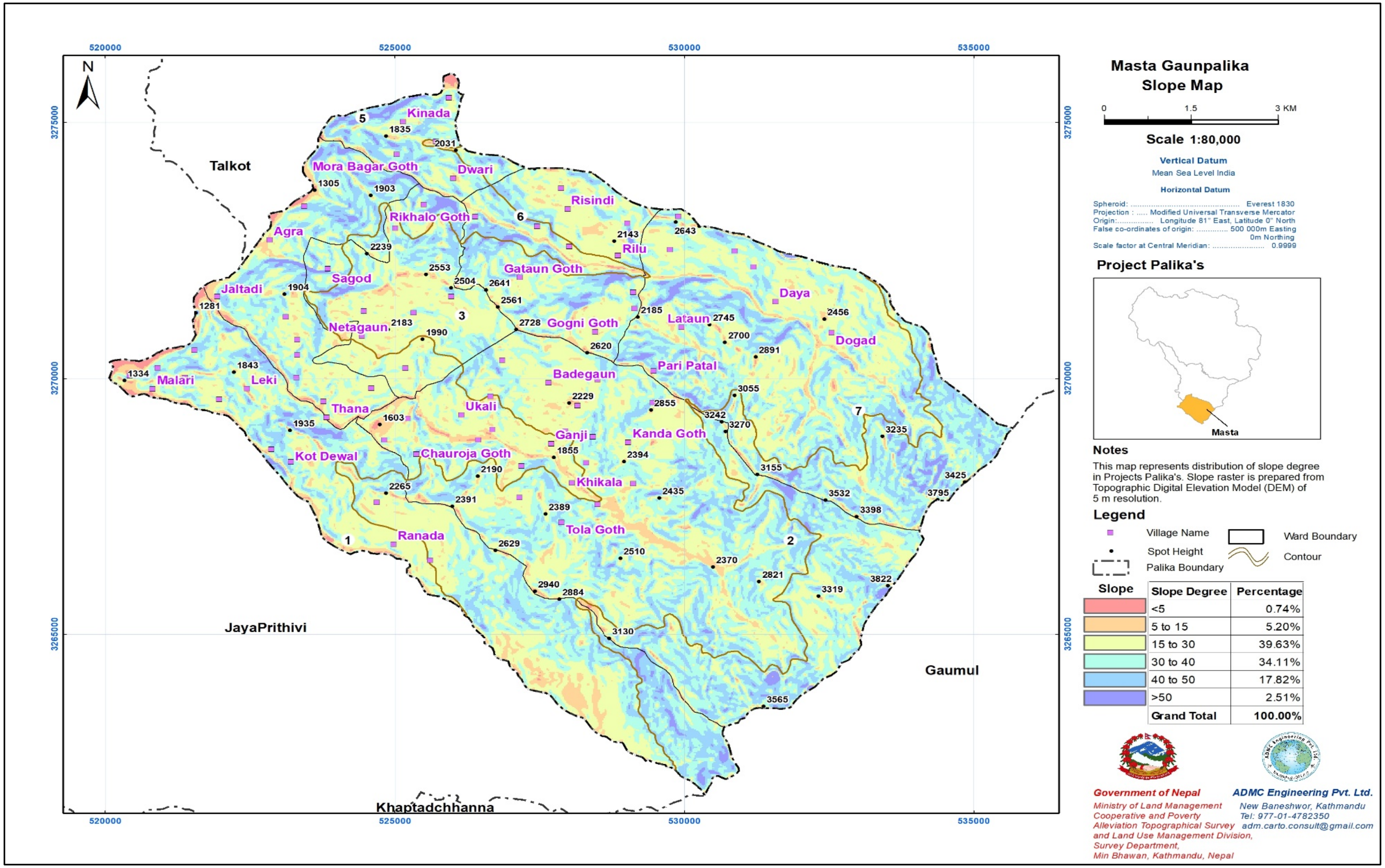

Figure 2.2: Slope Distribution Map of Masta Gaunpalika

2.4 Geology

The area falls in the Middle mountain range (Lesser Himalaya) to Higher mountain range (Higher Himalaya) and then to the Tibet, China (Tibetan Tethys zone). The Higher mountain is characterized by MCT (Main Central Thrust).

Geomorphologically, the area is characterized by river terraces, colluvium deposits and rocky slopes. The 'Seti River' is one of the major rivers in the area. The catchment area is characterized by very rugged and steep topography, which was resulted by the upliftment of the Himalayan Range.

The area is located in the Lesser Himalaya, Higher Himalaya and up to the Tethys Himalaya of Far Western Nepal. Following geological forms are seen in the study area:

Himal Group (Hm): is characterized by presence of Garnet-biotite gneisses, Kyanite-biotite gneisses, garnetiferous mica schists, augen gneisses, micaceous quartzites and thin bands of marble.

Ranimatta Fm (Rm): is characterized by gray to greenish gray shales, phyllite shales garnetiferous phyllites grayish white quartzites with carbonate beds and amphibolite.

Kushma Fm (Ks): is characterized by greenish gray, white fine to medium grained at places, ripple marked massive quartzites intercalated with green phyllites. Basic intrusions are abundant.

Lakharpata Fm (Lk): is represented by presence of bluish-grey dolomite, limestones and shale.

Ulleri Fm (Ul): is represented by feldspathic schists with augens of feldspar and quartz, augen gneisses intrusions of granite.

Basic Rocks (Br): are the basic igneous rocks with more vesicles.

Galyang Fm (Gl): is characterized by presence of dark grey to black phyllite and spotted white, fine-grained quartzite.

Suntar Fm (Sn): is comprised of fine to medium-grained, greenish grey sandstone and purple shale.

Masta Gaunpalika belongs to all the formations mentioned in the Regional Geology are **Ranimatta Fm (Rm), Kushma Fm (Ks), Lakharpata Fm (Lk), Basic Rocks (Br), Galyang Fm (Gl), Suntar Fm (Sn)** except **Himal Group (Hm), Ulleri Fm (Ul).**

Thrust:
MCT is the major geological structure found in the area.

Main Central Thrust (MCT):
The MCT strikes in southeast-northwest direction and separates the high-grade metamorphic rocks of the Higher Himalaya to the north and low-grade metamorphic rocks of the Midland Group of the Lesser Himalaya to the south.

Other Major Thrust:
The thrust is located southwest of the MCT and extended nearly parallel and perpendicular around the area.

Fold and Foliation:
Around the area, regional folds are not reported but minor and local folds can be seen.

Anticline: Anticlines are folds in which each half of the fold dips away from the crest. Major anticlinal folds have not been observed but some minor and local anticlinal folds can be seen.

Syncline: Synclines are folds in which each half of the fold dips toward the trough of the fold. Major synclinal folds have not been observed but some minor and local synclinal folds can be seen.

Quaternary Deposits represent the Sub – Recent to Recent sediments deposited by the fluvial action. They are divisible into two types in an ascending order: **Alluvium Deposits and Flood Plain Deposits.**

Alluvium Deposits: This is distributed on both sides of the rivers and streams with low gradient and open valley. They are characterized by river terrace deposits and are of unsorted, rounded to sub rounded pebbly and gravely materials mixed together with fine sand, silt as well as clay giving rise to the development of the fertile top fine soil usable for the cultivation.

Flood Plain Deposits (River Bed Deposits): It occurs along the riversides and on the flood plain (present river channel) itself which also contain the water during the winter season and cover the area as high as the water level rises during the heavy rainy season. In other words, this is the area that is covered by the flooding river and left barren during the dry season after depositing the various materials carried at flood time. It has alluvial loose sediments consisting of boulders, cobbles, pebbles, coarse sand and gravels mainly of sandstone, siltstone and claystone with silt. When mixed with clay it gives rise to the fertile top fine soil usable for the cultivation. The aggregates thus derived and deposited by the river often provide an excellent source of building and construction materials.

River Terraces also known as '**Tars**' in the Middle mountain are abundant in long strike valleys in a multistage and multilevel form. They are depositional in origin and are the remnants of an earlier river bed or flood plain. Several sets of these terraces with different heights above the present river ranging from few meters to hundred meters are noticed. The coarser materials in the terraces are boulders of granites, quartzite, limestone, sandstone derived from upstream of the Seti river catchment itself.

MINERAL RESOURCES
Iron, Copper, Cobalt, Nickel, Molybdenum, Phosphorite, Mica, Talc and Coal are the minerals which occurs in the area. Uranite and autonite mineralization has been recorded from Banku Quartzite of Bajhang (Nimli Gad). Stromatolitic phosphorite deposits in Bajhang District, where phosphorite has associated with Pre-Cambrian cherty stromatolite dolomite beds. (Source: DMG)

NATURAL RESOURCES
Surface as well as ground water, non – metallic minerals like river aggregates (sand, gravel, and pebbles) as well as natural forests and building stones like slate, quartzite, and limestone are the prominent natural resources in the area. The seasonal stream beds have enormous deposits of pebbles, gravels and sand as a good source of construction materials in the area. Proper management of these resources for optimum utilization for the livelihood of people is necessary.

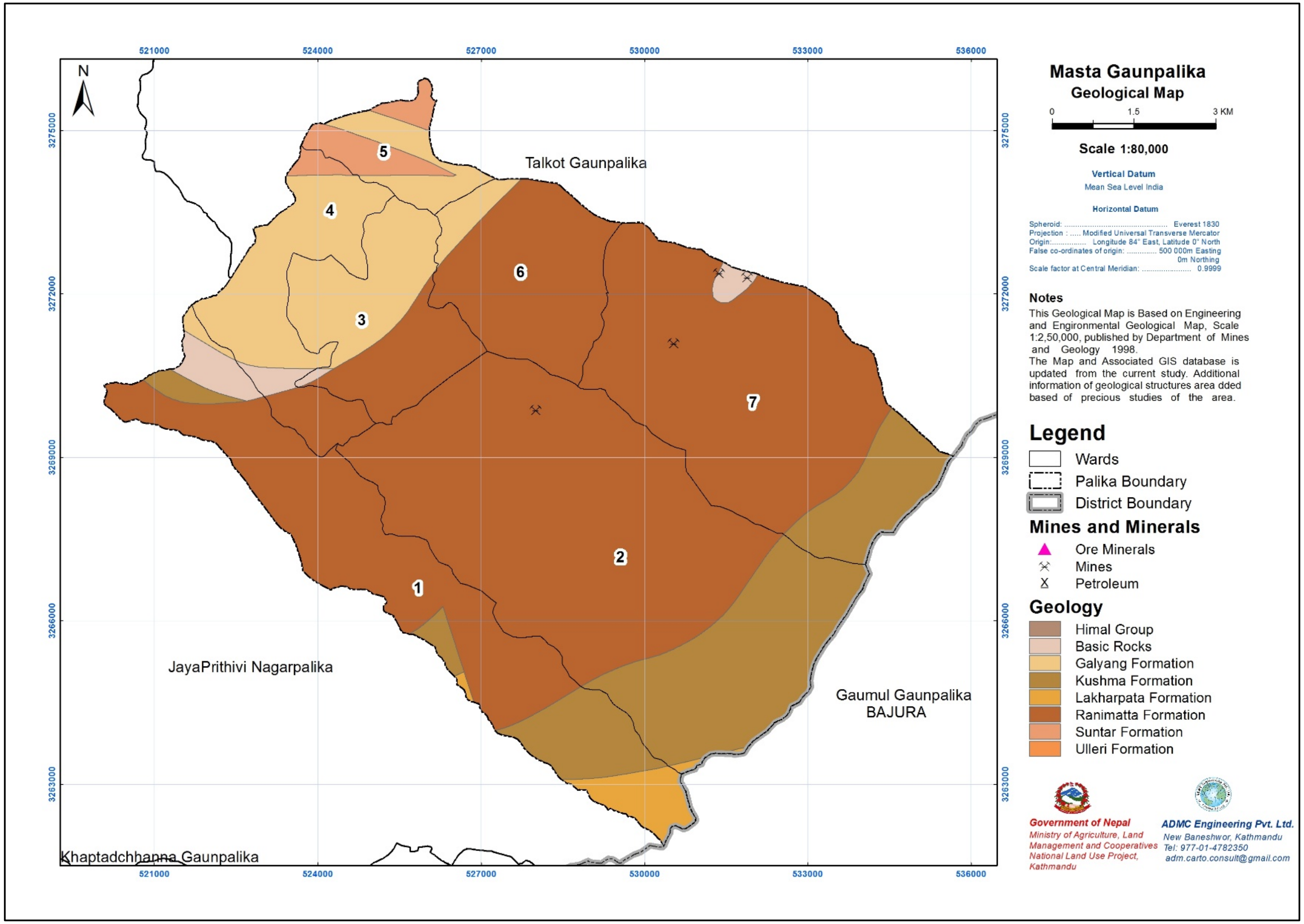

Figure 2.3: Geological Map of Project Area with Palika boundary

2.5 Streams and Canals

Major river flowing in the project area is Seti river. The headquarter "Chainpur" is situated at the bank of Seti river and Bauli Gaad. Major Canal system are not available but many small local canal system (Kulo) exists. The major river basin in this area is Seti River Basin. Many fractures and joints are present from which hot water springs are exposed out in the area. Dense vegetation in the sloppy area indicates that the rocks are highly porous but lack of water sources indicates that the rocks are less permeable.

2.6 Climate

The year is divided into four weather seasons in Bajhang, namely the winter season (December to February), the summer season (March to May), the monsoon season (June to September) and the post-monsoon season (October and November). The Gaupalika is represented by meteorological station at Chainpur Station. According to Chainpur station, the mean yearly minimum temperature is lowest (3.3^{0}C) in the month of January and it slowly rises from the month of Feb and attains highest (20.2^{0}C) in the month of July. Similarly, the mean yearly maximum temperature is the lowest (18.5^{0}C) in the month of January it slowly rises from the month of February and attains the highest (31.6^{0}C) in the month of June. Table 2.1 shows the Yearly Mean Temperature of Chainpur Station (1984-2013).

Table 2.2 shows the Yearly Mean Rainfall at Chainpur station. It is seen that the rainfall is intensified within Six months i.e. April to September, of the year. Highest rainfall (404.85mm) is obtained in the month July and lowest rainfall is in Nov/Dec.

Table 2.1: Yearly Mean Minimum Temperature in ^{0}C at Chainpur (west) Station, *Bajhang District* (1984-2013)

Temperature of Chainpur West (Bajhang) (1984-2013)												
Temp	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Min(avg.)	3.3	5.3	8.9	12.3	15.8	19.2	20.2	19.7	17.6	12.1	7.3	4.0
Max(avg.)	18.5	20.5	24.9	28.7	31.0	31.6	29.5	29.2	28.7	27.0	23.3	19.9
Average	10.9	12.9	16.9	20.5	23.4	25.4	24.8	24.4	23.2	19.5	15.3	11.9

Source: Department of Hydrology and Meteorology.

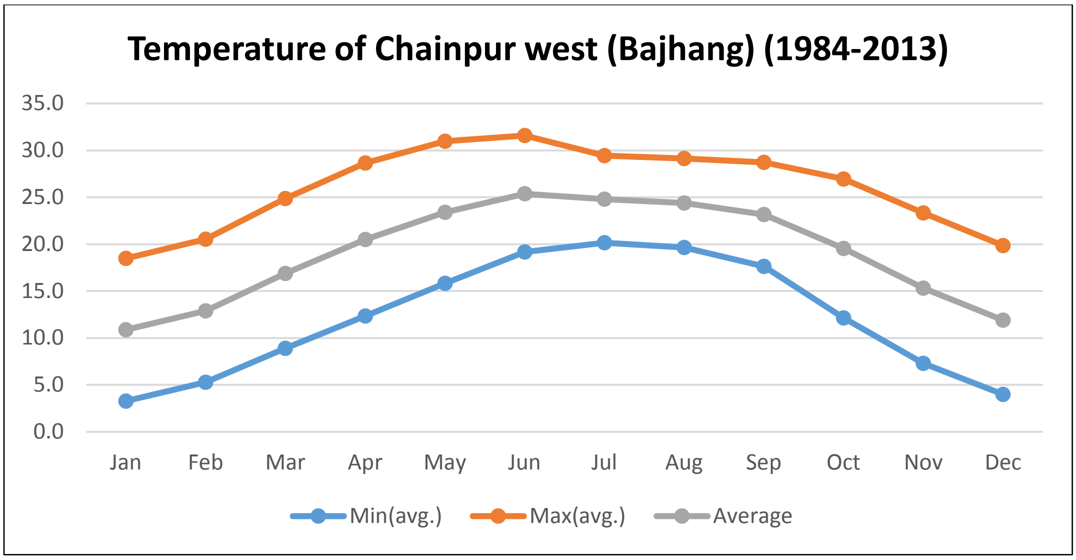

Figure 2.4: Monthly Mean Maximum Temperature in 0C at Chainpur (west) Station (1984-2013)

Table 2.2: Yearly Mean Rainfall (in mm) at *Chainpur(west) Station, Bajhang District (1984-2013)*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm.)	44.92	73.41	56.38	42.74	69.32	177.18	404.85	396.89	221.26	44.25	10.53	23.87

Source: Department of Hydrology and Meteorology.

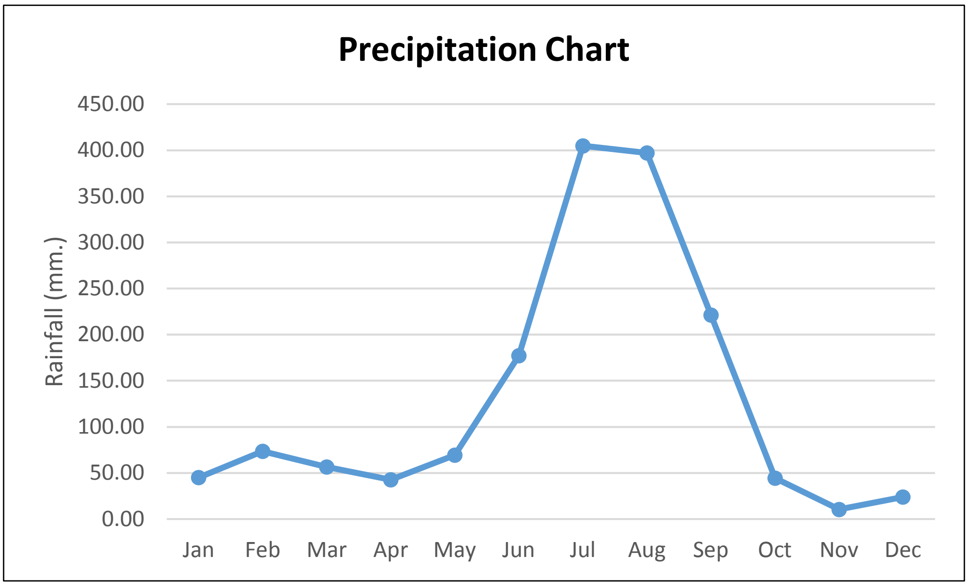

Figure 2.5: Monthly Mean Rainfall at at Chainpur(west) Station, Bajhang District (1984-2013)

Between the months of June and September of every year, the highest total rainfall is recorded i.e. 300.05 mm and the lowest total rainfall of 6.36 mm is recorded between the months of October and November. Table: 2.3 show Yearly Mean Seasonal Rainfall (in mm) at Chainpur (1984-2013).

Table 2.3: Yearly Mean Seasonal Rainfall (in mm) at Chainpur (*1984-2013*)

Season	Rainfall (mm)	Percent of seasonal rainfall with respect to annual rainfall (%)
Summer (Mar-May)	56.15	13.03
Monsoon (Jun-Sep)	300.05	69.62
Post Monsoon (Oct and Nov)	27.39	6.36
Winter (Dec-Feb)	47.40	11.00
Total rainfall	**430.98**	**100.00**

2.7 Vegetation/Land Use-Land Cover

Out of total 10905.18-hectare land, 63.4% area is covered by forest, 30.9% area is covered by agriculture followed by Riverine, lake and Marsh area which covers 1.1% area of the Gaunpalika. Public services cover about 0.4% and Residential covers 0.6% of the total area. However, Commercial, Mine and Minerals, Cultural and archeological & Industrial sectors cover small portion which are noticed below 0.01% of total area. Respectively, Other Land use area covers less than 3.6% of total area in this Gaunpalika. Whereas significant Mine & Minerals and Industrial land use distribution were not found in this gaunpalika.

Table 2.4: Land use Class

S.No	Landuse Class	Area (sqm)	Area (ha)	Percent
1	Forest	69184718.60	6918.47	63.4
2	Agriculture	33725206.37	3372.52	30.9
3	Other	3875438.03	387.54	3.6
4	Riverine, Lake and Marsh Area	1154027.14	115.40	1.1
5	Residential	669225.09	66.92	0.6
6	Public Service	438306.18	43.83	0.4
7	Commercial	3501.12	0.35	0*
8	Cultural and Archeological	1372.00	0.14	0*
	Grand Total	**109051794.53**	**10905.18**	**100**

*LESS THAN 0.01 PERCENT

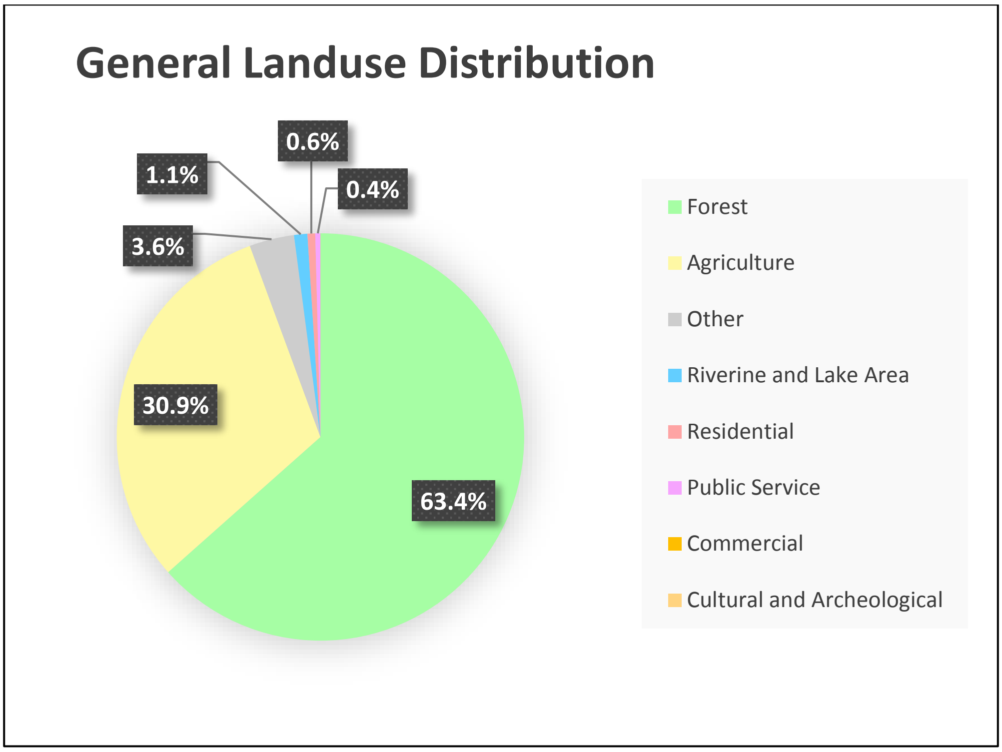

Figure 2.6: Land use Class

CHAPTER - 3

METHODOLOGY OF SOIL SURVEYING

3.1 Review of Soil survey methods

Soil survey includes study and mapping of soils in their natural environment. It is the systematic examination, description, classification and mapping of soils of an area. Soil survey consists of group of activities which are:

- Field work to study the important characteristics of soils and the associated external land features such as landforms, natural vegetation, slope etc.
- Laboratory analysis to support and supplement the field observations.
- Correlation and classification of soils into defined taxonomic units.
- Mapping of soils that is establishing and drawing soil boundaries of various kinds of soils, on standard topographical base map.
- Soil survey interpretation, that is making prediction about the potential of soils for alternative uses, like agricultural crops, grasses, fruit, forestry or plantation crops and Ascertaining their management requirements for sustained production.

The study methodology of soil map preparation can be divided in to two parts, i.e. 1) desk study as secondary information collection, analysis and report preparation and 2) field study as primary information collection with verification of secondary information with observation by the team of expert. In case of desk study, the secondary information was collected from various sources such as published and unpublished reports, various maps and other sources. The primary information of soil was collected using field sampling with strong support from GIS and RS analysis and other remote sensing techniques. However, the soil survey was comprised of identification, examination, classification and mapping of the soil and land units with characterization of both the physical and chemical properties of the soil units.

There are basically two approaches commonly used in other parts of the world for soil mapping using satellite remote sensing data which is available in both format as digital (softcopy) and imageries (hard copy).

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.

In these contexts, soil survey methods based on the visual image interpretation are reviewed here.

3.1.1 General Traversing

Studying and mapping of soils in the field are the two most important activities of the soil survey. The advancement of technology and technical knowledge has made change in the trend soil survey as if the basic means and methods remained same. The surveyor analyses the landform, geology, climate and vegetation and their relationship with morphological properties of soil by using aerial photo and satellite imagery before going to the field. After that, surveyor goes to the field to identify the points to be studied based on the intensity of mapping. Then, he observes the morphological characteristics such as texture, color, horizons, soil depth, moisture status, structure etc. of the soil at that point through field method and put these observed data on the map.

3.1.2 Grid survey

Grid survey is the field observations at fixed intervals in both directions. The setting of legend before, during and after the field observation is performed in this survey. In very steep terrain, water body, limited budget and large number of soil pit, the grid survey is difficult to perform. If it is necessary to reduce the number of sample site, we can do this by modifying the grid system considering the pedogenesis, water body, and slope, and landuse, degree of difficulties, research objectives and research budget producing accurate and sufficient data.

3.1.3 Free survey

The free survey is suitable for small scale survey where large areas of inaccessible terrain must be covered in a short time within a limited budget. The soil sampling points are maintained on the basis of changes in physiography interpreted through satellite imagery and other surface features such as soil colour, vegetation and land use. Number of sampling points depends on the uniformity of soil and mapper concentrates of inferred boundaries within the boundary. On small scales, the inferred boundaries are often accepted as soil boundaries and very limited efforts are made to find soils within the physiographic boundaries. On large scales, however, within the physiographic boundaries are recognized depending on the scale of mapping. Based on the differences in physiography, parent material, drainage class and profile development the grouping of soils of an area into defined soil map units.

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 GI Science technology. The entire methodology comprises three- tier approach furnished below in detail.

3.2 Desk Study

Before the field visit, ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Image (MSS and pan bands) dated Janurary and October 2018, Topographical Maps and map of land resources; Land System, Land Capability, Land Utilization and their related reports prepared by Land Resource Mapping Project (LRMP) published in 1984/86 were employed to identify the landforms and land units of survey area. All these layers and satellite images were made compatible for overlay analysis by geo-rectifying and geo-referencing them in same projection system prescribed by TSLUMD. Standard False Color Composite (RGB:432) of the project area at the scale of 1:10000 were produced. These imagery 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, were also produced 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 type units that was used for detailed soil survey. The soil mapping units were interpreted and delineated on the imagery with the aid of bio-physical-soil relationship such as topography, geology, drainage and land use. The physiographic units are further sub-divided based on land use/land cover as revealed in the image.

After delineating the land forms/units through available thematic maps and satellite images, pit location for soil sampling were fixed. Pit location was determined in the geo-referenced images covering at least each land forms/ units as identified in the images with the help of Land resources Map of LRMP. The major considerations while selecting the pits were 1) representation of similar characteristics of land form and soils, 2) priority for the cultivated and plain area, 3) discarded or less priority for the rock-out and very steep slope areas etc. Then, maps with pits were prepared at the scale of 1:10000 for field work. Altogether 35 soil pits were delineated for sampling the soil for this Gaunpalika. The spatial distribution of pit locations of Masta Gaunpalika is shown in Fig 6.2.

3.3 Field Survey

The landform and associated soil properties of the project area were identified through conducting preliminary reconnaissance survey during the pre-field visits. The preliminary survey was very useful for recognition of soil mapping units and selecting the appropriate soil pit to study the morphological characteristics and soil sample collection for the physical and chemical determination in various landform/unit. Physiography, landform and their associated soil properties were studied during the field work which was conducted 2076/05/27 to 2076/06/16 the selected soil pits. It is assumed that the soil sampled from the pits covers all units of delineated landform which was demarcated by using land system map, land use map, topographical map and ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Image for this project. At the time of field work, soil profile was observed as mentioned methods and procedure of specification and Terms of Reference of project. The soil profile of pit was described following the Soil Survey Manual of United States Department of Agriculture (USDA) and FAO guidelines 1998. The soil properties were observed based on the form of soil survey provided by TSLUND. The soil sampling was done from each horizon for the chemical and physical analysis of soil to know the fertility status of soil. Besides the topographical map, standard false color composite (FCC), land system maps for the basic information, the following equipment were used during the soil profile observation and sample collection:

a. Soil sample airtight plastic bag with Tag
b. Measuring Tape and Scale
c. Standard Soil description form
d. GPS (1m accuracy)
e. Digital Camera
f. Abney Level
g. pH an moisture meter
h. soil thermometer
i. Marker pen (Permanent)

j. Spade or Shovel
k. Knife
l. Munsell Color Chart

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

a. Soil Pit Number
b. Satellite Imagery
c. Higher category classification
d. Date of examination
e. Authors of description
f. GPS Location: Easting and Northing
g. Elevation (in meters of feet)
h. Micro-topography
i. Physiographic unit
j. Localities where pit is dug
k. Slope on which profile is sited (direction and degree)
l. Land use /land cover or Vegetation
m. Climate
n. Cropping pattern

1. 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 status
g. Presence of Salt or Alkaline.
h. Human Influence
i. Classification
j. Local name of soil
k. Series name
l. Pans
m. Depth of ground water

2. Description of Individual Soil Horizon

a. Horizon symbol
b. Depth of top and bottom of horizon (in centimeters)
c. Matrix Color (Moist/ Dry)
d. Mottling color
e. Texture
f. Coarse fragments
g. Structure
h. Consistency
i. Clay cutans (Clay Skin)
j. Pores
k. Features of Biological Origin
l. Content of roots
m. Nature of Boundary with Horizon below
n. PH Value
o. Number of Sample taken for Analysis
p. Porosity

The standard soil profile description form was slightly modified considering the information required reflecting ground realities and such form was attached in Appendix. Soil samples are collected from profiles with digging standard size for analysis in the soil laboratory.

3.4 Laboratory Soil Analysis

Soil Profile Data Analysis: The information containing in standard soil description form also known as spatial data includes physical and morphological attributes of soil pit brought from intensive field survey. Such information associated with the information of site characteristics, soil characteristics and horizon characteristics 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 same scale of geo-referenced base map projected on MUTM parameters.

Soil Physical-chemical Analysis: The soil sampled from the top horizon (0-20 cm) of each soil pit were analyzed to determine the physical and chemical properties including soil texture, pH, Nitrogen(N), Phosphorus(P) and Potassium(K), Organic matter (OM). These properties were analyzed to assess the fertility status and to assist in the soil classification. Laboratory Work was done in the Central Laboratory of Soil Management Directorate, Department of Agriculture, Hariharbhawan, Lalitpur, Nepal. In the laboratory the following methods were used to analyze the physical and chemical properties of sample pits:

Table 3.1: Methods followed in Laboratory to determine Chemical and physical properties of soil

Parameters	Analysis methods
Soil texture	Hydrometer method (Gee and Bauder, 1986).
Soil pH	Beckman electrode pH meter (Cottenie*et al.,* 1982)
Organic matter content	Graham's colorimetric method (Graham, 1948)
Nitrogen	Kjeldahl distillation (Bremner, 1982)
Phosphorous	Modified Olsen's (Olsen *et al.,* 1954)
Potassium	Ammonium acetate extraction method (Pratt, 1965) using flame photometry

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

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

Soil Mapping: Based on shape, size, tonal and color variation and relative height, the landform and land types of the project area were identified on, ZY (Ziyuan-3) 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. The Anaglyph Stereo Pair Visualization of MSS ZY(Ziyuan)-3-01 and ZY(Ziyuan)-3-02 Image was made to get the 3-Dimensional perspective of terrain relief, land use practices associated with the soil in entire project area. It helps in identification of boundaries of soil mapping units in 3 dimensional views because soil is 3 dimensional natural bodies. Soil association which is universally accepted for soil mapping and classification 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 soil mapping unit. Thus, classifications were made based on soil association. Based on morphological characteristics and chemical properties derived from Lab analysis is used to classify the soil following Soil Taxonomy (USDA/SCS, 1998).

CHAPTER – 4

LAND SYSTEM, LANDFORM AND LAND TYPES

Soils are considered as the integral part of the landscape and their characteristics are largely governed by the landforms in which they are developed. Physiography influences soil formation affecting the climate, vegetation of an area as if it is considered as passive factor of soil formation. Moreover, there is a close relationship between physiography and soil development which ultimately affects the availability of nutrients (Verma et al., 2005). The physiography has influential role in soil formation through slope and exposure. The flat topography has more depth of soil as compared to the steep slopes because the steep slopes are more prone to the erosion (Sehgal, 2002).

Soil properties like profile development, texture, structure, color, acidity, cation exchange capacity, base saturation etc. are related to landform. There is a close relationship between physiography and soils. The formation of the diverse group of soils can be attributed to the variation in topography causing erosion, leaching, sedimentation and other pedogenic processes modified by water table (Mini *et al.,* 2006). Thus, physiographic influence of soil properties has been recognized which ultimately leads to evolution of the soil-landscape relationship. Topographic maps, aerial photographs stereo-capability and remote sensing data provide useful tool for geomorphic analysis of the region and help in soil survey and mapping.

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, geology and slope and arable agriculture limits and then land units based on map able 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 were determined by detailed field soil survey. These observations were further studied on *Soil Association* for classification. Digital Terrain Model (DTM) is employed for delineation of landform, land units and land types for detailed soil survey at local level planning.

4.1 Land System

The project area lies in the Middle mountain and High Mountain range. It encompasses land system units of 9a, 13b, 13d, 14a, 14b and 15b basically differentiated based on geology and geomorphology. Physiography is further subdivided into landforms basically defined by the position of land surface in landscape and it is characterized by slope and its direction, elevation, rock exposure and soil type.

4.2 Land form

Landform is further subdivided into land units basically defined by the mapable size of land surface for demarcation in landscape by the user. And it is characterized by landscape features. The land units in the project area are shown as below:

- Intermediate position level.
- Depressions
- Khola, sandbar and flood plain

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 soil classes based on their texture are sand, clay and loams with intermediary class such as sandy loam. The texture is the relative proportion of sand, silt and clay particles in the soil. Soil texture of top layer is used for land system classification, soil suitability and classification of soil at family level. The soil textures found in project area are given with symbol in Table 4.3.

Table 4.1: Soil texture and symbol

Texture Classes	Symbol
Clay	Cl1
Clay Loam	Cl2
Loam	Lo1
Loamy Sand	Lo2
Sand	Sa1
Sandy Clay Loam	Sa2
Sandy Loam	Sa3
Silt	Si1
Silty Clay Loam	Si2
Silty Loam	Si3

4.3 Description of Individual Land Type Units (Masta Gaunpalika)

The land units defined by LRMP are further subdivided based on local field variation associated with the different land use practices. Altogether eight land units identified in the project are associated with the local micro-relief variations. The spatial extent covered by the Gaunpalika area is presented in Table 4.2 and distribution of the land units are shown in figure 4.1 and 4.2.

Table 4.2: Land System/ Land type

Region	Land System	Landform	Land unit	Description	Dominant slopes°	Area(Ha.)	Area(Sqm.)	Percent
High Mountain (Hm)	13	Alluvial plains and fans	13b	13b-Recent alluvial plain	<2	12.82	128182.31	0.1
			13d	13d-Ancient alluvial terraces	<5	19.84	198368.62	0.2
	14	Past glaciated mountainous terrain below upper altitudinal limit of arable	14a	14a-Moderate to steep slopes	<30	2886.76	28867565.61	26.5
			14b	14b-Steep to very steep slopes	>30	4466.11	44661146.43	41.0
	15	Past glaciated mountainous terrain above upper altitudinal limit of arable	15b	15b-Very steep slopes	>40	3364.18	33641785.64	30.8
Middle Mountain Region (Mm)	9	Alluvial plains and fans(depositional)	9a	9a-River channel	<1	155.48	1554750.56	1.4
Grand Total						**10905.18**	**109051799.17**	**100**

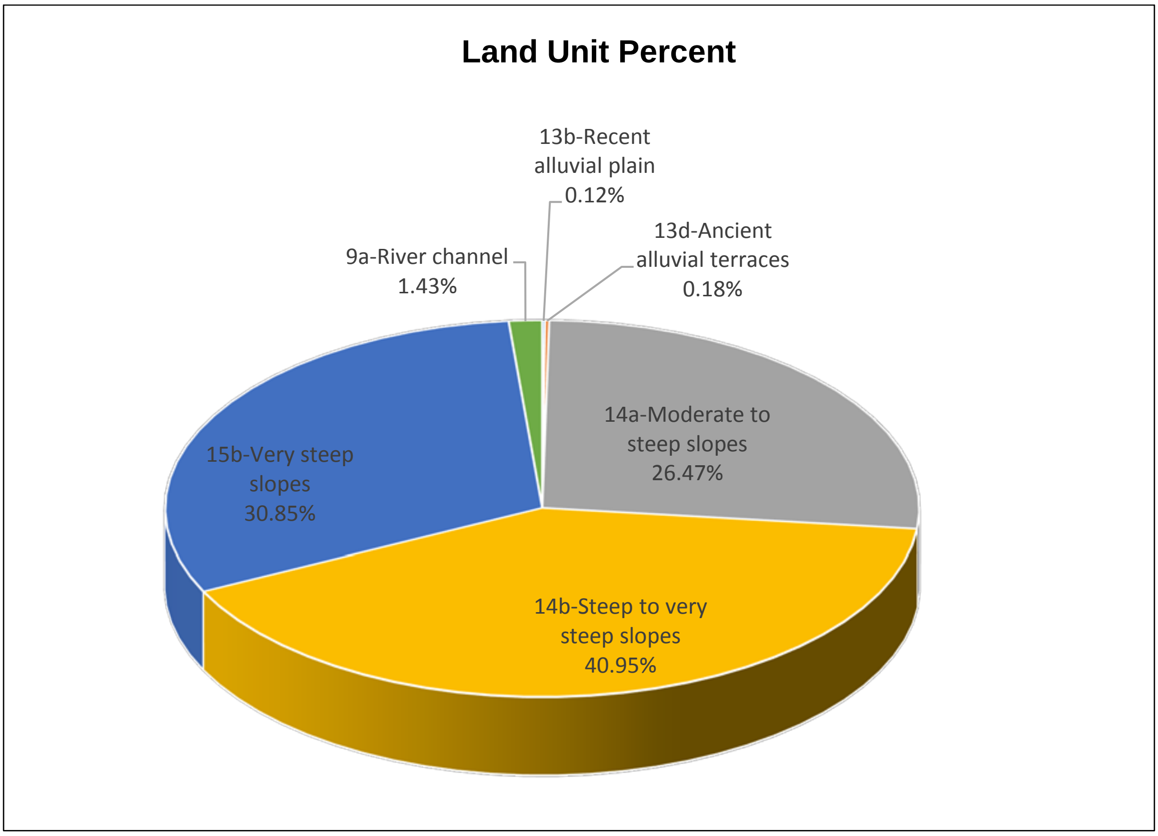

Figure 4.1: Distribution of Land Units

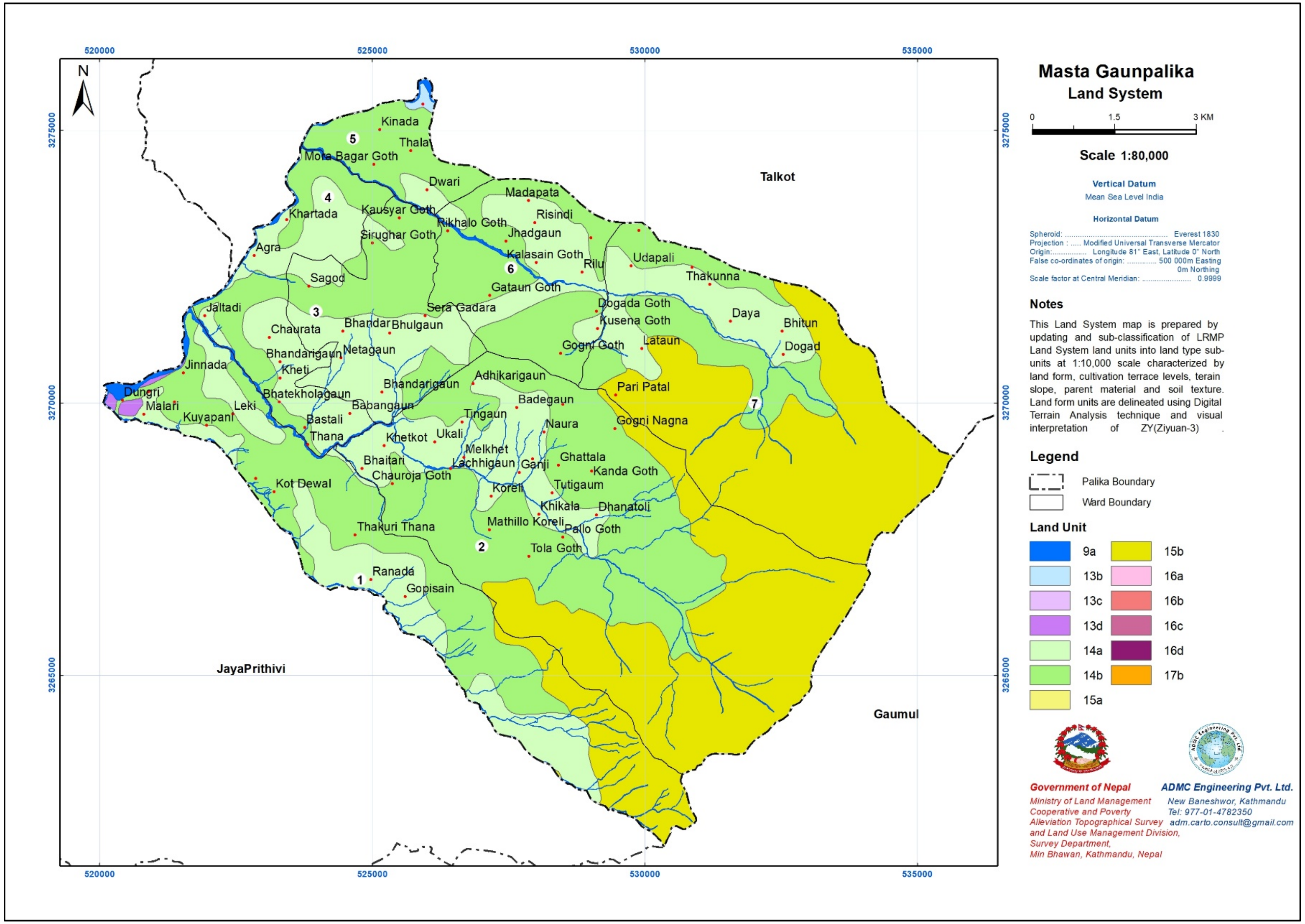

Figure 4.2: Spatial Distribution of Land Units

CHAPTER - 5

SOIL CLASSIFICATION SCHEME

Soil classification is the grouping of soils based on their properties for the purpose of studying and identifying them. The most widely used and accepted system of classification is the soil taxonomy developed by United States Department of Agriculture. Soil taxonomy provides a hierarchical grouping of natural bodies. The system is based on soil properties that can be objectively observed or measured, rather than on presumed mechanisms of soil formation. The system uses a unique nomenclature that gives a definite connotation of the major characteristics of the soils in question. It is truly international because it is not based on any one national language. Soil taxonomy is based on the properties of soils as they are found today which the outcome of the soil genesis is.

5.1 Soil Diagnostic Horizons

5.1.1 Diagnostic Surface Horizons

The diagnostic horizons that occur at the soil surface are called epipedons (from the Greek epi, over, and pedon, soil). The epipedon includes the upper part of the soil darkened by organic matter, the upper eluvial horizons, or both. It may include part of the B horizon if the latter is significantly darkened by organic matter. Eight are recognized, but only five occur naturally over wide areas. The other two, anthropic and plaggen, are the result of intensive human use. They are common in parts of Europe and Asia where soils have been utilized for many centuries.

Mollic: The mollic epipedon (Latin mollis, soft) is a mineral surface horizon noted for its dark color associated with its accumulated organic matter (>0.6% organic C throughout), for its thickness (generally >25 cm), and for its softness even when dry. It has a high base saturation greater than 50%. Mollic epipedons are moist at least three months a year when the soil temperature is usually 5° C or higher to a depth of 50 cm. These epipedons are characteristic of soils developed under grassland.

Umbric: The umbric epipedon (Latin umbra, shade; hence, dark) has the same general characteristics as the mollicepipedon except the percentage base saturation is lower. This mineral horizon commonly develops in areas with somewhat higher rainfall and where the parent material has lower content of calcium and magnesium.

Ochric: The ochric epipedon (Greek ochros, pale) is a mineral horizon that is either too thin, too light in color, or too low in organic matter to be either a mollic or umbric horizon. It is usually not as deep as the mollic or umbricepipedons. As a consequence of its low organic matter content, it may be hard and massive when dry.

Melanic: The melanic epipedon (Greek melas, melan, black) is a mineral horizon that is very black in color due to its high organic matter content (organic carbon >6%). It is character-istic of soils high in such minerals as allophane, developed from volcanic ash. It is more than 30 cm thick and is extremely light in weight and fluffy for a mineral soil.

Histic: The histic epipedon (Greek histos, tissue) is a 20 to 60 cm-thick layer of organic soil materials6 overlying a mineral soil. Formed in wet areas, the histicepipedon is a layer of peat or muck with a black to dark brown color and a very low density.

5.1.2 Diagnostic Subsurface Horizons

Many subsurface diagnostic horizons are used to characterize different soils in Soil Taxonomy each diagnostic horizon provides a characteristic that helps place a soil in its proper class in the system. We will briefly discuss a few of the more commonly encountered subsurface diagnostic horizons.

Argillic: The argillic horizon is a subsurface accumulation of silicate clays that have moved downward from the upper horizons or have formed in place. Examples are shown in Figure 3.4 and in Plate 1 between 50 and 90 cm. The clays often are found as coatings on pore walls and surfaces of the structural groupings. The coatings usually appear as shiny surfaces or as clay bridges between sand grains. Termed argillans or clay skins, they are concentrations of clay translocated from upper horizons.

Natric: The natric horizon likewise has silicate clay accumulation (with clay skins), but the clays are accompanied by more than 15% exchangeable sodium on the colloidal complex and by columnar or prismatic soil structural units. The natric horizon is found mostly in arid and semiarid areas.

Kandic: The kandic horizon has an accumulation of Fe and Al oxides as well as low-activity silicate clays (e.g., kaolinite), but clay skins need not be evident. The clays are low in activity as shown by their low cation holding capacities (<16 cmol c/kg clay). The epipedon that overlies a kandic horizon has commonly lost much of its clay content.

Oxic: The oxic horizon is a highly weathered subsurface horizon that is very high in Fe and Al oxides and in low-activity silicate clays (e.g., kaolinite). The cation-holding capacity is <16 cmol c/kg clay. The horizon is at least 30 cm deep and has <10% weatherableminerals in the fine fraction. It is generally physically stable, crumbly, and not very sticky, despite its high clay content. It is found mostly in humid tropical and subtropi-cal regions.

Spodic: The spodic horizonis an illuvial horizon that is characterized by the accumulation of colloidal organic matter and aluminum oxide (with or without iron oxide). It is commonly found in highly leached forest soils of cool humid climates, typically on sandy-textured parent materials.

Sombric: The sombric horizonis an illuvial horizon, dark in color because of high organic matter accumulation. It has a low degree of base saturation and is found mostly in the cool, moist soils of high plateaus and mountains in tropical and subtropical regions.

Albic: The albic horizon is a light-colored eluvial horizon that is low in clay and oxides of Fe and Al. These materials have largely been moved downward from this horizon. A number of horizons have accumulations of salt like chemicals that have leached from upper horizons in the profile.

Calcic: calcic horizons contain an accumulation of car-bonates (mostly $CaCO_3$) that often appear as white chalklike nodules.

Gypsic: Gypsic horizons have an accumulation of gypsum ($CaSO_4 \cdot 2H_2O$), and salic horizons have an accumulation of soluble salts. These are found mostly in soils of arid and semiarid regions. In some subsurface diagnostic horizons, the materials are cemented or densely packed, resulting in relatively impermeable layers called pans (duripan, fragipan, and placic horizons). These can resist water movement and the penetration of plant roots. Such pans constrain plant growth and may encourage water runoff and erosion because rainwater cannot move readily downward through the soil.

In the morphometric approach of classification, observable soil properties such as structure, form, color of soil matrix and mottling of the soil at different horizons, horizon designation and arrangement, structure, moisture condition and temperature condition, structure, translocation of carbonates, iron, manganese and clay are used. These properties are studied on the soil profile which is performed by digging the soil pit. Soil profile is the vertical section exposing the set of horizons in the wall of soil pit. The morphological attributes of each horizon are identified for the classification of soil. A soil scientist correlates these observed soil properties with the morphological properties of already existing classification system. The soil is taken from the soil profile for laboratory analysis to determine of physical and chemical properties of soil which assist in soil classification.

Soil classification of the Masta Gaunpalika was carried out by studying the morphological properties of soil through soil profile. After that, these morphological properties were correlated with soil types of USDA Soil taxonomy system of soil classification which is based on the observed and measurable properties of soil that exist today. In addition to this, world Reference Base for Soil Resources (WRBS) and indigenous soil classification system was also performed for soil classification.

5.2 Local Classification System

It is known that local farmers are considered as best engineers because of the fact that they know everything 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 indigenousknowledge of local people regarding soil naming and managementin Nepalesesociety, local farmers use to naming the soil base on color, texture and fertility of top soil.

Table 5.1: Local name of soil texture given by the local communities.

Texture	Local Terminology
Sand	Baluwa
Loam	Domat
Silt	Pango
Clay	Bangru
Sandy soil	baluwamitti

5.3 USDA Soil Taxonomy

There are six hierarchical categories of classification in Soil Taxonomy: (1) order, the highest (broadest) category, (2) suborder, (3) great group, (4) subgroup, (5) family, and (6) series (the most specific category). The lower categories fit within the higher categories. Thus, each order has several suborders, each suborder has several great groups, and so forth.

Order
Each of the world's soils is assigned to one of 12 orders, largely on the basis of soil properties that reflect a major course of development, with considerable emphasis placed on the presence or absence of major diagnostic horizons. As an example, many soils that developed under grassland vegetation have the same general sequence of horizons and are characterized by a mollicepipedon-a thick, dark, surface horizon that is high in non-acid cations. Soils with these properties are thought to have been formed by the same general genetic processes, but it is because of the properties they have in common that they are included in the same order: Mollisols. The names and major characteristics of each soil order are shown in Table 5.2.

Table 5.2: Names of Soil Orders in Soil Taxonomy with Their Derivation and Major Characteristics

Name	Formative Element	Derivation	Major characteristics
Alfisols	alf	Nonsense symbol	Argillic, natric, or kandic horizon; high-to-medium base saturation
Andisols	and	Jap, ando, black soil	From volcanic ejecta, dominated by allophane or Al-humic complexes
Aridisols	id	L. aridus,dry	Dry soil, ochricepipedon, sometimes argillic or natric horizon
Entisols	ent	Nonsense symbol	Little profile development, ochricepipedon common
Gelisols	ell	Gk. gelid,very cold	Permafrost, often with cryoturbation (frost churning)
Histosols	ist	Gk. histos,tissue	Peat or bog; >20% organic matter
Inceptisols	ept	L. inceptum,beginning	Embryonic soils with few diagnostic features, ochric or umbricepipedon, cambic horizon
Mollisols	oll	L. mollis,soft	Mollicepipedon, high base saturation, dark soils, some with argillic or natric horizons
Oxisols	ox	Fr. oxide,oxide	Oxic horizon, no argillic horizon, highly weathered
Spodosols	od	Gk. spodos,wood ash	Spodic horizon commonly with Fe, Al oxides and humus accumulation
Ultisols	ulf	L. ultimus,last	Argillic or kandic horizon, low base saturation
Vertisols	ert	L. verto,turn	High in swelling clays; deep cracks when soil is dry

Sub-order
Soils within each order are grouped into suborders on the basis of soil properties that reflect major environmental controls on current soil-forming processes. Many suborders are indicative of the moisture regime or, less frequently, the temperature regime under which the soils are found. Thus, soils formed under wet conditions generally are identified under separate suborders (e.g., Aquents, Aquerts, and Aquepts), as being wet soils.

Great Groups

The great groups are subdivisions of suborders. More than 400 great groups are recognized. They are defined largely by the presence or absence of diagnostic horizons and the arrangements of those horizons.

5.3.1 Soil Classification at Soil Sub-group Level

Subgroups are subdivisions of the great groups. More than 2500 subgroups are recognized. The central concept of a great group makes up one subgroup, termed Typic. Thus, the TypicHapludolls subgroup typifies the Hapludolls great group. Other subgroups may have characteristics that intergrade between those of the central concept and soils of other orders, suborders, or great groups. A Hapludoll with restricted drainage would be classified as an AquicHapludoll. One with evidence of intense earthworm activity would fall in the VermicHapludolls subgroup. Some intergrades may have properties in com-mon with other orders or with other great groups. Thus, soils in the EnticHapludolls sub-group are very weakly developed Mollisols, close to being in the Entisols order. The sub-group concept illustrates very well the flexibility of this classification system.

5.3.2 Soil Classification at Soil Family Level

Within a subgroup, soils fall into a particular family if, at a specified depth, they have similar physical and chemical properties affecting the growth of plant roots. About 8000 families have been identified. The criteria used include broad classes of particle size, mineralogy, cation exchange activity of the clay, temperature, and depth of the soil penetrable by roots.

Series

The series category is the most specific unit of the classification system. It is a subdivision of the family, and each series is defined by a specific range of soil properties involving primarily the kind, thickness, and arrangement of horizons. Features such as a hard pan within a certain distance below the surface, a distinct zone of calcium carbonate accumulation at a certain depth, or striking color characteristics may aid in series identification.

5.4 World Reference Base for Soil Resources (FAO)

The **World Reference Base for Soil Resources (WRB)** is the international standard taxonomic soil classification system endorsed by the International Union of Soil Sciences (IUSS). It was developed by an international collaboration coordinated by the International Soil Reference and Information Centre (ISRIC) and sponsored by the IUSS and the FAO via its Land & Water Development division. It replaces the previous FAO soil classification.

The WRB borrows heavily from modern soil classification concepts, including USDA soil taxonomy, the legend for the FAO Soil Map of the World 1988, the RéférentielPédologique and Russian concepts. The classification is based mainly on soil morphology as an expression pedogenesis. A major difference with USDA soil taxonomy is that soil climate is not part of the system, except insofar as climate influences soil profile characteristics. As far as possible, diagnostic criteria match those of existing systems, so that correlation with national and previous international systems is as straightforward as possible.
The WRB is meant for correlation of national and local systems. The level of detail corresponds to USDA soil taxonomy subgroups, without the soil climate information.

Comparisons of the United States and FAO-UNESCO Classification System

The structure, concepts and definitions of the WRB are strongly influenced by (the philosophy behind and experience gained with) the FAO-UNESCO Soil 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 US 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.

Table 5.3: Comparison of the FAO and the U.S. Systems of Soil Classification

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

Subunits: Orthic, Chromic, Calcic, Vertic, Ferric, Albic, Plinthic, Gleyic Brown Wooded, Acid Brown Forest soils	
NITOSOLS Latin nitidus = shiny, shiny ped surfaces. Sub-units: Eutric, Dystric, Humic	Paleudalfs, many Udults, 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 From Podzol 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 and Crop suitability analysis

Each crop requires specific soil and environmental conditions for proper growth. However, some plants grow in various soil conditions under extreme agro-ecological conditions. The plants growth is controlled by the availability of nutrients and soil moisture which are governed by the soil characteristics. The soil suitability analysis for crop growth was performed by establishing the suitability criteria for growing crops, forest and plantation crops. The land is delineated based on the suitable soil attributes. The land is classified into following categories based on the limitations for crop growth.

Highly Suitable (S1): Land has no limitations for the crop growth.

Moderately Suitable (S2): Minor physical limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful planning.

Marginally Suitable (S3): Moderate physical limitations significantly affecting productive land use and/or risk of degradation. Careful planning and conservation measures required.

Almost unsuitable (N1): High degree of physical limitation not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required.

Unsuitable (N2): Severe limitations. Use is usually prohibitive in terms of development costs or the associated risk of degradation.

5.5.1 Suitability analysis based on available soil nutrient and crop requirement

Soil suitability analysis is carried out by determining the nutrient content present in the soil sampled from the soil pit through laboratory analysis and these results are correlated with the crop nutrient requirement for proper growth.

5.5.2 Rating of soil fertility status

The soil fertility rating is performed by categorization of top soil parameters that encompasses top-soil rooting depth, workability (soil texture), soil drainage (permeability), alkalinity and acidity, content of organic matters, nitrogen, available phosphorus and, available potassium. After that, overall Soil fertility status is rated by the categorization of rooting depth, organic matter, soil texture, acidity and alkalinity, phosphorous content, potash content and nitrogen content. Soil fertility ratings based on chemical and physical properties of soil and their rating is presented in Table below. The Soil nutrients distribution of this Gaunpalika is shown in map figure 5.1

Table 5.4: Soil Depth Rating

Soil Root Depth		
>200	Very Deep	High Suitability
1100-200	Deep	
50-100	Moderately Deep	
25-50	Shallow	
<25	Very Shallow	Low Suitability

Table 5.5: Workability Rating

Soil Texture (Workability)		
(Loam)	Good	High Suitability
sit (Silt Loam)	Good	
sI (Sandy Loam)	Good	
sil+l(Silt Loam + Loam)	Good	
cI (Clay Loam)	Moderate	
cl+l/sit (Clay Loam + Loam over Silt Loam)	Moderate	
sicl (Silty Clay Loam)	Moderate	
sl+sicl (Silt Loam + Silty Clay	Moderate	

sicl+sl (Silty Clay Loam + Silt Loam)	Moderate	
sic (Silty Clay)	Fair	
sl + sc (Silt Loam + Silty Clay)	Fair	
c (Clay)	Poor	Low Suitability

Table 5.6: Soil Alkalinity and Acidity Rating

Soil Alkalinity & Acidity		
< 5.0	Very high acidic	Low Suitability
5.1– 5.5	High acidic	
5.6 – 6.0	Medium acidic	
6.0 – 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 5.7: Soil Organic Matter Content Rating

Organic Matter (%)		
>5	High	High Suitability
2.5 – 5	Medium	
1.0 -2.5	Low	
<1	Very low	Low Suitability

Table 5.8: Soil Total Nitrogen Rating

Total Nitrogen (%)		
>0.2	High	High Suitability
0.1 – 0.2	Medium	
0.06 – 0.1	Low	
<0.06	Very Low	Low Suitability

Table 5.9: Soil Available Phosphorous Rating

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

Table 5.10: Soil Available Potassium Rating

Available K_2O (kg/ha)		
>550	Very High	High Suitability
280 – 550	High	
110 – 280	Medium	
55 –110	Low	
<55	Very Low	Low Suitability

Table 5.11: 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

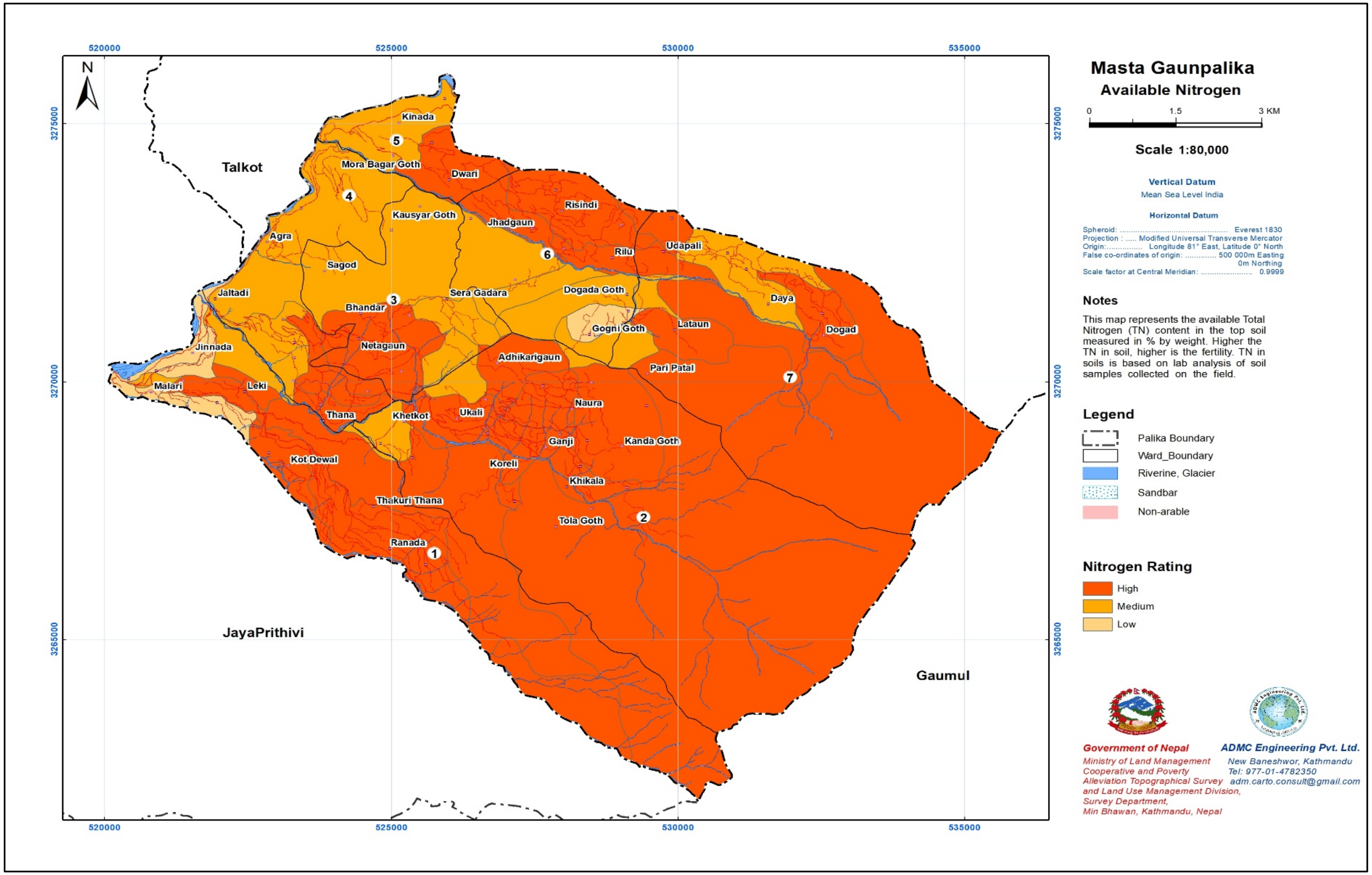

Figure 5.1: Available Nitrogen Distribution of Masta Gaunpalika

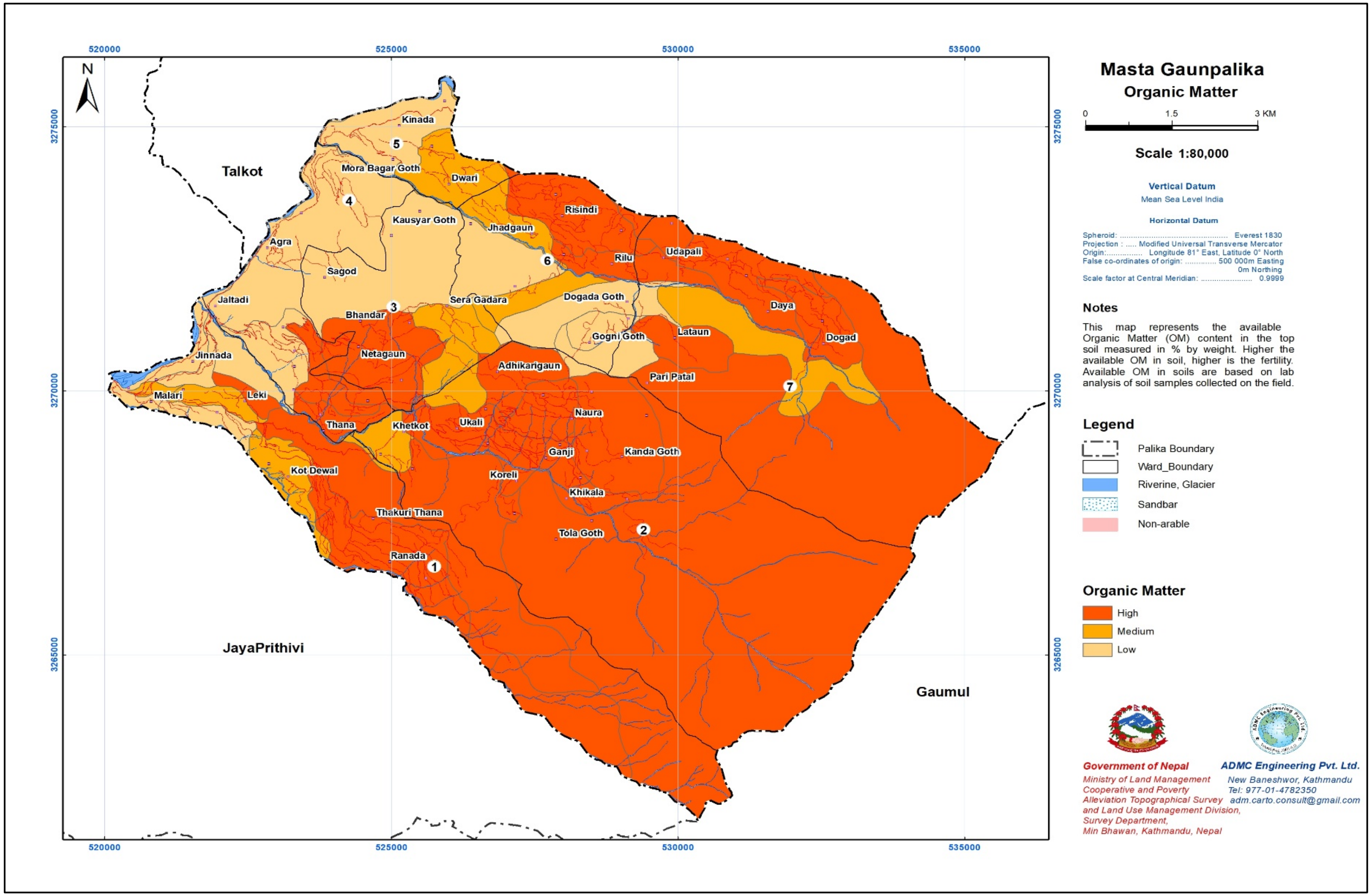

Figure 5.2: Organic Matter Distribution of Masta Gaunpalika

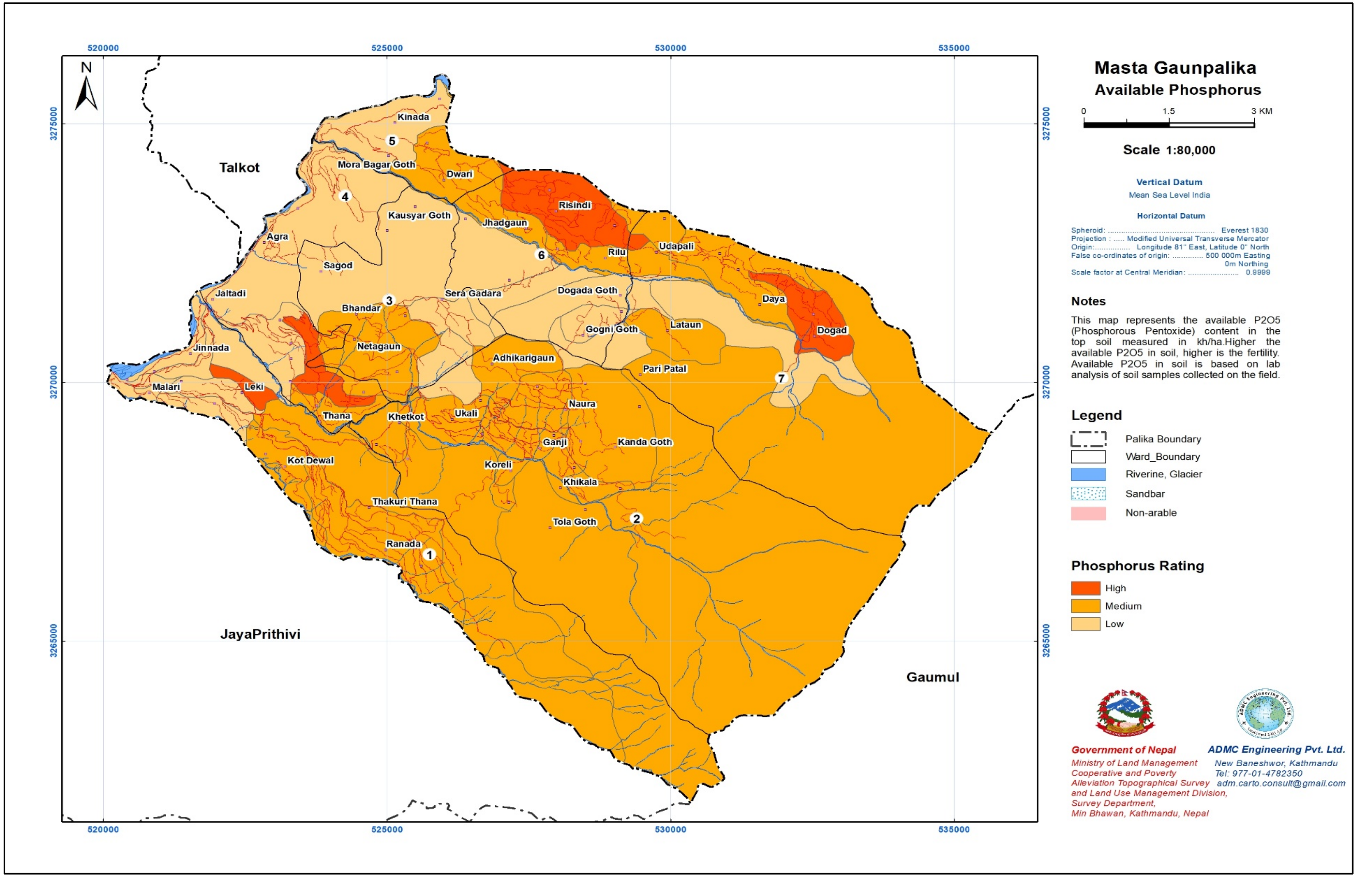

Figure 5.3: Available Phosphorous Distribution of Masta Gaunpalika

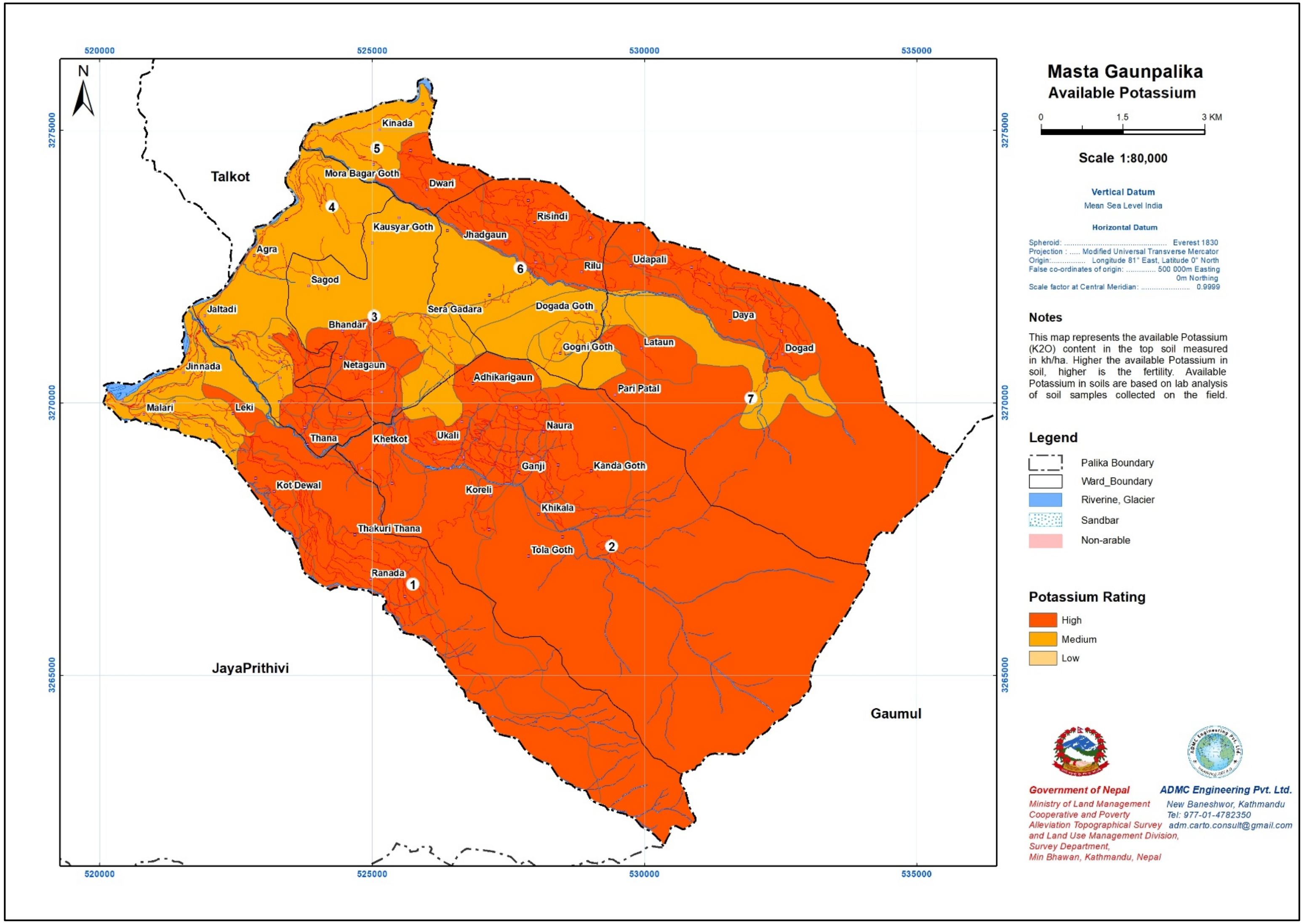

Figure 5.4: Available Potassium Distribution of Masta Gaunpalika

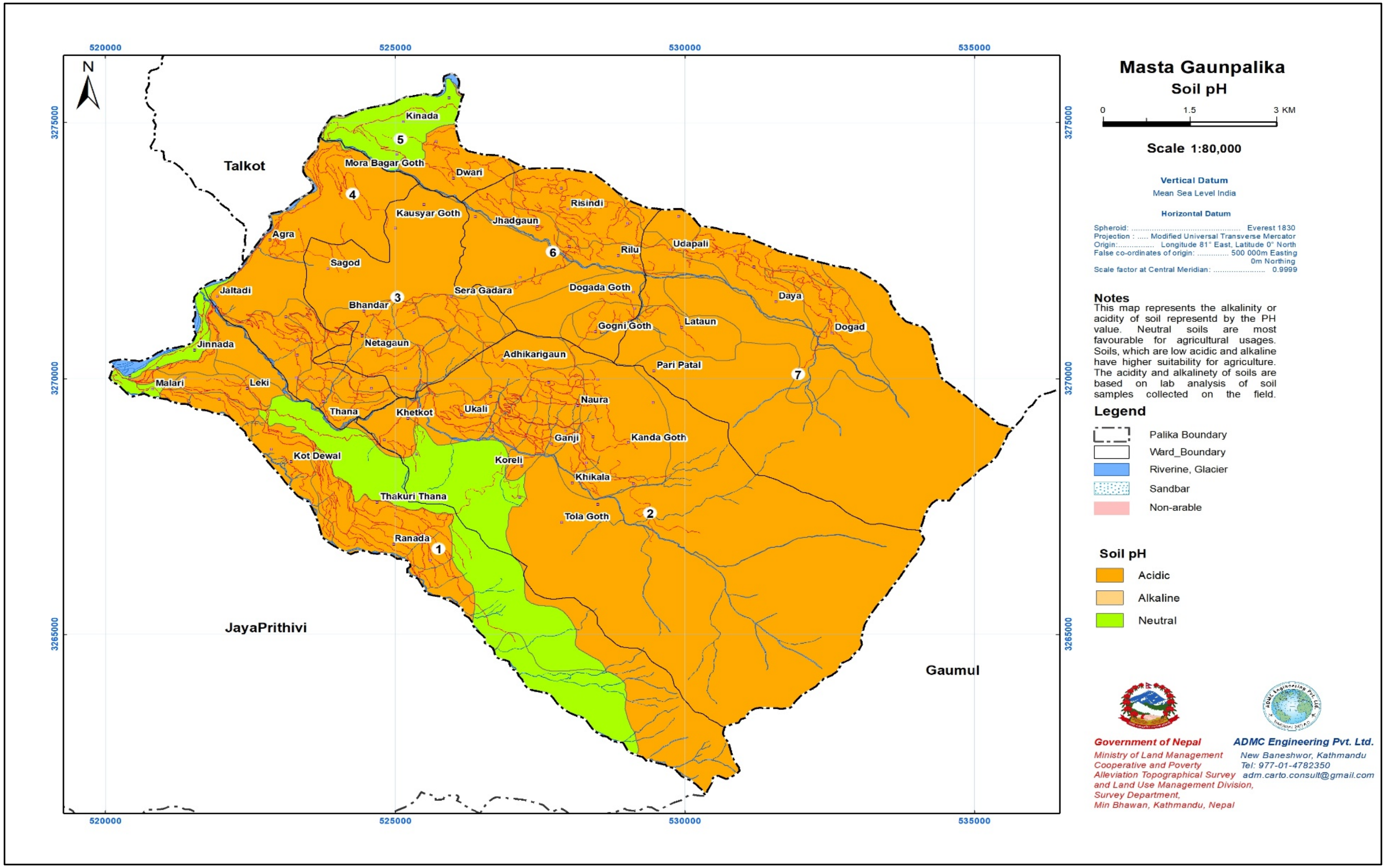

Figure 5.5: Soil PH Distribution of Masta Gaunpalika

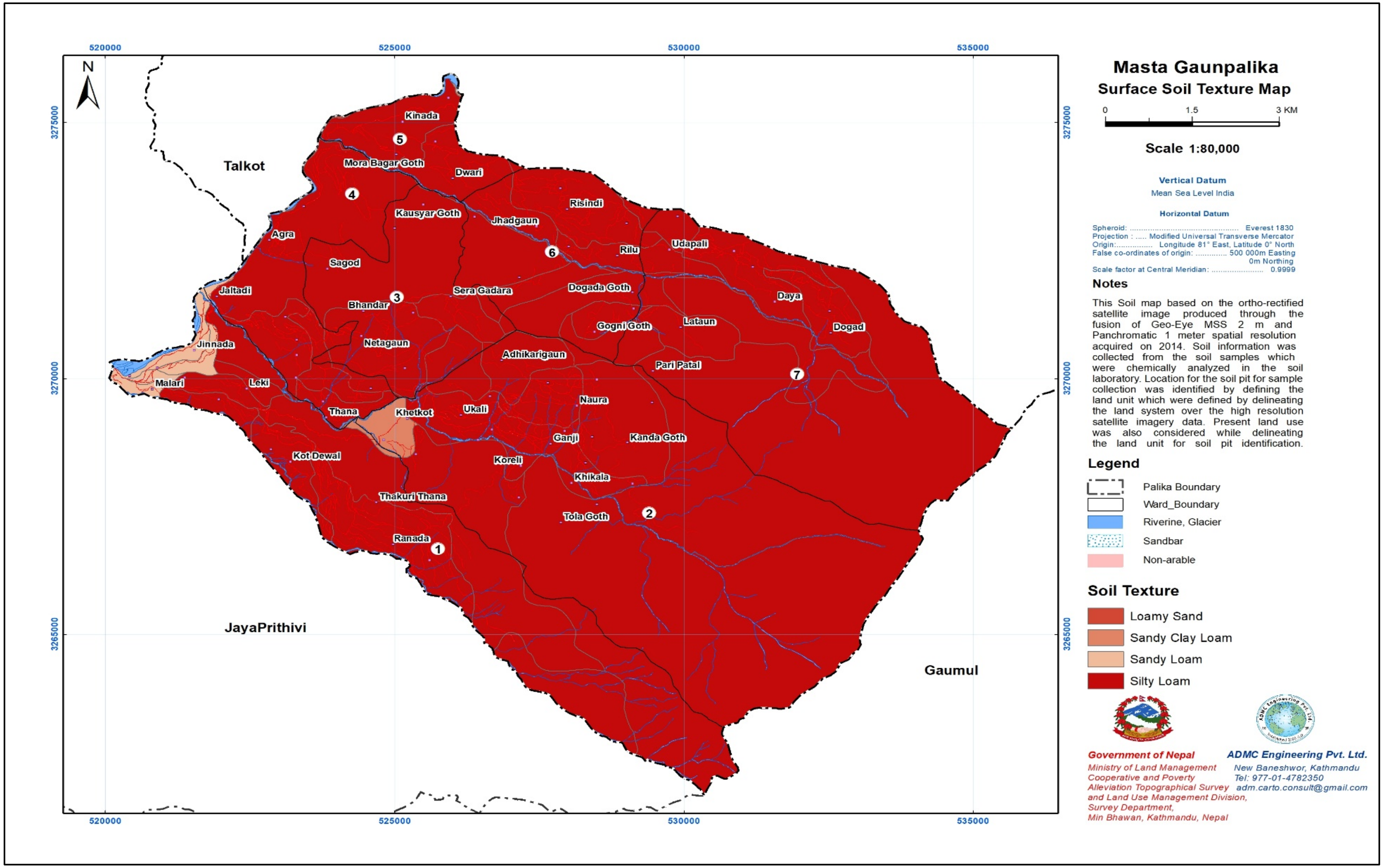

Figure 5.6: Surface Soil Texture Distribution of Masta Gaunpalika

CHAPTER - 6

SOIL TYPES AND GIS DATABASE

6.1 Soil Types

The soil types in the Masta Gaunpalika was categorized into order, sub-order, great-group, sub-group, family and series level by following the USDA soil taxonomy system of classification.

6.1.1 Soil types from order to sub-group level

The soils of Nagarpalika/Gaunpalika of Bajhang district are classified based on the morphological, chemical and physical properties of soil acquired from the soil profile study by digging the soil pit and soil mapping unit level. USDA soil taxonomy system of soil classification was adopted for the classification of soil in which soils are classified into order, sub-order, great group, sub-group, family and series levels. The soil classification of Gaunpalika is presented in the table 6.1.

The Masta Gaunpalika has two soil orders, three sub-orders, four great groups and eleven sub-groups were found from the survey of the soils. The detail descriptions of soil category are explained as below.

Table 6.1: Soil Taxonomy Classification of Masta Gaunpalika

<table>
<tr><th>Order</th><th>Sub Order</th><th>Great Group</th><th>Sub-Group</th><th>Area (Ha.)</th><th>Area (Sqm)</th><th>Percent</th></tr>
<tr><td rowspan="3">Entisols</td><td rowspan="3">Orthents</td><td>Torriorthents</td><td>Lithic Torriorthents</td><td>196.86</td><td>1968624.38</td><td>1.8</td></tr>
<tr><td rowspan="2">Ustorthents</td><td>Lithic Ustorthents</td><td>192.79</td><td>1927873.15</td><td>1.8</td></tr>
<tr><td>Typic Ustorthents</td><td>365.83</td><td>3658316.63</td><td>3.4</td></tr>
<tr><td rowspan="9">Inceptisols</td><td rowspan="2">Cryepts</td><td rowspan="2">Dystrocryepts</td><td>Humic Dystrocryepts</td><td>253.76</td><td>2537625.93</td><td>2.3</td></tr>
<tr><td>Humic Lithic Dystrocryepts</td><td>216.80</td><td>2167983.90</td><td>2.0</td></tr>
<tr><td rowspan="7">Udepts</td><td rowspan="7">Dystrudepts</td><td>Lithic Dystrudepts</td><td>124.03</td><td>1240266.82</td><td>1.1</td></tr>
<tr><td>Calcic Lithic Dystrudepts</td><td>407.71</td><td>4077116.49</td><td>3.7</td></tr>
<tr><td>Fulventic Humic Dystrudepts</td><td>0.03</td><td>317.18</td><td>0.0</td></tr>
<tr><td>Humic Dystrudepts</td><td>5043.56</td><td>50435601.23</td><td>46.2</td></tr>
<tr><td>Humic Lithic Dystrudepts</td><td>642.58</td><td>6425798.76</td><td>5.9</td></tr>
<tr><td>Lithic Dystrudepts</td><td>1819.11</td><td>18191109.51</td><td>16.7</td></tr>
<tr><td>Typic Dystrudepts</td><td>1562.54</td><td>15625370.52</td><td>14.3</td></tr>
<tr><td colspan="3">Unclassified</td><td>Riverine Area</td><td>79.58</td><td>795795.57</td><td>0.7</td></tr>
<tr><td colspan="4">Grand Total</td><td>10905.18</td><td>109051800.06</td><td>100</td></tr>
</table>

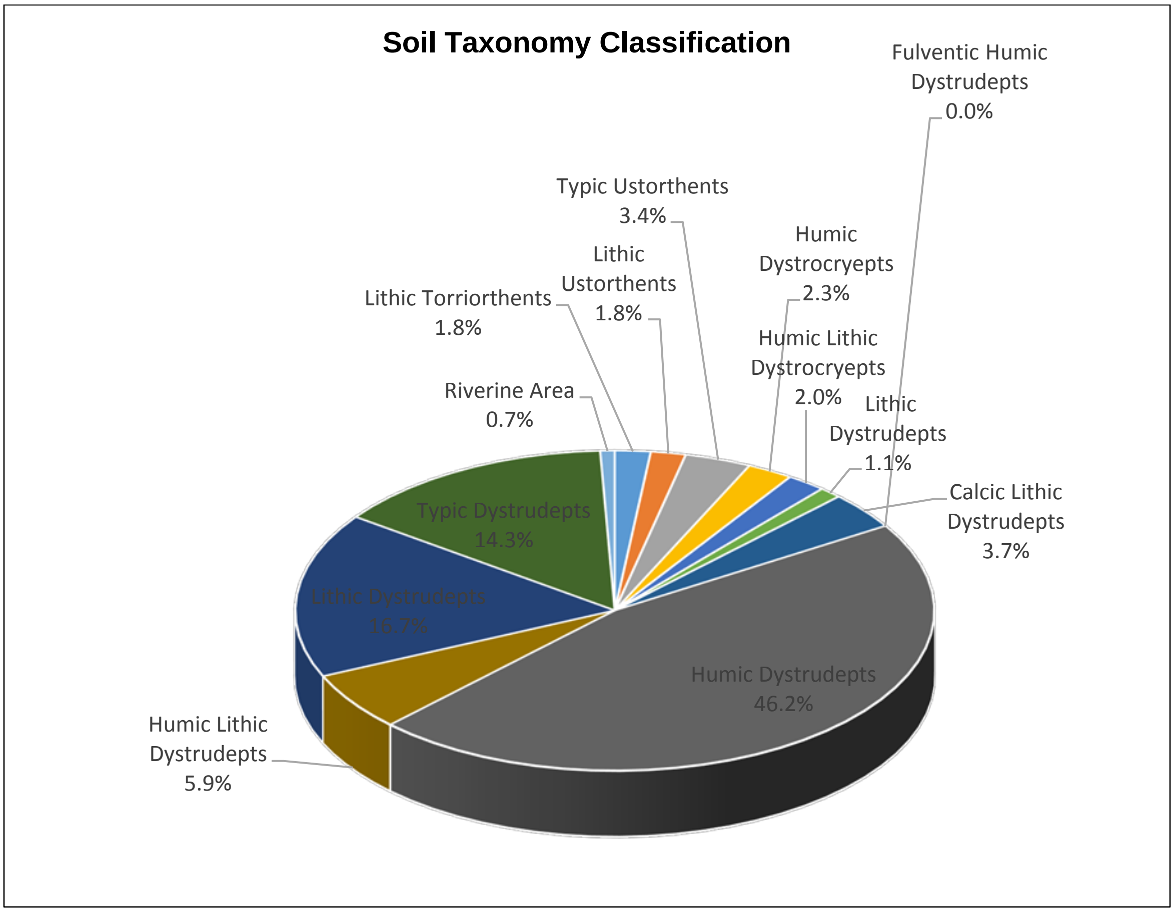

Figure 6.1: Distribution of Soil Taxonomy Classification

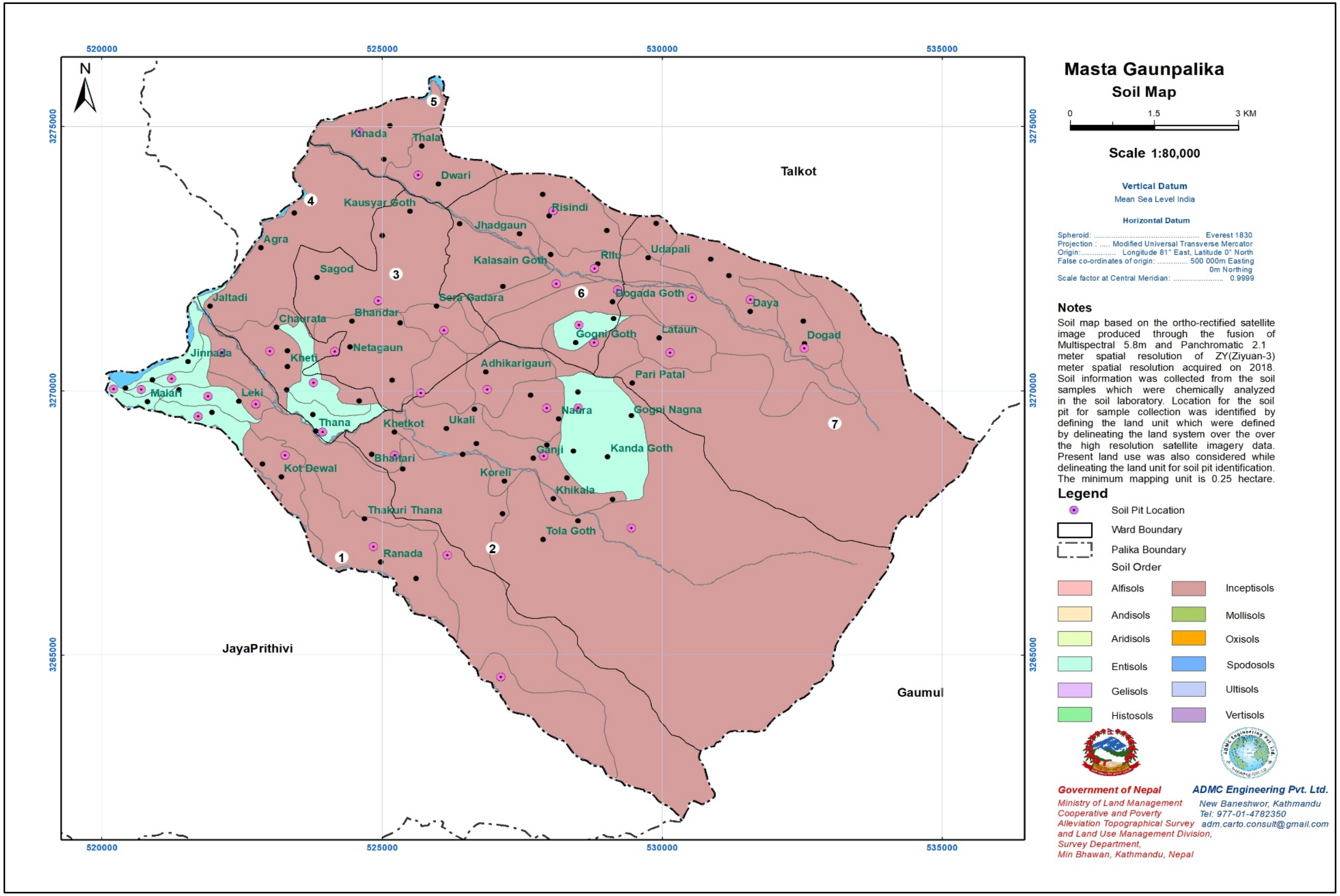

Figure 6.2: Soil Types and Spatial Distribution of Pit Locations of Masta Gaunpalika

Entisols: The central concept of Entisols is that of soils that have little or no evidence of the development of pedogenic horizons. Most Entisols have no diagnostic horizons other than an ochric epipedon. Very few have an anthropic epipedon. A few that has a sandy or sandy-skeletal particle-size class have a horizon that would be a cambic horizon were it not for the particle-size class exclusion. Very few Entisols have an albic horizon. In coastal marshes some Entisols that have sulfidic materials within 50 cm of the mineral soil surface have a histic epipedon. These are very recently developed mineral soils with no diagnostic horizonation other than an ochric or umbric epipedon. The main feature of Entisols is a very slight degree of soil formation, either because of limiting time available for development or because of exceedingly unfavorable conditions. These soils have too thin, dry and too little organic carbon and massive and hard when dry. These soils are found on young geomorphic surfaces such as flood plains and also on steep slopes where erosion removes soil materials as it is formed.

Fluvents: This group of Entisols does not have densic, lithic or paralithic contact within 25 cm of mineral soil surface and the sediments are fluvitile in nature with varying texture and low organic matter content, and stratification is its common feature. These are mostly brownish to reddish soils that formed in recent water-deposited sediments, mainly on flood plains, fans, and deltas of rivers and small streams but not in back-swamps where drainage is poor. The age of the sediments in humid regions commonly is a few years or decades or a very few hundred years. In arid regions it may be somewhat more. Many Fluvents are frequently flooded unless they are protected by dams or levees. Stratification of the materials is normal. Most of the alluvial sediments are derived from eroding soils or streambanks and contain an appreciable amount of organic carbon, which is mainly in the clay fraction. Strata of clayey or loamy materials commonly have more organic carbon than the overlying more sandy strata. Fluvents can have any vegetation and any temperature regime. They can have any moisture regime that does not meet the criteria for Aquents.

Ustifluvents: These are the Fluvents that have an ustic moisture regime and a temperature regime warmer than cryic. These soils are on flood plains along rivers and streams in areas of middle or low latitudes. Flooding can occur in any season but is most common in summer in the middle latitudes and during the rainy season in the Tropics. A few of the soils are flooded regularly in summer because of melting snow in high mountains, even though the summer is rainless.

Typic Ustifluvents: These are the Ustifluvents that have good or moderately good drainage and that do not have a fine particle-size class and clay of a swelling type in a major part of the upper 125 cm. These soils occur in relatively high areas on flood plains, and the water table is deeper than 100 cm, except for very brief periods. There are no redox depletions with chroma of 2 or less or aquic conditions within 50 cm of the mineral soil surface and no chroma of 0 or hue bluer than 10Y or aquic conditions within a depth of 100 cm. There normally is little or no evidence of alteration of the fine stratification in the alluvium. In some Typic Ustifluvents that have a fine-silty or fine particle-size class, however, stratification cannot be easily identified. Typic Ustifluvents are extensive along streams in the sub humid or semiarid parts of the Great Plains in other countries. Many of these soils are used as cropland, with or without irrigation. Others are used for summer grazing.

Inceptisols: The central concept of Inceptisols is that of soils that are of cool to very warm, humid and subhumid regions and that have a cambic horizon and an ochric epipedon. Inceptisols have many kinds of diagnostic horizons and epipedons. They can have an anthropic, histic, mollic, ochric, plaggen, or umbric epipedon. Only a very few Inceptisols, however, have a mollic epipedon. The mollic epipedon is restricted to soils with low base saturation below the epipedon. The most common diagnostic horizons are ochric and umbric epipedons, a cambic horizon, and a fragipan. Some Inceptisols have an umbric epipedon overlying a cambic horizon, with or without an underlying duripan or fragipan. A calcic or petrocalcic horizon or a duripan is common in sub-humid areas. All soils that have a plaggen epipedon are Inceptisols, and any soil underlying the plaggen epipedon is considered to be buried. Inceptisols commonly occur on landscapes that are relatively active, such as mountain slopes, where erosional processes are actively exposing unweathered materials, and river valleys, where relatively unweathered sediments are being deposited.

Ustepts: Ustepts are mainly the more or less freely drained Inceptisols that have an ustic moisture regime. They receive dominantly summer precipitation, or they have an isomesic, hyperthermic, or warmer temperature regime. Most Ustepts have an ochric epipedon and a cambic horizon. Many are calcareous at a shallow depth and have a Bk or calcic horizon. A few have a duripan or an umbric epipedon.

Dystrustepts: These are the acid Ustepts. They developed mostly in Pleistocene or Holocene deposits. Some of the soils that have steep slopes formed in older deposits. The parent materials generally are acid, moderately or weakly consolidated sedimentary or metamorphic rocks or acid sediments. The vegetation was mostly forest. Most of these soils have a thermic or warmer temperature regime. A common horizon sequence in Dystrustepts is an ochric or umbric epipedon over a cambic horizon. Some of the steeper soils have a shallow densic, lithic, or paralithic contact.

Fluventic Dystrustepts: These soils are on flood plains along rivers draining regions that have acid soils. They formed in Holocene or recent alluvium. They are subject to occasional flooding but receive little fresh alluvium.

Vertisols: The central concept of Vertisols is that of clayey soils that has deep, wide cracks for some time during the year and has slickensides within 100 cm of the mineral soil surface. They shrink when dry and swell when moistened. The vertisol soils are dominantly observed in sub-humid to semiarid climate where rainfall varies from 500 to 1500 mm per year with pronounced dry season. These soils mostly develop on parent materials of basaltic composition. The soil solum is thick (at least 50 cm), dark coloured cracking clay mineral soils that have high content (>30%) of clay. These soils swell on wetting and shrink on drying that induce the development of wide, deep craks. They are dominantly observed on flat terrain and strong swelling and shrinking action of smectite clays are observed. Before the advent of modern classification systems, these soils were already well known for their characteristic color, the cracks they produce during the dry season, and the difficulty of their engineering properties.

Usterts: These are the Vertisols in areas of monsoonal climate, and in tropical and subtropical areas that have two rainy and two dry seasons. Crack open and close once or twice during the year. Many of these soils formed in gently sloping areas of fine textured alluvium. Some are derived from basic igneous rocks. These groups of soil have cracks in normal years that are 5 mm or wider, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year. If irrigated, Usterts are used intensively, but large areas are used for grazing because of a lack of machinery to till the soils. These soils are basically very productive; provided they are managed well and with irrigation they can be cultivated for two crops in year.

Haplusterts: Haplusterts are the most common of the Usterts. They are derived from a variety of parent materials, including sedimentary rocks, alluvium, marl, and basic igneous rocks. Slopes range from nearly level to strongly sloping. This usterts soil has throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of mineral soil surface. They do not have calci or gypsic horizon.

Typic Haplusterts: The Typic subgroup of Haplusterts is centered on deep or very deep soils that do not have significant amounts of salts or sodium. In addition, these soils do not have a petrocalcic horizon, soil moisture regimes that border on aridic or udic, a calcic or gypsic horizon within a depth of 150 cm, a layer with less than 27 percent clay, or light-colored surface layers.

6.1.2 Soil types at Great-Group and family level

Differences in texture, mineralogy, temperature, and soil depth are primary bases for family differentiation. They meet the need for making practical prediction of landuse planning of a large area. In the present context, soil texture is used as descriptive criteria of soil family.

6.2 Soil GIS Database

Soil GIS database was prepared by the information gathering from soil pit and soil mapping unit. Soil Mapping Units were demarcated based on integration of Land System, Landform and Land units along with micro relief variation. Individual pit level information was gathered at soil mapping units because it contains multi-pits or pedons. The physical, chemical and morphological characteristics of soil profile at horizon level were contained in soil pit. The framework of entire soil database was presented in **figure 6.3**

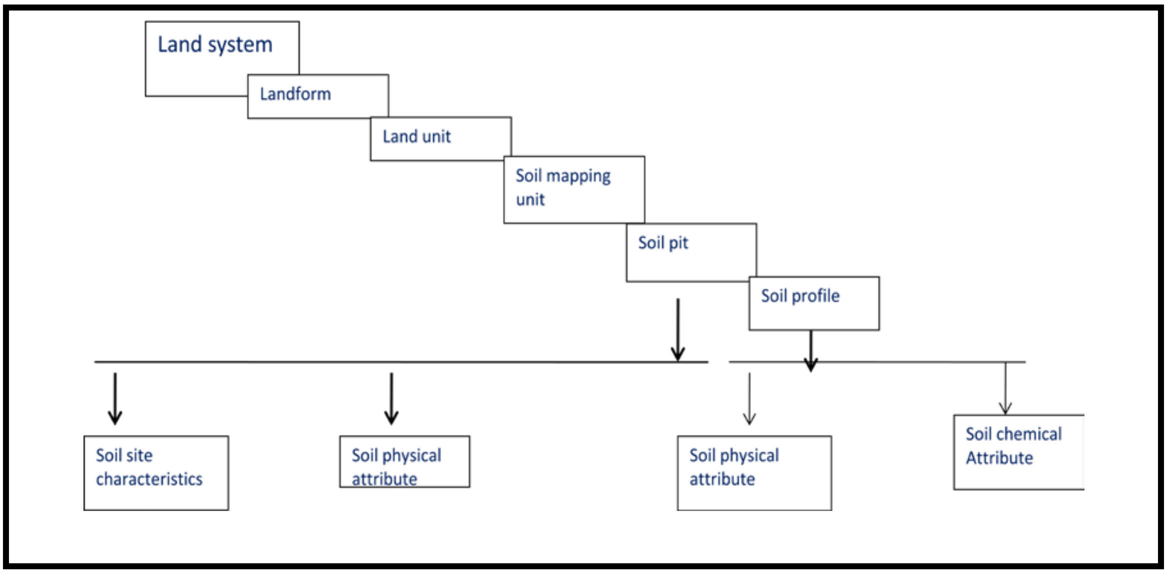

Figure 6.3: Identification of Soil Sampling Unit

The soil GIS database is stored and maintained relating with geo-database linking shape file to its attribute in attribute table. It 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. The description of field containing in soil GIS database has been given in Table 6.2 and 6.3

Table 6.2: Database for Soil Pits from Standard Soil Profile Description Form

S.N.	Data Field	Data Type	Description	Remarks
1	FID	Feature Id	Feature	
2	SHAPE	Geometry	Geometric Object type	
3	ID	String	Unique Object ID	
4	PIT_NO	String	Soil pit number	
5	CDSTRL_NO	Integer	Cadastral parcel number of the pit	
6	RMP_MP	String		
7	WARD_NO	Integer		
8	EAST	Double	Easting Co-ordinate Value of Pit	
9	NORTH	Double	Northing Co-ordinate Value of Pit	
10	ELEVATION	Double	Elevation of Land (m)	
11	PHY_UNIT	String	Physiographic unit	
12	IMAGE	String	Satellite image used	
13	DATE_	String	Date of digging soil pit or examination	
14	PHY_REL	String	Physiographic (local relief)	
15	LU_VEG	String	land use and vegetation	
16	SLP_DIR	String	Slope direction	
17	CROP_PTN	String	Cropping pattern	
18	SLOPE_DEG	String	Slope degree	
19	CLIMATE	String	Climate	
20	CLASS	String	High order of Soil classification	

S.N.	Data Field	Data Type	Description	Remarks
21	PARNT_MET	String	Parent material	
22	DRN_CLS	String	Drainage class	
23	MOIST_CON	String	Moisture condition	
24	DEPTH_GW	Integer	DEPTH of ground water	
25	HUMAN_INF	String	Human Influence	
26	TOTAL_HOR	Integer	Total number of horizon	
27	FIRST_HOR	String	First horizon or Top layer or epipedon	
28	SECND_HOR	String	Second horizon or Sub surface first or indopedon	
29	THIRD_HOR	String	Third horizon or sub surface second	
30	FORTH_HOR	String	Fourth horizon or sub surface third	
31	DEPTH_FH	Integer	Depth of first horizon	
32	DEPTH_SH	Integer	Depth of second horizon	
33	DEPTH_TH	Integer	Depth of third horizon	
34	DEPTH_4H	Integer	Depth of fourth horizon	
35	BOUND_FH	String	Boundaries of first horizon	
36	BOUND_SH	String	Boundaries of second horizon	
37	BOUND_TH	String	Boundaries of third horizon	
38	BOUND_4H	String	Boundaries of fourth horizon	
39	DIO_HR_FH	String	Diagnostic horizon of first horizon	
40	DIO_HR_SH	String	Diagnostic horizon of second horizon	
41	DIO_HR_TH	String	Diagnostic horizon of third horizon	
42	DIO_HR_4H	String	Diagnostic horizon of fourth horizon	
43	MXT_COL_FH	String	Matrix color of first horizon	
44	MUNSELL_FH	String	Munsell color of first horizon	
45	MOTTL_FH	String	Mottling of first horizon	
46	MOTTL_SH	String	Mottling of second horizon	
47	MOTTL_TH	String	Mottling of third horizon	
48	MOTTL_4H	String	Mottling of fourth horizon	
49	TXTURE_FH	String	Texture of first horizon	
50	TXTURE_SH	String	Texture of second horizon	
51	TXTURE_TH	String	Texture of third horizon	
52	TXTURE_4H	String	Texture of fourth horizon	
53	COFRAG_FH	String	Coarse fragment of first horizon	
54	COFRAG_SH	String	Coarse fragment of second horizon	
55	COFRAG_TH	String	Coarse fragment of third horizon	
56	COFRAG_4H	String	Coarse fragment of fourth horizon	
57	ST_FH	String	Structure of first horizon	
58	ST_SH	String	Structure of second horizon	
59	ST_TH	String	Structure of third horizon	
60	ST_4H	String	Structure of fourth horizon	
61	POR_FH	String	Porosity of first horizon	
62	POR_SH	String	Porosity of second horizon	
63	POR_TH	String	Porosity of third horizon	
64	POR_4H	String	Porosity of fourth horizon	
65	CONSIST_FH	String	Consistence of first horizon	

S.N.	Data Field	Data Type	Description	Remarks
66	CONSIST_SH	String	Consistence of second horizon	
67	CONSIST_TH	String	Consistence of third horizon	
68	CONSIST_4H	String	Consistence of fourth horizon	
69	ROOT_FH	String	Roots of first horizon	
70	ROOT_SH	String	Roots of second horizon	
71	ROOT_TH	String	Roots of third horizon	
72	ROOT_4H	String	Roots of fourth horizon	
73	ORD_SC	String	Order of soil Classification	
74	SUB_ORD_SC	String	Sub-Order of Soil Classification	
75	G_GROUP_SC	String	Grate group of Soil Classification	
76	GROUP_SC	String	Group of Soil Classification	
77	FAMILY_SC	String	Family of Soil Classification	
78	SERIES_SC	String	Series of soil Classification	
79	District	String	Name of Corresponding District	
80	Pit_Num	Double	Pit Number	Must contain digit of easting and Northing coordinates of each pit location
81	FY	Text	Fiscal Year	

Table 6.3: Database for Laboratory Analysis of Soil Pits

S.N.	Data Field	Data Type	Description	Remarks
1	**FID**	Feature Id	Feature	
2	**SHAPE**	Geometry	Geometric Object type	
3	**ID**	Long	Unique Object ID	
4	**PIT_NO**	Integer	Pit Number	
5	**CADASTRAL_NO**	Integer	Cadastral parcel number of the pit	
6	**HORIZON**	String	Horizon	
7	**PH**	Integer	pH (1:2.5%) H2O	
8	**TOTAL_N2**	Integer	Total Nitrogen (N%)	
9	**N_ST_RANK**	String	Nitrogen Status Ranking	
10	**P2O5**	Integer	Available Phosphorous (P2O5) Kg/ha	
11	**P_ST_RANK**	String	Phosphorous Status Ranking	
12	**K2O**	Integer	Available Potassium (K2O) Kg/ha	
13	**K_ST_RANK**	String	Potassium Status Ranking	
14	**OM**	Integer	Organic Matter (OM)%	
15	**OM_ST_RANK**	String	OM Status Ranking	
16	**SAND**	Integer	Sand %	
17	**SILT**	Integer	Silt %	
18	**CLAY**	Integer	Clay %	
19	**SOIL_TEXT**	String	Soil Texture	
20	**PIT_NUM**	Double	Pit Number(Unique Object ID)	Must contain digit of easting and Northing

				coordinates of each pit location
21	**RMP_MP**	String	Name of Corresponding Gaupalika/Nagarpalika	
22	**District**	String	Name of Corresponding District	

CHAPTER - 7

CONCLUSIONS

7.1 Conclusions

For the preparation of Soil Map of Masta Gaunpalika of Bajhang District, the Geo-Science Technology including Remote Sensing (RS), Geographic Information System (GIS) and Geographic Positioning System (GPS), visual interpretation and computer aided technology were used in integrated way. The soil sampling pit was selected covering at least one land unit considering the unique physiography and soil association. The parameters such as slope, land form and land type were used for the delineation of soil boundary.

The Gaunpalika is dominated by the slope less than one percent with alluvial deposits and therefore, relief has been less important factor for soil development, however, its effect has been seen at local level with variation in land configuration i.e. land form. Considering the river sediments and land form, the entire Gaunpalika has been represented with 9a, 13b, 13d, 14a, 14b and 15b land units. A total 35 pits were surveyed in this Gaunpalika. Based on land type/unit, soil survey revealed that the entire Gaunpalika is comprised of 6 land units in which 41.0% of the area falls under Steeply to very steep slopes, 30.8% of the area falls under very steeply slopes and 26.5%of area falls under Moderate to steep slopes and remaining area are river channel. The soil types found was Inceptisols and Entisols respectively in decreasing order of spatial extent. Among these Inceptisols order was dominantly (92.34%) found followed by Entisols (6.93%) and riverine area (0.7%). Considering genetic horizons and soil properties, altogether 11 types of soil was found in the Gaunpalika at the sub group level as per USDA system. Based on soil properties such depth, genetic horizons, and fertility characteristics, soils found in Gaunpalika are highly suitable for intensive agriculture.

7.2 Recommendations

Integrated use of Visual interpretation, computer aided technology and Geo-Science technology including Remote Sensing (RS), Geographic Information System (GIS) and Geographic Positioning System (GPS) was used successfully and found satisfactory for this project so that this technique for soil mapping and land use planning can be applied to other places of the country. However, there is need of criteria for soil fertility assessment by the project to create uniformity in data resources. The database of soil resources, landforms, land systems and units would be very useful for the country to formulate planning to cope with the low agriculture production, land degradation problem and climate change induced disaster. Thus, there is need of such study on other areas, dissemination of these data bases to local level and national planning on agriculture, industrial, forest, urban etc. sectors based on these databases. The Soil type found in this Gaunpalika was Inceptisols and Entisols in decreasing order. These types of soil order with more stable landscape for both Agricultural and forestry use are common in these soils. The relative stability of these landscape permits some leaching of top soils and weathering of the sub-soils. Based on the soil properties such as soil depth, genetic horizon, slope and fertility characteristics, soils found in this Gaunpalika were suitable for Agricultural and forestry.
Some other criteria that are to be considered are as follows;

- Promotion of sloping agricultural land technology (SALT) in sloping land.
- Awareness of integrated approaches of soil protection in school education.

- Promotion of erosion control technique such as contouring, terracing bio-engineering approach.
- Mulching of low productivity land for increases of productivity of land.
- A forestation on degraded forest and linkage networking with all related sectors.
- Involvement and mobilization local people in implementation of soil and land conservation.

सुझाव तथा सिफारिस

बझांग जिल्लाको विभिन्न गाउँपालिका र नगरपालिकामा खेति गरिने गरा-कान्लाहरु (terrace) को सतहको भिरालोपन (slope) १% भन्दा कम भएको स्थानमा सघन खेति पातीगर्दा भू-क्षय नहुनेहुदा संचित्त क्षेत्रमा सघन खेतिगरि आर्थिक विकास गर्न सूझाब दिईन्छ र साथै कोसे बालीहरु बोडी, भटमास, मास, मुंग आदि भित्री वा घुसुवा बालीको साथ साथै यी कोसे बालीहरु फसल चक्रमा पनि लगाउन शिफारिस गरिन्छ.

पानीको सतह नजिक करिब २५-३० फिट भन्दा पनि कम भएको ठाउमा बोरिंग गरि बर्षे भरि खेति पाती गर्न सकिनेको साथ साथैस तरकारी बाली र सघन खेति गर्न सम्भावना रहेकोले सो ठाउमा कम लागतमा बोरिंग गर्न शिफारिस गरिन्छ. बोरिंग भयेपछि ब्येवसायिक तरकारी खेति गरि त्यहाँ बसो बास गर्ने जनताको स्वास्थमा अनुकुल असर पर्नुको साथ साथै जीविकोपार्जनको लागि आर्थिक लाभ हुने देखिन्छ

दूध र मासुको प्रयाप्त उत्पादन नभएकोले बझांग जिल्लामा कुखुरापालन, बाख्रापालन, गाईपालन, भैसीपालन आदि गरि शरीरको लागि नभैनहुने प्रोटिन, खनिज तथा भिटामिन पाउनुको साथै आर्थिक उन्नति हुने हुदा बस्तु पालन गर्न शिफारिस गरिन्छ.

भिरालो जग्गामा घासे बाली जस्तै अमरिसो, सबै घासको खेति गरि बस्तु लाई ख्वाउनुको साथ साथै भिरालो जग्गामा हुने भू-क्षय बाट पनि रोक थाम गर्न सकिन्छ. विभिन्न अन्नबाली तथा तरकारी र फलफुल खेति गर्दा स्थानीय जातको बिउभन्दा उन्नत जातको बिउको प्रयोग गर्न शिफारिस गरिन्छ. उन्नत बिउको प्रयोगको साथ साथै मलखादको प्रयोग पनि ज्यादै महत्वपूर्ण हुन्छ त्येसर्थ: बढी भन्दा बढी प्रांगारिक मलको साथ साथै रसायानिक मलको शिफारिस मात्रामा प्रयोग गर्न शिफारिस गरिन्छ.

सिचाईको सुविधा भएको खेति जग्गामा खनजोत नगरी गहुँको खेति गर्न शिफारिस गरिन्छ. स्याउ र सुन्तला जस्ता फलफूलमा ह्रास (decline) देखिएकोले रोग किरा तथा सुक्ष्म तत्व लगायत खाध्य तत्वको एकिकृत व्यवस्थापन गर्न सुझाब दिईन्छ. विभिन्न ठाउमा पहाड कटाई गरि सडक बनाउने काम भैरहेको हुदा पहिरो बाट जोगाउन र माटोको भू-क्षय रोकथाम गर्न प्रबिधिहरु लागु गर्न शिफारिस गरिन्छ.

अति अम्लीय माटो भएको ठाउँमा कृषि चुनको शिफारिस मात्रा प्रयोग गर्न र साथै प्रांगारिक र रसायानिक मलको शिफारिस मात्रा प्रयोग गर्न शिफारिस गरिन्छ.

युरिया मलको मात्र प्रयोगले गर्दा माटो बिग्रिने र अम्लेय हुने हुदा युरियाको साथ साथै फस्फोरस र पोटाष मलको सन्तुलित प्रयोग गर्न शिफारिस गरिन्छ.

D. Land Capability

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CHAPTER - 1

INTRODUCTION

1.1 Background and Rationale

Background:

Land use planning has been defined as "The systematic assessment of land and water potential, alternative patterns of land use and other physical, social and economic conditions, for the purpose of selecting and adopting land-use options which are most beneficial to land users without degrading the resources or the environment, together with the selection of measures most likely to encourage such land uses." (Food and Agriculture Organization).

Land use planning is fundamental to the process of natural resource management and ecological sustainable development. It demands an integrated and strategic approach at national, regional and local levels to meet all needs. Land use planning should consider the sustainability, social impact and an assessment of what the land is capable of supporting and sustaining into the future and in the interests of the wider community. The demand on the use of our land to achieve many objectives requires the application of a rigorous process of planning. For example, some areas of land can support a wide range of uses whereas other areas support a small range of uses or certain types of uses. Effective planning involves anticipation and an understanding of land use and land management practices, and the participation by land users, planners, and the public and decision makers in the planning process.

The land capability classification is the grouping of a land units into defined classes based on its capability. It is a broad grouping of soils based on their limitations and designed to emphasize the hazards in different kinds of soils. It serves as a guide to assess the suitability of land for arable crops, grazing and forestry. The capability class is determined on the basis of soil properties such as soil depth, soil texture, permeability, organic matter, N, P, K content, pH of soil, erosion hazard, topography and severity of climate. The land capability classification provides necessary data that helps to find the combination of agricultural and conservation measures which would permit the most rigorous and proper use of the land without safeguarding the soil environment.

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.

Agriculture is the major sector in the country Nepal, which provides employment to the more than 65 percent of the people, contributing 33 percent in the national GDP. The production of major cereal crops plays an important role in agriculture production. The production of major cereals was reduced by 8 percent (Economic Survey, 2012/13). Low agriculture production is the major problem in Nepalese agriculture posing food security problem in the country. The major cause of low agriculture production is the cultivation of crops and soil management without scientific land resource data. Thus, land resource inventory data is necessary for environment friendly agriculture sustainability.

In this context, the Government of Nepal has recently formulated the 20-year Agriculture Development Strategy emphasizing to increase agriculture production to solve the food and nutritional security problems of the country safeguarding the environment. Also, the National Land Use Policy-2072 has been declared, which is focused to increase the productive capacity of land.

Rationale:

Land-use planning can be applied at three broad levels: national, district and local. For local level planning, information regarding the natural resource, socio-economic and demography of that are is necessary for effective planning which gives guideline for selection of land and what activities can be performed, when and who is responsible for those activities. However, Nepal has only regional level data base on land use, land system and land capability which were produced by Land Resource Mapping Project (LRMP, 1983/84). Realizing this fact, the Ministry of Land Reform and Management of Government of Nepal established the National Land Use Project (NLUP) in 2057/058 fiscal year to generate the necessary data bases on the land resources of the country.

In the first phase, the National Land Use Project of Nepal had initiated several projects at district level and prepared Land Resource Maps and Database at 1:50,000 scale for the whole Nepal. It had also prepared same kinds of maps and database for Kirtipur, Lekhnath, Madhyapur thimi and Bhaktapur Nagarpalika at larger scales. Finally, NLUP was mandated to prepare land resource maps of Nagarpalika/Gaunpalika of Nepal for local level planning through outsourcing modality.

Then, the National Land Use Policy 2069, had emphasized to manage land use in accordance with the land zoning policy of Government of Nepal which categorizes six land zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area. The policy had mentioned the land characteristics, capability of each category of land zones. In addition, the policy had pointed to form Land Use Council at the top of district and Nagarpalika/Gaunpalika level at the bottom which also highlighted the importance of preparation of Nagarpalika/Gaunpalika level maps and databases on natural resources.

During the course of implementation some updating and refinement had been felt in NLUP 2069. As a result, GON came up with **National Land Use Policy 2072**. The following land use categories has been designated for present land use mapping: Agriculture, Forest, Residential, Commercial, Industrial, Public Service, Mine and Minerals, Cultural and Archeological, Riverine and Lake Area, Excavation & Other. Later on, Land use act 2076 has integrated Excavation Area into the Mines and Minerals area under land use.

In this regards, (TSLUMD) has awarded the project Package 19 entitled: Preparation of Nagarpalika/Gaunpalika level land resources maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map and Nagarpalika/Gaunpalika profile for Land Use Zoning Map and Superimpose of Cadastral Layers), Data Base and Reports of 3 Gaunpalika of Bajhang District to our consultancy for fiscal year 2076/077. The Package 19 covers 3 Gaunpalika (Saipal, Talkot and Masta). Total no of wards in Saipal Gaunpalika is 5 wards, Talkot Gaunpalika is 7 wards and Masta Gaunpalika is 7 wards.

1.2 Objectives

The broad objective of topographical Survey and Land Use Management Division (TSLUMD), Package 19, (2076/077 fiscal year) is to prepare of Nagarpalika/Gaunpalika 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. Package 19 covers 3 Gaunpalika (Saipal, Talkot and Masta) of Bajhang. In order to fulfill the broad objective, the present study aims to prepare a present land use map of Masta Gaunpalika based on enhanced high-resolution satellite images originally provided by the TSLUMD office and detailed field survey. Therefore, the main objective of the study is:

i) To prepare Present Land Use Maps, GIS Database and Reports for the Masta Gaunpalika at 1:10,000 scales.

Scope

In order to achieve the above-mentioned objective, the following activities were conducted:

(a) Study the existing relevant maps, documents and database of the project area.
(b) Prepare Land capability maps for the selected Nagarpalika/Gaunpalika 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

Masta Gaunpalika is an important urban center in Bajhang district and it lies in Sudur Pashchim province in Nepal. Geographically, Masta is located at 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude. This Rural Municipality consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Municipality to the west, Bajura district to the south and Talkot Rural Municipality to the north. The total area of the Gaunpalika is 109.05 km². The total population of this Gaunpalika is 17909, of which male population accounts for 8537 and female population is 9372. However, all the wards vary in area and population size. Total number of households in the Gaunpalika is 2798.

This Gaunpalika is inhabited by different caste and ethnic groups. However, Masta Rural Municipality is predominated by Brahmin and Kshetri which are included under caste group. Nearly 81 percent people are belonged to this group. The second largest group is Dalit community where Kami, Damai and Sarki are main Dalit castes in this category in Masta. The other group i.e. Janajati that has sis population with only one household.

The location map of the study area has been shown in **Figure 1.1**

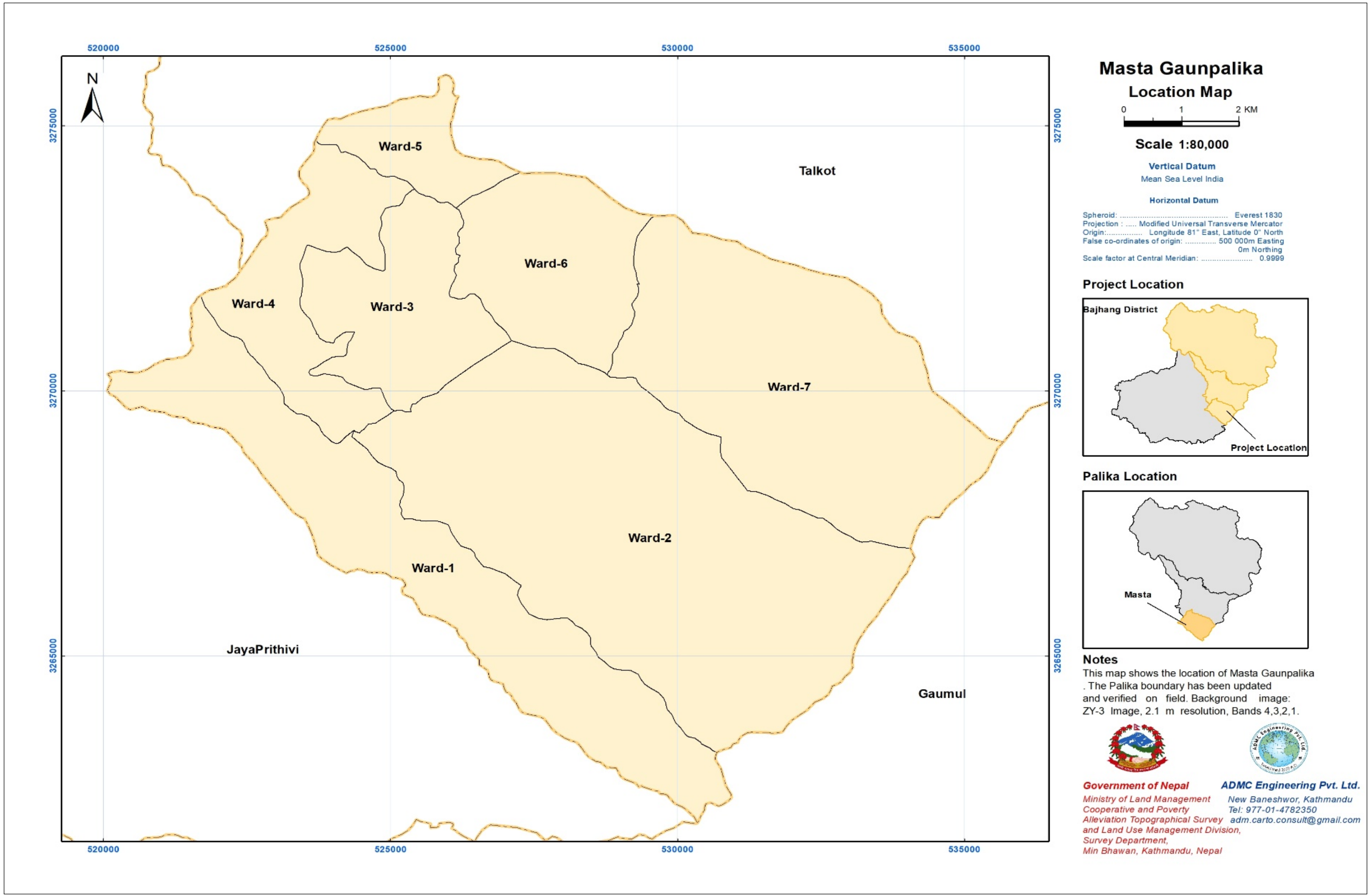

Figure 1.1 Location Map of Masta Gaunpalika of Bajhang District

CHAPTER - 2

CONCEPTUAL BASIS OF LAND CAPABILITY CLASSIFICATION

Land is the basic natural resource and it is limited to human beings. Land has been a matter of life and death, of survival or starvation. In the human life history, most of the sustenance and much of his fuel, clothing and shelter obtained from the land. Land is the basis for habitat and living space for man. The use of land should have been of major importance to man is, therefore, not surprising (Mather, 1986). The agricultural land classification provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long term limitations on agricultural use. The limitations can operate in one or more of four principal ways: they may affect the range of crops which can be grown, the level of yield, the consistency of yield and cost of obtaining it. To ensure a consistent approach when classifying land, the following assumptions are made:

1. Land is graded according to the degree to which physical or chemical properties impose long-term limitations on agricultural use. It is assessed on its capability at a good but not outstanding standard of management.
2. Where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate under drainage system, the land is graded according to the severity of the remaining limitations. Where an adequate supply of irrigation water is available this may be taken into account when grading the land. Chemical problems which cannot be rectified, such as high levels of toxic elements or extreme subsoil acidity, are also taken into account.
3. Where long-term limitations outside the control of the farmer or grower will be removed or reduced in the near future through the implementation of a major improvement scheme, such as new arterial drainage or sea defense improvements, the land is classified as if the improvements have already been carried out. Where no such scheme is proposed, or there is uncertainty about implementation, the limitations will be taken into account. Where limitations of uncertain but potentially long-term duration occur, such as subsoil compaction or gas-induced anaerobism, the grading will take account of the severity at the time of survey.
4. The grading does not necessarily reflect the current economic value of land, land use, range of crops, suitability for specific crops or level of yield. For reasons given in the preface, the grade cut-offs are not specified on the basis of crop yields as these can be misleading, although in some cases crop growth may give an indication of the relative severity of a limitation.
5. The size, structure and location of farms, the standard of fixed equipment and the accessibility of land do not affect grading, although they may influence land use decisions.

Vink (1975) defines land use as the ability of human being to manage their ecosystem in order to produce some of his needs. This indicates the ability of man to preserve or destroy land; i.e. man has a full control over land. Vink (1975) indicated that, as circumscribed by the earth, the area of what is considered to be land is finite and fixed in place. Land uses are subject to control by people, whose numbers are not fixed, who have many needs, and who move easily. According to Davis (1976) some areas of land have certain characteristics that make it more useful than other land areas. These include location and suitability of a particular piece of land.

As Speller berg (1992) noted, large forest areas have been cleared for agriculture and most remaining forests have sadly been damaged in some way. The consequence is increasing erosion and degradation. In addition, in more developed western countries, because of industrialization, the invasion on prime agricultural land was eminent. These problems bring about the need for classification. Dent, (1986) citing Jacks (1946), defines land classification as "the way of grouping of land according to its suitability for producing plants of economic importance".

The foundation of land classification lies in land resource inventories, starting with major geological surveys during the nineteenth century. The development of land capability schemes during the 1930s in the USA marks the beginning of the second major development in the subject, but the widespread adoption of land capability schemes only began after 1960 (Davidson, 1992).

The assessment of land capability involves an evaluation of the degree of limitation posed by permanent or semi-permanent attributes of land to one to one or more land uses. The American system of land assessment goes back to 1930s, but it came into effect only after 1961 when a comprehensive book was published (Klingebiel and Montgomery, 1961). The Soil Conservation Service of the US Department of Agriculture evolved the technique and it will be referred to as the USDA method. Integral to the assessment procedure is an evaluation of soil erosion hazard, wetness, soil and climatic limitations. Land capability assessment is based on a broader range of characteristics than soil properties. Information on slope, angle, climate, flood and erosion risk as well as on soil properties is required (Davidson, 1992).

Land capability could be the land to sustain a specified land use without insignificant onsite or offsite degradation or damage of land resources (US department of Agriculture & State Planning Commission, 1989). Generally, the land capability classifications refer to the grading of the ability of land. Land capability classification system originally devised by the US Department of agriculture and has been used widely since the 1950s to assess the appropriate use of various type of land for agriculture usages in identifying land uses and management practices that can minimize soil erosion, especially induced by rainfall (Brady & Well, 2002).

Land capability assessment is therefore 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 Nagarpalika/Gaunpalika level requires assessment of each individual physiographic land unit for agricultural land use. 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 Gaunpalika level.

2.1 Review of LRMP Land Capability Classification

In between 1980 and 1985, 266 Land Capability Maps were made by the Land Resource Mapping Project (LRMP) covering entire 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 the very less limitations for arable agriculture or forestry development usages. The categorizations of classes are 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 is 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
`
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 Terai 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 is generally 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 suite the local conditions of Nepal. The entire Hilly 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 Nagarpalika/Gaunpalika Level Land Capability Classification

Land capability classification for present study at Gaunpalika level, at large scale 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) and is adapted to suite the context of present study and the context of agricultural soil management in Nepal as a whole.

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 Nagarpalika/Gaunpalika, 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.**

Class						
I	II	III	IV	V	VI	VII
Degree of limitations						

↓

Sub-Class			
Soil	Topography	Erosion	Wetness
Dominant limitation			

↓

Unit					
1	2	3	4	5	Etc
Similar management requirement					

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 less superior 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	Code
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	Code
Steep Slope	t1
Surface channel dissection	t2

Table 2.4 Unit code for sub-class erosion deficiency

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

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

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

v) The map layout and legends are as specified by National Level specification for the Preparation of Nagarpalika/Gaunpalika Level Land Resource Maps, Database and Reports, 2019.

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

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

viii) The report covers details of the methodology adopted in preparation of the soil capability maps of the selected Nagarpalika/Gaunpalika. 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, nitrogen, available phosphorus, and available potassium. The ratings of these parameters are presented below.

Table 3.1 Topsoil Root Depth Rating

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

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

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

Table 3.3 Soil Drainage Rating

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

Table 3.4 Soil Alkalinity and Acidity Rating

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

Table 3.5 Soil Organic Matter Contain Rating

Organic Matter (%)		
>5	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 (%)		
>0.2	High	High Suitability
0.1 – 0.2	Medium	
0.06 – 0.1	Low	
<0.06	Very low	Low Suitability

Table 3.7 Soil Available Phosphorous Rating

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

Table 3.8 Soil Available Potassium Rating

Available K_2O (kg/ha)		
>550	Very High	High Suitability
280 – 550	High	
110- 280	Medium	
70 – 110	Low	
<70	Very Low	Low Suitability

Table 3.9 Soil Permeability Rating

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

3.2.2 Topography Criteria

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

Table 3.10 Topographic Deficiency Criteria due to Slope

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

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

3.2.3 Erosion Susceptibility Criteria

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

Table 3.11 Soil Erosion Susceptibility

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

3.2.4 Surface Drainage Criteria

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

Table 3.12 Drainage Deficiencies

Drainage Deficiency (Wetness)	
Water Logging	Dw
Flooding	Df
High Water Table	Dwt

3.3 Land Capability Evaluation Method

Land capability of land unit (i.e. land system land type/soil mapping unit) is evaluated based on above mentioned criteria and rating of the land unit is designated with appropriate land capability class along with its specific management limitations. Figure 3.1 shows the general approach for classification and designation of land capability class to a land unit.

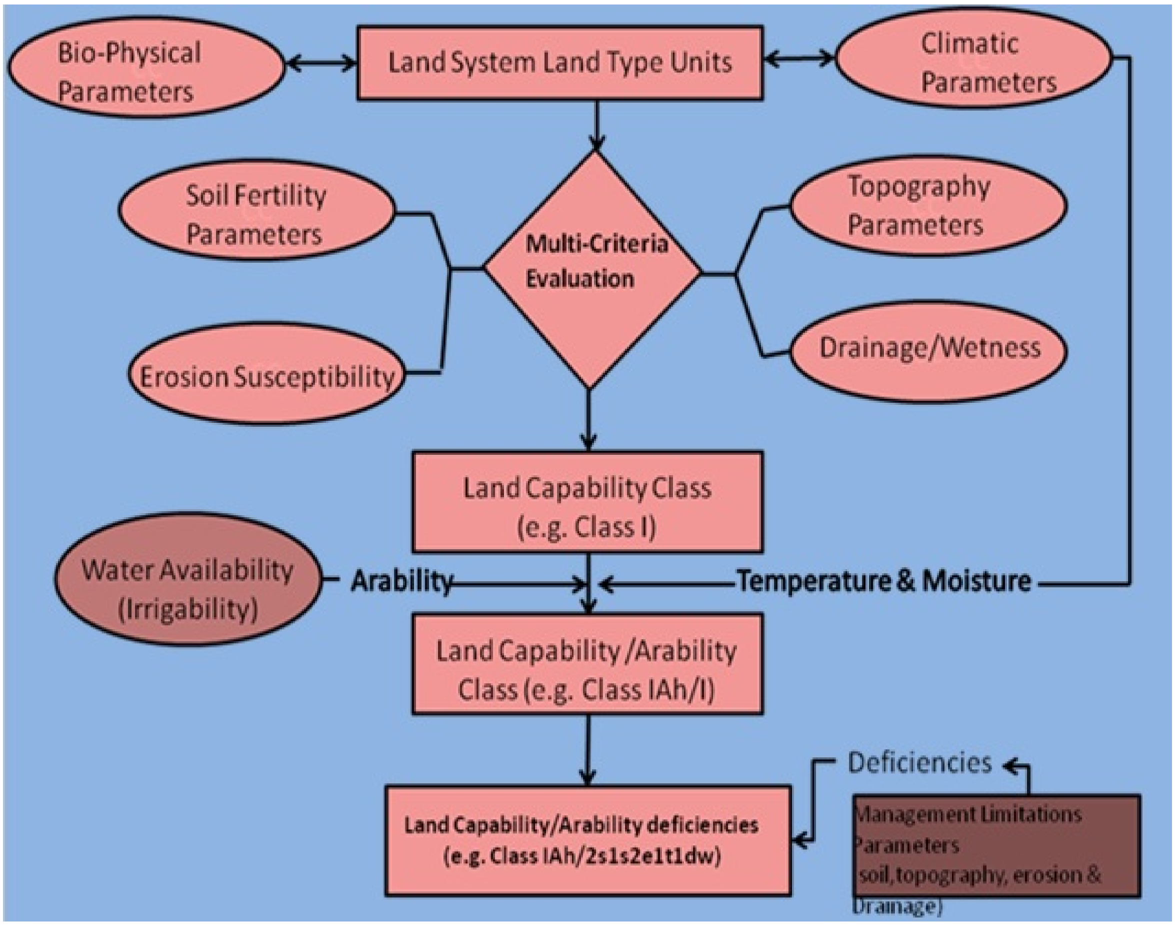

Figure 3.1 Land Capability Classification Method Flow Diagram

CHAPTER - 4

PRESENT LAND CAPABILITY CLASSES OF MASTA GAUNPALIKA

Land capability classification of the land type units was conducted on the basis of various criteria of soil and other parameters. This chapter presents the result of land capability class coverage in Masta Gaunpalika. The chapter also presents the summary of each type of management limitations as represented by the capability sub-class and units.

Land Capability of Masta Gaunpalika was conducted on the basis of the soil properties, terrain slope, erosion and drainage characteristics. The land capability class distribution in the Gaunpalika is presented in the Table 4.1 and Figure 4.1 and spatial distribution of land capability class of the Gaunpalika is shown in the map figure 4.2. Majority of land (51.4%) consists of land capability class IIIAh/2, 46.9% land has IVCh/5 class and 0.9% land has Non-Arable Land class. These classes are fairly suitable for irrigated farming crops and Terracing is compulsory to control erosion when used for agriculture and some lands consists of lands with moderately severe limitations that limit the choice of crops and/or require very careful management practices.

Table 4.1 Land Capability Classes of Masta Gaunpalika.

Land Capability	Area (sqm)	Area (Ha.)	Percent	Description
IIIAh/2	56058486.57	5605.85	51.4	Lands characterized as moderately to steeply sloping (5-30 degrees) slopes, Subtropical Climatic Zone, Humid moisture regime, diversified crops and moderately suitable for arable agriculture.
IVCh/5	51175270.19	5117.53	46.9	Lands characterized as too steep (>30°slopes), Cool temperate Climatic Zone, Humid moisture regime, lands are tentatively classified as non-arable.
Non-Arable Land	1818043.09	181.80	0.9	Non-Arable
Total	**109051799.86**	**10905.18**	**100**	

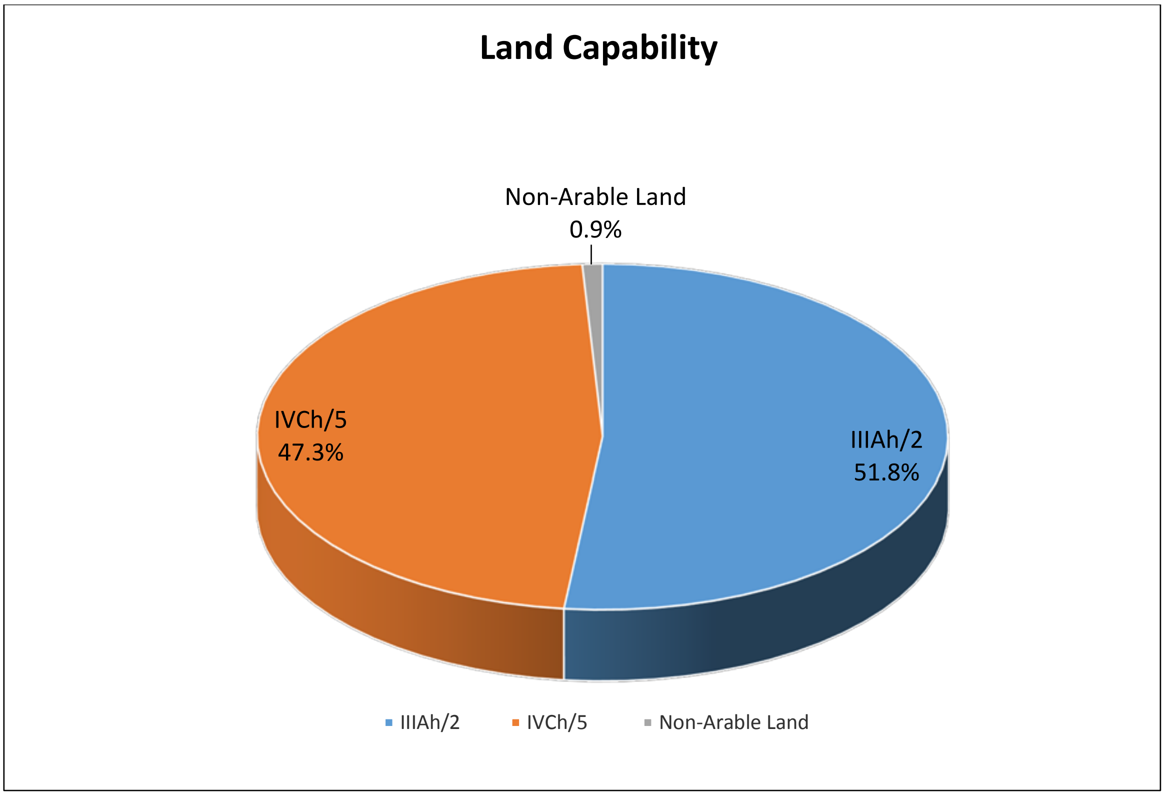

Figure 4.1 Distribution of Land Capability Classes

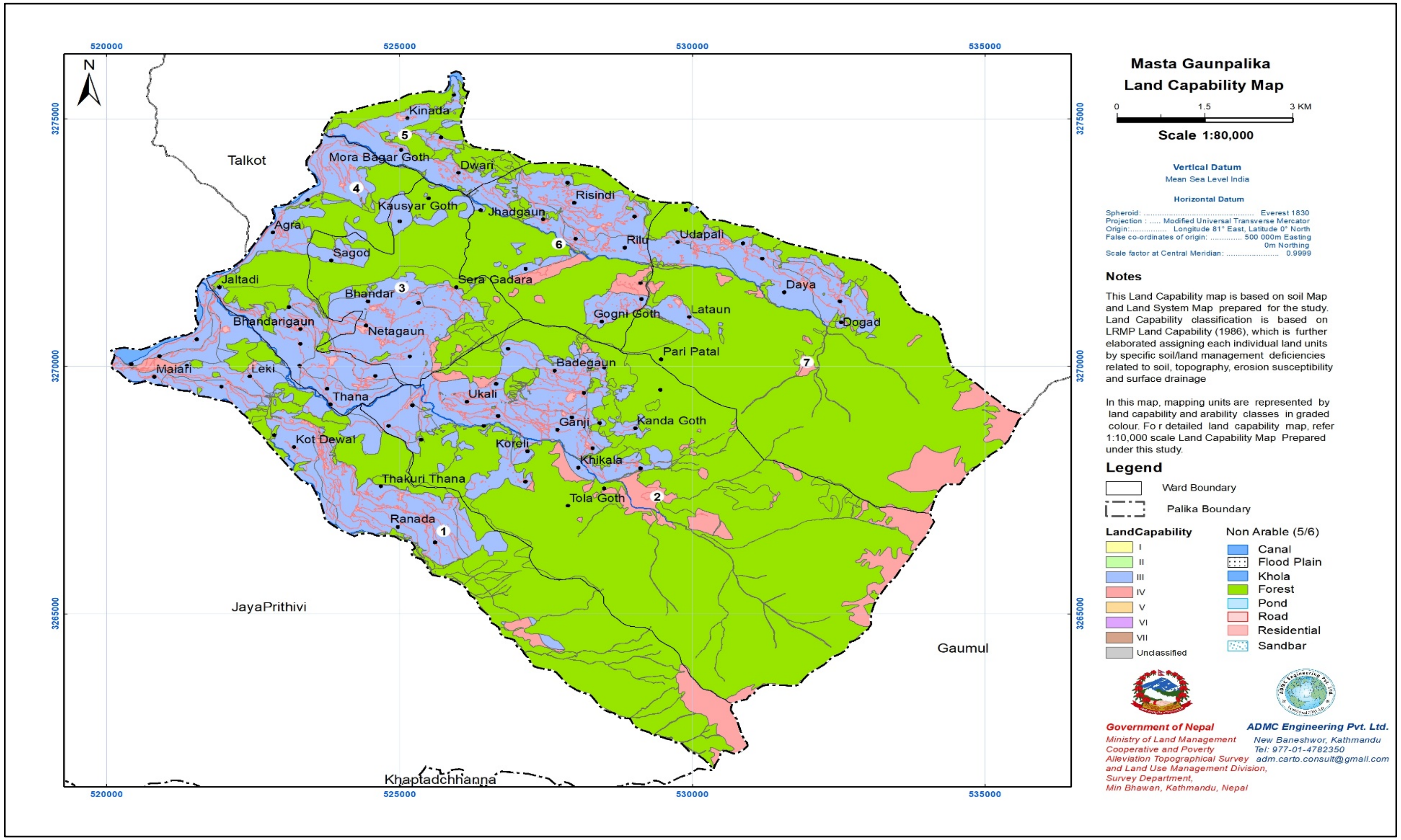

Figure 4.2 Spatial Distribution of Land Capability Classes of Masta Gaunpalika.

4.1 Land Capability GIS Database

The land capability GIS data is stored in vector geo-database and “shape” file formats as a single land unit class which contains a hierarchy of sub-classes that are defined in various attribute fields of vector GIS database. Table 4.2 represents the data model of GIS database.

Table 4.2 Land Capability GIS Attribute Data

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

CHAPTER - 5

CONCLUSION

5.1 Conclusion

Land capability classification of Masta Gaunpalika was carried out on the basis of topography (slope), soil parameters (depth, texture, drainage, PH, OM, N, P, and K), climate, erosion hazard and land management. The classified lands are ranked best suited for agricultural uses without degrading the soil for long term sustainable basis in class I. The class I land is the most suitable for the agriculture, forestry and grazing with few or no limitations of soil and erosion parameters. The increase in class number of land capability indicates that there are increasing the 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 area of this Gaunpalika is classified in land capability Class IIIAh/2 that covers 5605.85 ha. It has moderate soil limitations. Thus, this land needs careful management and conservation for optimum productivity and uses for agriculture. Terracing is compulsory to control erosion when used for agriculture. There are few limitations to traditional forest use provided adequate ground cover is maintained.

Classification of land based on its capability or suitability becomes very useful tool 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 Suggestions

There is need of criteria for soil fertility assessment for land capability class by the project to create uniformity in data resources. The database of land capability classes would be very useful for the country to formulate planning to cope with the low agriculture production, land degradation problem and climate change induced disaster. These databases play vital role in sustainable use of natural resources safeguarding the environment. Thus, there is need of such study on other areas, dissemination of these data bases to local level and local and national planning on agriculture, industrial, forest, urban etc. sectors based on these databases.

निष्कर्ष तथा सुझाबहरु

यस गाउँपालिकाको कूल क्षेत्रफल मध्ये करिब ३७ प्रतिशत जमिन कृषि जमिनको रुपमा बर्गीकरण गरिएको छ । कृषि भूमिमा बाहैं महिना सिंचाईको सुबिधा भएको जमिन निकै कम छ । यस गाउँपालिकामा खेती गरिने जमिनमध्ये करिब ८० प्रतिशत भन्दा बढि जमिन भिरालो र ससाना पाटाहरु रहेका छन् र बांकि करिब २० प्रतिशत जमिन मात्र समतल खेत रहेका छन् । समतल खेतमा मुख्यतया बर्षमा धान र हिंउदमा गहु खेती गरिन्छ भने पाखो बारीमा मुख्य बर्षे बालीको रुपमा मकै र कादो वा मकै र भटमास खेती गरिन्छ भने हिउदमा गहु वा आलु, प्याज, बिभिन्न तरकारी बालीहरुको खेती गरिन्छ । उच्च पहाडी भेगमा बर्षामा खेतमा धान र पाखोमा मकै वा आलु, मुख्य बालीको रुपमा खेती गरिन्छ । खेतामा हिउंदे बालीहरुमा गहु, आलु, बिभिन्न तरकारी बालीहरु, तोरी, प्याज, लसुन लगाउने गरिन्छ । यस गाउपालिकामा बाली सघनता मध्यम देखि उच्चस्तरको रहेको छ । खेतमा भन्दा पाखो बारीमा बाली सघनताको स्तर बढि देन्छि । सामान्यतया खेतामा मुख्य दुई बाली लगाइन्छ भने पाखो बारीमा बर्षमा मुख्य बाली मकैसंग अन्य बालीहरु कोदो, भटमास, मास, बोडी समेत मिश्रित वा घुसुवा बालीको रुपमा लगाउने गरिएको देखिन्छ भने हिउंदमा मुख्य बालीको रुपमा गहु वा तारी लगाउने प्रचलन रहेको छ । यस गाउंपालिकामा समग्र कृषि बालीहरुको उत्पादन राष्ट्रिय उत्पादनको तुलनामा करिब आधा मात्र रहेको छ र ६० प्रतिशत परिबारलाई आफ्नो उत्पादनबाट करिब ६ महिना भन्दा बडिसम्मलाई मात्र खान नपुग्ने अबस्था रहेको ।

पशु पालन पहाडी खेती प्रणालीको अभिन्न अंग हो र यस गाउंपालिकाका अधिकांश परिबारहरुले पनि कृषि बालीका साथै केही पशु बस्तुहरु खासगरि केही गाई गोरु, भैसीं र बाख्रा प्राय सबै परिबारहरुले पाल्दै आएका छन् । गाई गोरु खास गरि मल र खेतबारी जोत्नका लागि र भैसी मल तथा दुध उत्पादनका लागि र बाख्रा नगद आम्दानीकां लागि पाल्ने गरेको पाइन्छ ।

यस गाउँपालिकामा किसानहरु खेत–वारीमा रसायनिक मलको प्रयोग निकै कम मात्रामा प्रयोग गर्ने गरेका छन् । तर पनि केहि किसानहरुले विगत केहि बर्ष बाट खास गरी गहुँ बालीमा युरिया प्रयोग गर्दै आएका छन् । जसले गर्दा जमिनको माटोमा अम्लीयपना बढ्दै गएर जमिनको उर्बरा शक्तिमा ह्रास हुदै गइरहेको देखिन्छ ।

यस गाउँपालिकामा खेतीयोग्य जमिन प्राय विभिन्न बालीहरुको उत्पादनमा प्रयोग गरिएको छ तर बहुबर्षीय बालीहरु जस्तै फलफूल तथा अन्य नगदे बालीहरुको खेति प्राय न्यून रहेको छ । विगत केहि बर्ष यता युवाहरु गाउँबाट रोजगारी को लागि बाहिर जाने प्रबृत्ति बढे संगै गाई भैंसी को संख्या गाउँमा घट्दै गईरहेको छ र परिवारमा काम गर्ने जनशक्ति को कमि भएर गाउँ बस्ती भन्दा टाढा रहेको खेति गरिने पाखो जमिन बाँझो छोड्ने चलन बढ्दै गईरहेको देखिन्छ ।

माटो परिक्षणको नतिजा अनुसार यस गाउँपालिकामा खेति गर्न योग्य भनि वर्गीकरण गरिएको करिव ९० प्रतिशत क्षेत्रफलमा सबै प्रकारका बर्षे वा वहुवर्षिय कृषि बालि लगाउन सकिने देखिएता पनि अधिकांश जमिन भिरालो वा अति भिरालो पाखो वारी भएकोले प्राबिधिक रुपमा ३०° भन्दा भिरालो जमिनमा बर्षे वाली हरु जस्तै मकै, कोदो, फाफर आदि लगाउन उपयुक्त देखिदैन । तर पनि किसानहरु सबै किसिमको जमिनमा बर्षे वालीहरु नै लगाउदै आएका देखिन्छ । स्थलगत अध्ययनका क्रममा अवलोकन गर्दा खेति प्रणाली परम्परागत तौर तरिका बाट गरिदै आएको देखियो । केहि किसानहरुले सिफारिस गरिएका धान, गहुँ, मकै र आलुका जातहरु लगाउने गरेको भएता पनि खेति गर्ने तौर तरिका परम्परागत नै रहेकोले उत्पादनमा खासै बृद्दी भएको देखिदैन ।

गाउँपालिकामा कृषि तथा पशुपालनका प्राविधिक जनशक्ति कम भएको र भएका प्राविधिकहरु समेत निम्नस्तरका जे। टि / जे। टि। ए। हरु मात्र कार्यरत रहेकाले त्यस्ता कम अनुभवी प्राविधिकहरुले किसानहरुलाई आवश्यक प्राविधिक ज्ञान तथा सेवा प्रदान गर्न सक्ने देखिदैन । गाउँपालिकाका भौगोलिक अवस्था, माटोको भौतिक तथा रसायनिक गुण हावापानी तथा स्थानिय कृषकहरुको आवश्यकतालाई समेत दृष्टिगत गरि भू–उपयोग योजना अनुसार कृषि तथा पशुपालन व्यवसायको सम-सामयिक सुधार ल्याउन निम्न अनुसार को सुझावहरु प्रस्तुत गरिएको छ :

माटोको उर्बरा शक्ति कायम गर्न

१. **अति भिरालो जमिनमा खेति गर्न नियन्त्रण गर्ने** : **जमिनको उचाई, हावापानी भिरालोपनाको स्तर र मोहडाको आधारमा ३०° भन्दा बढी अनि भिरालो जमिनमा बर्षे वालीहरु जस्तै धान, मकै, गहुँ, कोदो, फाफर**, **आलु तथा तरकारी वालीहरुको सघन खेति गर्न कृषकरुलाई निरुत्साहित गर्ने ।**
२. **भिरालो जमिनमा वहुवर्षिय वालीको खेति प्रणालीको प्रबर्धन** : **१५°-३०° सम्मको भिरालो जमिनमा सकेसम्म एक बर्षे वालीको सट्टा फलफूल खेति**, **अन्य वहुवर्षिय नगदेवालिहरु सहितको कृषि वन प्रणालीको स्थापना गर्ने ।**

३. **एकिकृत वाली तथा पशुपालन खेति प्रणालीको प्रबर्धन गर्ने : नेपालको मध्ये पहाडी क्षेत्रमा ब्यबसायिक कृषि तथा पशुपालन ब्यबसायको विकास गर्न खोज्दा परम्परा देखि दिगो रुपमा गर्दै आएको एकिकृत वाली उत्पादन तथा पशुपालन पद्धति क्रमस धोस्त हुदै गईरहेको छ र न कृषि उत्पादनको ब्यबसायीकरण हुन सक्यो न पशुपालन ब्यबसाय नै ब्यबसायीकरण भएको छ । पशुपालन ब्यबसायलाई वाली उत्पादन ब्यबसायबाट अलग गराउदा वाली र पशु जन्य उत्पादन हरुको लागत बढ्न गई साना किसानहरु कृषि ब्यबसायबाट नै पलाएन हुने अवस्था मा पुग्छन । तसर्थ पहाडी क्षेत्र मा एकिकृत कृषि तथा पशुपालन ब्यबसायलाई नै ब्यबसायीकरण गर्न आब्श्यक नीति तथा कार्यक्रम तर्जुमा गरि समन्धित गाउँपालिकाहरुले नै संचालन गर्नु पर्दछ ।**

४. **युरियामलको प्रयोगलाई निरुत्साहित गर्ने : यस गाउँपालिकामा रसायनिक मलको प्रयोग त्यति धेरै नभएता पनि विगत केहि बर्षयता केहि किसानहरुले युरिया मललाई गोठे मलको प्रतिस्थापन गर्ने गरि प्रयोग शुरु गरेको पाईयो । यसबाट माटोमा अम्लीयपनमा वृद्धि भइ माटोको उर्वराशक्तिमा कमी भइ लगाइएका बालीहरुको उत्पादन घट्न जाने र कृषि उत्पादनहरुको लागत समेत बढ्ने हुनाले युरिया मलको प्रयोगलाई प्रोत्साहन गर्नु हुँदैन । यदि सिंचित खेतमा उन्नत जातका वालीहरु लगाउने भएमा आवश्यक मात्रामा** DAP **जस्ता रासायनिक मल प्रयोग गर्न किसानहरुलाई प्रोत्साहन गर्ने ।**

५. **संरक्षणमुखी खेति प्रणालीको प्रवर्धन : भिरालो तथा स-साना बारीका पाटाहरु नियमित खनजोत गरि परम्परागत अन्न तथा छोटो समयमा पाक्ने वाली लगाउने भन्दा अन्य एक बर्षे वालीहरु जस्तै पिंडालु, तरुल तथा सकरखण्ड जस्ता बजारमा उच्च मुल्यमा विक्री गर्न सकिने वालिहरुको व्यवसायिक खेति प्रणालीको विकास गर्ने जसबाट कम लगानीमा उच्चतम नगद आम्दानी लिन सकिन्छ ।**

६. **अन्न वालीहरुको उत्पादन र उत्पादकत्व वृद्धि : यस गाउँपालिकामा प्राय सबै कृषि वालीहरुको उत्पदकत्व न्यून रहेको पाईएको छ । खासगरी खाद्य वालीहरु तथा आलुको उत्पदकत्व वृद्धि गरि खाद्यान्न तथा आलुको आयात प्रतिस्थापन गर्न निम्न सुझावहरु प्रस्तुत गरिएको छ :**

७. **सघन खाद्यान्न वाली उत्पादन : यस गाउँपालिकामा समथल खेतियोग्य सिंचित जमिन निकै कम छ । स्थलगत अध्ययन अनुसार यस गाउँपालिकाको कुल खेतियोग्य** करिब **१०९०५.१८** हेक्टर **जमिन मध्ये करिब ३३७२.५२ हेक्टर** (**३०.९**%) **सिंचित खेत रहेको छ । यस सिंचित खेतमा सघन खाद्यान्न वालीहरु जस्तै धान, मकै र आलु जस्ता वालीहरु उन्नत प्रविधिको प्रयोगगरी बढी उत्पादन गर्ने कार्यक्रमहरु संचालन गर्ने ।**

८. **बाली पद्दति यस गाउँ पालिकामा उपलब्ध कृ :षि भूमिलाई बाली उत्पादनको दृष्टिकोणबाट खेत र बारीमा बिभाजन गरिएको छ । खेतलाई वर्षभरि सिंचाई उपलब्ध हुने र टारी खेतहरु बिभाजन गर्न सकिन्छ । स्थलगत अध्ययन अनुसार प्राय सबै खेतमा बर्षामा धान र हिउँदे सिजनमा प्राय गहुँ, तरकारी र कहिँ कहिँ तोरी बाली लगाउन ,आलु खेति गरेको पाइन्छ । सिंचित र टारी खेतमा लगाइने बालीहरुमा खास फरक देखिदैन । सबै खेतमा धान आलु वा सडकको पहुँच भएका क्षेत्रमा-गहुँ वा धान- – नगदे बालीको रुपमा धान मौसमी तरकारी बालीहरु लगाउन उपयुक्त देखिन्छ ।**

९. त्यसै गरि पाखो बारीमा पनि मुख्य बर्षे बाली मकै र हिउँदमा गहुँ, फापर, आलु, हिउँदे तरकारी लगाउने गरेको पाइन्छ । तर समुन्द्र सतहबाट १०००- १५००मिटर उचाइको पाखो बारीमा बर्षे वालीको रुपमा मुख्य बाली मकै संगै कोदो, भटमास , मास, बोडी र हिउंदमा गहुँफापर , आलु लसुन आदि लगाउने , गरेको पाइन्छ। तर समुन्द्र सतहबाट २०००-३००० मिटर उचाइमा बर्षामा मुख्य बलीको रुपमा आलु र हिउंदमा गहुँ, फापर, सिमी जस्ता बाली लगाउन उपयुक्त हुन्छ । यस बाहेक १५°-३०° भिरालो पाखो जमिनमा अन्य खाध्य बाली जस्तै तरुल, पिडालु तथा सखरखण्डअदुवा ,, बेसार ,फलफूल ,अलैची , कफी तथा चिया बाली लगाउन उपयुक्तहुन्छ । ३०° भन्दा बढी भिरालो जमिनमा भने अन्न बाली लगाउन उपयुक्त नहुने हुनाले हावापानी अनुसार फलफूल र अन्य बहुबर्षीय नगदेबालीहरू नै लगाउन सिफारिस गरिन्छ ।

१०. उच्च उत्पादन हुने बालीहरुको प्रबर्धन सघन बाली अन्तर्गत खाद्यान्य उत्पादनको लागि धान :, मकै, गहुँ र आलुका सिफारिस गरिएका जातहरु लगाउन प्रोत्साहन गर्ने ।

११. उच्च मुल्यका बालीहरुको प्रबर्धन भिरालो जमिनमा खासगरी समुन्द्र सतहबाट :१०००-१५०० मिटरको उचाइसम्म तरुल, पिडालु, सकरखण्डसुन्तला जातका फलफूल , किवी, अलैची र कफी लगाउन उपयुक्त हुन्छ भने समुन्द्र सतहबाट २०००-३००० मिटर सम्म बर्षे आलु लसुन र स्याउ ,प्याज , तथा ओखरका बिरुवा लगाउन उपयुक्त देखिन्छ।

१२. त्यसैगरी अन्न तथा फलफूल बालीबाहेक क्रस जर्सी गाई तथा ब्रोयर क्रस बाख्रा पालन पनि आर्थिक दृष्टिकोणबाट फाइदा जनक देखिन्छ ।

E. Risk Report

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Chapter 1: INTRODUCTION

1.1 Background and Rationale

The importance of Land Use Planning role in the prevention and the restriction of consequences of major hazard accidents need to be analyzed. Inversely, Land use planning without due consideration on disaster aspect are not effective. Mainstreaming disaster risk reduction in Land Use Planning can systematically reduce impact of specific hazard. The main objective of this study is to investigate the risk factor associated in land use plan going to be prepared in the study area. Risk assessment, that identifies the severity and spatial distribution of risk and generates the necessary information and data for risk sensitive land use planning is essential for land use zone designation. It discusses the elements of risk, such as hazard (mainly: flood, landslide, seismic, fire and industrial) and vulnerability as guiding issues for formal land use planning.

Lack of formal planning increases the adoption of informal ways of planning, which may or may not be effective. There is a gap between the formal and informal planning systems. The government is trying to ensure planned future land use to prevent injury, human trauma and loss of life, and to minimize property damage due to diastral events like flood, earthquake landslide etc. In most cases, human response to the hazard is based on the structural measures like construction of protection wall (against landslide), flood defenses, especially levees, storage reservoirs, floodwalls, and diversions (against landslide). Contrary, the approach of land use planning should be largely recognized as the way forward, where development decisions are based on the knowledge of the prevailing and expected future risks.

The recurring heavy losses in Nepal due to diastral events can be reduced by using policies, structural measures and planning tools, such as Land use planning (LUP). A LUP is an essential planning tool for successful and systematic disaster risk reduction like flood. Government of Nepal has already prepared land use plan of flood plain zone in many districts of Terai. In contrary, the area has been seen suffering due to flood recurrently. This triggers for carrying out of such planning task based on the risk layer to ensure risk sensitive land use planning.

1.2 Objectives of the Study

Objective of this risk study is to identify the areas which are more prone to risk events potentially caused by flood, landslide, earthquake, fire and industry within the study area.

1.3 Study Area

There is a famous temple of Masta Kul Dewata in ward number 3 which is worshipped with devotedly by the common people of Bajhang. This Kul Dewata is very popular in this area including surrounding districts. Before reconstruction of state by constitution 2073, one of the of VDC name was Masta in Bajhang district which is related with Masta Kul Dewata. In this context, after reconstruction of local level, among the twelve, one unit of local level became Masta Gaunpalika by merging three previous VDCs ie. Kotdewal, Masta, Bhatekhola and Rilu. Masta Gaunpalika is located 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude covering an area of 109.05 square kilometer. This Gaunpalika consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Nagarpalika to the west and south and Talkot Gaunpalika to the north. The location map of the study area has been shown in Figure 1.

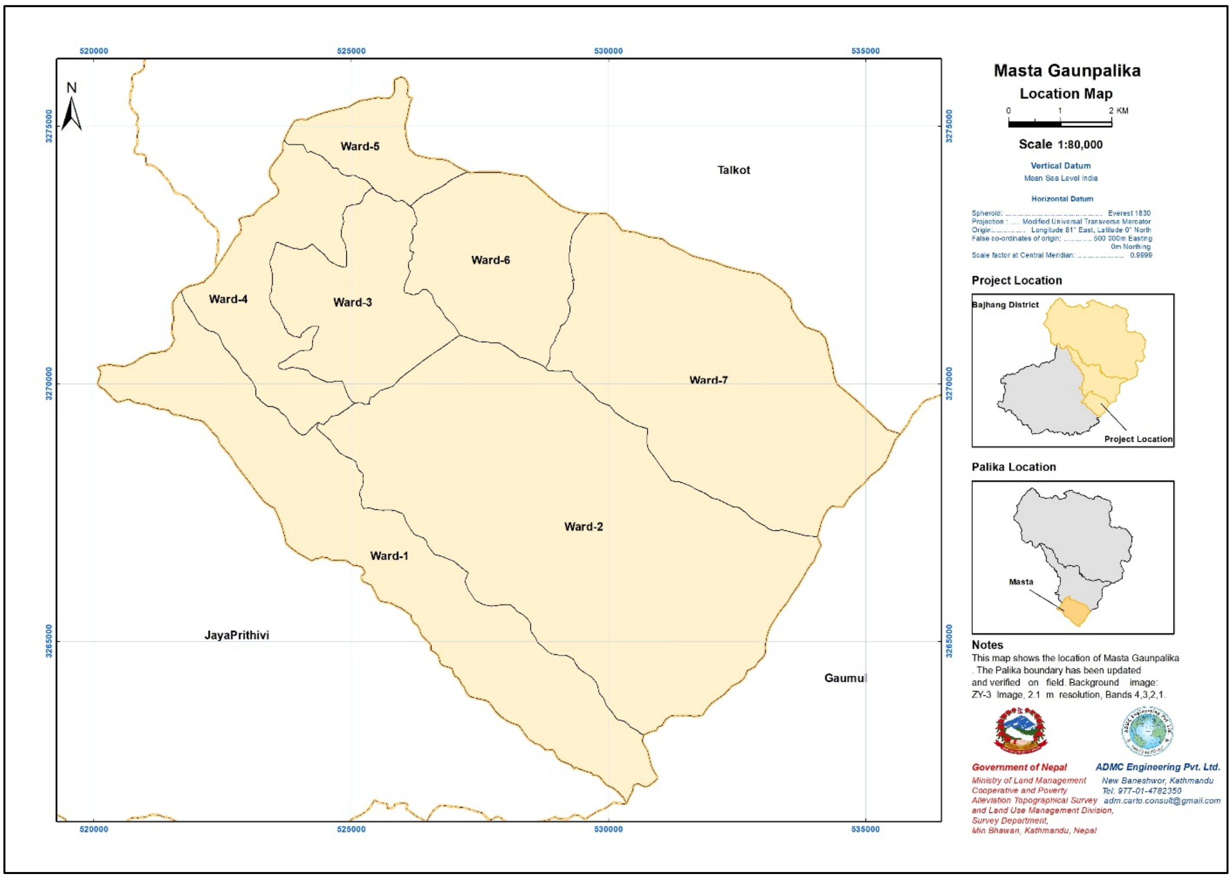


Figure 1 : Location Map of Masta Gaunpalika

Chapter 2: CONCEPTUAL BASIS OF RISK MAPPING

2.1 Risk and its relation to Land Use Zoning

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.

2.1.1 Land Use Planning or (Zoning) and Disaster Risk Reduction

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(Directorate et al., 2013).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.

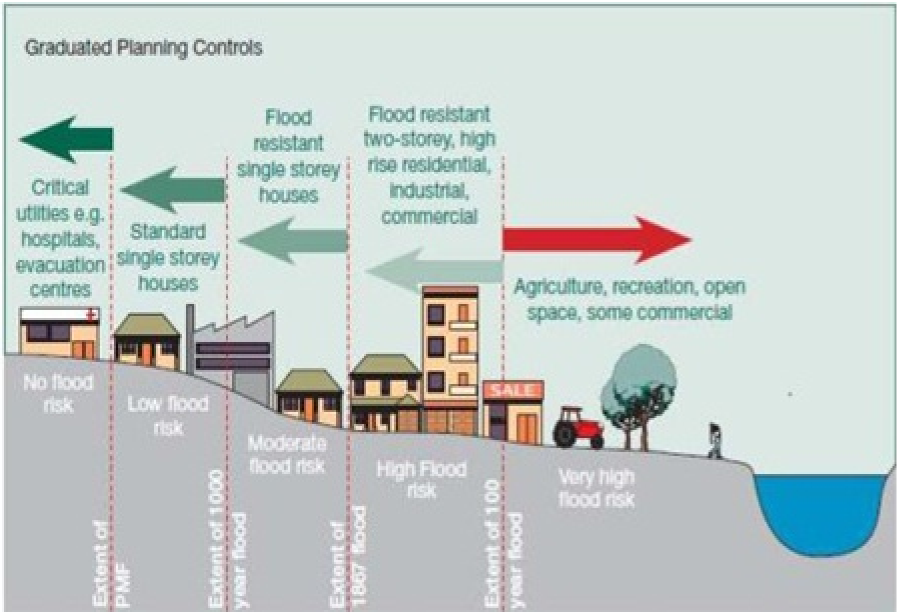


Figure 2: Distribution of land use on floodplain to reduce risk

2.2 Relation of vulnerability and hazard with Risk

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 depends 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 understand 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):

a. Traditional deterministic approach: 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.

b. 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.

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:

a) Economic
b) Social
c) Cultural

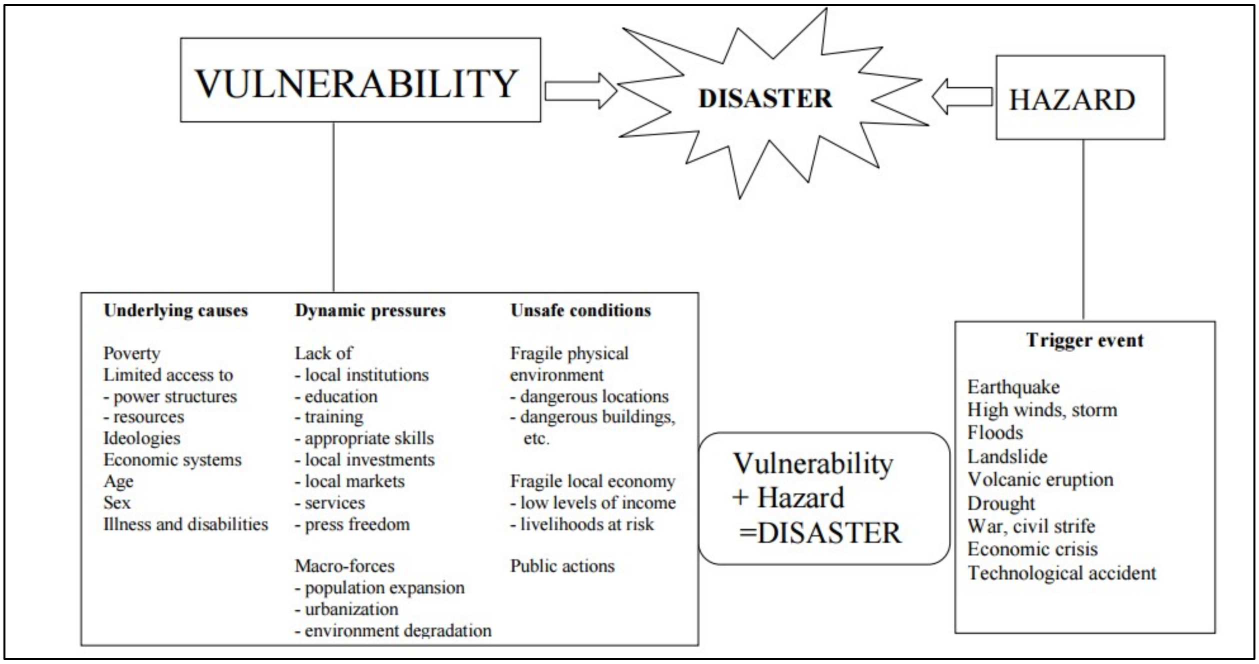


Figure 3: Factors of Disaster

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 no 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. When Hazard and vulnerability meets there occurs disaster.

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 mapping process, risk factors have been specified related to the following event:

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

2.3.1 Mathematical Understanding of Flood Risk

According to EU Directive (COM, 2006) for flood management, "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. In this context flood risk can be considered as the actual threat, in other words the real source 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. In general, risk as a concept incorporates the concepts of hazard {H} (initiating event of failure modes) and vulnerability {V} (specific space/time conditions). It is customary to express risk (R) as a functional relationship of hazard (H) and vulnerability (V).

{R} = {H} □ {V}

in which the symbol □ represents a complex function incorporating the interaction of hazard and vulnerability. Consequently, in mathematical terms it can be expressed as:

R = {H} x {V}

Since vulnerability is a dimensionless quantity (Villagran, 2006), risk could be measured in the same units as hazard. In quantitative terms, annualized risk can be estimated as the product of probability of occurrence of the hazardous phenomenon and the actual consequence, combined over all scenarios. According to the methodology of estimating average (annualized) hazard, the expected value of flood risk can be calculated as follows:

$$E(X) = \int^{\infty} x \cdot V(x) \cdot f\ (x) dx$$

Where, X is the actual flood damage caused by the flood hazardous phenomenon, f(x) is the p.d.f. that describes this phenomenon and V(x) is the vulnerability of the system towards the corresponding magnitude of the phenomenon. It is obvious that such an estimation involves major restrictions such as: can be applied only on hazards of natural origin due to probabilistic analysis although it abides to a general methodological framework, it is highly case specific highly dependable on expert’s judgment.

Chapter 3: METHODOLOGY

3.1 Flood Risk

Flood is a natural event of rising water level in a stream, lake, reservoir or coastal region (Friesecke, 2004). Flood is too much water in the ‘wrong’ place.(Singh, N, 2013). 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 of time. 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, N, 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.(Singh, N, 2013).

Natural Hazard and Flood events are part of nature which have always existed and will continue to exist. Floods are climatological 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 riverine 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 stop building development in immediate risk areas.

3.1.1 Data

Data for the Flood Risk Study can be classified into various group 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 center line etc.
- Discharge data at strategic points, manning's constant, river boundary information etc.

3.1.2 General Approach and Methodology Framework

Various methodological frameworks exist in Nepal for flood modeling. It is generally accepted that 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); that is towards measures that are mainly driven by the need of cultural heritage protection and also by the socioeconomic conditions of the area concerned. In this context, a thorough analysis of the study area is needed before developing a workflow chart, in order to apply the prescribed methodology over flood hazard scenarios to the specific case-study areas of special cultural interest within the same Prefecture. An applied methodological framework for flood risk assessment, in general, is shown in the following page.

The concepts of hazard, vulnerability and risk have been extensively used in various disciplines with a different meaning, impeding cross-disciplinary cooperation for facing hazardous events. Even for natural hazards, such as floods, no unique definitions and assessment procedures have been widely accepted. In this paper we propose a comprehensive way for defining and assessing flood risk and vulnerability in the flood-prone areas. The suggested methodology follows a three-step assessment approach: a) annualized hazard incorporating both probabilities of occurrence and the anticipated potential damages b) vulnerability (exposure and coping capacity) in the flood-prone areas and c) annualized flood risk (estimated on annual basis). The methodology aims to assist water managers and stakeholders in devising rational flood protecting strategies.

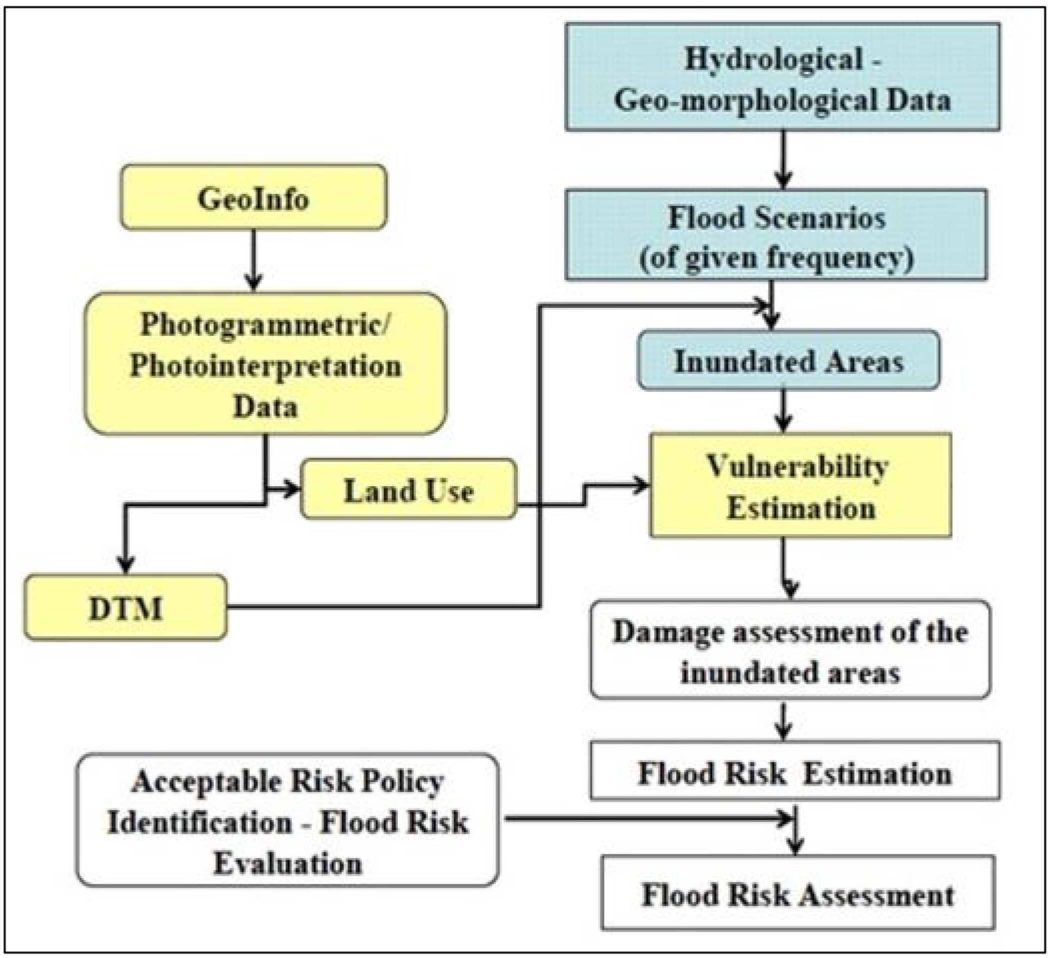


Figure 4 : Methodological Framework for Flood Risk Assessment

3.1.2.1 Flood plain

The land that lies next to the river or along the river side during normal river flow and submerged during the flood (Shahiriparsa& Vuatalevu, 2013).

3.1.2.2 Flood hazard map

Flood Hazard Maps refers to the map that provides information on inundation like predicted inundation, inundation depth etc. as well as evacuation routes graphically in understandable format. Flood hazard mapping is one of the good example of non-structural measures for minimizing risk(Map et al., 2003).The flood hazard maps include the information on historical as well as potential future flood events in different probability. This can be the basis for determining land use control, flood proofing of constructions and flood awareness and preparedness. FHM provides information on type of flood, the flood extent; water depths or water level, flow velocity or the relevant water flow direction(Prinos, 2008). Flood Hazard maps should be considered before any investments or implementation of development projects.

3.1.2.3 Flood modelling

It is an engineering tool that provides accurate information regarding flood profile. The governing factor for causing flood are rainfall, run off, catchment characteristics and return period (Kute, Kakad, Bhoye, & Walunj, 2014). The main input data for calculating flood hazard maps is the occurrence probability and the amount of high water discharge in rivers (Prinos, 2008).

Flood discharge calculation is a prominent task for designers of hydraulic structures and river training works. This task is made more difficult as Nepal lacks sufficient hydrological information (Rijal, 2014). To carry out the calculation of flood flow different approaches can be selected based on site condition and available data. There are various methods adopted for calculating flood discharges like Rational Method, Empirical Formula (Modified Dickens's formula), Water and Energy Commission Secretariat (WECS) Approach, Flood - Frequency Method etc.

The rational method is applied for the peak flow calculation of smaller basin that responds to storms as it is simple and requires limited data. In this method it is assumed that intensities of rainfall and infiltration are uniformly distributed in time and space. The smaller basin here refers to the upper limit of 25 km^2(Hua, Liang, & Yu, 2003).

The Empirical Formula (Modified dickens formula) has been derived for northern India. The formula uses the catchment area as a single parameter affecting the flood peak and other factors are constant based on the specific region. This formula is applicable only in the region from which they were developed and when applied to other areas can at best give rough estimates (K. Subramanya, 2006).

Flood frequency method is the statistical method of frequency analysis of flood flow. The method is more time consuming as minimum data of 30 years should be essentially considered. If the length of records is less than 10 years, frequency analysis should not be adopted (K. Subramanya, 2006).

WECS/DHM (1990) method considers whole country as single hydrological region. The regionalization was done for low flows, long term flows and flood flows. It is the modified form of WECS (Water and Energy Commission Secretariat) approach of 1982 which was jointly developed by WECS and DHM (Department of Hydrology and Meteorology) in cooperation with WMO (World Meteorological Organization), WERDP (Water and Energy Resource Development Project, until 1989) and WISP (WECS/NEA Institutional Support Programme) in 1990 (Shrestha ,et al., 2010).The following equations is used for flood flow of any river of catchment area 'A' below 3000 m according to the regional hydrological analysis report published by Water and Energy Commission Secretariat cited in (Manandhar, 2010);

$$\mathbf{Q_{10} = 1.8767\ (A + 1)^{0.8783}}$$

$$\mathbf{Q_{100} = 14.63\ (A + 1)^{0.7342}}$$

Where, the subscript 10 and 100 stand for the return periods in number of years.

The flows for any other return period 'R" is then given by:

$$\mathbf{Q_R = \exp\ (1n\ Q_2 + 3\ \sigma)}$$

Therefore, from the study of all the methods used for flood discharge, WECS/DHM method is found to be appropriate for the study, so the study has used this method for the calculation of flood discharge for the return periods of 10 years, 20 years and 100 years.

3.1.2.4 Manning's roughness coefficient (n)

The Manning's roughness coefficient, n, is commonly used to represent flow resistance(Phillips & Tadayon, 2006).The friction parameters have been considered as the form of Manning's roughness coefficient (n)(Shahiriparsa, Heydari, Sadehian, & Moharrampour, 2013).

Values of Manning's n may be assigned for conditions that exist at the time of a specific flow event, for average conditions over a range in water-flow depths, or for anticipated conditions at the time of some future flow event. The value assigned to a reach should represent the composite effects of the factors that tend to retard flow (Aldridge and Garrett, 1973). In developing the ability to assign n values, a person must rely to a great degree on values that have been verified and on values that have been assigned by experienced personnel (Aldridge and Garrett, 1973; Thomsen and Hjalmarson, 1991).The general procedure for determining n values is to select a base value of n for the bed material and then select n-value adjustments for channel irregularities, alignment, obstructions, vegetation, and other factors.

N-value	Remarks
0.01	Smooth Channel
0.07	Rough Channel
0.04	Average Value

Utilizing this procedure, the value of n is computed as,

[0.035± 0. 001], for the range of 0.3 and 0.4

Based on this criteria, the study has assigned 0.035 for n value.

3.1.2.5 Applications used for flood modelling

- Geographic Information System (GIS): GIS is computer based system for mapping and analyzing spatial data. GIS is considered to be revolutionary new technology which increases ability to make decision and solve problems. GIS differs from other information system as it integrates common data base operations like query and statistical analysis, unique visualization and geographic analysis benefits offered by maps. This is helpful for explaining events, predicting outcomes and planning strategies. The careful analysis of spatial data using GIS can provide detail information on problem like pollution, deforestation, natural disasters and suggest the way to address them. GIS comprises of five components i.e. hardware, software, data, people, and methods(Is & Of, 2000).

- Hec Geo-Ras: HEC-Geo Ras is an extension for ArcGIS. This extension allows users with limited GIS experience to create an HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM) and complementary data sets. Water surface profile results may also be processed to visualize inundation depths and boundaries (Ackerman, 2011). HEC-Geo RAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS using a graphical user interface (GUI).

- Hec-Ras: HEC-RAS is numerical analysis software. It is a computer program that models the hydraulics of water flow through natural rivers and other channels (Prinos, 2008). “It is an integrated package of hydraulic analysis programs, in which the user interacts with the system through the use of a Graphical User Interface (GUI)”(Brunner, 2010).This provides the details of flood profiles. This software is easily available and has precise calibration accuracy (Kute et al., 2014).This is the major part of the modeling where flood simulation is done. This program is one-dimensional which means the flow is considered to be uniform from point to point upstream to downstream. It includes numerous data entry capabilities, hydraulic analysis components, data storage and management capabilities, and graphing and reporting capabilities(Prinos, 2008).HEC-RAS system is the composition of four one-dimensional river analysis components viz; steady flow water surface profile computations, unsteady flow simulation, movable boundary sediment transport computations, water quality analysis(Brunner, 2010).

3.1.2.6 Steady Flow water surface profile

This component of modeling system is intended to calculate water surface profiles. The system can handle a single river reach, a dendritic system, or a full network of channels. The component is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. The basic computational procedure is based on the solution of the one-dimensional energy equation. Friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head) are used for the evaluation of Energy loss while momentum equation is applied in situations where the water surface profile is rapidly varied. These situations include mixed flow regime calculations i.e., hydraulic jumps, hydraulics of bridges, and evaluating profiles at river confluences (stream junctions).The steady flow system is designed for application in flood plain management and flood insurance studies to evaluate floodway encroachments (Brunner, 2010).

3.1.2.7 Unsteady Flow simulation

This component is capable of simulating one-dimensional unsteady flow through full network of open channels. This component was basically designed for subcritical flow regime calculations. However, new releases of the model can now perform mixed flow regime (subcritical, supercritical, hydraulic jumps, and drawdowns). Special features of this component include: Dam break analysis; levee breaching and overtopping; Pumping stations; navigation dam operations; and pressurized pipe systems. Sediment(Brunner, 2010).

Upon discussion with NLUP authorities, it was found that that the study should also aim to evaluate land use plan from disaster (flood) management perspective for which requires the evaluation of flood way encroachment. From the above study it is found that, steady flow analysis is designed to evaluate flood way encroachment. Therefore, steady flow analysis has been used for the flood simulation as required for the project. At the same time lack of unsteady flow data has made this project to choose steady flow analysis.

3.1.2.8 Disaster Risk Management 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. This Ministry functions as:

- 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

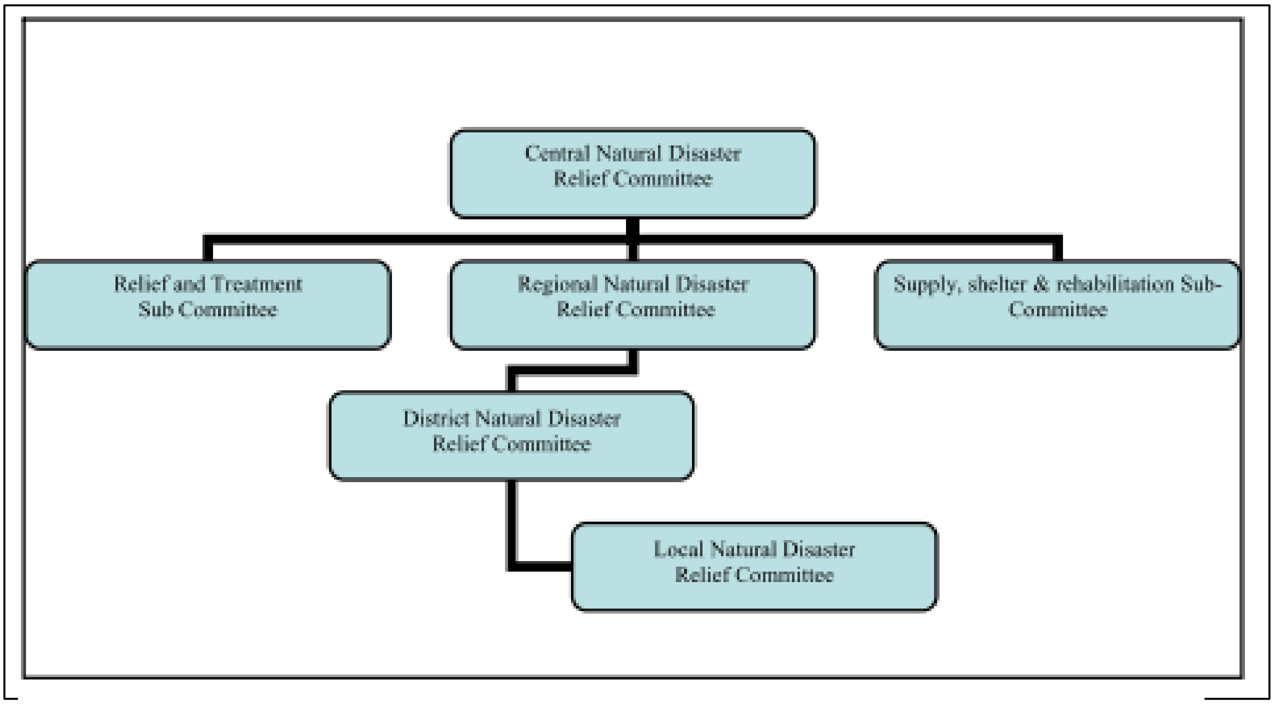


Figure 5: Disaster Relief Committee of Nepal

Some related act and regulation formulated in Nepal for disaster management according to (Asia et al., 2009) are as follows:

- 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)

3.1.2.9 Floods in Nepal

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 rainfall with average 1700 mm annually contributes to surface water flow in average annually 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 disasters causes average annual loss of 309 lives and affects 27654 families (Asia et al., 2009).

3.1.3 Methods

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 was 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.

3.1.3.1 Data Collection

Data-collection is the systematic gathering of information necessary for our study. The information can be of people, objects or phenomena. Haphazard collection of data may create difficulty in answering the set question in a conclusive way (Chaleunvong, 2013).The method applied for collecting data is both qualitative and quantitative. Different techniques applied for the collection of data are: available information, observation, interviewing face to face, written questionnaire and focus group discussion (Chaleunvong, 2013). Among these techniques, this project has applied all techniques except focused group discussion.

3.1.3.2 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. Total sample size of 10 was taken for the interview.

3.1.3.3 Data Analysis

Nepal is highly vulnerable to natural disasters. The country has been facing different types of disaster such as earthquake, landslide, flood, thunderstorm, GLOF, avalanche, fire, drought, and epidemics every year. These disasters are found to occur in different parts of the country due to various reasons such as rugged and fragile geophysical structure, very high peaks, high angle of slopes, complex geology, variable climatic conditions, active tectonic processes, unplanned settlement, increasing population, weak economic condition and low awareness.

Basically, there are three types of hazards in this Rural Municipality. The main hazards are landslide, river cutting and flood which are common in this area. In addition to those, fire, windstorm, thunderstorm, epidemics, droughts etc. are also frequently occurring here. According to the Rural Municipality Profile and the discussion with local representatives, 2070 households are prone to various types of disasters. The houses and settlements located in steep slopes as well as nearby river bank and stream are more vulnerable. Landslides, river cutting and floods are considered most of the problematic hazard in this area due to several river and stream.

Table 1: Natural hazards in Masta

Ward No.	Location	Natural hazards				
		Landslide	**River cutting**	**Flood (Number)**	**Others (Number)**	**Total**
1	Kadesain, Kojyakhal, Tusharpani, Dadabhir, Gaithi Ban, Jaltadi, Maljhuli, Samadeu				944	944
2	Badegaun, Bhattekhola, Ramalikhola, Khikala	80			50	130
3	Rithepatha, Dalit Basti, Tal Bojyadi, Bhimani-Bhawani Primary School, Paneri Khola, Bhaise Khola	150		150	100	400
4	Sagaud, Khatad, Hile- Namasi Khola, Khada-Kuri Kol	153	233	145	65	596
Total		383	233	295	1159	2070

Source: Field survey, Masta Rural Municipality Profile, 2075

In the summer season, landslide, flooding and river cutting events occur regularly. A large quantity of private properties, public infrastructures and common properties damage every year during the summer season. According to obtained information, ward number two, three and four are more vulnerable from landslide and three and four from flooding and four from river cutting. In the total (383 households), 80 households of ward number two, 150 of ward number three and 153 of ward number four are more affected by landslide. Similarly, out of the total (295 households), 150 households from ward number three and 145 households from ward number four are at risk to the flooding point of view.

Conversation with local people

From the interview with local people, flood is uncertain in the study area. Bank cutting has been major problem which has created probability of entering flood in many parts along the river. Many agricultural lands have been converted to river bank due to bank cutting. Some dams constructed to check flood are in ruining condition due to the current of water while many has been swept away. According to the local people, flooding which can be controlled with the construction of embankment. Water logging has been a serious problem in the area.

There is a chance of entering flood to the area as bank cutting has found to be serious. Conversion of agricultural land to flood plain due to bank cutting can warn regarding the threat of flood to enter the in the nearby area. Flood has been probable threat for the people in the study area.

Discussion:

The flood damaged the physical infrastructures such as school buildings, canal, drinking water projects, roads, bridges etc. in this area. As reported by local people, local representatives and personnel that the road situation during monsoon is very poor due to continuous flooding, erosion and landslides. The flood caused losses of school building and damage of roof from windstorm and its total disaster estimated value is 0.9 million NRs. Currently, there are eleven hydroelectricity projects located along the different streams which are also prone to flash flood.

Table 2: Loss/Damage of public properties

Hazard	Ward No.	Schools		Canal/drinking water		Road/bridges	
		Number	Loss (Rs)				
Landslide		1		2	40,000	1	50,000
Flood	3	1	400, 000	3	105,000		
Windstorm	1	1	500, 000				
Fire							
Total			90,000		1,45,000		50,000

Source: Field survey; Masta Rural Municipality Profile, 2075

Analysis for watershed area determination and calculation of water discharge

In this phase, Seti Nadi and Dwari Gad are the major river which was digitized from the Satellite imagery. Digital elevation model, shown in figure as grid model was prepared by using contour and spot height point from the topographic map. Water discharge for return periods of 10 years, 20 years and 100 years were calculated with the determination of watershed area shown in figure below using Flow direction and Flow accumulation. The process involved is given below:

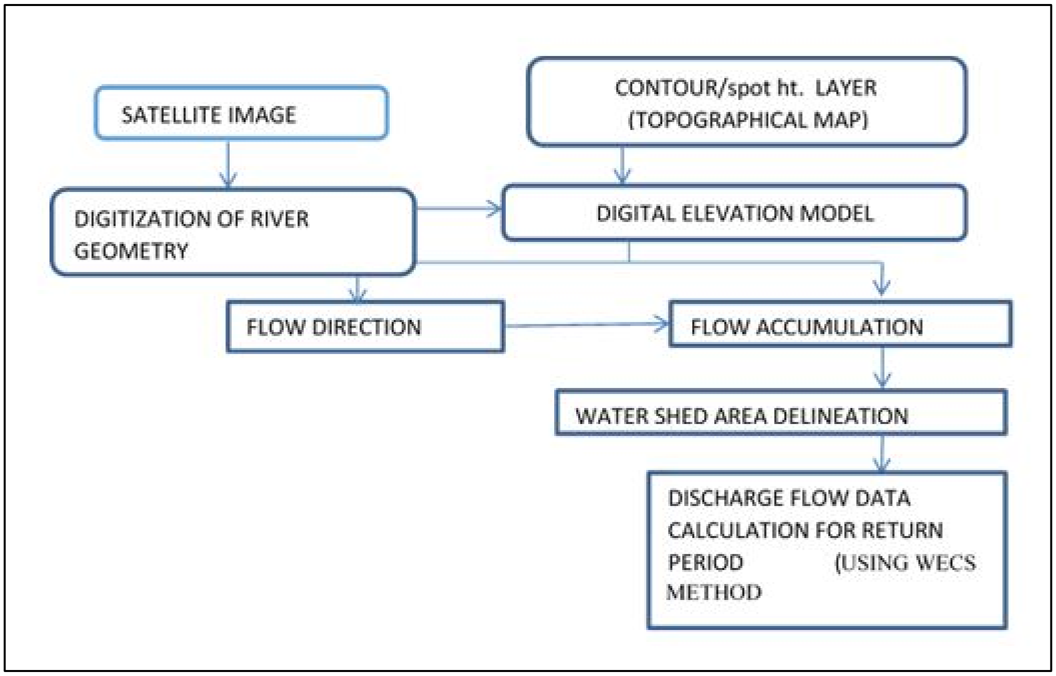


Figure 6: Process for Watershed area determination and discharge calculation

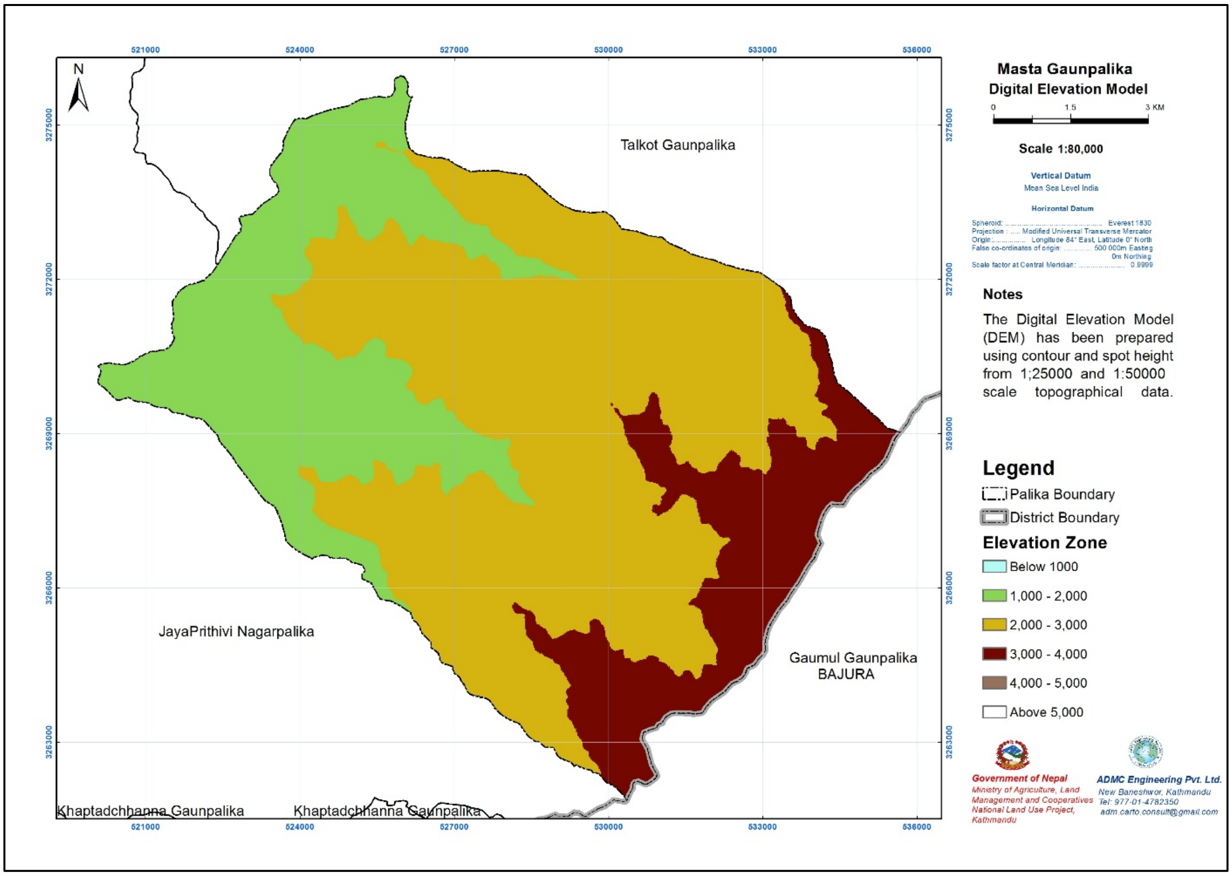


Figure 7 : Digital Elevation Model

Table below shows the Yearly Mean Rainfall at Chainpur (west) Station. It is seen that the rainfall is intensified within six months i.e. April to September, of the year. Highest rainfall (404.8 mm) is obtained in the month July and lowest rainfall is in November.

Table 3: Yearly Mean Rainfall (in mm) at Chaunpur(west) Station,Bajhang (1984-2013)

Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rainfall (mm.)	44.92	73.41	56.38	42.74	69.32	177.18	404.85	396.89	221.26	44.25	10.53	23.87

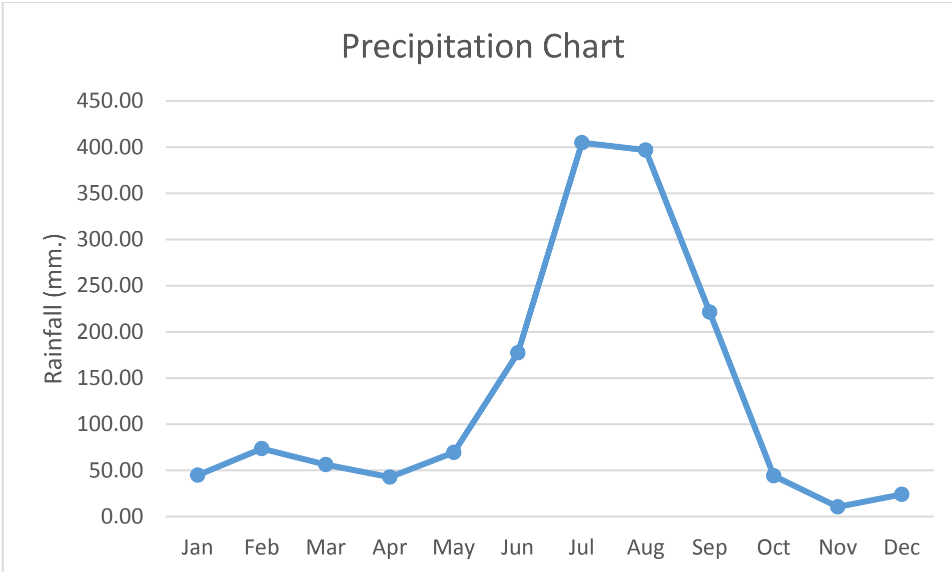


Figure 8 : Yearly Mean Rainfall at Chainpur (west) Station (1984-2013)

Calculated flow discharge for the given catchment area of return period is given below:

Table 4: Discharge for return period for Seti River

River	Catchment area (Below 3000 m)	Peak Flood (m^3/sec)					
		2 years	5 years	10 years	20 years	50 years	100 years
Bauli Gad	132.444259	138.053	224.92	290.27	358.25	454.11	531.67
Dewari Gad	30.807466	39.18015	68.79	92.32	117.67	154.68	185.52
Ghatganga Khola	29.094194	37.32039	65.72	88.32	112.72	148.38	178.13
Jadari Gad	141.178628	145.9584	237.01	305.35	376.33	476.26	557.00
Kalanga Gad	375.080926	342.9765	529.39	664.17	800.85	988.83	1137.67
Kalanga Nadi	110.810533	118.189	194.34	252.02	312.28	397.62	466.92
Sani Gad	126.771206	132.8847	216.99	280.37	346.37	439.53	514.98
Seti Nadi A	2.425174	5.533585	10.91	15.56	20.86	29.01	36.13
Seti Nadi B	46.819864	56.05248	96.34	127.86	161.50	210.10	250.27
Seti Nadi C	193.666548	192.3443	307.26	392.47	480.30	603.01	701.52
Seti Nadi D	283.53513	268.4494	420.43	531.50	644.90	801.92	926.98
Seti Nadi E	321.539912	299.6979	466.31	587.49	710.83	881.10	1016.36
Seti Nadi F	474.125467	421.1488	642.17	800.55	960.23	1178.61	1350.69
Seti Nadi G	692.557912	587.1078	877.73	1082.99	1288.00	1565.85	1783.07
Seti Nadi H	885.593388	728.419	1075.13	1317.71	1558.52	1882.97	2135.32
Seti Nadi I	1167.093353	928.0265	1350.19	1642.43	1930.58	2316.24	2614.49

River	Catchment area (Below 3000 m)	Peak Flood (m³/sec)					
		2 years	5 years	10 years	20 years	50 years	100 years
Seti Nadi J	1544.165188	1186.51	1701.25	2053.75	2398.93	2857.82	3210.63
Suni Gad	69.818591	79.13693	133.26	174.98	219.06	282.17	333.90
Syanban Khola	1.131065	3.647551	7.37	10.65	14.43	20.31	25.50
Talkoti Gad	57.881497	67.29259	114.42	150.99	189.81	245.64	291.58
Taru Gad	74.130895	83.35397	139.93	183.44	229.35	294.98	348.71

Pre-Processing in GIS environment

Here in this part, RAS layers (Stream centerline, river banks, flow path centerlines and cross sections) were created as shown in figure below which was later followed by layer setup and finally RAS-GIS import file was created which was ready for processing in Hec-Ras.

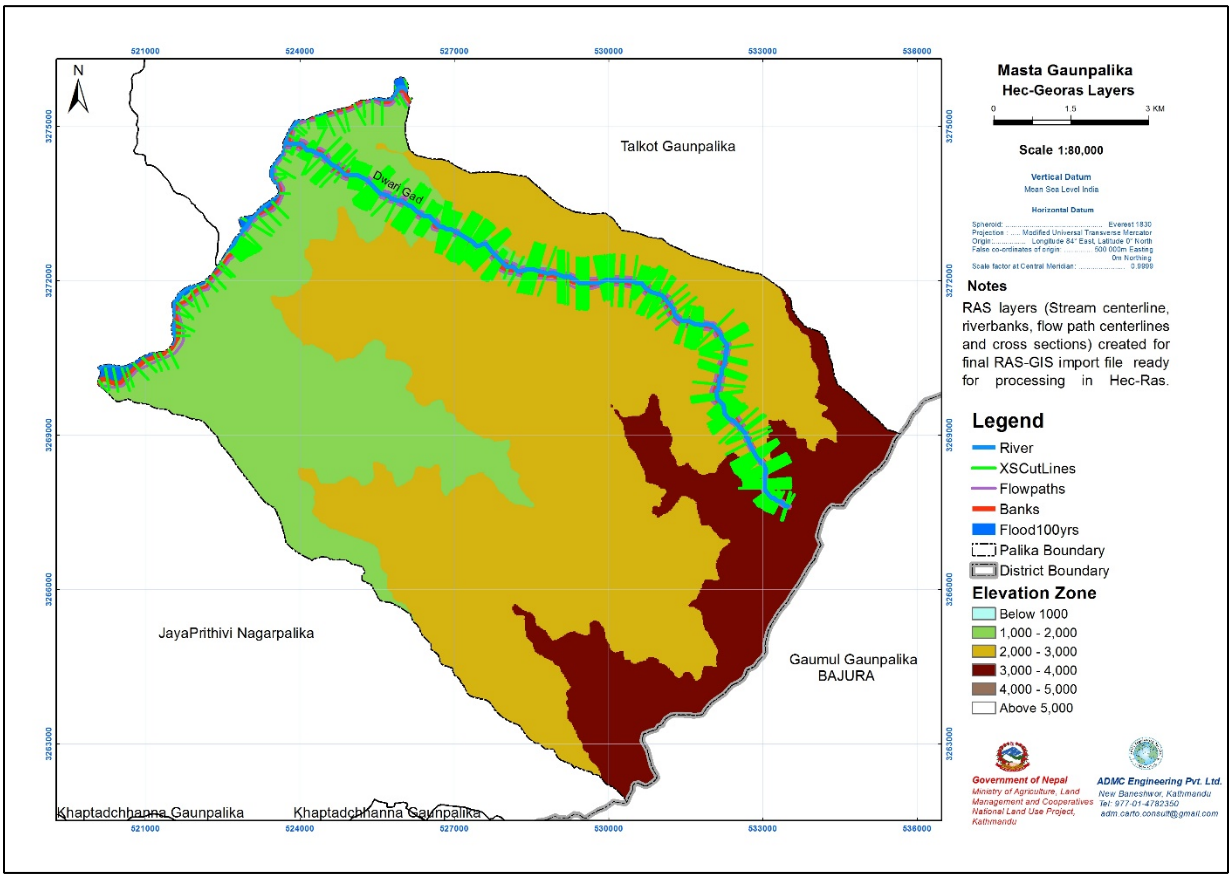


Figure 9: Hec-Georas Layers

HEC-RAS Processing

The import file thus created in HEC-Geo RAS was imported in Geometric Data Editor interface in HEC-RAS. The flood discharge for return period which we have calculated from WECS/DHM method was entered in steady flow data. Reach boundary conditions were defined as critical depth for both upstream and downstream. Manning's constant for left and right bank was set as 0.04 while 0.035 was set for centre of channel. Mixed analysis was done in steady flow analysis. Then the generated data was exported in GIS format. Process involved here is shown in figure below. Water surface profile for return periods is given in the following figures.

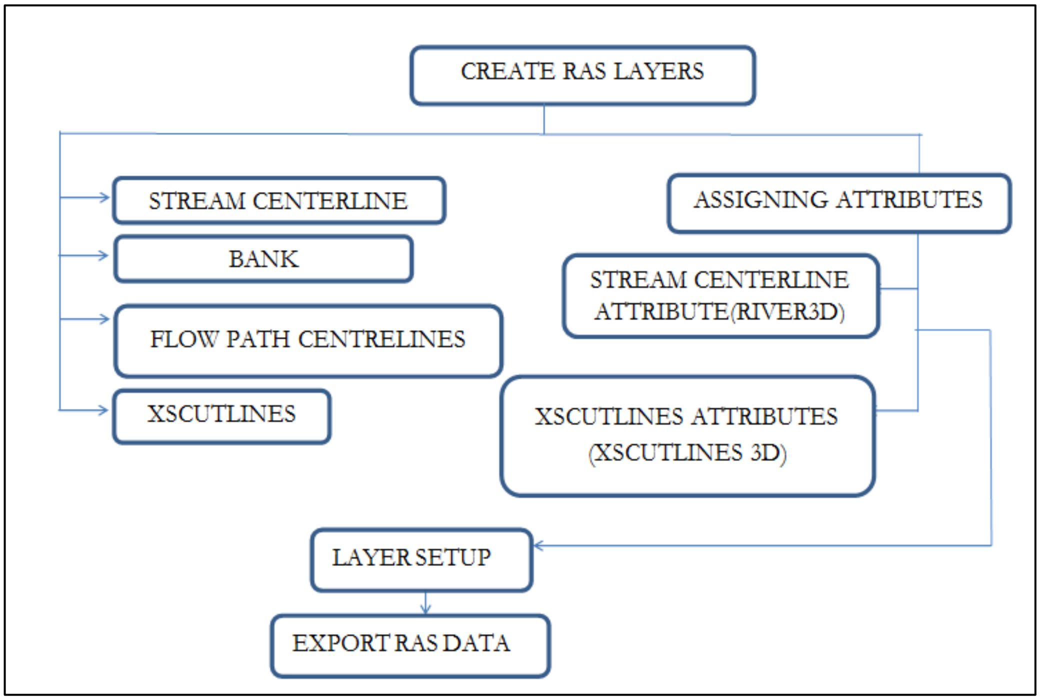


Figure 10: Flowchart for processing in HEC RAS

Processing

In this phase inundation mapping was performed with the generation of water surface which was later followed by flood plain delineation. The process involved is given below and the delineated flood is given in figure 11.

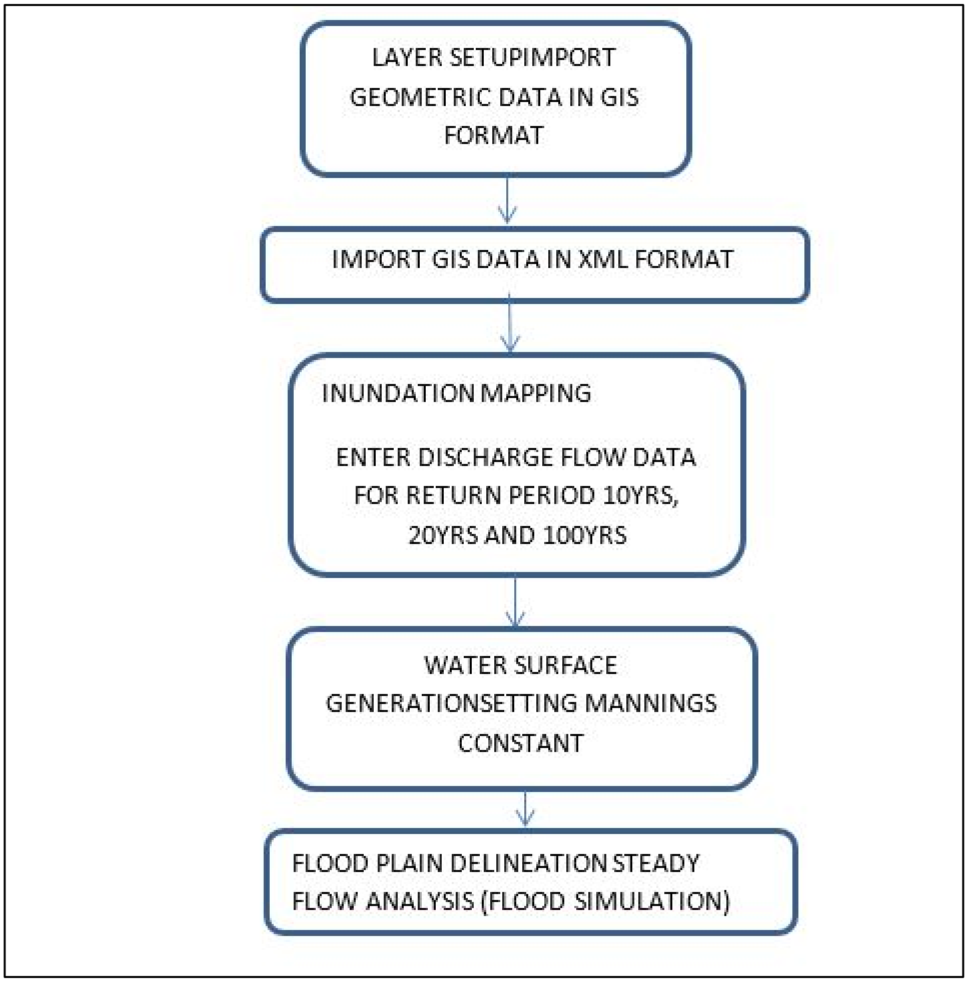


Figure 11: Process Involved in Hec Geo-Ras Processing

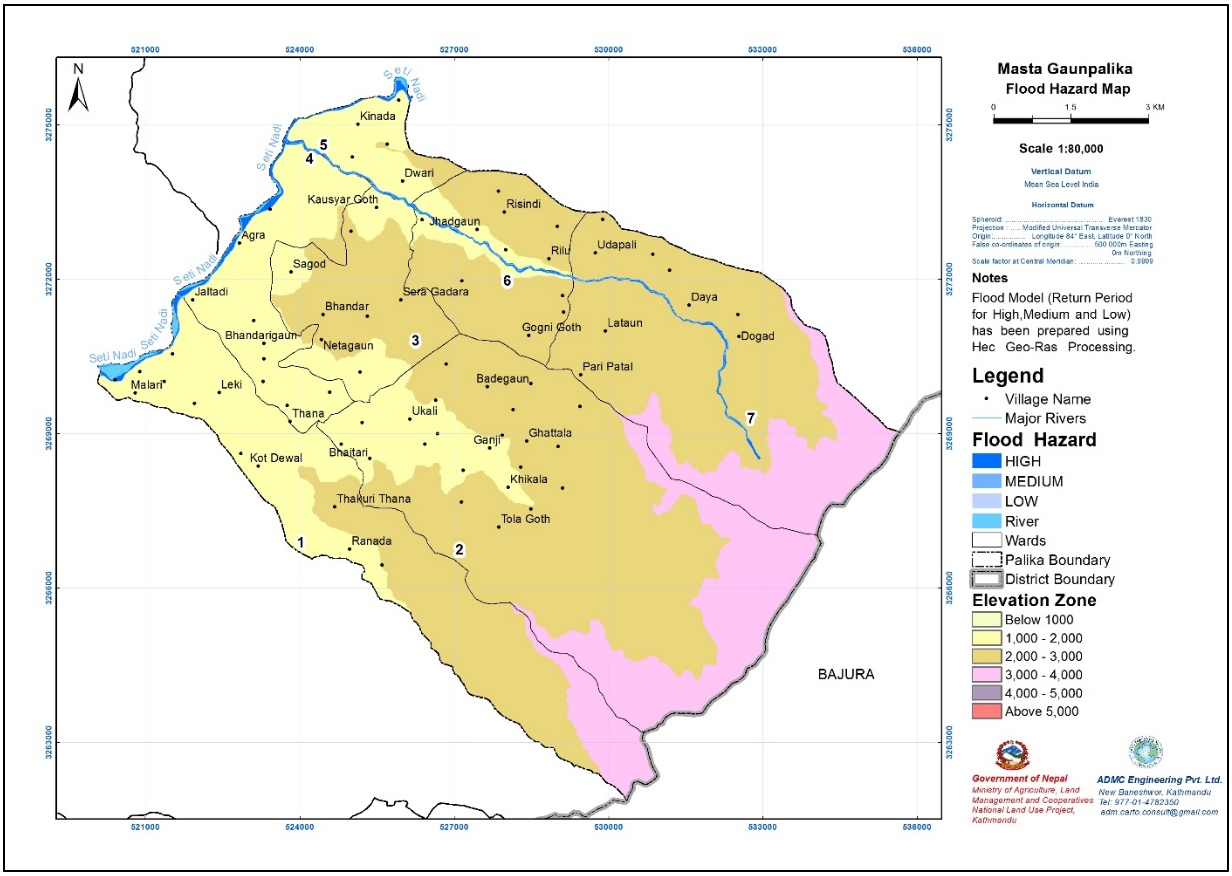


Figure 12: Flood Hazard Model for High, Medium and Low

3.1.4 Result

This delineated flood model is later used for the evaluation of land use planning by using overlay analysis in GIS environment. This process is discussed in the following section. The present land use information in the study area renders the following statistics.

Table 5: Present Land Use under Flood Risk

Land Use Type	Area (Sq. m.)	Area (Hectares)	%
Agriculture	596445.8244	59.644583	37%
Forest	489921.153	48.992114	30%
Riverine and Lake	527494.6231	52.749463	32%
Other	10568.1394	1.056813	1%
Public	7302.996229	0.730303	< 1%
Res	2170.452158	0.217045	< 1%
Grand Total	**1633903.188**	**163.390321**	100%

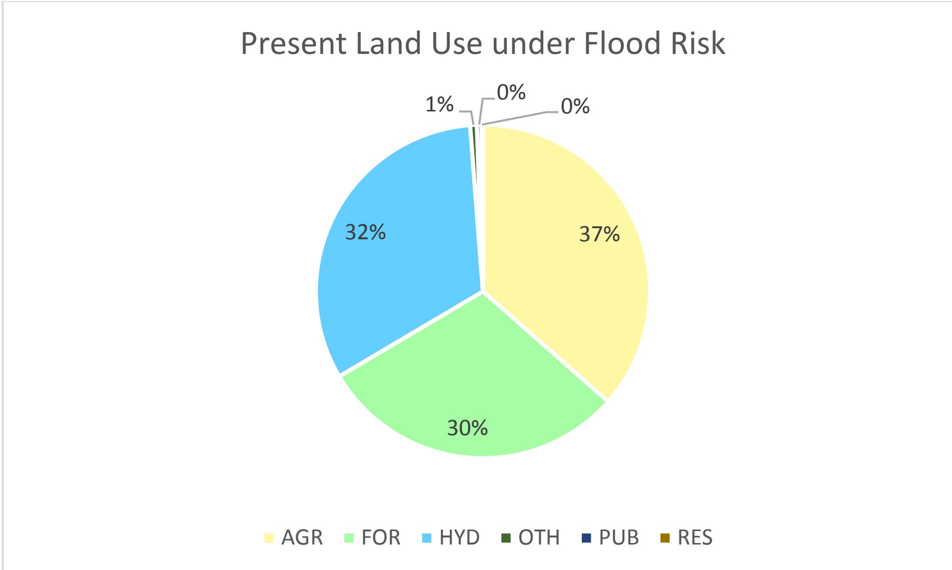


Figure 13 : Classified land use under flood Risk

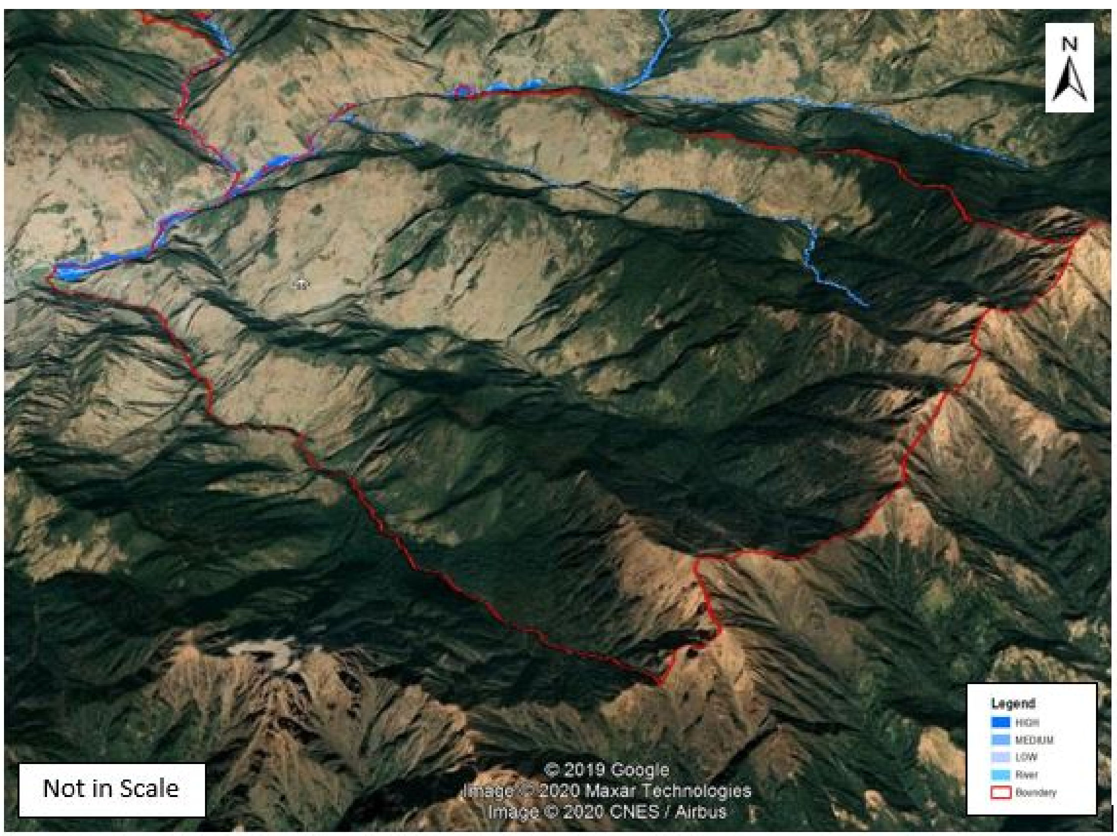


Figure 14 : Flood Risk overlaid over satellite Image

Preparing Flood Hazard Map

Flood hazard map was prepared by overlaying land use map with flood area polygon for return period. This has given clear picture of possible flood that can affect land use of the area. The assessment has been done for period which is represented in given map.

The land use zone that tends to be inundated for different return period is represented in figure 15. The data obtained for return period of 10 years, 20 years and 100 years has been graphically represented in Figure. Flood assessment for return period 30-100 years, 10-30 years and at least once in 10 years are considered as Low, Medium and High in Probability level of a hazard scenario.

Table 6: Vulnerability Class and Flood Prone Area

Vulnerability Class	Area (Sq. m.)	Area (Hectares)	%
Low	200642.0512	20.064208	18.13%
Medium	195263.2354	19.526323	17.65%
High	710503.2786	71.050327	64.22%
Grand Total	**1106408.565**	**110.640858**	100.00%

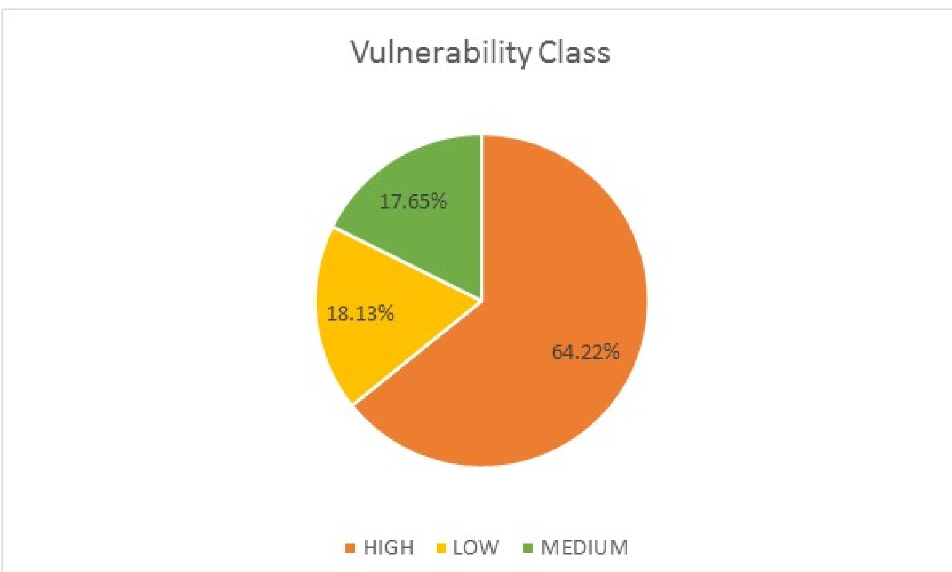
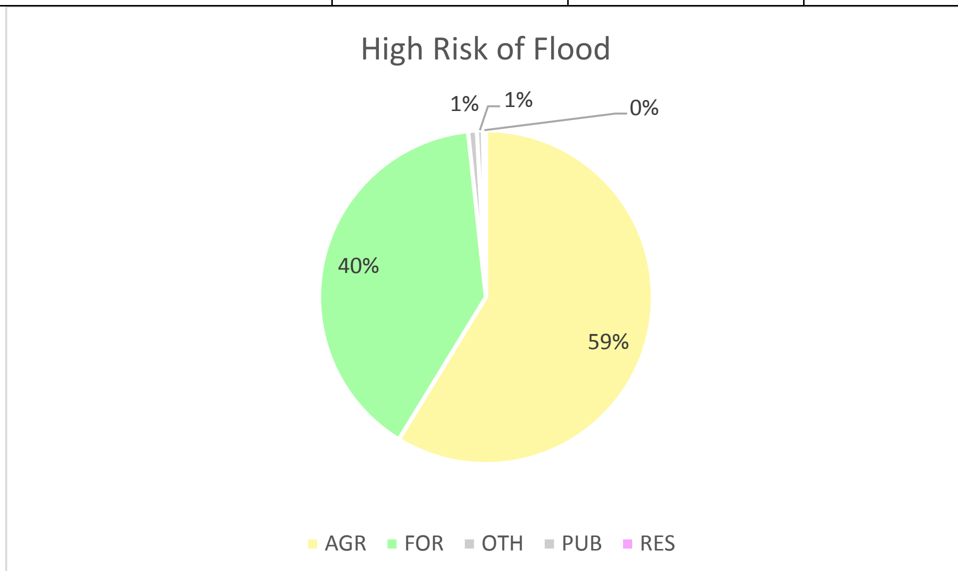
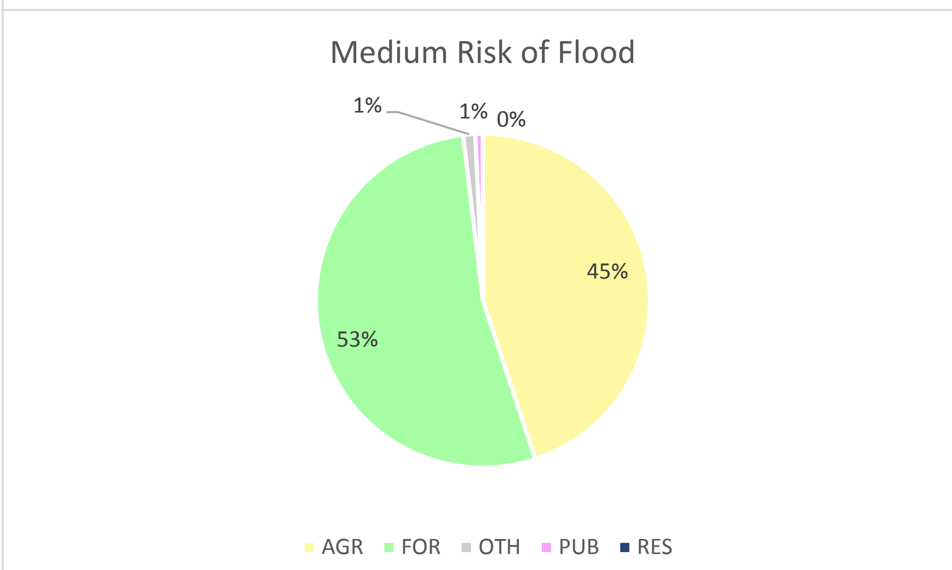


Figure 15 : Flood Depth for return period for High, Medium and Low

Table 7: Land Use Class and Flood Prone Area

Landuse	Low (ha)	Medium (ha)	High (ha)
Agriculture	9.13	8.77	41.74
Forest	10.52	10.39	28.09
Other	0.23	0.23	0.60
Public Use	0.18	0.14	0.41
Residential	0.01	< 1	0.21
Grand Total	**20.06**	**19.53**	**71.05**





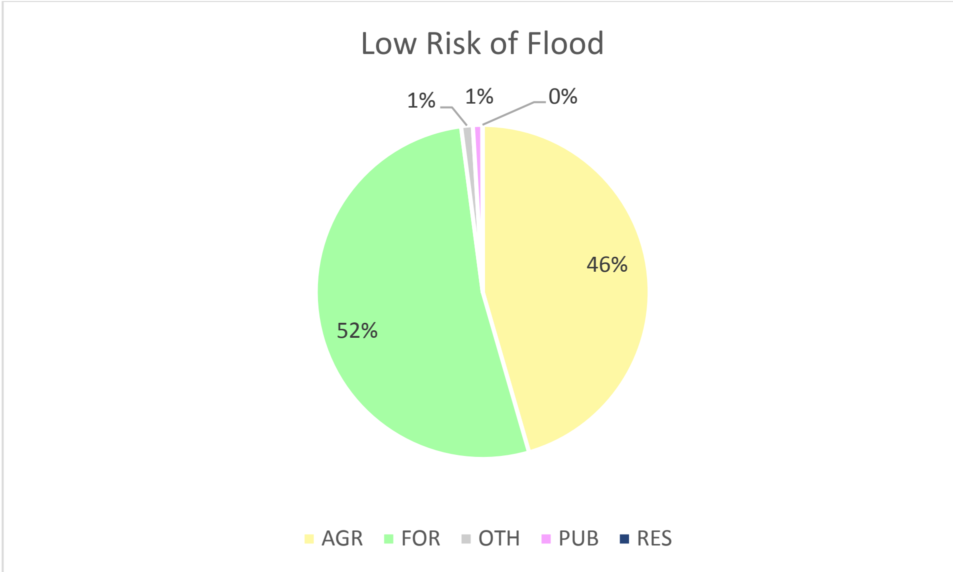


Figure 16 : Flood Prone Zone for Masta Rural Muncipality

3.1.5 Discussion

The result acquired through the analysis reveals the fact the study area needs immediate action to take against flood such as river training or embankment or levee construction to protect the given area by flood. Settlement like Dungri, Khartada and surrounding area are more prone to flood as revealed by the study. The people in such area are at risk of flood hazard so these people needs to be shifted from these areas to the area free of flood and other risk.

3.2 Fire Risk

Fire hazard is another most common natural hazard in Nepal. Fire disaster occurs mainly in the dry season between April to June. During this season the temperature in the Tarai region rises above 35° Celsius and it rains seldom. Fire disaster takes place mostly in the rural areas of the Tarai , middle Hill as well as mountain region of Nepal. Fire hazards are significantly increased with hotter dry seasons, which add to the frequency, and the intensity, of bush and forest, creating a greater hazard to life and property.

Fire hazard is also common problem in this area. The problem of fire hazard in the spring season makes very serious in the villages. Kachchi houses made by woods and thach of roof make easy for catching and spreading fire. Most of the households use firewwod for their cooking fuel which results fire spreading problem. Forest fire usually takes place during dry season in each year. Domesticated animals in the grazing land and wild animals, both are affected by the forest fire especially in the upper part of Masta Rural Municipality.

Objective of the Study:

1. Assess the status, damages and impacts of firing on forest, settlement and others.
2. Identify fire sensitive areas and causes of fire;
3. Identify preventive and control measures of fire;

Cause of Firing:

1. Very few fires are naturally caused in Nepal (NBS, 2002). Karkee (1991) observed that 40% of forest fires in the mid-hills are caused by accidents while 60% are started deliberately e.g. Shifting cultivation, forest encroachment.
2. Cattle grazing for new grass and smokers known causes of forest fires.
3. Although it is not common, local communities identified bamboo as a fire igniter. Friction exerted between bamboo culms within the clumps sometimes produce fire.
4. In settlement areas, due to negligence while cooking, firing is common house and shelter.
5. 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.
6. Industrial and chemical fires: These 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.

3.2.1 Data

The data used for analysis are as follows:

- Forest Area along with its type and maturity
- Hydro meteorological data for DHM (Department of Hydrology and Meteorology)
- Industrial, Settlement, Commercial, Public places, Petro-Chemical station with probable Fire Risk
- Major Transmission line in the study area
- Past Studies, Literature reviews, reports etc. regarding Fire Hazard in the study area
- Forest fire Identification and Monitoring system, GON/ICIMOD.

3.2.2 General Approach and Methodology Framework

General Approach: The general approach for the fire risk layer data collection are as follows:

i. For Forest:

- Identification of community forest or other plantation.
- Identification of types of forests other plantation and present management status.
- Identifying nearby settlement areas and foot trail or road along or inside the Community forest other plantation.
- Identification of risk, and its characterization with environmental effects.
- Identification of extend of fire risk area.

ii. For settlement areas and petro-chemical station.

- Identification of settlement areas and others.

- Identification of types of settlement with present status.
- Identifying nearby industries, petro-chemical station and forest.
- Identification of probable risk, its characterization with probable environmental effects.
- Identification of extend of fire risk area.

Methodology Frameworks:

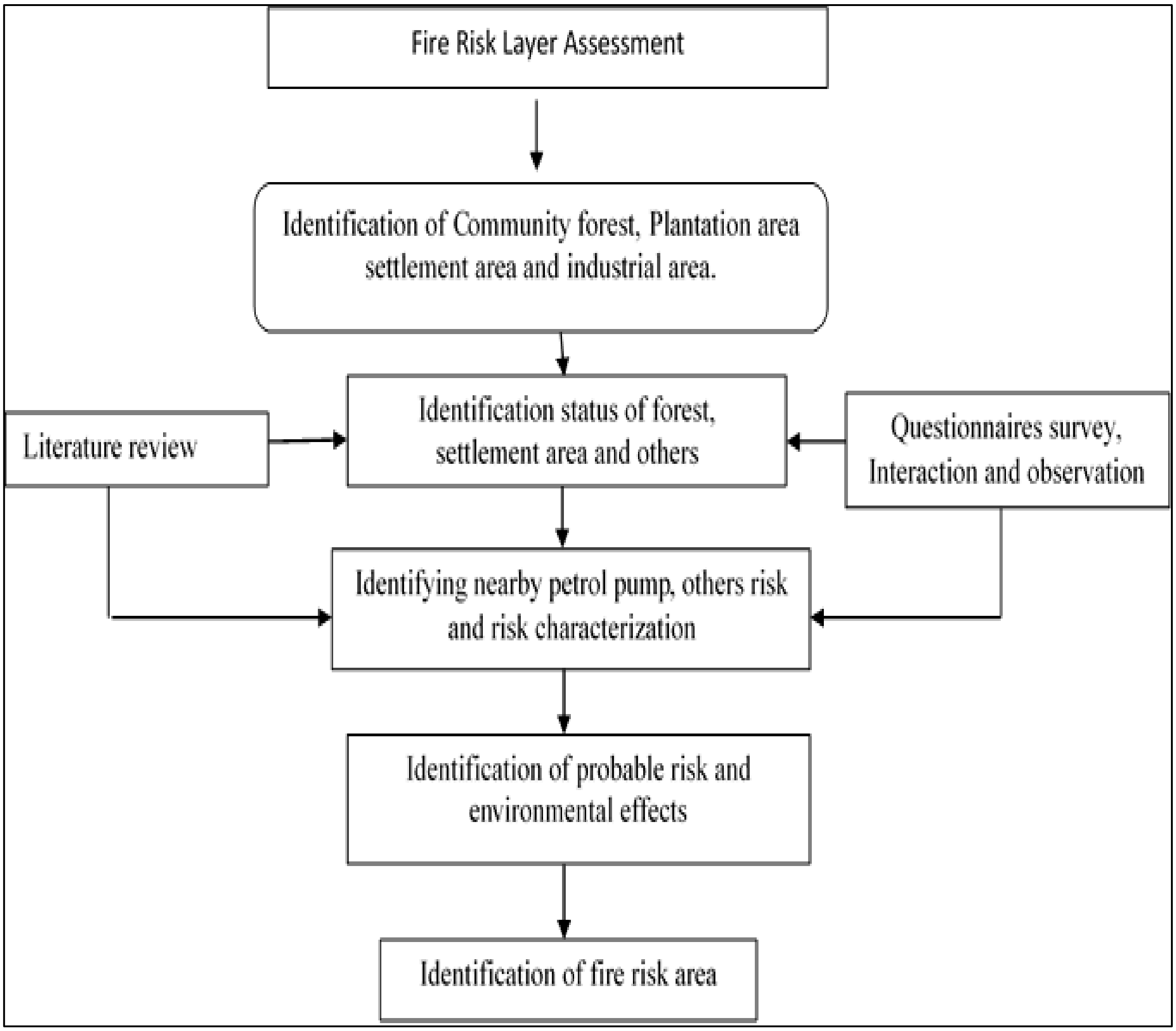


Figure 17: Flowchart for Identification of Fire Risk

3.2.3 Methods

The following methods were adopted for the collection:

- **Literature Review**

The relevant information was collected from various books, publications, journal etc. to access the fire risk. Similarly, different types of maps such as topographical map, images were also studied. Required relevant information has been drawn from different internet websites.

- **Field Investigation**

A detailed field investigation was carried out for the data collection. Each Gaunpalika was visited during the field visit. The data regarding to community forest, settlement status, industries and Petro-chemical station was taken. Along with this, the probable environmental impact created by past firing was collected.

- **Questionnaires Survey and Interaction approach**

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

3.2.4 Result

Forest Fire has been seen in the past in the study area and has done significant damage to the local ecosystem. Study from Forest Fire Detection and Monitoring system from ICIMOD has been tracing forest fire from satellite data available from 2012. Major portion of the study area is covered with forests so there is significant risk of forest fire. In addition, scattered Bamboo plantations were seen in this package which is fire sensitive too since it produces large amount of leaf litters. Plantation areas nearby the settlements, in general are more fire sensitive than the other areas due to possibility of extending fire from the settlements. So some distance should be maintained to minimize the risk of firing spreading from settlement area. Similarly, possibility of ignition of fire is higher in the forests adjoining trails or roads. So some distance should be maintained to minimize the risk.

Many studies suggest that fire occurring in chure and hilly region are due to the carelessness of human behavior. Poor handling of fire for cooking and other purposes, electrical short circuits, poor wiring, poor handling of gas cylinders and stoves, throwing cigarette butts carelessly, human negligence and lack of adequate fire safety measures are the major factors contributing to the outbreak of fires. The settlement areas of this package are particularly susceptible to fire hazards due to the heat, the house with thatch roofing, and frequent lightning strikes and windstorms. Most incidences of fires occur in the dry summer season, festivities, crop harvesting, and load-shedding.

3.2.5 Discussion

There is significant forest cover in this area. Planted area encroachment nearby settlement and trail will increase the risk of forest fire, but in community forest these things are managed by community so the risk of firing is also low.

Most of the houses in the study area were constructed from locally available raw material. Houses with straw roofing are very susceptible to fire hazards as the material easily catches fire. In addition, houses for residential purpose are developed in cluster basis which are more susceptible of catching fire and spreading over there immediately due to close connectivity especially in the dry season. In the study area Improper management of straw; use of mechanical threshers; burning straw for heat; feeding cooking stoves with rich husks and packed long cow dung; preparing animal feed on outdoor stove throughout the day and other causes are the main reason for firing. Since the majority of houses were built from stone and wood, there is high risk of firing at any time during cooking and heating. This risk could be reduced if we can give proper attention after cooking and house heating. During site visit, besides few cases we don't find any devastating firing records that have damaged whole settlement area. One good aspect of settlement pattern of the study area is that, scattered settlement area, which will reduce the firing risk in whole settlement areas. But, the settlement area must be built in clumped pattern with good spacing, which will reduce the firing risk. Along with this, artificial pond must be built to control fire if it occurs suddenly at house or at whole settlement area.

Concrete building of sub urban areas as well as rural areas they area also risk to firing because of fault electric wiring and equipment, and LPG gas, but the risk is low. Regular maintenance of those equipment will reduce the risk. Similarly, due to electric short, factories and industries are also in risk of firing. Firing on industries is very hard to control, so the loss on environment and on natural resources will be very high. So, some distant should be kept between two industries and with settlement area too which will reduce spreading of firing from one industries to another industry and on settlement area. Petro-chemical sources station are always at high risk. The impact of firing on petro-chemical station is huge which will destroy live and property and cause huge environmental and economic losses. So, this should be kept at least 1km far from the settlement area.

Finally, fire preparedness activities most be carried out, which includes spreading messages through television, radio, street drama, video, folk songs, drills, posters, pamphlets, and hoarding boards to reduce the risk of firing.

3.3 Landslide Risk

Landslide is defined as “a collapse of a mass of earth or rock from a mountain or cliff” as per Oxford dictionary. Landslides can result in enormous casualties and huge economic losses in mountainous regions. In order to mitigate landslide hazard effectively, new methodologies are required to develop a better understanding of landslide hazard and to make rational decisions on the allocation of funds for management of landslide risk. Recent advances in risk analysis and risk assessment are beginning to provide systematic and rigorous processes to enhance slope management. In recent years, risk analysis and assessment has become an important tool in addressing uncertainty inherent in landslide hazards. (F.C Dai, 2001).

3.3.1 Data

The data used for the analysis are as follows:

- Topographic Data
- Satellite Images
- Geological Data
- Survey/Questionnaires

3.3.2 General Approach and Methodology Framework

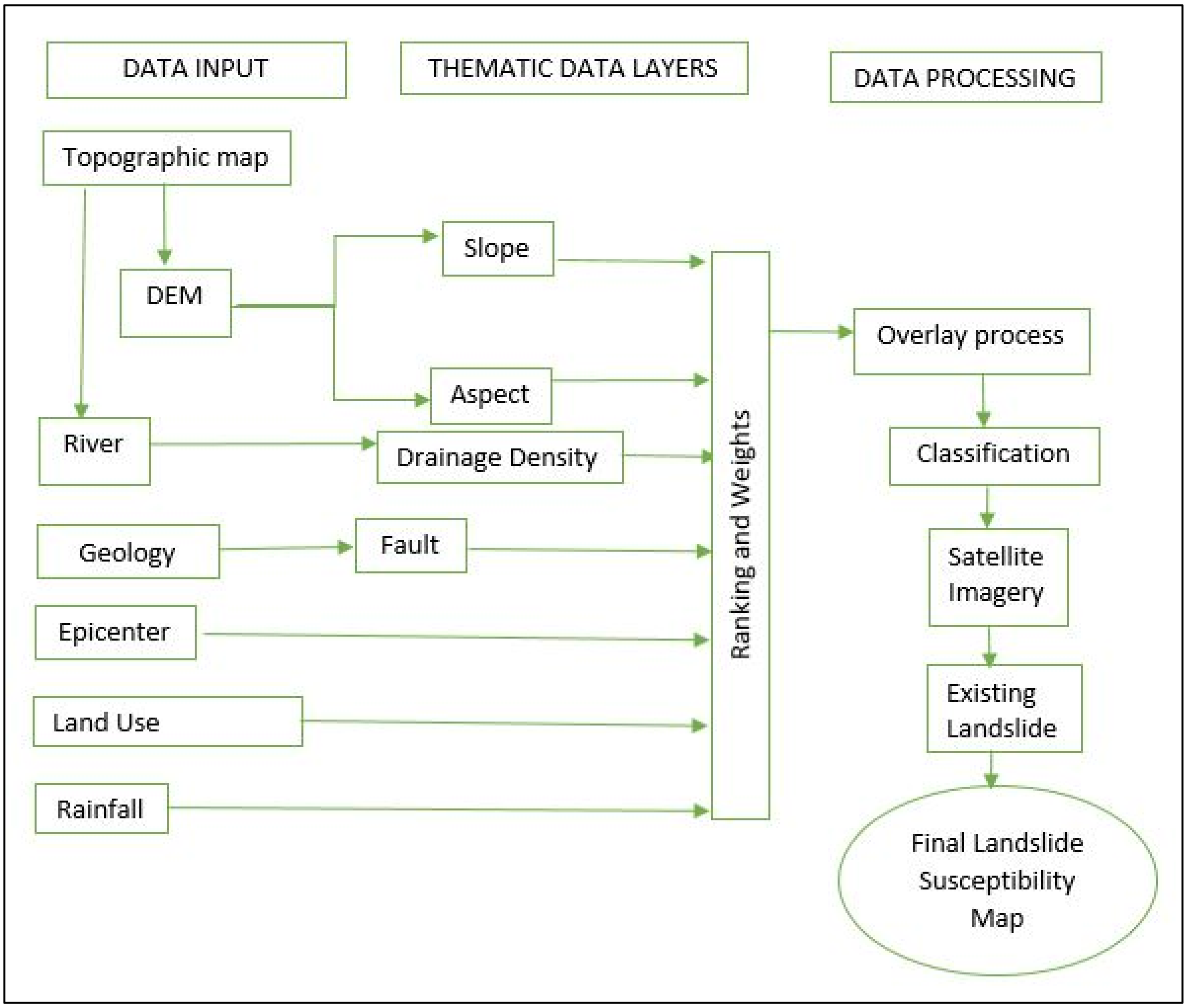


Figure 18: Flowchart for Identification of Landslide Risk

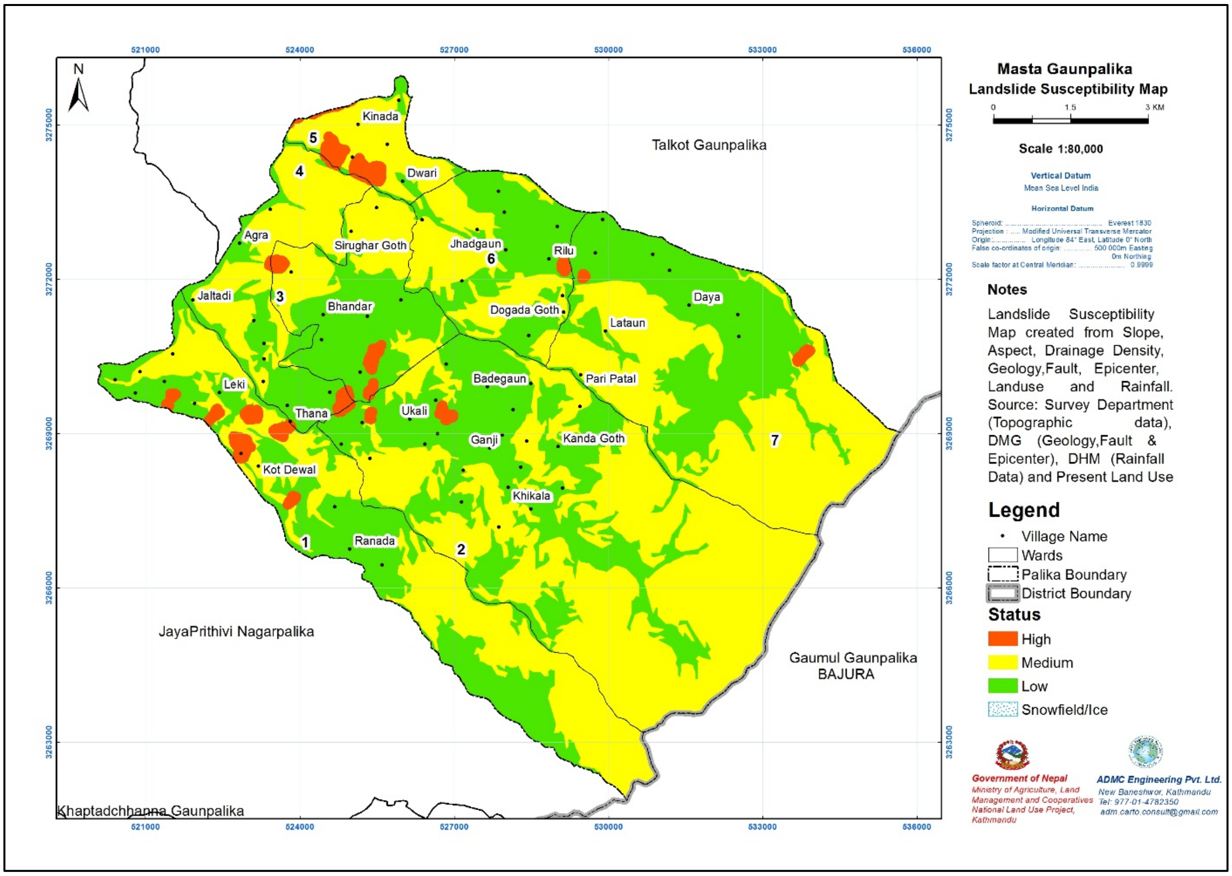


Figure 19: Landslide Susceptibility Map for Masta Gaunpalika

These are the major causes of Landslide.

1. Geological causes
    a. Weak or sensitive materials
    b. Weathered materials
    c. Sheared, jointed, or fissured materials
    d. Adversely oriented discontinuity (bedding, schistosity, fault, unconformity, contact, and so forth)
    e. Contrast in permeability and/or stiffness of materials

2. Morphological causes
    a. Tectonic or volcanic uplift
    b. Glacial rebound
    c. Fluvial, wave, or glacial erosion of slope toe or lateral margins
    d. Subterranean erosion (solution, piping)
    e. Deposition loading slope or its crest
    f. Vegetation removal (by fire, drought)
    g. Thawing
    h. Freeze-and-thaw weathering

i. Shrink-and-swell weathering

3. Human causes
   a. Excavation of slope or its toe
   b. Loading of slope or its crest
   c. Drawdown (of reservoirs)
   d. Deforestation
   e. Irrigation
   f. Mining
   g. Artificial vibration
   h. Water leakage from utilities

3.3.3 Methods

The following methods were adopted for the collection:

- **Literature Review**

The relevant information was collected from various books, publications, journal etc to access the landslide risk. Similarly, different types of maps such as topographical map, images were also studied. Required relevant information has been drawn from different internet websites.

- **Field Investigation**

Disaster such as floods, landslides, thunderstorm, fire, hailstorm, windstorm and epidemic brings a huge loss in life and properties every year in Nepal during summer season. Due to diverse geographical coverage, Nepal is prone to various geological and hydro-meteorological hazards. Nepal's geographic location also makes it extremely susceptible to such activity. Here, it is tried to show type of disaster, losses and damages induced by different kinds of disaster.

Landslide is the second important hazard though it is not common in this Rural Municipality. There are many small landslides all over the villages. Major landslides which are more sensitive, located in ward no two, three and four by which 40 households are affected by lossing their private land, houses and animals. Similarly, the flood and windstorm damaged private property such as house, and goth in ward number three which affected 23 households. The estimated total value of disaster (damages and losses) caused by the landslides, flooding windstorm is NPR 45, 15,000.

Table 8: Loss/damage of private properties

			Area	**Loss (Rs)**				
Landslide	2,3, 4	40		3,050,000	12	400,000	4	55,000
Flood	3	13		500,000				
Windstorm		10			10	450,000		
Fire							5	60,000
Total				35,50,000				1,15,000

Source: Field survey, Masta Rural Municipality Profile, 2075

- **Questionnaires Survey and Interaction approach**

The data were collected through the extensive consultation with government representatives at various levels, experts and professionals, local communities and industrial stockholders. Additionally, interactive methods were adopted to collect the data among local government representatives.

- **GIS Analysis**

The available topographic data were analyzed during the landslide risk assessment.

3.3.4 Result

There is significant risk of landslide in this Gaunpalika that damage settlement and agricultural land. Tola Goth, Dungrakot and Bhate kholagaun are the settlement areas which are under risk of landslide.

3.4 Seismic Risk

Seismic Hazard is defined as the probabilistic level of ground shaking associated with the reoccurrence of the earthquakes. It is realized by depicting levels of chosen ground motion that likely will not be exceeded in specified exposure of time. (DMG, 2002)

3.4.1 Data

The analyzed data has been used from the secondary data. The data has been produced by maps of Epicenter of the Earthquake in Nepal Himalaya, Probabilistic Seismic Hazard Assessment Map of the Nepal Himalaya (DMG, 2002), and Seismic Risk Zonation Map of the Nepal Himalaya (Bajracharya, 1994).

3.4.2 General Approach and Methodology Framework

The seismicity deals with the preliminary investigation of maximum credible earthquake and seismic coefficient of the project area. 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 and the Lesser Himalaya.

Preliminary seismic hazard assessment of the country using Gumbel's third asymptotic extremes with the instrumental seismicity database of ISC is carried out by Bajracharya (1994) for different return periods 50, l00, 200 and 300 years, Attenuation model with mean value of McGuire and Oliveira ".

Return period (years)	Effective Horizontal seismic coefficient (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 coefficients 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:

- Simplest Method
- Empirical Method
- 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.

3.4.3 Methods

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Where, A_{eff} is effective design seismic coefficient

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

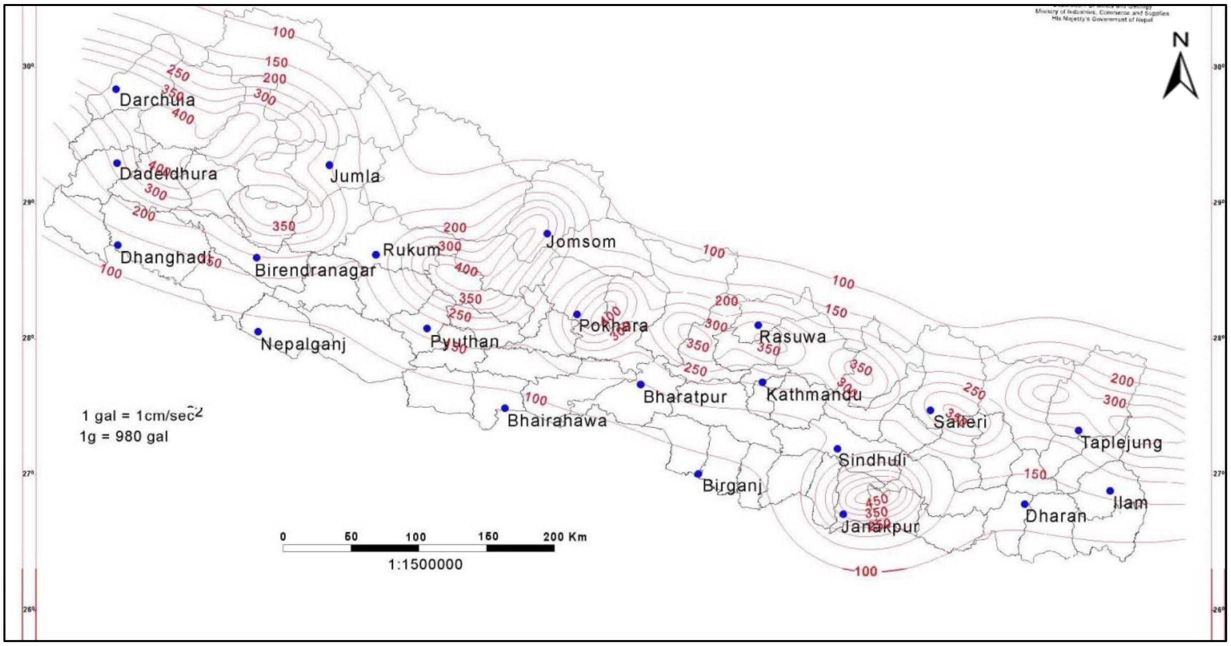

Figure 20: Probabilistic Seismic Hazard Assessment Map of the Nepal Himalaya

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.

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3.4.4 Result

For the minimum acceleration of 200-gal, reduction factor of 0.50 the calculated effective design seismic coefficient is approximately 0.10.
For the maximum acceleration of 400-gal, reduction factor of 0.50 the calculated effective design seismic coefficient is approximately 0.20.

Hence, the design horizontal seismic coefficient ranges from 0.10 to 0.20 (calculated values).The maximum and minimum value shows that the return period is between 100 to 200 years. In every 200 years, the area feel big earthquake with peak horizontal acceleration of between 0.10 to 0.20 g.

3.4.5 Regional Seismicity

The evolution of the great Himalayan arc is the result of collision between the Indian and the Eurasian tectonic plates. As the Himalaya lies in the plate boundary, the region is considered as one of the seismically active zones of the World as evidenced by many great earthquakes from the historical time. 1897 Asam earthquake, 1905 Kumaon earthquake, 1934 Nepal-Bihar earthquake, 1950 Asam earthquake, 2005 Kashmir earthquake, 2015 Gorkha earthquake are the great earthquakes that shocked the entire Himalayan region during the last century.

Regional seismicity map is presented in Figure below. Data from 1994 to August 2018 are compiled from USGS, ISC and NSC catalogs.

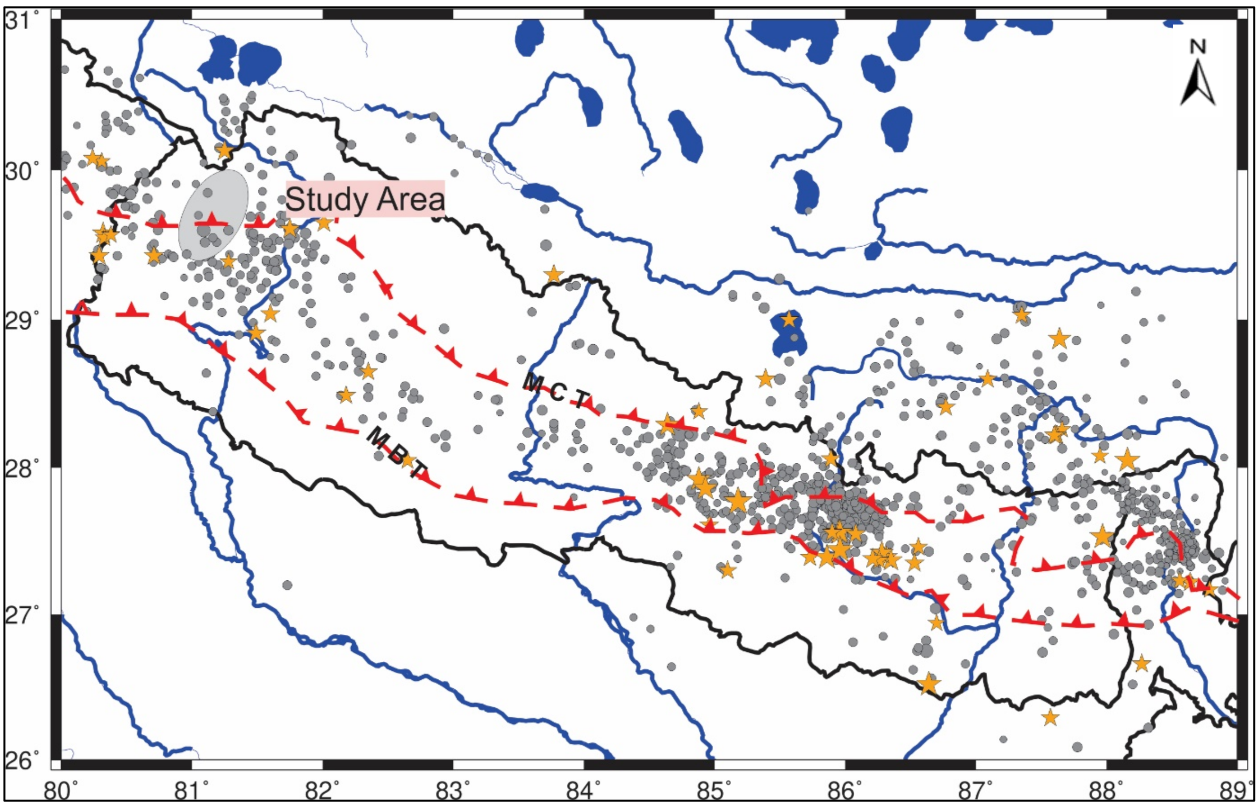

Figure 21: Epicentral map showing regional seismicity in and around Nepal. Grey colored dot represents epicenters of earthquake (1994-July, 2018) with magnitude Ml >4.0, orange colored stars represent epicenters of earthquake with magnitude M > 5.0.

Source: National Seismological Center

3.4.6 Seismicity in Nepal

As Nepal lies in the central part of the Himalaya, many great to strong earthquakes have occurred since the historical time. However, the seismic network was introduced in 1978 by the National Seismological Center (NSC) under Government of Nepal evidences of strong to large historical earthquakes are recorded in monuments and other archaeological documents.

In this regard the earthquake catalog of the Nepal Himalaya is still incomplete so as to determine the nature of recurrent large earthquakes.
The tectonic features such as the Main Central Thrust, the Main Boundary Thrust, Himalayan Frontal Thrust and other active regional faults are the main sources of the earthquake in Nepal. Nepal has experienced several great and strong earthquakes over the past centuries that have resulted in substantial property damage and loss of life. Recent earthquakes of larger magnitude that have occurred in Nepal are summarized in Table below.

Table 9: Summary of earthquakes of Nepal with M>6.

S.N.	Location of epicenter	Year	Magnitudes
1.	Sindhupalchok, Central Nepal	1833	8.0
2.	Darchula, Far Western Nepal	1916	7.3
3.	Chainpur, Eastern Nepal	1934	8.3
4.	Dolakha, Central Nepal	1934	6.8
5.	Kaski, Western Nepal	1954	6.4
6.	Darchula, Far Western Nepal	1966	6.3
7.	Darchula, Far Western Nepal	1966	6.1
8.	Bajhang, Far Western Nepal	1980	6.5
9.	Udaypur, Eastern Nepal	1988	6.6
10.	Taplejung, Eastern Nepal	2011	6.9
11.	Gorkha, Central Nepal	2015	7.9
12.	Dolakha, Central Nepal	2015	7.3

Source: National Seismological Center

Discussion:
The area is close to Main Central Thrust than Main Boundary Thrust. Seismicity analysis shows low seismic activities in the project area which lies in the Central Seismic Gap of the Himalaya. The area exhibits thrust regime of seismotectonic stresses.

3.5 Industrial Risk

The basic cause of pollution is industrialization. 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. No industry is found in this area, so there is no chance of industrial risk.

Methodology Frameworks:

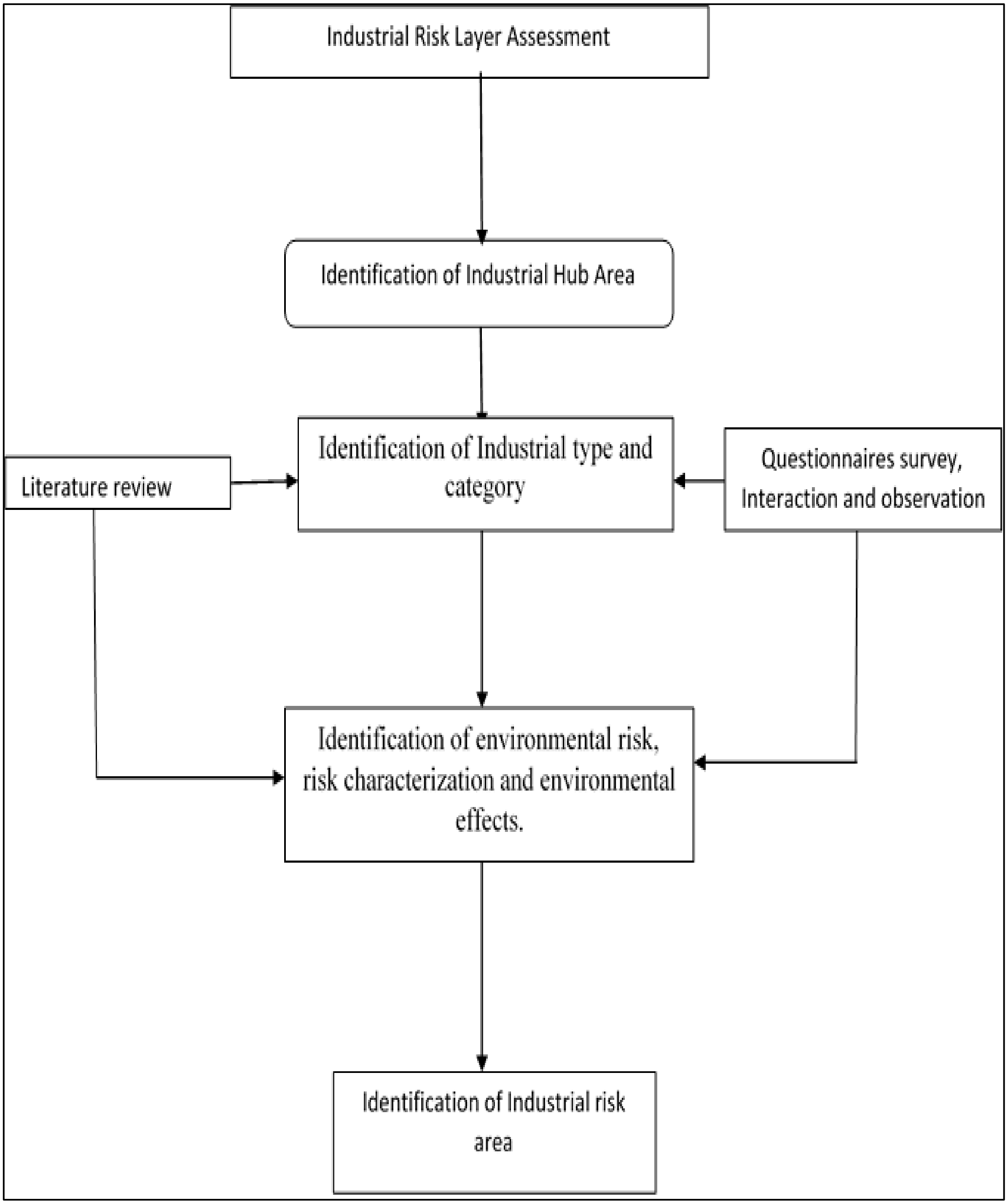

Figure 22: Flowchart for Identification of Industrial Risk

3.5.1 Methods

The following methods were adopted for the collection:

- **Literature Review**

The relevant information was collected from various books, publications, journal etc. to access the fire risk. Similarly, different types of maps such as topographical map, images were also studied. Required relevant information has been drawn from different internet Web Pages.

- **Field Investigation**

A detailed field investigation was carried out for the data collection. Each Muncipality/Gaunpalika was visited during the field visit. The data regarding to industry type, category, capacity and probable environmental impact created by that environment was collected.

- **Questionnaires Survey and Interaction approach**

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

3.5.2 Result

No major industries were found in this Gaunpalika. So, there is no industrial risk in this Gaunpalika.

3.5.3 Discussion

Industries mainly affects the air quality, sound quality and water quality in the surrounding area. The industrial risk will be higher at the nearer site and vice versa. The risk due to air pollution will increase or decrease depending on the flow of air and also depends on 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. The volume of industries present on this Gaunpalika is zero, although pollution controls measures should be properly installed in order to minimize environmental impact. Furthermore, separate corridor must be made for industrial growth in sustainable and environmental friendly way.

3.6 Health Center related health hazards and risks

There are 9 Health centers in the Gaunpalika. It is located adjacent to the main settlement of the Gaunpalika. Local people visit the center for basic health service but in case of serious illness and degenerative diseases they visit higher order hospitals located at Dhangadhi or at Kathmandu. Whereas Health Centers are essential components of basic service provisions at the local level, the immediate surroundings of the facility are not devoid of hazards and risks.

Hospitals and health centers produce hazardous wastes and improper disposal pose health risks to the local people and the visitors. The risks are primarily associated with

- Hazardous waste collection and disposal space
- Burial pits outside the building
- Disposal area for chemical waste
- Incineration furnace related gases and residues

From environmental health perspective the incinerator ash, discarded medicines, cytotoxic substances and solid chemical waste should be treated through secured landfill. To minimize health risks posed by hospital wastes (general and bio-medical) and to ease disposal, treatment of waste is required. This is primarily to:

- disinfect the waste so that it is no longer the source of infection.
- reduce the volume of the waste.
- make waste unrecognizable for aesthetic reasons.
- make recycled items unusable.

All health facilities must have operational manuals in order to address health risks associated due to their location and wastes/risks posed by their activities.

3.7 Other Risk in the study area

3.7.1 Soil Erosion

Soil erosion is a major issue in Nepal, causing the loss of topsoil and fertility in agricultural land in mountainous terrain. Estimation of soil erosion in Nepal is essential because of its agriculture-dependent economy (contributing 36% to national GDP) and for preparing erosion control plans (Koirala Et al., 2019). Soil erosion by rainfall and surface water flow is generally affected by five factors: Rainfall erosivity, soil erodibility, topography, surface coverage, and support practices (Renard, 1997).

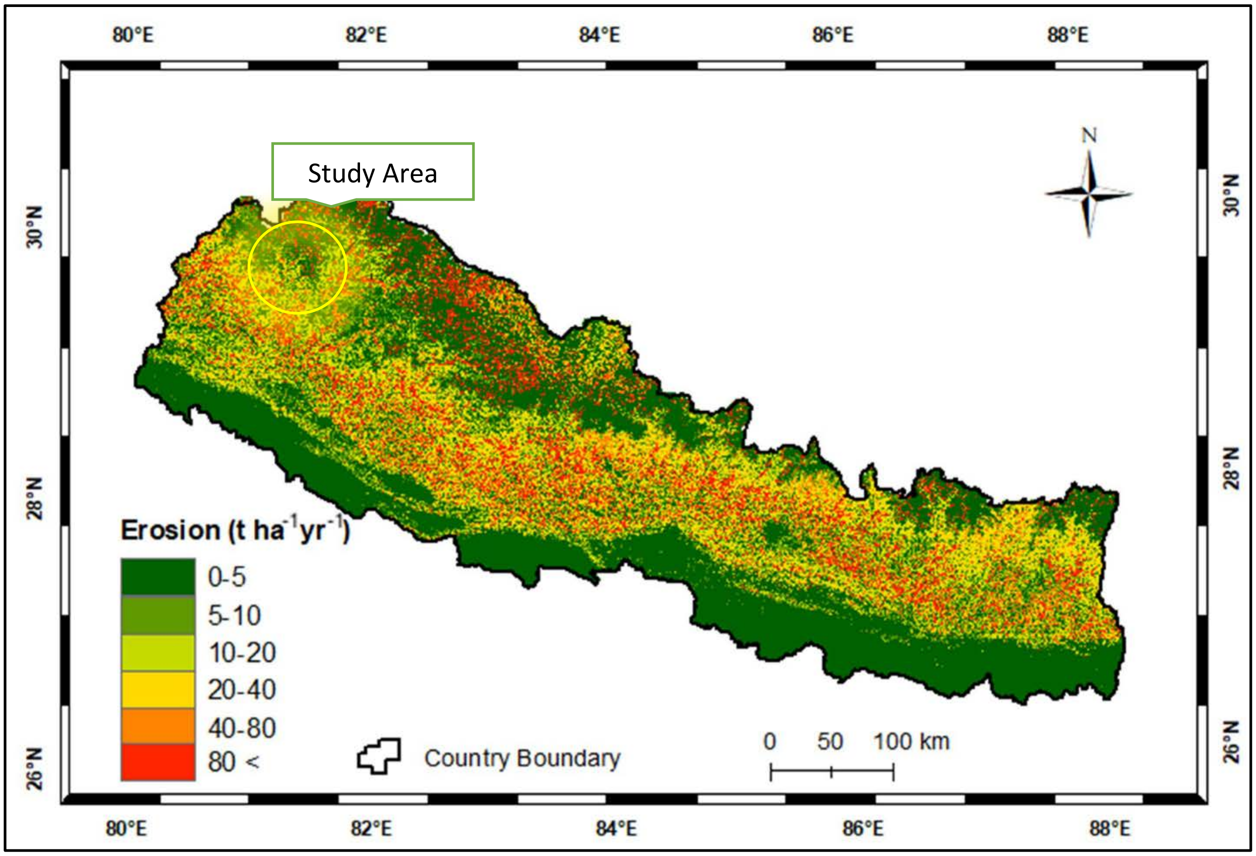

Figure 23: Map of Nepal showing Potential Soil Erosion Rate (t / ha /yr.) of Nepal

(Source: Koirala Et al., 2019)

According to a recent study, soil erosion in Nepal is found higher in the hills and mountainous regions compared to terai. As seen in the map above, terai region with relatively flat terrain have less potential soil erosion as compared to hills and mountains with steep to very steep. Further the study reported the mean soil erosion rate was significantly high (34 t ha-1 yr^{-1}) for steep slopes (> 26.8%) and low (3 t ha^{-1} yr^{-1}) for gentle slopes (< 5%). Based on LULC, the mean erosion rate for barren land was the highest (40 t ha^{-1} yr^{-1}), followed by agricultural land (29 t ha^{-1} yr^{-1}), shrubland (25 t ha^{-1} yr^{-1}), grassland (23 t ha^{-1} yr^{-1}) and forests (22 t ha^{-1} yr^{-1}).

Masta Gaunpalika of Bajhang District, lies in the steep to very steep region with very less area falling under flat terrain. The area above 4500 m. with mostly rocky terrain have lesser impact of soil erosion whereas areas below 4500 with steep slope and loose soil have higher impact of soil erosion. The region with steep to very steep slope has higher tendency of soil erosion rate ranging from 20-80 ton/ha/year and above whereas flat terrain has lesser tendency of soil erosion rate ranging from 0-20 ton/ha/year. The study also elaborates, the mean erosion rate for barren land found to be the highest followed by agriculture, shrubland, grassland and forests.

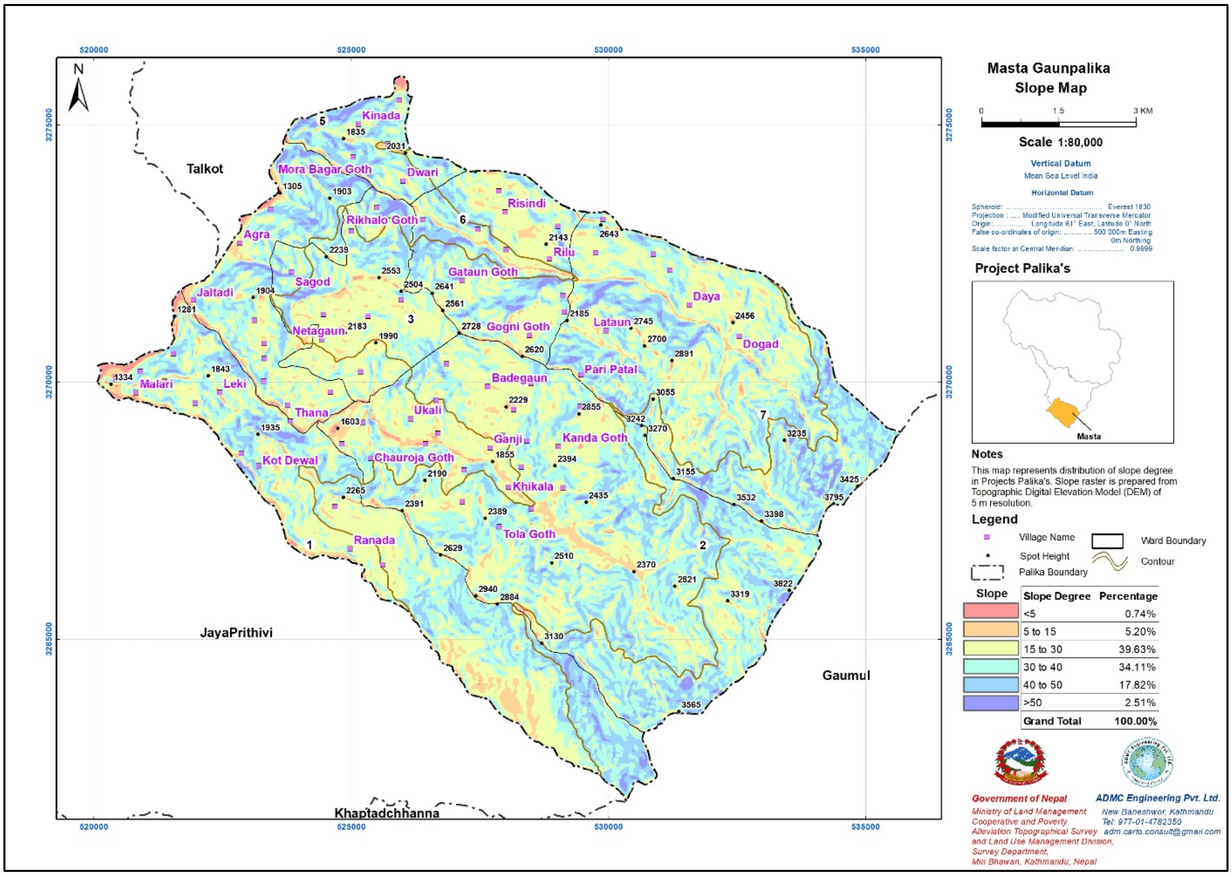

Figure 24: Slope Map of Masta Gaunpalika

(Data derived from topographical map, Survey Department)

Some parts of Masta face the problem of drought. Uneven and irregular monsoonic rainfall is the main factor of drought. The mountainous region (the northern belt) is generally dry. The lack of irrigation facilities makes the problem even more serious as prolonged drought condition has adverse effect in crop production.

Also, Windstorm occur mainly during the dry season between March to May. Thunderbolt occurs during the monsoon and hailstorm takes place during the beginning and end of the monsoon. Hailstorm causes heavy losses of agricultural crops though human life loss is seldom. Windstorm and thunderbolt cause the loss of human life as well as physical property.

Chapter 4: RISK IN THE STUDY AREA

4.1 Existing risk in the study area

The study area holds major threat of Landslide along road, flood and inundation alongside the rivers and forest fire. Major rivers flowing though the study area are Seti Nadi and Dwari Gad. Mainly the agricultural area is under high threat from the flood and inundation. Other existing threats include the Forest Fire Hazards. Natural Forest Fire risk is seen in dry season. In case of Seismic risk, Main Central Thrust is the thrust line which is near from the study area considered as the weak zone. The area is prone to landslide mostly in the sloppy terrain alongside road in monsoon season. The intensity of the damage is moderate to high and proper management practice can help reduce to prevent further damages.

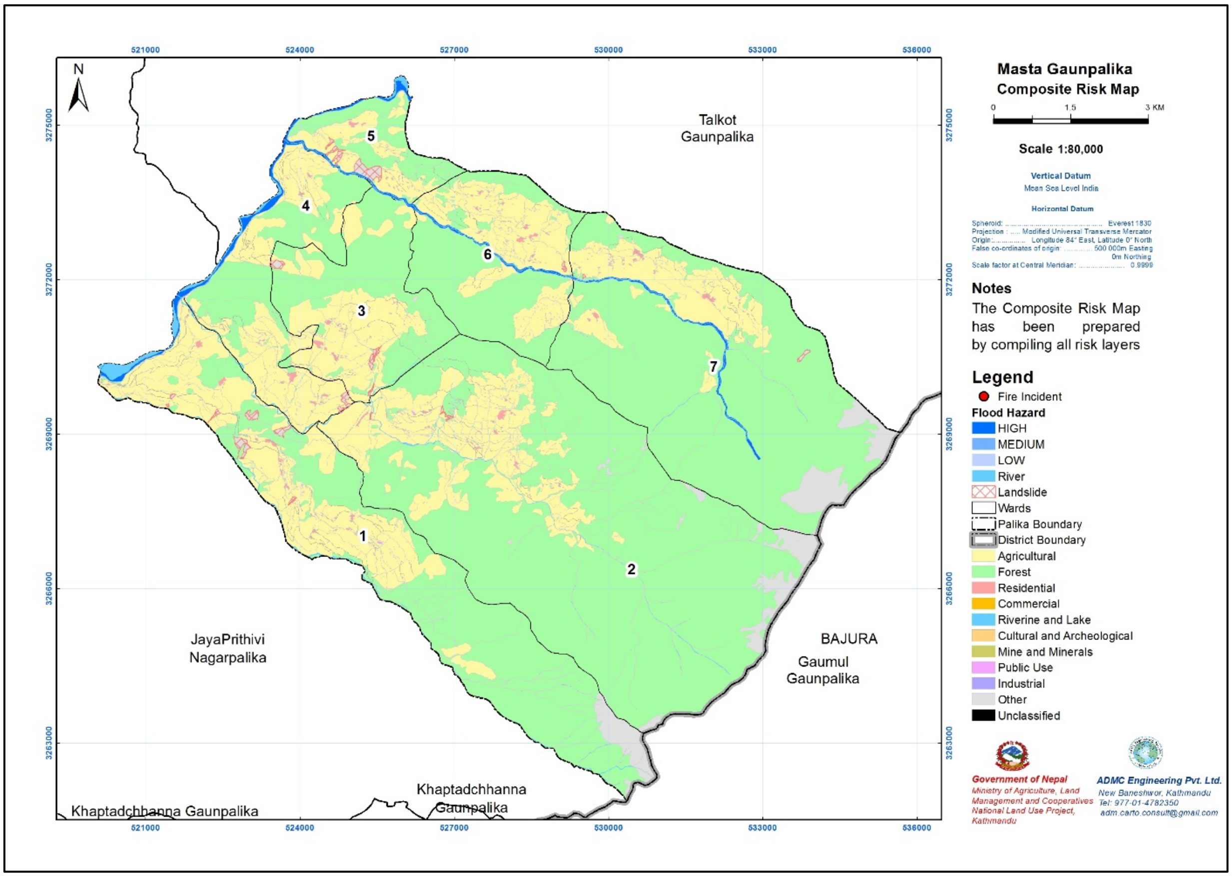

Figure 25: Composite Risk Map of Masta Gaunpalika

4.2 Potential risk in the study area

The identification of potential risk areas is very difficult task because nature may not follow the hazard model developed by the human beings. However, the modelling of the existing risk areas could be used to estimate or predict the future potential risk areas. Based on the existing risk in the project areas it can be concluded that the existing hazard risk areas are prone to future potential risks as well. 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 or as the open spaces.

4.3 Risk Data Model

The risk developed for Risk data is shown in Table below.

Table 10: Risk Data Model

Field	Data Type	Description	Remarks
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	
GaPa/NaPa	Text	Gaunpalika/Nagarpalika Name	
DISTRICT	Text	District Name	
REMARKS	Text	Any remarks regarding the feature	
SHAPE LENGTH	Double	Meter	
SHAPE AREA	Double	Area in m^2	

4.4 Risk GIS Database

There exist diversities in Risk type. Land use mapping focuses different types of risk such as fire, flood, landslide, seismic, industrial etc. Similarly, from the view of proximity of occurrences, risk can be hieratically classified as different level: such as High, Medium and Low. Different level have been given to the risk type and its level as per **TSLUMD Specification 2076**. Following is the risk dataset schema:

Table 11 : Specification for Risk GIS Database

	LEVEL1	**LEVEL2**	**Gaunpalika**	**District**	**REMARKS**
Risk theme types	**Risk type**	**Risk Level**			
Fire	Fire	High, medium, low			
Flood	Flood	High, medium, low			
Landslide	Landslide	High, medium, low			
Seismic	Seismic	High, medium, low			
Industrial	Industrial	High, medium, low			
Other	Other	High, medium, low			

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study area holds major threat of landslide along road, flood and inundation alongside the rivers. Presence of steep slopes, weak geological condition and degraded forest areas indicate that the area is more vulnerable to landslides. The study area is close to the MCT relative to the MBT and Seismicity analysis shows low seismic activities in the study area which lies in the Central Seismic Gap of the Himalaya. The study area exhibits thrust regime of seismo tectonic stresses. Also, some of the epicentre from the past earthquakes are falling in the study area. There may be significant risk of forest fire mostly in dry season and it is because the major portion of the area is covered with forest. Flood risk is comparatively high due to the presence of the Seti River and its tributaries around the area.

5.2 Recommendations

This study leads to the following recommendations:

- Fire preparedness activities must be carried out, which includes spreading messages through television, radio, street drama, video, folk songs, drills, posters, pamphlets, and hoarding boards to reduce the risk of firing.
- Low lands area adjacent to the present network of river plain are the potential flooding areas. So, these areas are suitable for the cultivation (of both dry and wet) but not for the construction of buildings.
- As the MCT (Main Central Thrust) passes closure and nearer to the area the vicinity of landforms around it is considered to be the geologically weak zones bearing various fractures and joints which sometimes gives rise to the opening of hot springs (tato pani) that can be the matter of tourist attraction and its promotion.
- In the belts where active faults passes through the slope failure is most likely to trigger. It demands the plantation of trees to reduce the rock fall and landslides to some extent.
- Any engineering activities (roads, hydro power and irrigation constructions as well as urbanization and other related activities) should be carried out by meeting the proper technical norms and standards (like avoiding the "along the dip slope" but against it).
- The mighty Seti River is originated in the high himal and flows down south passing around Chainpur. Glacial lakes near its source and possible avalanche nearby would be a threat of flash flood caused by GLOF (Glacial Lake Outburst Flood) that might create havoc to the settlements down south along its way as is the case of Seti in Kaski few years back. Proper measures is recommended that should be carried out to avoid such calamity.
- Maintenance of stone-walls and retaining walls and the application of contour or terrace farming should be done.
- This data can aid in proper zoning of the study area keeping in mind the risk aspect and help to make proper planning for sustainable development.

सारांश

यस गाउँपालिकामा बिध्यमान प्रभाव/जोखिमहरूमा पहिरो तथा बाढी रहेको छन् । पहिरोको जोखिमको विश्लेषण multicriteria लाई लिएर गरिएको छ । भिरालोजमिन, कम्जोर भौगोलिक संरचना भू-उपयोगको अवस्था, बनको रास, तथा वर्षाको मात्रा पहिरोको जोखिम निधार्रन गर्नु प्रमुख भूमिका खेलेको छ। यसका अलावा बाटोको निर्माण पनि मुख्य करम्तत्वको रुपमा रहेको छ । गा. पा. मध्य पश्चिम तथा पु. पश्चिमका केहि छेत्रमा पहिरोको उच्च जोखिम रहेको, समग्रमा मध्य र नदीकिनार तथा सम्म जमिनमा पहिरोको कम जोखिम रहेको पहिन्छ। येसैगरी HECRAS र स्थलगत अध्ययनबाट बाडीका क्षेत्रको निधारण गरिएको हो। निश्चित समय अन्तर (return period) का आधारमा बाढीको विश्लेषण गर्दा सेती नदी किनार तथा देउराको दोभानमा उच्च जोखिम क्षेत्र रहेको पाहिन्छ ।

भूकम्प अर्को एउटा महत्तोपूर्ण जोखिम हो। बझांङ समग्ररुपमा भूकम्पको रुपमा कम जोखिमको क्षेत्रमा रहेको पनि पश्चिम नेपालमा लामो (sesmic gap) रहेकाले भूकम्पीय जोखिमलाई उच्च रुपमा लिनुपर्ने हुन्छ। तेसैगरी यस पालिकाको मध्य दक्षिण भागमा रहेको जंगल क्षेत्र डढेलोको जोखिम मुक्त रहेको पाइन्छ। बागथालाका क्षेत्र तथा देउरा क्षेत्रमा कचीघरहरु रहेका छन् र आगोबाट सतर्कता अपनाउनु पर्ने देखिन्छ। गा. पा. औधोगिक क्षेत्रमा पेट्रोलियम छैनन् र यी जमिन यहाँ देखिदैन ।

बाढी जोखिम हेर्दा सेती नदीको उपल्लो क्षेत्रमा हुने हिमताल र तिनीहरुको अवस्थालाई अध्ययन गर्नु पर्ने देखिन्छ।

सुझावहरू:

जोखिमको व्यवस्थापन/न्यूनीकरणका लागि निम्न सुझावहरु रहेका छन् ।

- जोखिम व्यवस्थापन गर्न पूर्व तयारीका कामहरु जस्तै जनचेतना, पुर्व तयारी अव्यास (Monk Drill) गर्न पर्दछ।
- बाडी जोखिमका छेत्रमा उपयुक्त प्रकारका बाली नाली लगाउनु पर्दछ।
- उच्च भीरालो क्षेत्र तथा Fault-Line वको क्षेत्रमा ब्रिक्षारोपन् गरि पहिरो जान र ढुंगा खस्न बाट बचौंन सकिन्छ। बाटो बनाउदा उपयुक्त engineering प्रविधि अपनाउन पर्दछ। जथा भावी बाटो खन्न हुदैन। माटोको क्षयीकरण रोक्न Bio-Engineering प्रविधि अपनाउन पर्दछ । जसमा विभिन्न प्रकारका स्थानीय घाँस तथा बिरुवा रोप्नु पर्छ ।
- जोखिमको प्रकार र भौगोलिक क्षेत्र अनुसार उपयुक्त खेती प्रणाली तथा जमिनको प्रयोग गर्नुपर्छ। जोखिमको विश्लेषण तथा नक्सांकन गा. पा. का विकाश निर्माण का विभिन्न गतिविधि गर्न ज्यादै महत्वपुर्ण आधार रहेका ले यस्ता जोखिमलाई अझ सुक्ष्म रुपमा अध्ययन गर्न पर्छ ।

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F. Land Use Zoning

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Chapter - 1
INTRODUCTION

1.1. Background and Rationale

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 off-site effects for farming. In contrary, land use zoning is the suitability classification of land for various land use purposes. The suitability classes are rated from the most suitable to the least. Each suitability class is therefore designated a zone with suitability ratings. Based on the suitability of land for various land use classes, land use zones are classified into eight broad categories with associated ratings. The zoning is done for agriculture, forest, pasture, industry, settlements, wildlife conservation, tourism and recreational, wetland and parks/natural reserves.

Land is very scarce natural resource on which our life is highly reliant. It is a basis of socio-economic development of every country. For sustainable development of society, this resource should be wisely managed. Many countries around the world are nowadays paying their utmost attention to various land management issues for sustainable socio-economic development and environmental management.

Land is a basic resource of livelihood for almost seventy five percent of the population in Nepal. Population growth, lack of physical infrastructure, scattered small sized land parcels and haphazard subsistence farming practices have resulted low productivity and food deficit. Similarly, high rate of migration from hilly region to urban and plain fertile land (Terai land) has created unplanned settlement and loss in agricultural production and unsustainable livelihood. There are no any controlling measures for migration and convincing rural development plans for uplifting rural population. This imbalance and unplanned land use has directed towards deterioration of natural setup. Also, due to landless and jobless people's problem, encroachments on public and government lands (like forests) for squatter farming and settlement have been alarming. These are the reasons; the traditional land management is being handicap for implementing community driven sustainable land use planning and zoning programs.

Nepal being a developing nation, massive urban land has been encroached as slums and real estate market has been well flourished since last 2 decades specifically in large Nagarpalika and fringe areas. Almost all economic activities in these areas depend on lands and so is the pivotal for economic development. There has been existed unsystematic and unhealthy real estate business in the absence of effective land use planning and zoning. The utility services are also very poor in the developmental areas due to lack of updated planning and monitoring. All these facts have resulted serious problems on settlement pattern and has deteriorated the urban-rural environment. The state being the guardian, it needs to pay serious attention to face, overcome and tackle the ever-growing problem.

In Nepal, the Government is trying to cope with various land related issues in national and local level. The highly fertile agricultural land is getting urbanized haphazardly in many urban/ semi urban areas. In many places, agricultural lands have been left unused and abandoned. The available land is not being used on its optimum level. Crop production is not according as the suitability and capability of the land. In many places, human activities with mountainous land is causing various disasters such as landslides and flooding. Consequently, Nepal has a serious threat of facing problem of food security and hunger in future. Similarly, unplanned settlement and unhealthy habitat, lack of urban infrastructure, natural disaster, and environmental degradation are other serious challenges to be faced in future.

To cope with these challenges, available land should be managed appropriately. Land use planning is one of the tools for getting optimum benefit from scarce land resource. Sustainable socio-economic development of a country is highly dependent on the proper use and utilization of resources available. Land is one of these resources. Therefore, a comprehensive land use plan is highly essential for the national development. The importance of land use plan can be understood from an example of the land use policy formulated during the rule of King Prithivi Narayan Shah (1834 AD), he said as:

- Shift the village situated in the irrigable land to the other high lands
- Shift the houses from the plain plots of lands to the other places; and construct cannels and irrigate those plots
- Shift the villages situated near the mines area to the other places; explore the mines and use the mines

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 Reform and Management, National Land Use Project has taken an initiative to prepare land use zoning maps of Nepal in different level such as district and Nagarpalika level. Recently, GoN has land use Act 2076 which has mentioned the main objectives of the land use program as given below:

- 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 Nagarpalika and urban oriented Gaunpalika 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.

In this context, this study is being carried out for the purpose of preparing land use zoning maps and implementation of land use policy for getting optimum benefits from land in the national and local level. In this project, the land use zoning of 3 Gaunpalika (Saipal, Talkot and Masta) of Bajhang district is under study. The scope of this project is limited to

- Studying the existing relevant maps, documents, and database of the project area
- Preparing land use zoning maps of the selected Nagarpalika/Gaunpalika at 1:10000 scale portraying different zones and sub zones as per the Government's Land Use Act 2076 BS. (Land use Specification 2076)

- Designing appropriate GIS database logically on land use zoning for the selected Nagarpalika/Gaunpalika.
- Discussing accuracy, reliability and consistency of data
- Preparing detailed reports, describing methodology, criteria and distribution of different land use zones and sub zones with GIS data models and databases.

1.2. Objectives of the Study

The main objective of the study is to prepare a scientific and comprehensive land resource inventory at Nagarpalika/Gaunpalika level and assess and delineate land use based on land types, associated soils and land capability classes with the main to formulate a sound and sustainable land use planning. The present study aims to fulfill the following major objectives:

- Classify agricultural lands for the purpose of identifying most suitable and lucrative crop production and classify land for non-agricultural purpose based on land types and associated land characteristics
- Classify Hazardous area in terms of Flood, Fire, Landslide, Seismic, industrial and other risks.
- Prepare land use zoning maps of the selected Nagarpalika/Gaunpalika at 1:10,000 scale portraying different zones and sub- zones as per the Governmental Land Use policy.
- prepare appropriate GIS database on present land use zoning of the selected Nagarpalika/Gaunpalika.
- prepare reports on conceptual basis and methodology of land use zoning and Models of GIS database

The specific objectives of this study are:

- To perform landuse zoning of Masta Gaunpalika by using different available data sources by using multi-criteria analysis in GIS.
- To produce land use zoning map at 1:10,000 scale showing different zones and sub-zones as per the Government's Land Use Act 2076 BS. (Land use Specification 2076).
- To prepare appropriate GIS database of proposed land use zoning.
- To prepare detailed report containing conceptual basis and methodology, criteria of land use zoning, distribution of different land use zones and data models of GIS database.

1.3. Study Area

Masta Gaunpalika is an important urban center in Bajhang district and it lies in Sudur Pashchim province in Nepal. Geographically, Masta is located at 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude. This Rural Municipality consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Municipality to the west, Bajura district to the south and Talkot Rural Municipality to the north. The total area of the Gaunpalika is 109.05 km². The total population of this Gaunpalika is 17909, of which male population accounts for 8537 and female population is 9372. However, all the wards vary in area and population size. Total number of households in the Gaunpalika is 2798.

This Gaunpalika is inhabited by different caste and ethnic groups. However, Masta Rural Municipality is predominated by Brahmin and Kshetri which are included under caste group. Nearly 81 percent people are belonged to this group. The second largest group is Dalit community where Kami, Damai and Sarki are main Dalit castes in this category in Masta. The other group i.e. Janajati that has sis population with only one household.

The location map of the study area has been shown in **Figure 1**

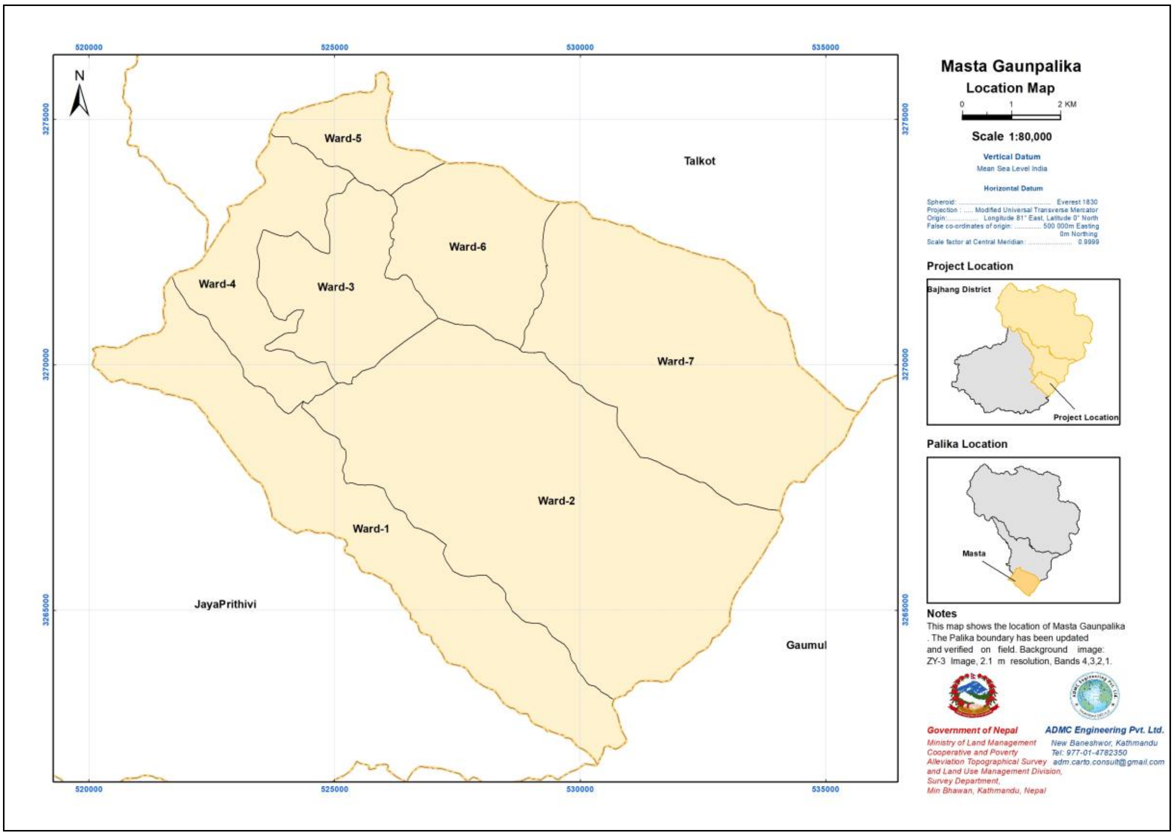

Figure 1: Location Map of Masta Gaunpalika

Chapter - 2
CONCEPTUAL BASIS OF LAND USE ZONING

This chapter presents the conceptual basis and principles of land use zoning. Further, it highlights on the parameters and criteria used for land use zoning and finally give detailed description of land use zones identified in the study area.

2.1 Land Use Zoning, Principles and Criteria

Considering the importance of land use zoning, Topographical Survey and Land Use Management Division **(TSLUMD),** Under Ministry of Land management, Cooperatives and Poverty Alleviation **(MOLCPA-Nepal),** has under laid the following concepts for the land use zoning:

- Classification of land into agricultural area, residential area, commercial area, industrial area, public service area and other uses,
- Identifying areas of potential residential, commercial, industrial and public utility keeping balanced environment.
- Classifying agricultural land into comparatively advantageous sub-areas on the basis quality of land, land capability, irrigation facilities to increase productivity.
- Proper conservation of natural resources including forest, shrub, rivers, rivulets and swampy land etc.
- Multi-Criteria Analysis (MCA) using spatial data pertaining to topography, soil, moisture, drainage, and climate and socio-economic and infrastructures was done.

The Land Use Plan is intended to identify, illustrate and express preferences for use of land in the area based on physical features and constraints, the characteristic of areas and neighborhoods, site suitability for particular types of land use activities, economy and availability of public services and infrastructure. Additionally, the Land Use Plan will provide policy, guidance and assistance in the decision-making process relative to land use and land development issues affecting the community.

Zoning is a device of land use planning used by mainly the local governments in most of the developed countries. The word is derived from the practice of assigning permitted uses of land based on mapped zones which separate one set of land uses from another.
Land use zoning determines the types of activities that can occur on the land, such as residential housing or crops harvesting activities. While an area may be zoned for a particular type of use, some or all of that area may not be used as zoned (an example would be an area zoned for residential use that is still partially in agricultural use). As such, the zoning designations the map portrays and reflects both current conditions and anticipated conditions.

Theoretically, the primary purpose of zoning is to separate land uses that are thought to be incompatible to each other. In practice, zoning is used to prevent new development from interfering with existing residents or businesses and to preserve the "character" of a community. Zoning is commonly controlled by local governments such as Nagarpalika or Gaunpalika, though the nature of the zoning regime may be determined or limited by state or national planning authorities or through enabling legislation. In Australia, land under the control of the Commonwealth (federal) government is not subject to state planning controls. The US and other federal countries are similar. Zoning and urban planning in France and Germany are regulated by national or federal codes. In the case of Germany this code includes contents of zoning plans as well as the legal procedure and zoning usually includes building design, very specific green space and compensation regulations.

Basically, urban zones fall into one of five major categories: residential, mixed residential-commercial, commercial, industrial and special (e. g. power plants, sports complexes, airports, shopping malls etc.) and rural zones are mainly agricultural. Each category can have a number of sub-categories, for example, within the agricultural category there may be separate zones for cereal crops, cash crops, horticulture, agro-forestry and others.

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 Nagarpalika/Gaunpalika District. Land is divided into zones from the zoning code which describes the intent and regulations of each particular zone category. A typical zone will set forth regulations for permitted land uses.

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.

Main principle of land use planning can be listed as

- Land use planning is orientated to local conditions in terms of both method and content.
- Land use planning considers cultural viewpoints and builds up on local environmental knowledge.
- Land use planning takes into account traditional strategies for solving problems and conflicts.
- Land use planning assumes a concept which understands rural development to be a "bottom-up" process based on self-help and self-responsibility.
- Land use planning is a dialogue, creating the prerequisites for the successful negotiation and co-operation among stakeholders.
- Land use planning is a process leading to an improvement in the capacity of the participants to plan and take actions
- Land use planning requires transparency. Therefore, free access to information for all participants is a prerequisite.
- The differentiation of stakeholders and the gender approach are core principles in land use planning.
- Land use planning is based on interdisciplinary cooperation.
- Land use planning is an iterative process; it is the flexible and open reaction based on new findings and changing conditions.
- Land use planning is implementation-orientated.

The concept of land use zoning is come forward to achieve mainly the following specific objectives:

- To provide for a mixture and variety of land uses in appropriate locations throughout the study area
- To identify prime land areas for suitable agricultural crop production.
- To identify and set aside prime land areas for future quality industrial growth and development.
- To create stable, attractive, safe residential neighborhoods which contain a range of supportive commercial, institutional, and public facilities

- To create stable and functional commercial centers based on site suitability and compatibility with adjacent land uses.
- To provide for the appropriate location and distribution of public facilities such as parks and schools throughout the community.
- To promote rehabilitation and improvement of the living environment in older neighborhoods and areas characterized by conflicting patterns of land use.
- To promote land use activities appropriate to the features and characteristics of the natural landscape.
- To support and promote consistency between the Land Use Plan and current land use pattern.
- To provide for adequate transitioning and buffering between residential uses and industrial and commercial uses.
- To promote growth in areas adjacent to existing urban development so that public services and facilities may be provided efficiently and economically.

In this particular project, the following main concept is put forward for land use zoning

- Classification of land into Agricultural area, Residential area, Commercial area, Industrial area, Forest area, Public service area and other uses.
- Identifying areas for potential residential, commercial, industrial and public utility keeping balanced environment.
- Classifying agricultural land into comparatively advantageous sub-areas on the basis of quality of land, land capability, and irrigation facilities to increase productivity.
- Proper conservation of natural resources including forest, shrub, rivers and rivulets and swampy land etc.

Based on these principles, objective and concept of land use planning, land use zoning is carried out giving special attention to the following broad criteria:

- Sufficient land should be zoned at appropriate locations throughout the area to accommodate the expected growth in population and other growth needs of the study area within the lifetime of the Plan.
- Zoning should be designed to promote particular uses in appropriate locations, to reduce conflict of uses and to protect resources both natural and human-made. 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 redevelopment 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 Land Use Act 2076 BS.

On the basis of the aforementioned broad criteria, the following specific criteria are used for zoning:

Existing (present) land use

Land capability and land system identified by the analysis of soil characteristics (PH value, Nitrogen, Phosphorous, Potash, Organic Matter etc.), soils moisture, temperature, drainage, irrigation, slope, elevation, aspect, topography etc. Suitability identified on the basis of the neighborhood and spatial analysis (distance from roads, markets, settlements, river and stream and other hazards)

For this project, the studies on land capability, land system and present land use classification were reviewed carefully. The base for this study is LRMP classification scheme. Further elaboration on LRMP classification is done on report on Land Capability mapping by the other study group. During land use zoning, the symbols and codes used on these earlier study reports were used. The detailed review is done on the other reports (For further details, please refer the reports on land capability, land system, and soil study). Similarly, the TOR provided by TSLUMD is taken as reference for categorizing the various land use zones.

2.2 Land Use Zones and their Descriptions

Based on the Land Use Act, 2076 and Land Use Mapping Specification, 2076, the following land use categories has been designated for land use zoning task:

1. Agricultural
2. Residential
3. Commercial
4. Industrial
5. Forest
6. Public uses
7. Other Zone
8. Mine and Minerals
9. Cultural and Archeological
10. Riverine, Lake and Marsh Area

The land use zoning has been carried out on the basis of multi criteria analysis using present land use, In this study, our results have been verified on the ground as per the instruction of Land Use Act, 2076 and Land Use Mapping Specification, 2076 and categorized the study area on the following zones and sub zones as shown in the table 1.

Table 1: Land use zoning scheme of the study area

Zone No	Zone Type	Sub type	Description
Zone 1	Agricultural Zone	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
		Zone 1G	Other Agriculture Area
Zone 2	Residential Zone	Zone 2A	Existing residential zone
		Zone 2B	Potential area for residential zone
Zone 3	Commercial Zone	Zone 3A	Governmental institutions Service areas
		Zone 3B	Business area
Zone 4	Industrial Zone	Zone 4A	Areas under industrial use
		Zone 4B	Potential areas for industrial use
Zone 5	Forest Zone	Zone 5A	Existing forest
		Zone 5B	Potential area for forest including barren lands, wet lands etc.
Zone 6	Public Use Zone	Zone 6A	Areas under roads, railways, bus parks, airport and landfill site etc.

Zone No	**Zone Type**	**Sub type**	**Description**
		Zone 6B	Area under Hydrography (Snowy Mountain Area)
		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
		Zone 6G	Government Institutional area
		Zone 6H	Open Space/area
Zone 7	Other Zone	Zone 7	Other Area (As per requirement)
Zone 8	Mine and Minerals Zone	Zone 8A	Existing Mine and Minerals Area
		Zone 8B	Potential Mine and Minerals Area
Zone 9	Cultural and Archeological Zone	Zone 9A	Existing Cultural and Archeological Areal
		Zone 9B	Potential Cultural and Archeological Areas
Zone 10	Riverine, Lake and Marsh Zone	Zone 10A	Existing Riverine and Lack Area
		Zone 10 B	Potential Existing Riverine and Lack Area

Chapter -3
METHODOLOGY

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

3.1 Data

There are many different sources of information on existing land use and land cover and on changes that are occurring. Local planning agencies make use of detailed information generated during ground surveys involving enumeration and observation. Interpretation of large-scale aerial photographs also has been used widely. In some cases, supplementary information is inferred on the basis of utility hookups, building permits, and similar information. Major problems are present in the application and interpretation of the existing data. These include changes in definitions of categories and data collection methods by source agencies, incomplete data coverage, varying data age, and employment of incompatible classification systems. In addition, it is nearly impossible to aggregate the available data because of the differing classification systems used (James R. Anderson et. al. 2001).

The primary data source used for the land use classification in this project is high resolution satellite image (Spatial Panchromatic 2.1 m and MSS 5.8m, Spectral 4 bands). Various other vector, raster and imagery data sets were used as ancillary data, which enhanced interpretation and classification of land use classes.

Besides, the present land use, land capability and soil maps were prepared as part of the present study, which are also the major data sources for the preparation of Nagarpalika and Gaunpalika level Land Use zones.

Various data sources are used in this land use zoning. Some main data sources are

- Very high-resolution satellite image of the study area
- DGPS observation data from field for enhancing geometric quality of the image
- GIS vector data (shape file) of mainly land capability, land system, present land use, Administrative boundary (Nagarpalika/Gaunpalika Ward).
- Various maps (Land system, Capability) and data (Reports etc.) from LRMP
- Socio economic data and village profile
- Risk layers

3.2 Methods

A rule based Multi Criteria Evaluation (MCE) methodology was developed for optimum use of land resources of the Nagarpalika/Gaunpalika under the following broad land use zones: Agricultural area, Residential area, Commercial area, Industrial area, Forest area, Public service area and other category. The input for the application is a number of maps of each Palika (so-called 'criteria' or 'effects'), and a criteria tree that contains the way criteria are grouped, standardized and weighed. The output of MCA based on weight/rating consists of composite index maps that indicate the extent to which criteria for different classes of land capability or suitability for land use zoning for a location are met. For example, on the basis of maximum productivity and fertility, agricultural areas has been divided into sub areas of cereal/food crops areas; cash crops areas; vegetable production areas, fruit orchards, areas used for animal husbandry and grassland/grazing lands, fish farming area and Agro- forestry. The MCE Criteria was developed as per guidance by the environmental friendly perspective and as far as possible. Special care should be given to maintain and preserve maximum forest areas, protection of food crop.

Land use zoning is carried out on the basis of GIS based spatial analysis using multi-criteria analysis on several available data sets. GIS vector data (shape file) of mainly land capability, land system, present land use and socio-economic data are used. These data files comprised the various parameters like soil characteristics, land form, land type, arability, slope, elevation, drainage system, topography, existing land use, crop patterns, population density and other necessary parameters used for land use zoning.

A rule base was developed by using multiple criteria on the basis of expert knowledge for land use zoning. These criteria were used to identify a suitable land use zone.
For example, to identify a potential area for future industrial use, the following criteria were used:

Those land units which are:

- Within a certain distance from road network
- Lower population density and less residential use
- Not of much importance from agricultural crop production point of view e.g. dry land
- Not within a certain distance from forest, wetland, water body
- Not within a risk prone areas

These kinds of analysis were carried out by using GIS attribute query and spatial analysis based on various data fields on the data files. ArcGIS 10.0 software was used for GIS analysis.

Apart from these kinds of criteria formed on the basis of expert knowledge, some subjective analysis and logical inference was applied for land use zoning.
For example,

- The bed of a stream should not be used for agricultural but it can be used for forest plantation or grass land (though it can be very suitable for rice crop production).
- If a small unit of a land use zone (e.g. Zone 5) was found surrounded by some other land use zone (e.g. Zone 6), then the former zone was merged to the later.

3.3 General Approach and Methodology Framework

Land use zoning class and suitability ratings is evaluated based on aforementioned criteria and the land use unit is designated with appropriate land use zone class along with its suitability value. The approach for classification and designation of land use zones is presented on the following schematic diagram:

Figure 2: Methodology used for land use zoning

Chapter - 4
LAND USE ZONES OF THE STUDY AREA

4.1 Land Use Zones

Zoning of the area for regulation of land use practices does not necessarily mean to copy the present land use pattern one to one. Present land use practice can be a reference but it should not necessarily indicate the same pattern for land use zoning. It is because the land use to be imposed in future might give pressure on the agriculture land which may be highly suitable for diversified crops as well. On the other hand, spatial overlay analysis performed with the built up area based on the national topographic database and that rendered by the present study of land use mapping(residential) has revealed that enormous amount of agricultural land has sustained attack just for newly developed residential area. More importantly, the residential expansion has not taken care whether the area was cultivable or not. It has only seen the accessibility and proximity to the existing residential area.

Taking this fact into consideration and analyzing the rate of expansion of built up within the certain time interval, present residential area has been proposed in the area surrounding the existing residential area. While expanding such areas, due attention has been given to protect vegetative area as well as pond area under the subcategory of agricultural land.

Based on the existing land use of the Gaunpalika described in the land use section of this report and considering the increasing trend of land use changes quite visible during the field visit, growing urbanization and industrialization trend along the industrial corridor and growing population and increasing demand of land for non-agriculture uses, land use zoning of the Gaunpalika has been prepared to address the need:

- to meet the increasing demand for land to accommodate the growth of population due to rapid urbanization
- to regulate and control land use changes in areas designated as agriculture zone
- to protect and preserve areas which are environmentally sensitive

Thus, taking into consideration the above issues, land use zoning of the Nagarpalika/Gaunpalika has been prepared and is presented in Table 2. This table has been prepared in accordance with TOR requirement to prepare Land use zoning according to TSLUMD definition of land use zones. Accordingly, the table has ten zones with each zone with sub-zones as can be seen in the Table 2. Zone 1 in the table represents agriculture area which has been identified and demarcated on the basis of quality of land, land capability, and irrigation facilities which would contribute to increase agriculture productivity. The concept is that land use changes in non-agriculture use in this zone must be discouraged as well as controlled. Zone 2 covers existing residential area as well as potential area for future residential growth. Potential area for future residential expansion has been identified and demarcated on the basis of proximity to existing residential area, access road, access to infrastructural services and facilities and topography avoiding low land and flood prone areas. Zone 3 covers the commercial zone comprising of areas occupied by existing government institutions, community services and commercial activities. Zone 4 represents existing industrial areas as well as areas identified and demarcated as potential area for future expansion of industrial activities which would likely to take place in near future. Zone 5 represents forest area. If there are large chunks of barren land and wetlands then it must be protected and developed as forest zone. These barren lands and wetlands have been identified and demarcated in the forest zone. Zone 6 in the table is self-explanatory and does not need further explanation. The most important aspect of this zone is identifying and demarcating public land containing man made features, governmental institutional areas, public utilities, public institutional area, Snowy mountain area, offices, picnic spots and recreational areas etc. Zone 7 indicates the zoning of land that fall under other areas. Zone 8 represents existing mine and minerals areas as well as areas identified and demarcated as potential area for future mine and mineral utilization. Zone 9 represents the existing cultural and archeological areas as well as area identified and demarcated as potential area expansion or development of possible cultural and archeological sites. Zone 10 represents existing environmentally sensitive areas like water sources, rivers and streams, canals, ponds etc and need to be protected against encroachment as well as identified areas suitable for water diversion or collection for irrigation and other purpose.

Figure 3 provides graphical presentation of percentage distribution of different zones in terms of Gaunpalika's area and percentage distribution of sub-zones of each zone in terms of area of each zone.

The Land Use Zones identified in this Gaunpalika are summarized on the following table:

Table 2: Land use zones of the study area

Zone Type	Zone Sub Types	Area (Sqm.)	Area (Ha.)	Zone Type Area (Ha.)	Percent
Agricultural Zone	1A-Cereal crop production area	29122698.04	2912.27	3363.96	30.85
	1B-Cash crop area	2286.73	0.23		
	1C-Horticultural area	395353.84	39.54		
	1D-Animal husbandry area	713572.30	71.36		
	1F-Agro forestry area	2282427.03	228.24		
	1G-Other Agriculture Area	1123295.97	112.33		
Commercial Zone	3A-Service areas	3241.46	0.32	2.55	0.02
	3B-Business area	22299.76	2.23		
Cultural and Archeological Zone	9A-Existing Cultural and Archeological Area	1372.00	0.14	0.14	0*
Forest Zone	5A-Existing forest	69151800.18	6915.18	7276.27	66.72
	5B-Potential area for forest including barren lands, wet lands	3610869.67	361.09		
Public Use Zone	6A-Areas under roads, railways etc	681036.24	68.10	70.71	0.65
	6C-Open spaces, picnic spots, recreational etc	1690.10	0.17		
	6E-Public health, education library, police station, fire station, telephone, electricity areas etc	24421.40	2.44		
Residential Zone	2A-Existing residential zone	661437.13	66.14	76.32	0.70
	2B-Potential area for residential zone	101730.77	10.17		
Riverine, Lake and Marsh Area	10A-Existing Riverine and Lake Area	1152261.91	115.23	115.23	1.06
Grand Total		**109051794.53**	**10905.18**	**10905.18**	**100.00**

*LESS THAN 0.01 PERCENT

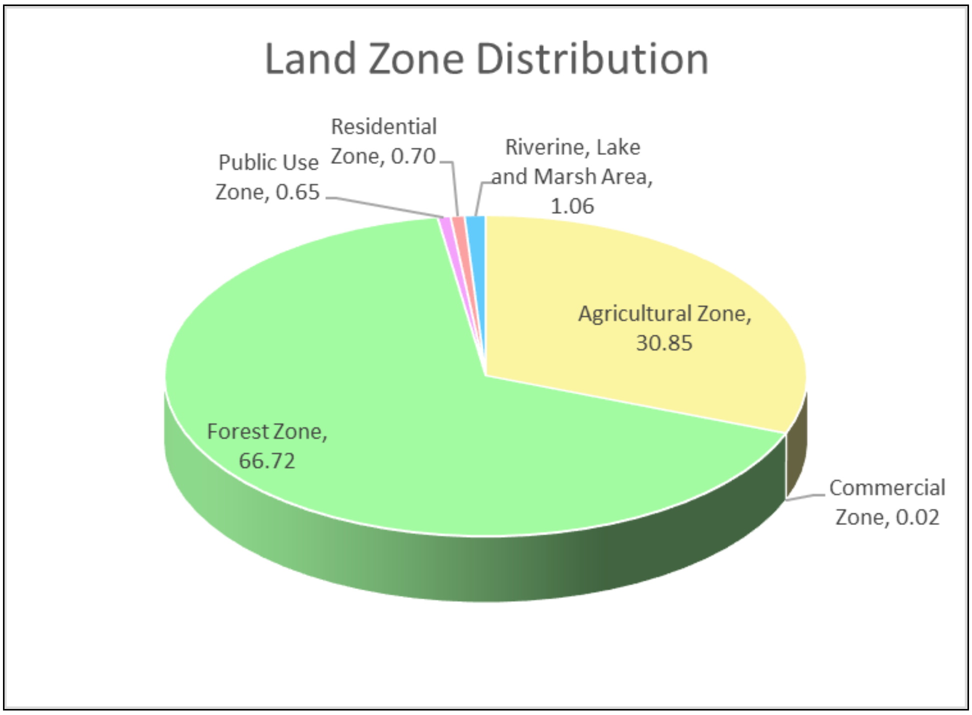

Figure 3: Details of Land Use Zoning of Masta Gaunpalika

Table 3: Present Land Use to Land Use Zone Transition Table

From Present LandUse	To Landuse Zone	Area (Ha.)	Percent
AGR	Agricultural Zone	3342.59	30.65
	Commercial Zone	2.23	0.02
	Public Use Zone	22.19	0.20
	Residential Zone	10.17	0.09
COM	Commercial Zone	0.33	0*
	Public Use Zone	0.02	0*
CULARCH	Cultural and Archeological	0.14	0*
FOR	Forest Zone	6915.18	63.41
	Public Use Zone	3.28	0.03
HYD	Public Use Zone	0.18	0*
	Riverine, Lake and Marsh Area	115.23	1.06
OTH	Agricultural Zone	21.37	0.20
	Forest Zone	361.09	3.31
	Public Use Zone	0.43	0*
PUB	Public Use Zone	43.83	0.40
RES	Public Use Zone	0.78	0.01
	Residential Zone	66.14	0.61
Grand Total		**10905.18**	**100.00**

Table 4: Land Use Transition

	To Land Use Zone							
From LandUse	Agricultural Zone	Commercial Zone	Cultural and Archeological	Forest Zone	Public Use Zone	Residential Zone	Riverine, Lake and Marsh Area	**Existing Total (Ha.)**
AGR	3342.59	2.23			22.19	10.17		3377.18
COM		0.33			0.02			0.35
CULARCH			0.14					0.14
FOR				6915.18	3.28			6918.46
HYD					0.18		115.23	115.40
OTH	21.37			361.09	0.43			382.89
PUB					43.83			43.83
RES					0.78	66.14		66.92
Proposed Total (Ha.)	3363.96	2.55	0.14	7276.27	70.71	76.32	115.23	10905.18

4.2 Land Use Zoning GIS Database

The following database schema is used for preparation of GIS database

Table 5: Database schema used for land use zoning

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	
SHAPE	Geometry	Geometric Object type	
ID	Integer	Unique Object ID	
ZONE NO	String	Zone No	
ZONE TYPE	String	Zone type	
SUB ZONE TYPE	String	Subzone Type	
GAUPALIKA/NAGARPALIKA	String	GAUPALIKA/NAGARPALIKA /Municipality Name	
DISTRICT	String	District Name	
FY	String	Fiscal year of data preparation	

Chapter - 5
CONCLUSIONS

5.1 Conclusions

Land use zoning of the Gaunpalika under study was carried out based on the present land use data, land capability taking the witnesses of current remotely sensed image with the help of ground-based information. According to the capability and susceptibility of the Gaunpalika which gives an idea about what is potential in particular area. However, the prevailing land use is the point of departure. The population of the palika in 2011 as per national census is 14951 and as per the projection, the Palika will grow with the rate of 1.61 percent per annum the population of the palika will reach 18797 in 2021 and 22080 in 2031. It has been assumed that about 50 percent of the population will be accommodated in the existing settlements as the no of houses per settlement is too low per year(<5). Further about 50 percent of additional population will be accommodated in the ward center and palika centers. In this context, residential and necessary infrastructure area have been identified subjectively, expert judgment and as per the recommendation of palika. It has been assumed that about 0.5 ropani land will be required per HH to accommodate family, livestock and kitchen garden. Detailed calculation is as below:

Area Requirement for Settlement Development

Year	Population	Increase in Popn	Additional HH	50% HH accommodated in planning area	Area req (@0.5 ropani)	Area in Ha	Area @ of 1 ropani(0.05Ha)
2011	14951						
2021	18797	3846	726	363	181	9.07	18.46
2031	22080	3283	619	310	155	7.74	15.76

Note: Population Projection is based on 1.61% Growth Rate

The land susceptibility as well as capability map reveals that land which has been identified at low risk of land slide, flood, earthquake, nearby the existing road network and other services are suitable for integrated settlement development. In the proposed integrated settlements, it is proposed to be planned as per planning norms and standard 2013 (DUDBC2013) which requires 5% of open space, about 20% for circulation along with lands for other infrastructure and services.

For other settlements, mere extension into Bari and nearby khet will fulfill the demand of land for settlement. Most of the existing land use has been retained. However, some places which have been proposed as potential commercial and settlements are identified in Dwari, Ganji, Kot Dewal and Bhandarigaun of the Gaunpalika. Similarly, a small industrial area has been proposed to accommodate agro-industry in this palika. It has been proposed far from settlement with high accessibility on non-arable land. Other land uses like agriculture for specific crops has been proposed in different settlements as per land capability.

Lack of clear guidelines on the classification system has posed a level of difficulty in assigning the classes of different hierarchy in land zoning, especially in assigning forest and public use category. The system does not say in which category the plantation should be kept as neither it belongs to the category of Forest nor is it explicitly on agricultural use. This has posed a degree of ambiguity to assign the proper land zoning codes.

The study shows that the most of the part of the Gaunpalika, about 66.72% is forest and hence categorized as Forest zone. The present land under residential use and potential residential use for future is about 0.70%. The land suitable for commercial activities is almost 0.02%. Within the agricultural land, most of the land is found suitable for cereal crop, agro-forestry, animal husbandry, horticulture and cash crop production. For public utility uses, about 0.65% of the land is identified. In existing riverine and lake area, about 1.06% land is identified.

The proposed land use zones are based on rigorous study of present land use scenario supplemented by the soil capability, socio-economic aspect and future prospect for expansion and development works at the same time keeping in view of risk information collected during the study. Residential, Public and Commercial area are major categories which have been proposed realizing the need based on the population growth trend and expansion compared to the topographic and demographic data of 1992-1995. Area such as Mine and Minerals have not been proposed for now because of the lack of resources at the respective organizations related to them.

5.2 Recommendations

Comprehensive database model for land zoning provided by TSLUMD facilitated in establishing the physical model very much but if proper criteria of defining the land zoning in an objective sense is provided, then it would further enhance the consistency of the final product.

The land use zoning of an area highly depends upon the availability of some other primary as well as secondary data such as land capability, land system, soil etc. of the area. For this purpose, latest satellite imagery of highest possible resolution would be very much useful. Similarly, the other data mentioned above should also be accurate and timely updated. Field verification of the final maps would enhance the accuracy of the mapping output. Above all, awareness training on importance of land use zoning for local bodies should be organized for better implementation of land use policies and programs.

सल्लाह तथा सुझाव

भूमिको समुचित उपयोग र प्रभावकारी व्यवस्थापन गर्दै अधिकतम र दिगो लाभ हासिल गर्ने उद्धेस्यले प्रस्तावना गरिएको भू-उपयोग ऐनका आधारमा यस गा.पा.को भू-उपयोग क्षेत्रहरुलाई विभिन्न क्षेत्रमा वर्गिकरण गरिएको छ । भू-उपयोग नीति २०७२ र भू-उपयोग ऐन २०७६ मा निर्दिष्ट गरिएका १० वटा क्षेत्रहरु (क. कृषि क्षेत्र, ख. आवासीय क्षेत्र, ग. व्यवसायिक क्षेत्र, घ. औद्योगिक क्षेत्र, ङ. खानि तथा खनिज क्षेत्र, च. वन क्षेत्र, छ. नदि खोला तथा सिमसार क्षेत्र, ज. सार्वजनिक उपयोगको क्षेत्र, झ. सांस्कृतिक तथा पुरातात्विक महत्वका क्षेत्र र ञ. नेपाल सरकारबाट आवस्यकता अनुसार तोकिएका क्षेत्र) मध्ये “खनिज तथा खानि क्षेत्र” तथा “अन्य क्षेत्र” बाहेक आठ वटा भू-उपयोगका क्षेत्रहरु प्रस्ताब गरिएको छ । यी क्षेत्रहरुको वर्गीकरण गर्दा भूमिको वस्तुस्थिति, जनसंख्या वृद्धिदर, खाद्य तथा आवासको आवस्यकता, आर्थिक विकास तथा पूर्वाधार निर्माणका लागि भूमिको माग लगायतका विषयलाई आधार लिइएको छ । यसैगरि भू-उपयोग नीति तथा ऐनले जोखिमयुक्त क्षेत्रमा बसोबासलाई निरुत्साहित गर्ने उद्धेश्यले त्यस्ता क्षेत्रको नक्सांकन गर्ने कार्य पनि महत्व दिइएको छ । यस गा.पा.मा / न.पा.मा देखिएका वाढी, पहिरो, वन डढेलो, भूकम्प र अन्य प्रकोपहरुको अध्ययन, विश्लेषण तथा नक्सांकन गरिएको छ । उल्लेखित विषयवस्तुलाई समेटेर आगामी दिनमा विकास निर्माणका योजना तयार गर्न सहयोगी भूमिका निर्वाह गर्ने उद्धेस्यले यो प्रतिवेदन पेश गरिएको छ जुन पालिकाका विभिन्न विकास निर्माणका काम तथा योजना बनाउन उपयोगी हुनेछन । यस अध्ययनको क्रममा गाउँपालिकाका पदाधिकारी तथा अन्य व्यक्तिहरु संग भएका प्रस्तुतीकरण तथा छलफलबाट विभिन्न सकारात्मक सुझावहरु प्राप्त भएका कुराहरुलाई समेटेर बर्गिकरण गरिएको हो । वर्तमान भू-उपयोग र प्रस्तावित भू-उपयोग क्षेत्र हेर्दा कृषिबाट आवास, व्यवसायिक तथा सार्वजनिक उपयोगको क्षेत्रमा केहि जमिन रुपानान्तरण भएको छ । वन क्षेत्र खासै घटेको छैन । कृषि योग्य क्षेत्र भित्र गाउँपालिकाका लागि उपयुक्त नगदेवाली, अन्नवाली र फलफुल खेती उचाईका आधारमा सिफारिस गरिएको छ । विशेषगरी धान, गहुँ, मकै, आलु जस्ता बालीहरु लगाइएको यो क्षेत्रमा कृषि आधुनिकीकरण गरि व्यवशायिक लाभ लिन जरुरी छ। यसैगरि, हिमाली जडिबुटी र दुर्लव जातजातिका बनस्पतिहरुको संरक्षण तथा प्रबर्धन र औधोकिकरण गरि रोजगारीको सृजना गर्न पनि जरुरी छ । यस पालिकामा देखिएका जखिममुक्त बसोबास क्षेत्रहरुमा एकितृत बस्ति को अवाधरानालाई अवलम्बन गरि व्यवस्थित गर्न पनि उत्तिकै जरुरी देखिन्छ। केहि खानी तथा खनिज क्षेत्रहरुको प्रारम्भिक अध्ययन भएको हुँदा, त्यस्ता क्षेत्रको बिस्तृत अध्ययन गरि उत्खननको सम्भावनालाई पनि पालिकले मध्यनजर गर्न जरुरी छ । नेपाल सरकारले पर्यटन वर्ष २०२० मनाइ रहेको अवस्थामा यस पालिकामा रहेका संस्कृतिक, पुरातात्विक, धार्मिक र प्राकृतिक पर्यटकिय स्थलहरुलाई अझ पर्यटकमैत्री बनाई प्रचारप्रसार गर्न जरुरी देखिन्छ।

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APPENDIX: Land Use Zoning Map of Masta Gaunpalika

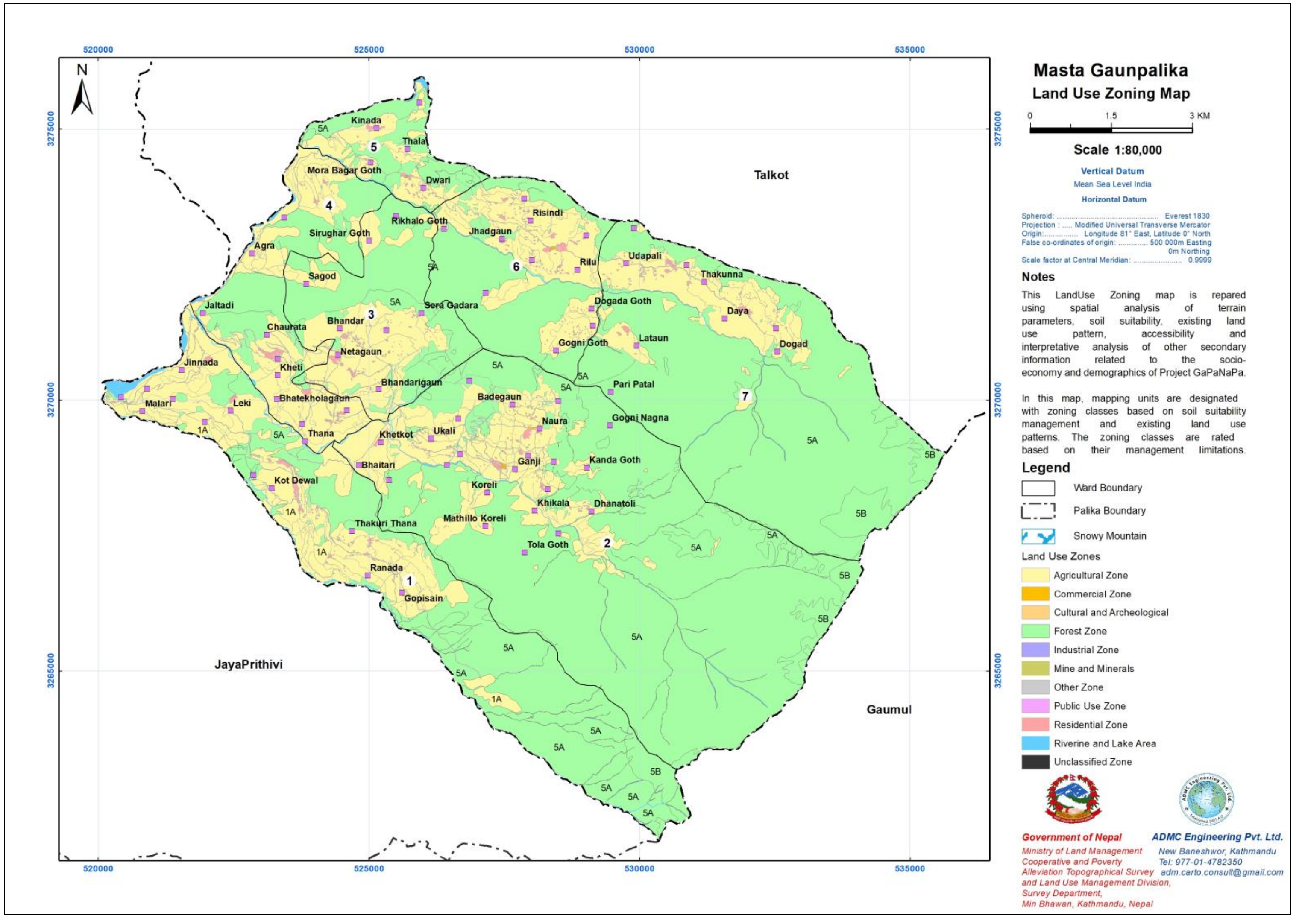

Figure 4: Land Use Zoning Map of Masta Gaunpalika

G. Cadastral Layer Superimpose with Land Use Zones

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Chapter - 1
INTRODUCTION

1.1. Background and Rationale

Government of Nepal has adopted the National Land Use Policy, 2072 with a vision to achieve sustainable social, economic and environmental development through optimum use of land and land resources. For this purpose it has assigned a goal to classify the whole land of the country in different classes (like agriculture, forest, residential, commercial, industrial, public use, mine and minerals, cultural and archaeological, riverine and lake area, and other designated) based upon the landscape characteristics, capacity, capability and needs; and to prepare and implement a hierarchical land use plan within 10 years; and complete the land use planning and its implementation in the district, urbanizing Nagarpalika/Gaunpalika and areas adjoining to major roads within 5 years. For this purpose a Topographical Survey and Land Use Management Division (TSLUMD) will continue to carry out this function until such Department is established.

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. The National Land Use Policy 2072 envisages land-use planning to be applied at three broad levels: national, district and Nagarpalika/Gaunpalika. 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 data base 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, we need very detailed information for local level planning at the Nagarpalika/Gaunpalika 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 data base 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 Nagarpalika/Gaunpalika level.

Sustainable land resource management requires a systematic approach towards a comprehensive study of land use patterns, land forms, soil, vegetation, climate and other socio-economic aspects of the study area. The land use practice has a direct impact on environment, ecology and other socio-economic factors of the study area. Realizing this need, Government of Nepal, Ministry of Land Management Co-operative and Poverty Alleviation, Topographical Survey and Land Use Management Division (TSLUMD) has undertaken an initiative to study and map the present land use pattern and soil characteristics as well as land capability and land use zoning based on soil and physiographic characteristics at Nagarpalika/Gaunpalika level. The proposed land use plan given in the land use zoning maps need to be implemented on the ground. In the local level while implementing the land use zoning, the current land tenure pattern like ownership, use and size and shape of the individual parcels need to be dually considered. The overall objectives of a land use planning implementation process are to improve the production and productivity of land; and individual property and their usage is involved. Therefore, a comprehensive picture of the current land use, proposed land use given in the zoning maps and the individual property information given in the cadastral maps and records need to be dually looked into.

The superimposition of cadastral layer on land use zoning serves this purpose. This activity is carried out for individual Nagarpalika/Gaunpalika in the project area (Package 19) and maps and detailed report for each Nagarpalika/Gaunpalika has been prepared.

The rationale for the preparation of Nagarpalika/Gaunpalika 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 propose land use. For all land related decision making land ownership and land tenure information provide essential in gradient. The implementation of land use plan cannot be successes 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 Nagarpalika/Gaunpalika.

More specifically this information will be necessary for the following:

i. Delineation of land parcels according to land use zoning viz. Agricultural area; Residential area; Commercial area; Industrial area; Forest area; Public Service area; Mines and Minerals area; Cultural and Archeological area; Riverine, Lake and Marsh Area and Other designated areas.
ii. Classification of land parcels for the purpose of non-agricultural land uses.
iii. Delineation of the areas for conservation of forest, shrubs/herbs, river, wetlands for achieving environmental balance.
iv. 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.
v. Preparation of Nagarpalika/Gaunpalika level data base and maps using GIS for the implementation of Nagarpalika/Gaunpalika land use plan.
vi. Management of land resources on the basis of land characteristics as well as the conceived policy of the government.

1.2. Objective and Scope of the Study Area

The broad objective of Topographical Survey and Land Use Management Division (TSLUMD) Package 19 (2076/77 fiscal year) is to prepare Nagarpalika/Gaunpalika level land use maps, soil maps, land capability maps, land use zoning maps, Land hazard maps, cadastral layer superimposition and preparation of profile. In this regards, the Topographical Survey and Land Use Management Division (TSLUMD) has awarded to conduct the project entitled Package 19: Preparation of Nagarpalika/Gaunpalika level land resources maps (Present Land Use Map, Soil Map, Land Capability Map, Land Use Zoning Map and Nagarpalika/Gaunpalika Profile for Land Use Zoning Map, Land Hazard Maps, and Superimpose of Cadastral Layers), Data Base and Reports of Bajhang District to our consultancy for fiscal year 2076/77.The Package 19 covers 3 Gaunpalika (Masta, Talkot, Saipal).

As for other themes, separate maps and report for each Nagarpalika/Gaunpalika for the superimposition of cadastral layer has been prepared. This report is prepared to describe the Nagarpalika/Gaunpalika wise superimposition of cadastral layer of Package 19.

The main objective of the study is to prepare 1:10,000 scale map of Cadastral Layer superimposition on Land Use Zones, prepare data base and report of Masta Gaunpalika of Bajhang district.

Scope of this study included the following activities for the Nagarpalika/Gaunpalika under study:

i. Collect and prepare seamless cadastral maps at 1:10000 scale
ii. Collect land use zoning maps and present land use maps at 1:10000 scale
iii. Prepare cadastral layer superimposition map on present land use and land use zoning at 1:10000 scale.
iv. Classify the cadastral parcels according to present land use and land use zoning.
v. Design GIS database on cadastral parcels with zoning characteristics and current land use
vi. Report on the accuracy, reliability and consistencies of data, and
vii. 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 study area has been already described in the present land use section this report.

Chapter - 2

CONCEPTUAL BASIS OF SUPERIMPOSE OF CADASTRAL LAYER

This chapter describes the conceptual basis behind the superimposing of cadastral layer on land use zoning map.

2.1 Concepts

The superimposing of the land use zoning in cadastral layer is useful for implementation the national land use policy at the Nagarpalika/Gaunpalika 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 that as per the standards for planning set by national government. A local comprehensive plan of cadastral layer guides a community's land use, conservation of natural resources, economic development, and related public services. For this, it needs 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". 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 B.S. 2021 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 1:10000 scales. The digital data provided by TLSUMD is from the digitization of the existing up to date maps from the former DOLIA 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 maps which provide information about current 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 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. If, for example, only 60% of the land designated for residential use is in active use or development, it would suggest that making more residential zoning available is not necessary. 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, heavy industrial, waste storage, and so forth so that people get a clear visual impression of how land in the 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.

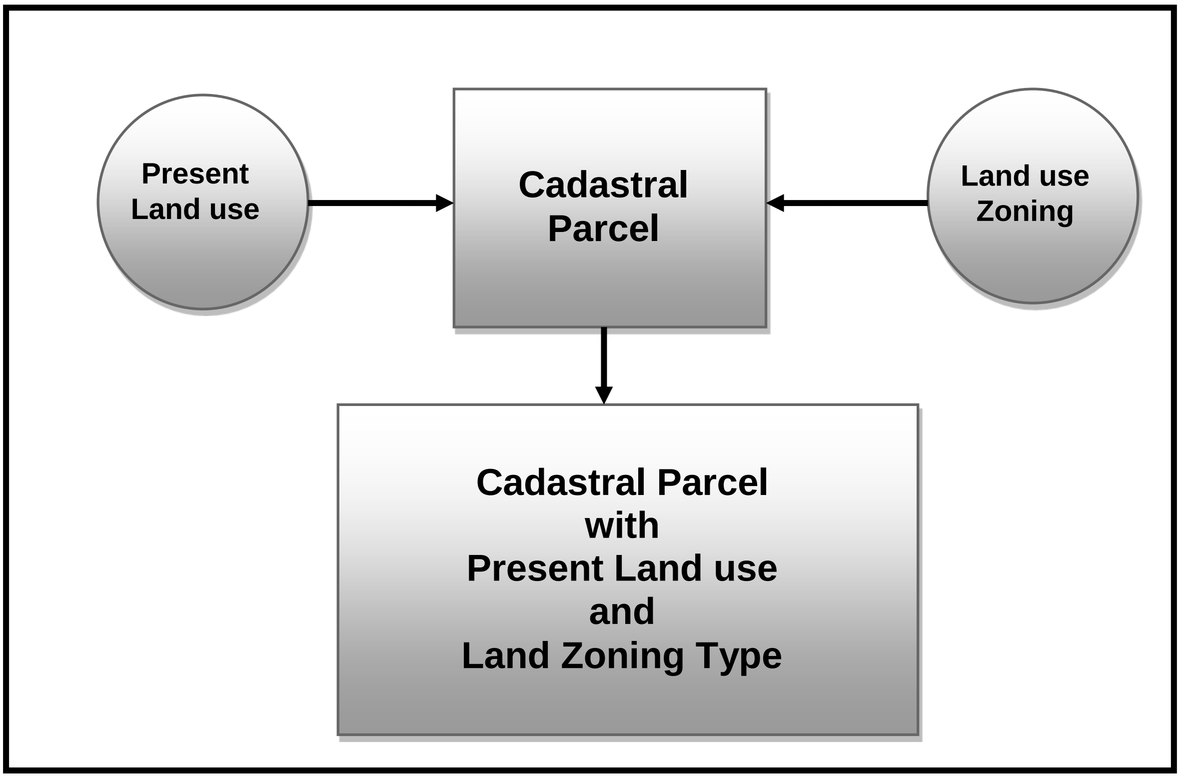


Figure 2.1: Spatial Function Related to Spatial Databases

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 data bases (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 will provide information on proposed use of the particular parcel. The overlay function will as well provide information on the proposed change of use parcel wise, and will as well provide a summary on the overall change in land use anticipated upon the implementation of the land use zoning.

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. This 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 to the land use and land use zoning will enable 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. Nagarpalika/Gaunpalika level. For the preparation of the cadastral layer to be superimposed on land use and land use zoning maps of the project areas, the following methodological approach was adopted.

3.1 Data Sources/ Acquisition of Cadastral Maps and Data

The original source of cadastral data for the Nagarpalika/Gaunpalika of district was respective Survey Office who maintains the original cadastral maps and records, and those cadastral maps were digitalized by former DOLIA and stored as sheet wise geodatabase in .gdb format. This was made available to the project TSLUMD for this exercise. TSLUMD has provided digital copies of each land cadastral maps in vector format together with the attribute database. The data thus obtained were synchronized with national reference frame. The data were based on the digitization of related cadastral maps available with the Survey Office and current to the date of digitization by former DOLIA.

List of grid sheet maps in Bajhang district as per Nagarpalika/Gaunpalika, of which were in the Package 19 project area and their corresponding cadastral geodatabase tiles files are listed in the Appendix.

The present land use and land use zoning maps for the study area were prepared by this Company under the separate components of the project as per the TOR. The land use zoning map of the Gaunpalika is based on the categories of National Land Use Policy, 2068 of Government of Nepal.

3.2 Scanning

In case of unavailability of digital cadastral maps, scanning of paper maps was performed and database was generated by following the standard adopted by former Department of Land Information and Archive. Scanning of each sheet was carried out at the DPI of 200 following the standard operation procedure set by former DOLIA.

3.3 Georeferencing of Cadastral Data

A sheet-wise grid-sheet digital cadastral database was available for the project. Therefore geo-referencing was not necessary. This was carried out with the help of ortho-rectified satellite image of the area. The steps adapted to geo-referencing and superimpose cadastral parcel on land use zoning map within the prescribed area is shown in Figure 3.1.

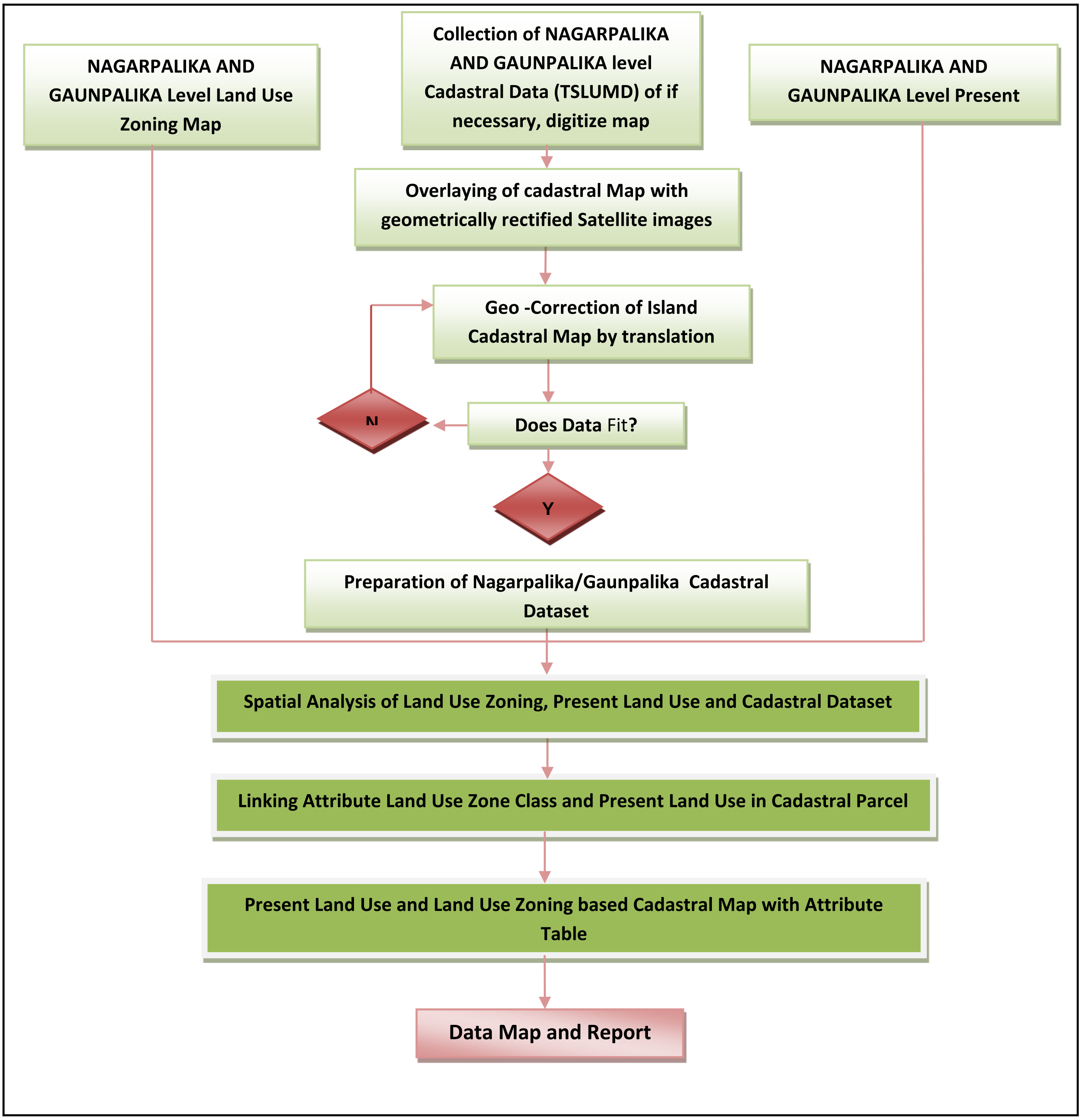


Figure 3.1: Schematic Diagram of Methods Adopted

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 geo-referenced in national reference frame, the following method was applied. The details of ortho-rectification are given in Land Use Report:

- A team of surveyors visited project areas for carrying out survey of GCPs as necessary using DGPS technology.
- Using these control points orthorectification of 5.8m Multispectral and 2.1m panchromatic spatial resolution of ZY (Ziyuan-3) Imagery was made.
- The geo-referencing was carried out matching the sharply identifiable common points GCPs in the cadastral map and the ortho-rectified image map. Geo-correction of vector layer of cadastral data need GCPs at least on the four corners of the map sheet, however to maintain the accuracy, and ensure even distribution of errors the consultant used 10 GCPs in one cadastral map sheet for geo-referencing. A 2nd degree polynomial transformation was applied for rectification of the vector layer of cadastral dataset after assigning the required GCPs. Due to larger errors in source data, mainly due to the plane tabling methodology using limited local control, 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 (1:10000). 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 and an error report has been generated.

Details of national reference system coordinate used are presented in table 3.1.

Table 3.1: Projection Parameters Adopted

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

Some of the constraints the consultant faced during the rectification process are listed below:-

- Very difficult to find easily identifiable ground control points corresponding to the distinct features
- Adjacent sheets are difficult to match and create problem to get seamless mosaics even after polynomial, similarity transformation or triangulation.

3.4 Digitization and Preparation of Digital data

Georeferencing and matching with the ortho-rectifiied image maps provides a common geodetic framework for all related maps, and will therefore provide a common basis for overlay and other GIS operation functions.

3.5 Preparation of Nagarpalika level Seamless Cadastral Dataset

A ward level and subsequently Gaunpalika level seamless cadastral datasets of vector cadastral layer 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 unsurveyed areas.

3.6 Superimpose of Nagarpalika Level Seamless Cadastral Dataset on Land Use Zoning Map

Spatial Analysis of land use zoning map and cadastral dataset was carried out by overlaying Gaunpalika 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 Gaunpalika 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.

As per the data made available by TSLUMD, prepared by former DoLIA (Department of Land Information and Achieving), following categories have been defined for each parcel in the attribute table.

Parcel Type

Code	Description
0	Private
20	River
30	Forest
60	Government
70	Institution

Parcel Land use

Code	Description
0	Mixed
10	Kulo/Canal
20	River
22	Pond
24	Lake
26	Steep Area
30	Forest
32	Grassland
34	Bush
36	Sand/Gravel
38	Rock
40	Metalled Road
45	Gravelled Road
50	Earth Road
60	Residential
65	Industrial
70	Institutional
74	Heritage
80	Cultivation
85	Open Area
90	Park

These categories have also been referred subjectively to define the land use but mostly referring to the present land use database prepared from satellite image. The possible reason for some inconsistencies seen in the cadastral database could be due to the land use change that have occurred since the cadastral database have been prepared which needs to be updated with latest data. These discrepancies have been subjectively analyzed and consulted with the client.

Chapter - 4

CHARACTERISTICS OF THE SUPERIMPOSE OF CADASTRAL PARCEL

Some analysis of the superimposition of cadastral maps over the present land use and the land use zoning map is provided here. Some details on the suitable conversion upon comparison of zoning map with the present land use with respected to surveyed cadastral plans are as well provided.

The Cadastral Survey in Bajhang district was carried out long ago. Due to lack of a land use zoning regulations the parcel size and use have undergone random conversions over the years. Similarly due to the lack of strict regularizations on maintenance of public and government land some changes have undergone in their uses as well. Accuracy of the original plane table survey should as well be considered while assessing on the figures on the database, however this will have limited implications on the scale of the map 1:10,000.

At the time of digitization, the Gaunpalika had 45232 land parcels and area covered in the survey was 7213.31 ha.

4.1 Cadastral Parcel Superimpose on Present Land Use

Table 4.1 shows the present characteristics of cadastral parcels that falls in the Gaunpalika under study.

Table 4.1: Parcel Characteristics of Present Land Use

Present Landuse Class	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest	39459432.32	3945.94	356	54.70%
Agricultural	31557846.96	3155.78	41501	43.75%
Riverine, Lake and Marsh Area	562934.20	56.29	328	0.78%
Residential	430056.16	43.01	2936	0.60%
Other	109414.48	10.94	44	0.15%
Public Service	12968.07	1.30	62	0.02%
Cultural and Archeological	210.59	0.02	2	0.0003%
Commercial	200.53	0.02	3	0.0003%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

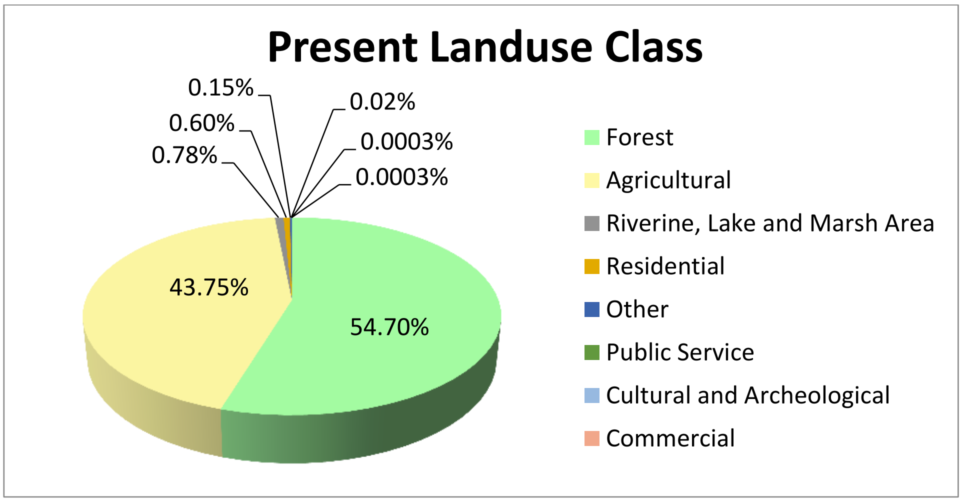


Figure 4.1: Distribution of Parcels over Present Land Use (%)

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 Gaunpalika under study of Bajhang district of Nepal. In the cadastral area of the Gaunpalika out of the designated 10 classes, zoning for all seven classes except other specially designated classes were planned. The distribution of parcels over proposed landuse zone is shown on table and chart below.

Table 4.2: Parcel Characteristics of Land Use Zoning

Proposed Landuse Class	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest	39504983.43	3950.50	360	54.77%
Agricultural	31455535.18	3145.55	40978	43.61%
Riverine, Lake and Marsh Area	562941.46	56.29	328	0.78%
Residential	528906.00	52.89	3194	0.73%
Public Service	58410.10	5.84	281	0.08%
Commercial	22076.55	2.21	89	0.03%
Cultural and Archeological	210.59	0.02	2	0.0003%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

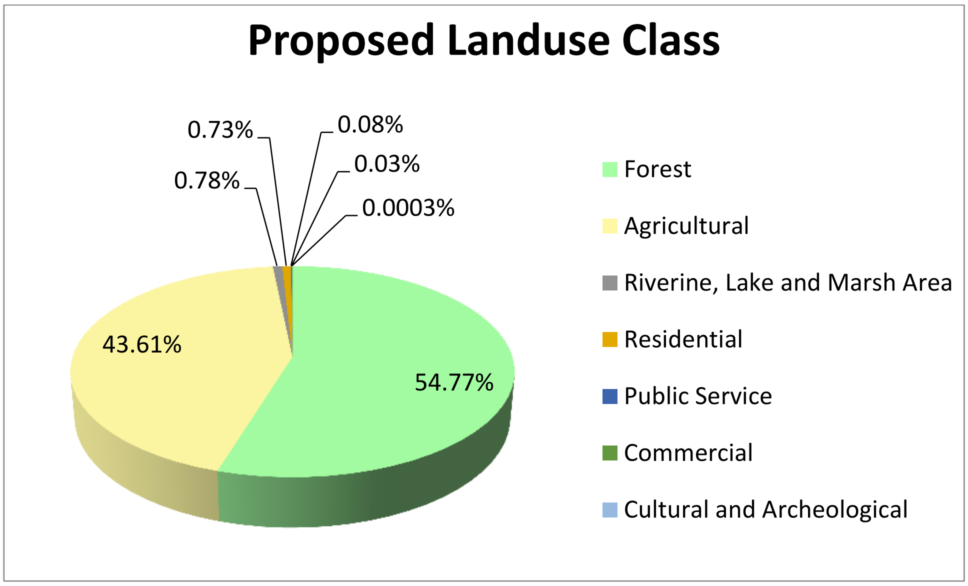


Figure 4.2: Distribution of Parcels over Land Use Zoning (%)

Parcel characteristics: This could be assessed from the superimposition of present land use and proposed land use given in the land use zoning maps. The parcel characteristics could be analyzed with this superimposition. Table 4.3 gives the details.

Table 4.3: Parcel Characteristics of Present Land Use Land Use Zoning Superimposition

Present Land Use/ Proposed Land Zoning	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest/Forest	39451614.36	3945.16	355	54.69%
Agricultural/Agricultural	31350092.20	3135.01	40936	43.46%
Riverine, Lake and Marsh Area/Riverine, Lake and Marsh Area	562857.56	56.29	327	0.78%
Residential/Residential	427577.70	42.76	2910	0.59%
Agricultural/Residential	101328.30	10.13	284	0.14%
Other/Agricultural	97625.03	9.76	41	0.14%
Agricultural/Public Service	42824.74	4.28	191	0.06%
Agricultural/Forest	41579.61	4.16	2	0.06%
Agricultural/Commercial	21938.21	2.19	87	0.03%
Public Service/Public Service	12968.07	1.30	62	0.02%
Other/Forest	11789.46	1.18	3	0.02%
Forest/Agricultural	7817.95	0.78	1	0.01%
Residential/Public Service	2478.46	0.25	26	0.003%
Cultural and Archeological/Cultural and Archeological	210.59	0.02	2	0.0003%
Commercial/Commercial	138.34	0.01	2	0.0002%
Agricultural/Riverine, Lake and Marsh Area	83.90	0.01	1	0.0001%
Riverine, Lake and Marsh Area/Public Service	76.64	0.01	1	0.0001%
Commercial/Public Service	62.19	0.01	1	0.0001%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

Note: Conversion from Forest to Agriculture or Public Service or Residential is due to unavoidable geometrical inconsistencies and therefore requested to be read as negligible and ignored.

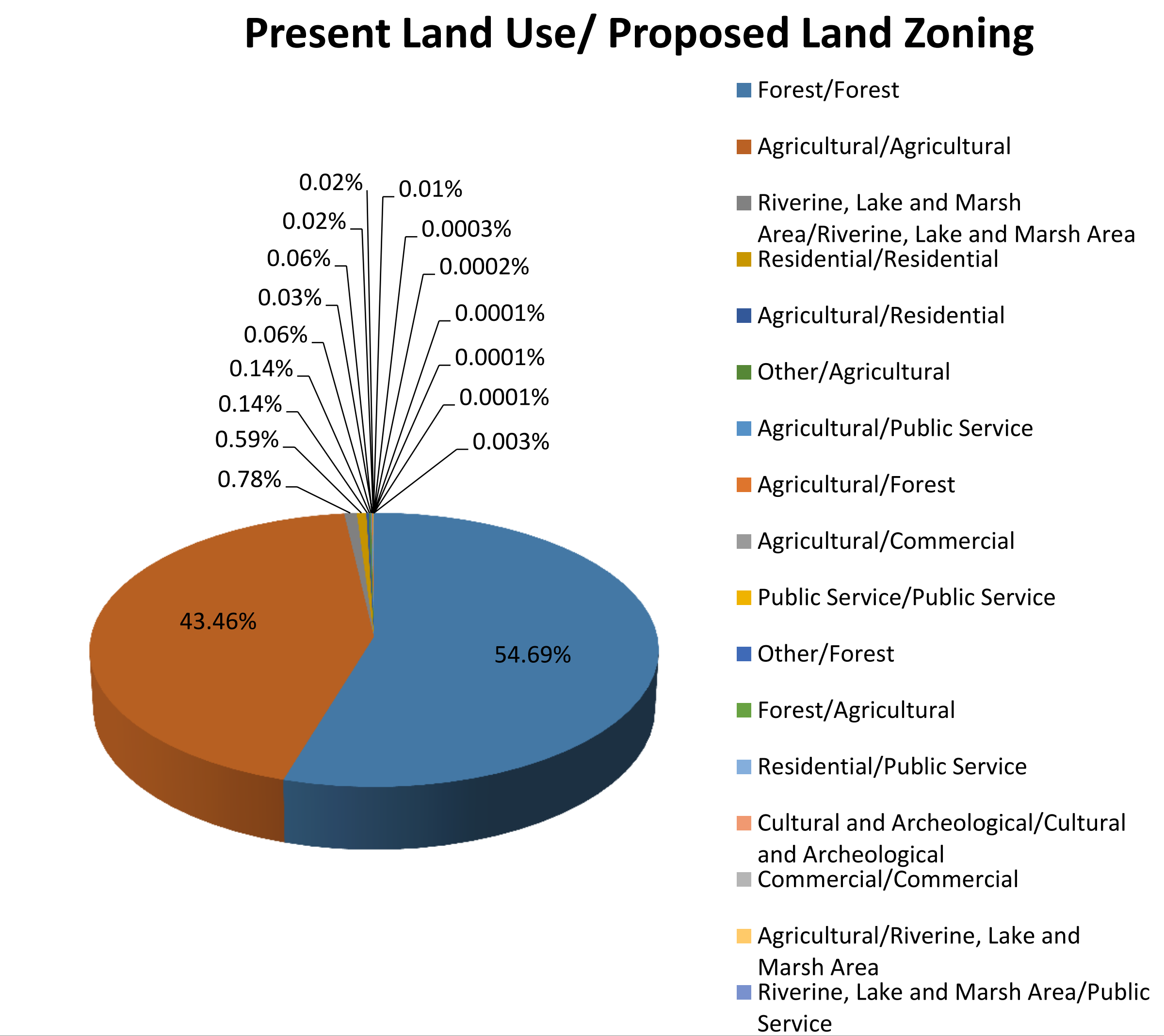


Figure 4.3: Parcel of Present Land Use versus Proposed Land Use (%)

Chapter - 5

CONCLUSIONS

5.1 Conclusions

Land use planning and management is a distinctive cross-sectorial issue, as many stakeholders are involved. Therefore, single measures have very little impact in reducing demand for land. To reach a sustainable level of land use, a wide variety of instruments, including fiscal, economic, regulatory and planning tools, must be used in combination. Furthermore, the activities, strategies and instruments must involve the relevant stakeholders, such as representatives from the administration (national, regional and local level) and the different disciplines (regional versus urban planning, nature conservation and environment protection, economy and traffic) in order to efficiently achieve a sustainable level of land use. Even more important would be the involvement of the local bodies, the local people and the local user groups, which has been very much emphasized in the National Land Use Policy 2072, and its implementation directives, 2072 and recently published Land Use Act 2076.

The present exercise is fruitful and it produced required maps, data base and reports on the theme, which will be fundamental technical reference for implementing land use plan at the local level. Such a database will certainly help the concerned authorities to think of the ongoing practices on the lands, the finite resources of the country. It will further help to develop plan for the local areas and implement accordingly. In this sense, the exercise can be regarded as milestone for the planners and authorities working within the area.

5.2 Recommendations

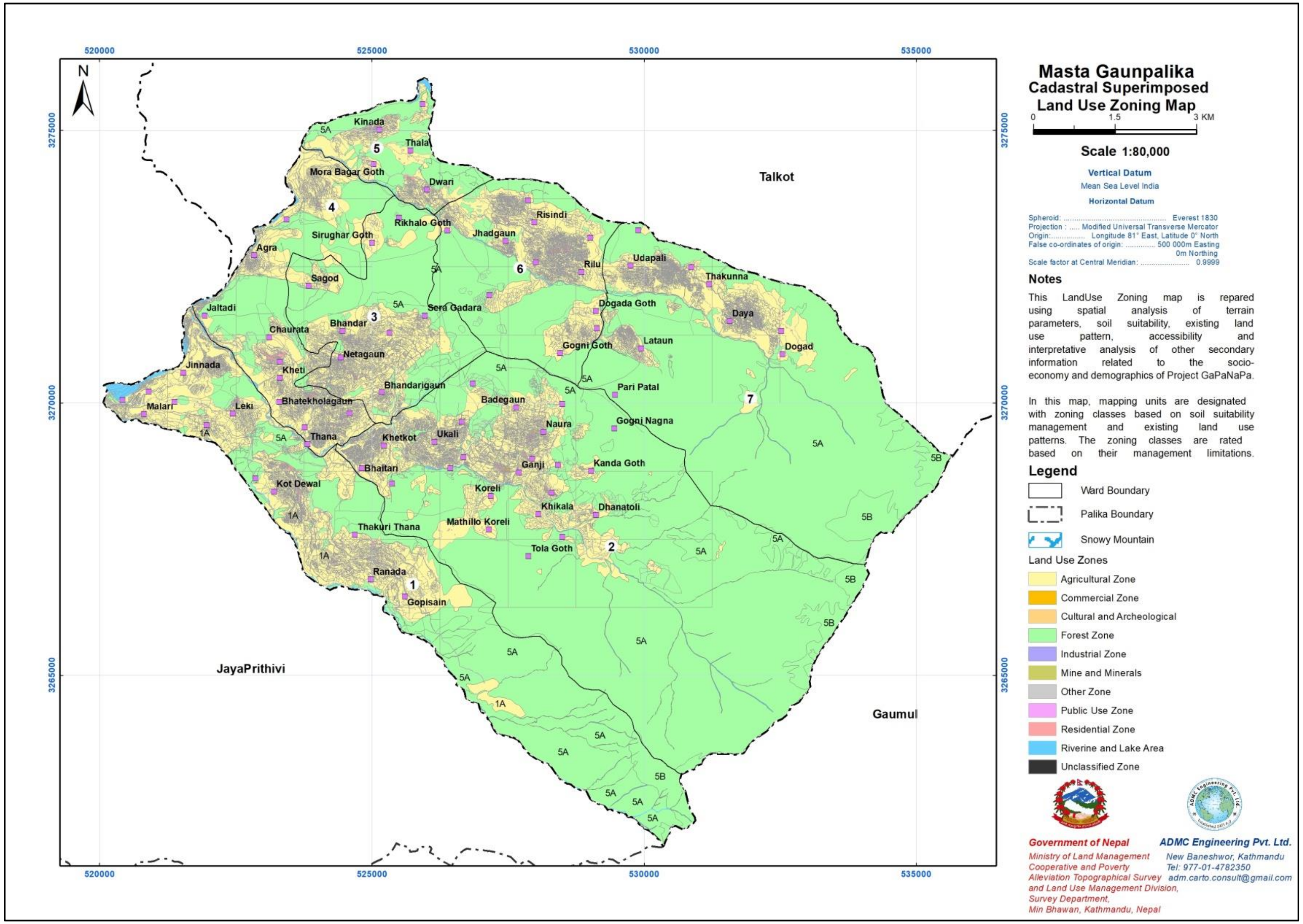
The study team has observed that the digital cadastral databases provided by through TSLUMD are not adequately accurate as seen from the differences in consistency rendered by the variation of map scales. During field work, ortho-rectification and geo-referencing few under and overlapping and mismatch with the ground reality could be seen. Therefore it is recommended that the parcel wise data could be used for reference only and boundary adjudication of proposed land use zoning should be implemented cautiously. Regarding some inconsistencies, we observed two scenarios. First there were cases of land abandonment where land was registered in individual name but the land was left uncultivated for many years. This situation led to growth of forest in the registered cultivated land. Second, there were cases of 'Aailani' land where people had occupied the land but they had not formal entitlement/registration certificates. As a result, in the map, the area appears as cultivated one but not registered as private land.

It is highly recommended that the land use zoning implementation on the ground has to be confirmed through local consultation, for which these technical maps and data should be used as important reference.

सारांश तथा सुझाव

वर्तमान र प्रस्तावित भू-उपयोगको क्षेत्र वर्गीकरण नक्सामा कित्तानापी नक्सालाई super-impose गरि विश्लेषण गर्दा सामान्यत super-impose भएको पाइन्छ। यस्तो super-impose गर्नको लागि सहि र अध्यावधिक कित्तानापी नक्साको आवस्यकता रहेको छ। यस अध्ययनमा प्रयोग भएको कित्तानापिका नक्सा केहि वर्ष पुराना रहेको र अहिलेको अवस्तामा निश्चित रुपमा केहि परिवर्तन भएको अवस्ता छ। यसका अलावा कित्ता नापी नक्सामा काम गर्दा स्थानीय समुदाय/सरकार संग बिस्तृत रुपमा सहकार्य/परामर्श गर्नु पर्ने हुँदा प्राप्त super-impose map लाई सन्दर्भ सामग्रीका रुपमा लिन उपयुक्त देखिन्छ। बिशेषगरि, कित्तानापीका नक्सहरुको प्रयोग गर्न पुर्व, पालिकाका सहरी/ग्रामिण बिकाशका मापदण्डहरु निर्धारण गरि साथसाथै सामाजिक र आर्थिक विकाशको आवस्यकताहरुलाई पनि मध्यनजर गरि योजना बनाउन गरुरी देखिन्छ।

Appendix 1: Cadastral Superimpose Map of Masta Gaunpalika



H. Profile of the Nagarpalika/Gaunpalika

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CHAPTER -1

MASTA GAUNPALIKA - AN OVERVIEW

1.1 Context/Naming and Origin

There is a famous temple of Masta Kul Dewata in ward number three which is worshipped with devotedly by the common people of Bajhang. This Kul Dewata is very popular in this area including surrounding districts. Before reconstruction of state by constitution 2073, one of the of VDC name was Masta in Bajhang district which is related with Masta Kul Dewata. In this context, after reconstruction of local level, among the twelve, one unit of local level became Masta Gaunpalika by merging three previous VDCs ie. Kotdewal, Masta, Bhatekhola and Rilu.

1.2 Location

Masta Gaunpalika is located 81° 12' 18.80" to 81° 21' 58.79" Eastern longitude, and 29° 28' 46.28" to 29° 36' 24.69" Northern latitude covering an area of 109.05 square kilometer. This Gaunpalika consists of former Kotdewal VDC (nine wards), Masta VDC (nine wards), Bhatekhola VDC (nine wards), and Rilu VDC (nine wards). It is surrounded by Bajura to the east, Jaya Prithvi Nagarpalika to the west and south and Talkot Gaunpalika to the north.

1.3 Settlements and Administrative Units

According to the present constitution of Nepal, the local level administrative unit is known as Gaunpalika (Rural Municipality) and Nagarpalika (Municipality) and they are formed by merging two or more VDCs/municipalities partly or fully. There are total twelve local units Gaunpalika/Nagarpalika in Bajhang. Out of total, there are ten Gaunpalikas and two Nagarpalikas in Bajhang. Masta is one of the ten Gaunpalikas of Bajhang. The local unit is further divided into different wards ranging from five to seven.

Table 1.1: Distribution of Major Settlements by Ward

Ward No.	Name of previous VDC	Merged wards	Area	Name of major settlement
1	Kotdewal	1, 2, 3, 4, 5, 6, 7, 8, 9	19.39	Gopisen, Ranada, Thakurithana, Leki, Bhulari
2	Masta	1, 2, 3, 4, 5, 6, 7, 8, 9	36.86	Tingaun, Gaura, Melkhet, Bhaitari, Khetkot
3	Bhatekhola	2, 3, 4, 5, 8	8.59	Bhandar, Bhandarigaun, Khagod, Sirughar Goth, Kosyang Goth
4	Bhatekhola	1, 6, 7, 9	8.22	Bhulgaun
5	Rilu	8, 9	3.73	Kinada, Dwari, Khala, Maurakhagar Goth, Tallachaur
6	Rilu	5, 6, 7	9.11	Rilu, Risindi, Rigalo Goth, Satanu Goth, Kalasen Goth
7	Rilu	1, 2, 3, 4	23.35	Degaha, Bhitamal, Daya, Thakunna, Latauna
Total			**109.23**	

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2070

There are seven wards in this Gaunpalika. A ward consists of many villages. There are about 37 major villages/settlements. All nine wards of Kotdewal VDC have been merged into present ward number one of Masta. Likewise, all wards of Masta have been changed into ward number two of this Rural Municipality. Former VDC, Bhatekhola has been divided into two wards (three and four) of Masta. In the same way, ward number five, six and seven were constructed by dividing Rilu VDC. Ward number two is larger ward of this Gaunpalika followed by seven and one. The small ward is five in terms of area which has 3.73 square kilometer followed by four and three.

Roof Types

Basically, there are two types of house, Kachchi and Pakki on the basis of construction materials. All houses are Kachchi in this Gaunpalika made of wood, bamboo, log and twigs with zinc, straw and thatched roofing. In the context of roofing nearly 90 percent houses are made of stone/slate followed by thatch (4.6 %). Similarly, about 4.5 percent houses are roofed from jasta/zinc. Very limited houses are made of from wood and mud in this village.

Table 1.2: Status of roof type in Masta

Ward No.	Khar Roof	Jasta Roof	Tile/ Stone Roof	Wood Roof	Mud Roof	Total
1	3	10	552	2	0	**567**
2	23	19	520	1	0	**563**
3	5	8	304	1	15	**333**
4	87	31	171	1	1	**290**
5	7	21	291	2	1	**322**
6	2	17	319	2	0	**323**
7	1	21	373	1	0	**400**
Total	**128**	**127**	**2530**	**10**	**17**	**2798**
Percent	**4.6**	**4.5**	**90.4**	**0.4**	**0.6**	**100**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

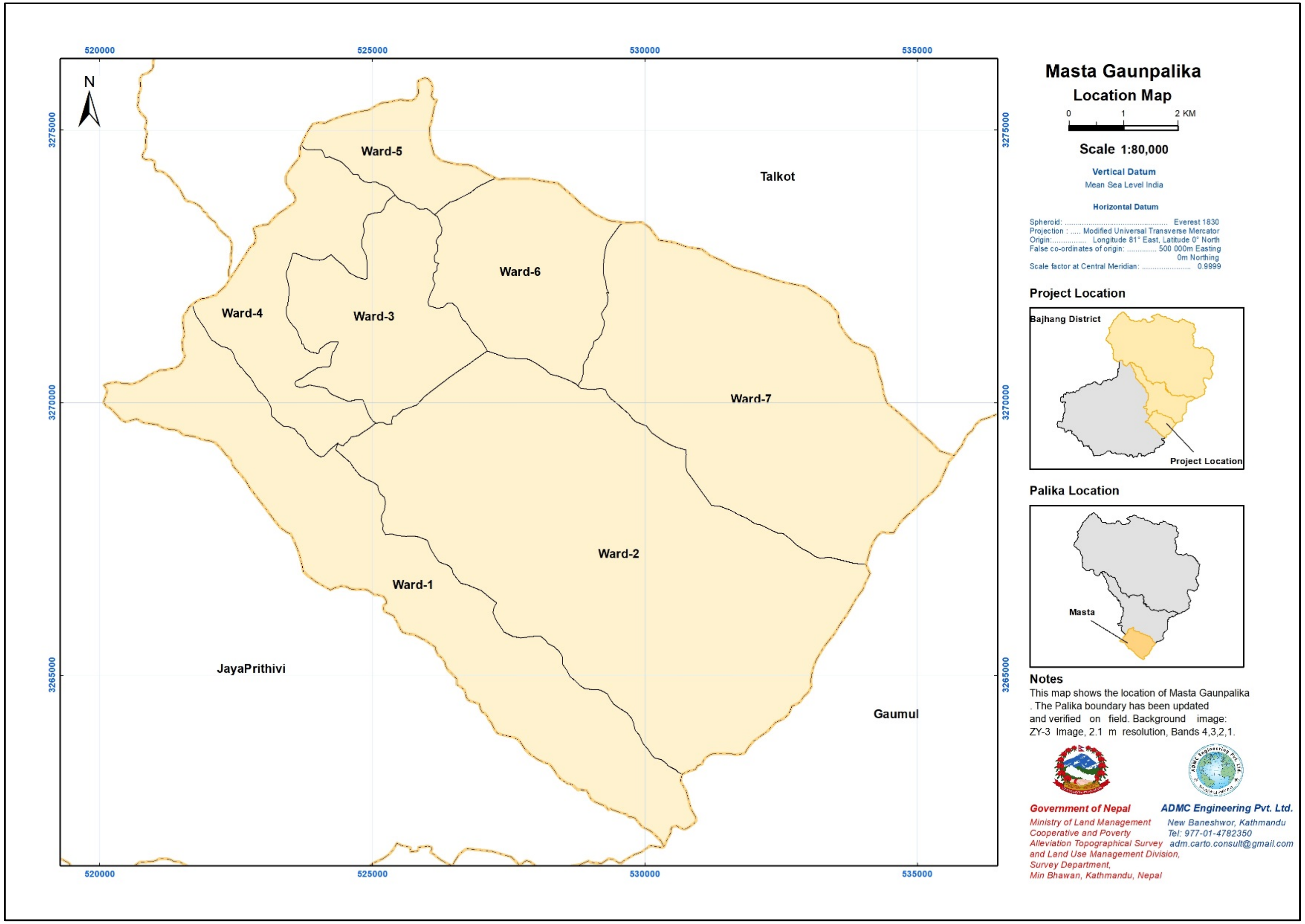

Figure 1.1: Location Map of Masta Gaunpalika

CHAPTER 2

PHYSICAL SETTINGS

2.1 Physiographic Region

Bajhang is one of the districts located in the high mountain region. This district is mountainous and some basins in river side. There is Middle Mountain, High Himalaya and Himalaya. Masta Gaunpalika ranges from 1257.51m. to 3926.82 m. The micro topographic variations are depicted in the terms of Shaded Relief Map, Slope Map and Digital Elevation Map which are shown below and following sub-chapters.

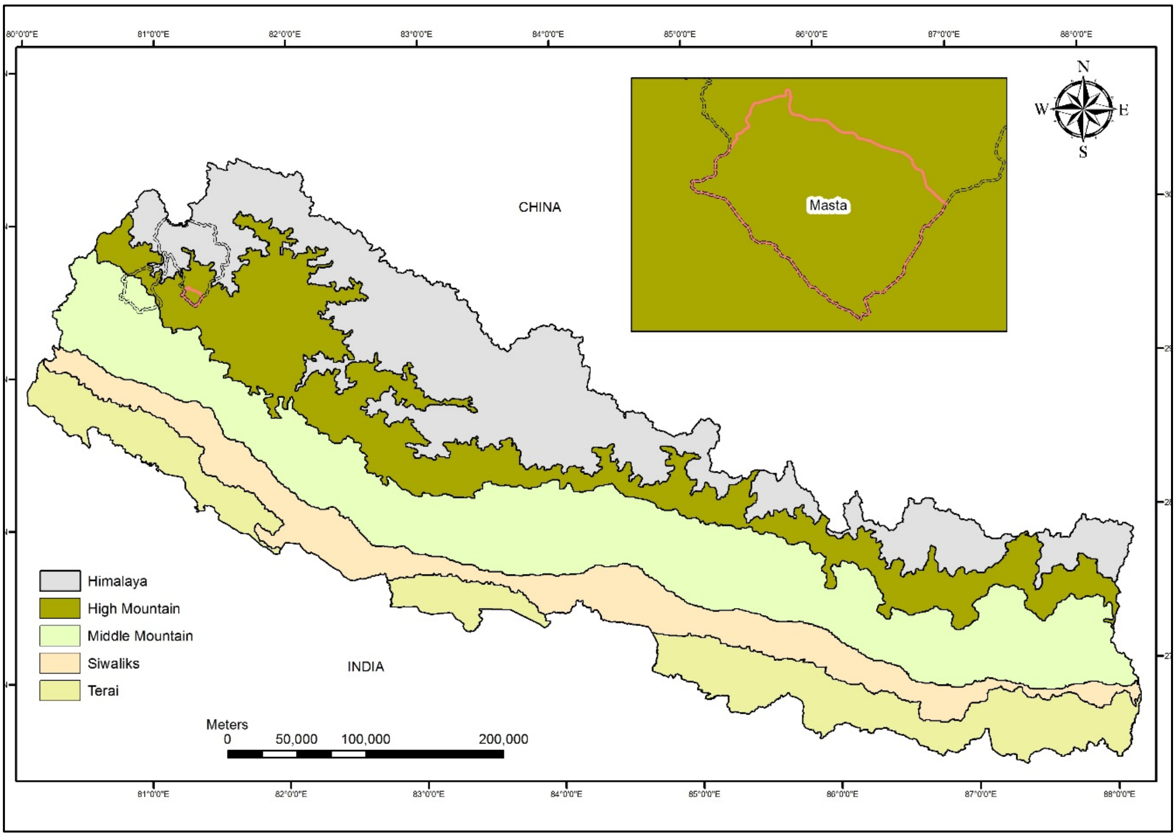

Figure 2.1: Physiographic Region of Masta Gaunpalika

2.2 Geomorphology

Geomorphologically, the area is characterized by river terraces, colluvium deposits and rocky slopes. Its terrain presents an irregular assemblage of deeply dissected mountains and short ranges with diverse trends with slopes ranging from 0.0340^{0} to 77.2597^{0} and covering the major portion of by less than 80^{0} Slope.

2.3 Geology of Masta Gaunpalika

REGIONAL SETTING

- The area falls in the Middle mountain range (Lesser Himalaya) to Higher mountain range (Higher Himalaya) and then to the Tibet, China (Tibetan Tethys zone). The Higher mountain is characterized by MCT (Main Central Thrust).
- Geomorphologically, the area is characterized by river terraces, colluvium deposits and rocky slopes. The 'Seti River' is one of the major rivers in the area. The catchment area is characterized by very rugged and steep topography, which was resulted by the upliftment of the Himalayan Range.

Figure 2.2: Main Central Thrust (MCT) Observed about 5-10 Kms ahead from Chainpur, Bajhang

GEOLOGIC DESCRIPTIONS

BEDROCK

- The rocks are Igneous, Sedimentary and Metamorphic type. The main lithology of the project area is Slate. Beside Slate, Quartzite, Marble, Phyllite and Limestone with intrusion of basic igneous rocks are other types of rock found in this area. The age of the rock is ranging from Precambrian to Ordovician period.
- The area has more than 40% steep slope because of the nature of the rock. Slope influences the soil formation which controls soil erosion and water movement in the soil along with the other soil forming factors and affecting the soil characteristics.
- The rocks are classified as Midland Group and Surkhet Group of Lesser Himalaya, Higher Himalaya Crystalline and Tibetan Tethys sedimentary zone.

REGIONAL GEOLOGY

The area is located in the Lesser Himalaya, Higher Himalaya and up to the Tethys Himalaya of Far Western Nepal.

Himal Group (Hm): is characterized by presence of Garnet-biotite gneisses, Kyanite-biotite gneisses, garnetiferous mica schists, augen gneisses, micaceous quartzites and thin bands of marble.

Ranimatta Fm (Rm): is characterized by gray to greenish gray shales, phyllite shales garnetiferous phyllites grayish white quartzites with carbonate beds and amphibolite.

Kushma Fm (Ks): is characterized by greenish gray, white fine to medium grained at places, ripple marked massive quartzites intercalated with green phyllites. Basic intrusions are abundant.

Lakharpata Fm (Lk): is represented by presence of bluish-grey dolomite, limestones and shale.

Ulleri Fm (Ul): is represented by feldspathic schists with augens of feldspar and quartz, augen gneisses intrusions of granite.

Basic Rocks (Br): are the basic igneous rocks with more vesicles.

Galyang Fm (Gl): is characterized by presence of dark grey to black phyllite and spotted white, fine-grained quartzite.

Suntar Fm (Sn): is comprised of fine to medium-grained, greenish grey sandstone and purple shale.

Masta Gaunpalika belongs to all the formations mentioned in the Regional Geology are **Ranimatta Fm (Rm), Kushma Fm (Ks), Lakharpata Fm (Lk), Basic Rocks (Br), Galyang Fm (Gl), Suntar Fm (Sn)** except **Himal Group (Hm), Ulleri Fm (Ul).**

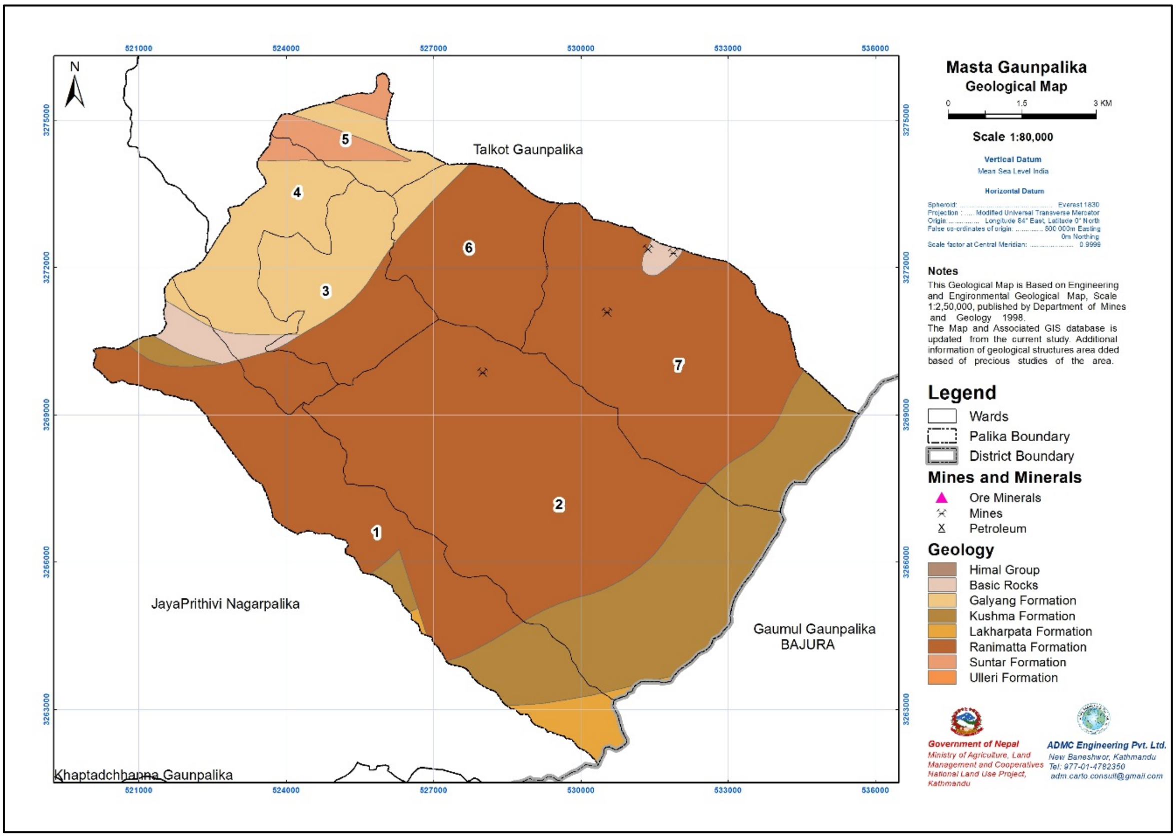

Figure 2.3: Geological Map of the Masta Gaunpalika

GEOLOGICAL STRUCTURES

Thrust:

MCT is the major geological structure found in the area.

Main Central Thrust (MCT):

The MCT strikes in southeast-northwest direction and separates the high-grade metamorphic rocks of the Higher Himalaya to the north and low-grade metamorphic rocks of the Midland Group of the Lesser Himalaya to the south.

Other Major Thrust:

The thrust is located southwest of the MCT and extended nearly parallel and perpendicular around the area.

Fold and Foliation:

Around the area, regional folds are not reported but minor and local folds can be seen.

Anticline: Anticlines are folds in which each half of the fold dips away from the crest. Major anticlinal folds have not been observed but some minor and local anticlinal folds can be seen.

Syncline: Synclines are folds in which each half of the fold dips toward the trough of the fold. Major synclinal folds have not been observed but some minor and local synclinal folds can be seen.

SURFICIAL DEPOSITS

Quaternary Deposits represent the Sub – Recent to Recent sediments deposited by the fluvial action. They are divisible into two types in an ascending order: **Alluvium Deposits and Flood Plain Deposits.**

Alluvium Deposits: This is distributed on both sides of the rivers and streams with low gradient and open valley. They are characterized by river terrace deposits and are of unsorted, rounded to sub rounded pebbly and gravely materials mixed together with fine sand, silt as well as clay giving rise to the development of the fertile top fine soil usable for the cultivation.

Flood Plain Deposits (River Bed Deposits): It occurs along the riversides and on the flood plain (present river channel) itself which also contain the water during the winter season and cover the area as high as the water level rises during the heavy rainy season. In other words, this is the area that is covered by the flooding river and left barren during the dry season after depositing the various materials carried at flood time. It has alluvial loose sediments consisting of boulders, cobbles, pebbles, coarse sand and gravels mainly of sandstone, siltstone and claystone with silt. When mixed with clay it gives rise to the fertile top fine soil usable for the cultivation. The aggregates thus derived and deposited by the river often provide an excellent source of building and construction materials.

Figure 2.4: Flood Plain Deposited by Seti River

River Terraces also known as '**Tars**' in the Middle mountain are abundant in long strike valleys in a multistage and multilevel form. They are depositional in origin and are the remnants of an earlier river bed or flood plain. Several sets of these terraces with different heights above the present river ranging from few meters to hundred meters are noticed.

The coarser materials in the terraces are boulders of granites, quartzite, limestone, sandstone derived from upstream of the Seti river catchment itself.

Figure 2.5: River Terraces made by Seti River

STREAMS AND CANALS

Major river flowing in the project area is Seti river. The headquarter “Chainpur” is situated at the bank of Seti river and Bauli Gaad. Major Canal system are not available but many small local canal system (Kulo) exists. The major river basin in this area is Seti River Basin. Many fractures and joints are present from which hot water springs are exposed out in the area. Dense vegetation in the sloppy area indicates that the rocks are highly porous but lack of water sources indicates that the rocks are less permeable.

MINERAL RESOURCES

Iron, Copper, Cobalt, Nickel, Molybdenum, Phosphorite, Mica, Talc and Coal are the minerals which occurs in the area. Uranite and autonite mineralization has been recorded from Banku Quartzite of Bajhang (Nimli Gad). Stromatolitic phosphorite deposits in Bajhang District, where phosphorite has associated with Pre-Cambrian cherty stromatolite dolomite beds. (Source: DMG)

NATURAL RESOURCES

Surface as well as ground water, non – metallic minerals like river aggregates (sand, gravel, and pebbles) as well as natural forests and building stones like slate, quartzite, and limestone are the prominent natural resources in the area. The seasonal stream beds have enormous deposits of pebbles, gravels and sand as a good source of construction materials in the area. Proper management of these resources for optimum utilization for the livelihood of people is necessary.

2.4 Drainage/Hydrology

Bajhang district with an area of 3,422 sq. km. lies in the mountainous region. Seti River is perennial in nature. The major river and its tributaries flow here from north to south that flows in the designated Gaunpalika' and Nagarpalika. In the monsoon season, these small rivers and streams are filled with huge volume of water that can create the situation of floods. The Hydrologic map and Seti River and its main tributaries at the confluences with the Seti River is depicted in Fig. 2.7 and Fig. 2.8 respectively.

The major river flows from north to south. The Seti Nadi and Dwari Gad is the major river in this Gaunpalika. Beside these there are some local streams originated within the study area itself. In the summer season, these small rivers and streams are filled with huge volume of water that can creates the situation of floods. Fig 2.6 shows the hydrology map of the Masta Gaunpalika.

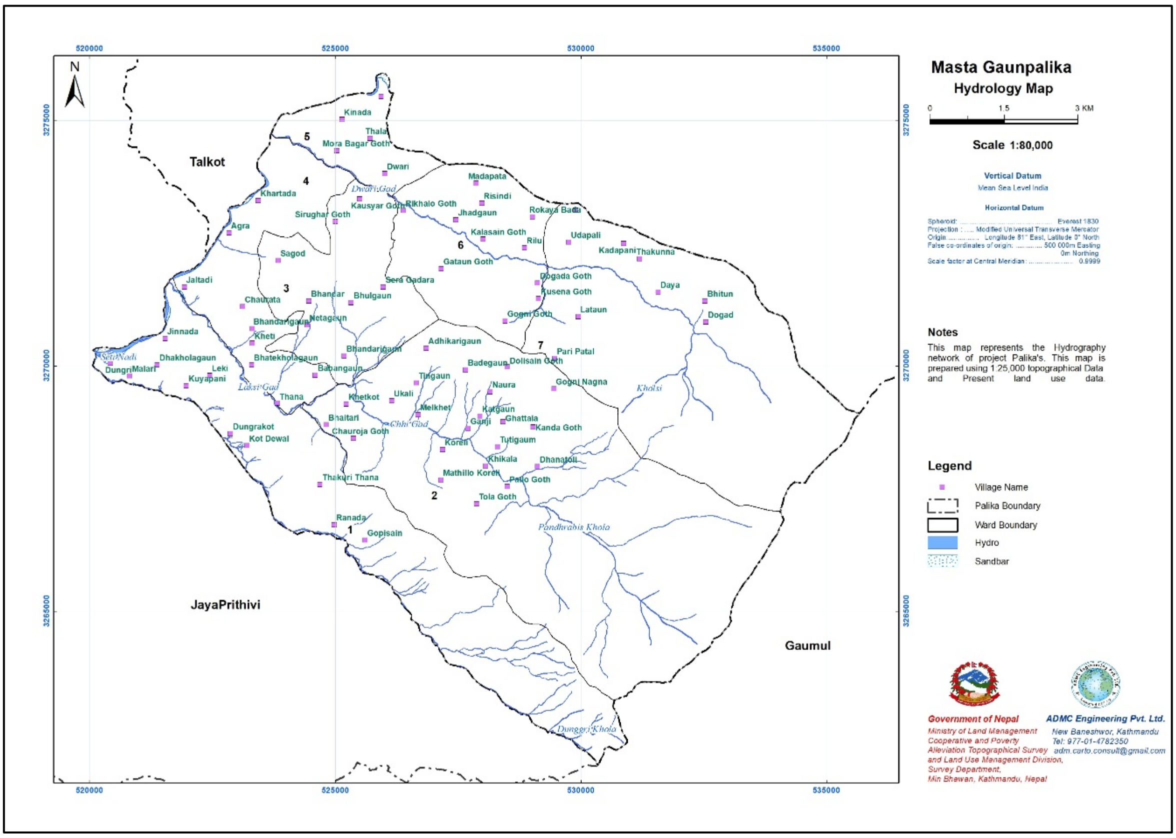

Figure 2.6: Hydrology Map of Masta Gaunpalika

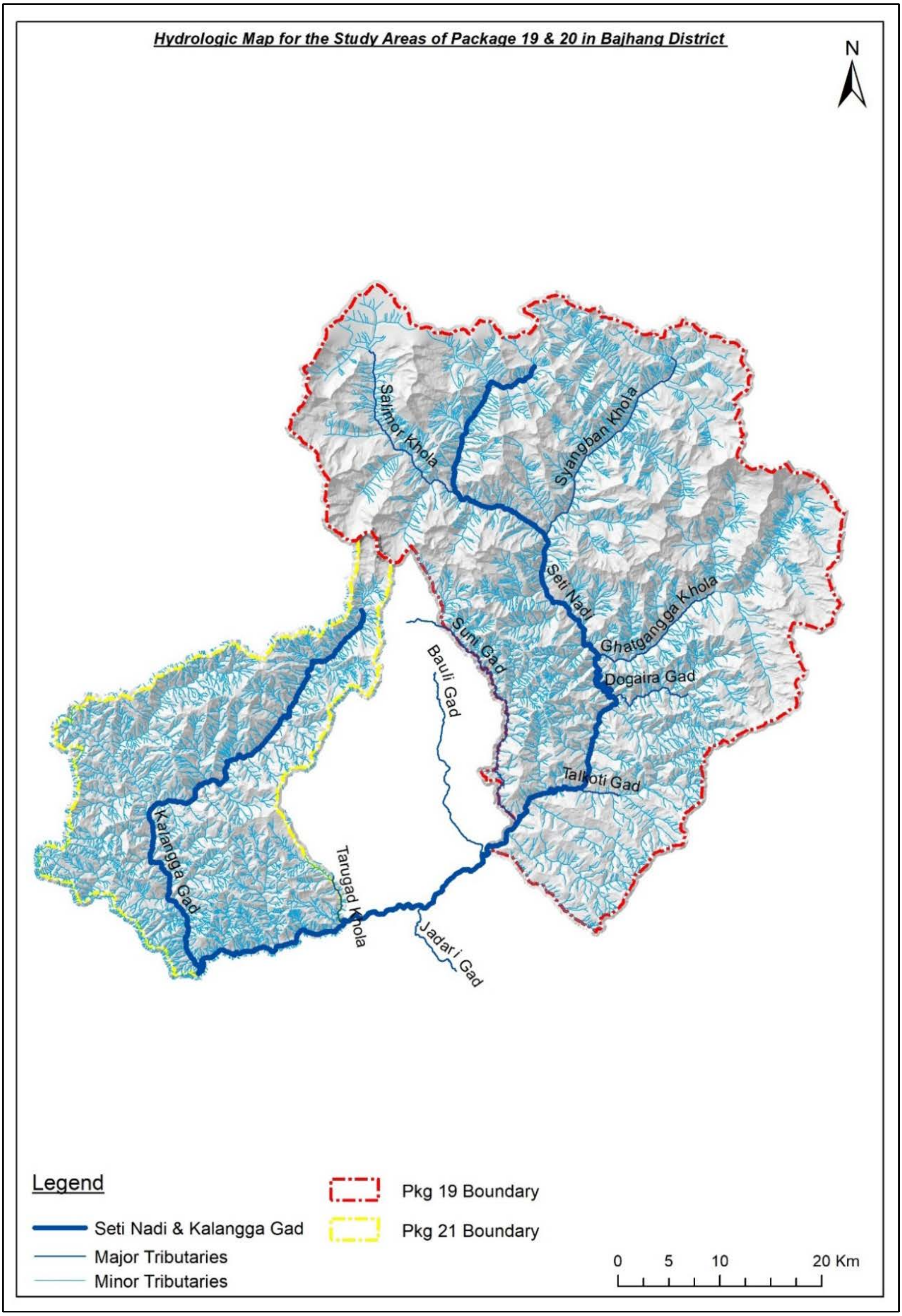

Figure 2.7: Hydrology Map for the study Areas of Bajhang District

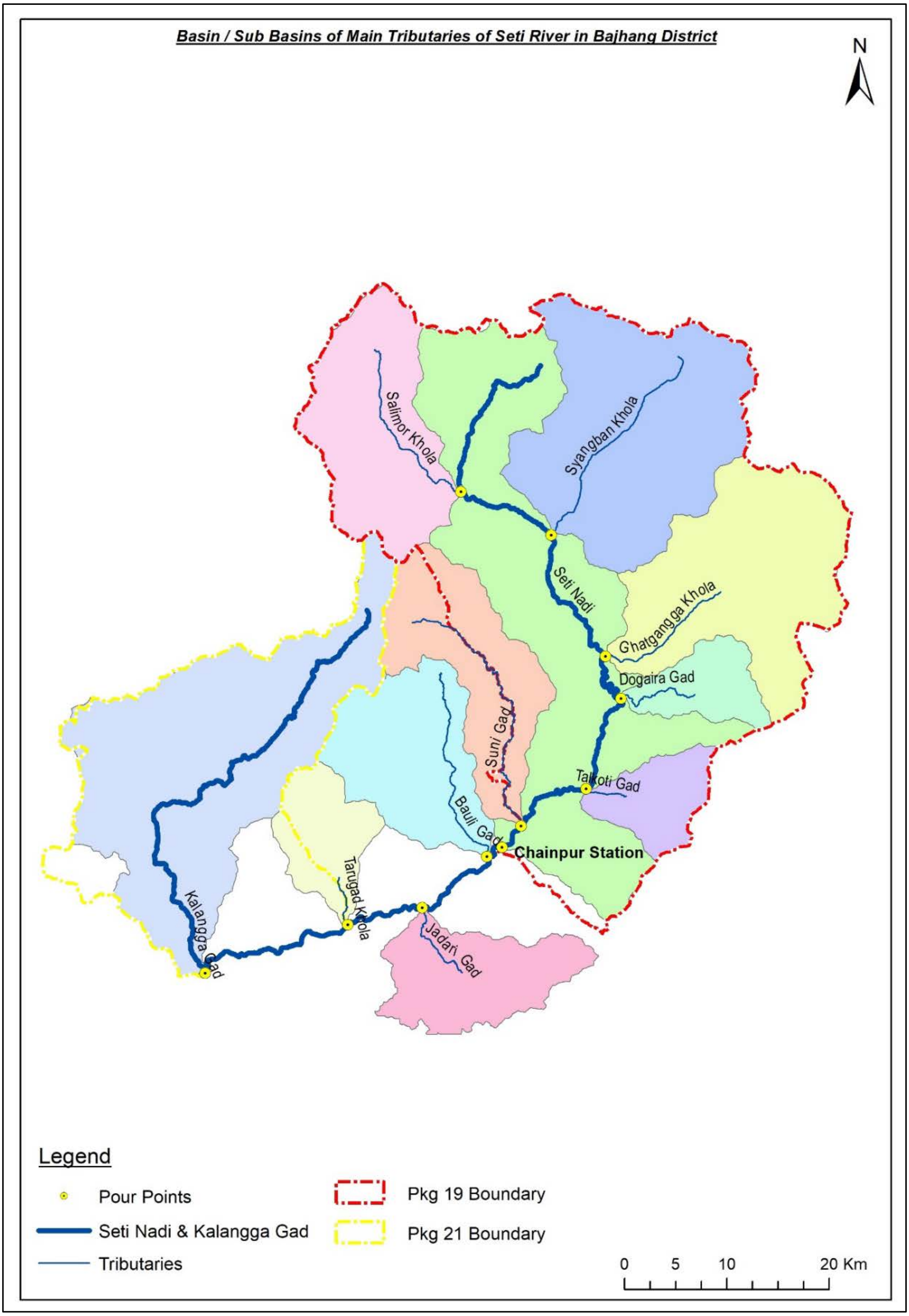

Figure 2.8: Seti River and Its Main Tributaries Availed in Study Areas of Bajhang District

2.5 Terrain

Terrain is the vertical and horizontal dimensions of land surface. It determines the drainage pattern, depth and profiles of soil, land use pattern and susceptibility of land surface to denudation and natural hazards. The Slope of this Masta Gaunpalika ranges ranging from 0.0340 ^{0} to 77.2597^0 and covering the major portion of by less than 80^0 Slope.

2.5.1 Elevation

The elevation is an important topographic element affecting the soil formation. Elevation influences the soil formation by affecting the type of vegetation and soil type along with the climatic factors. The elevation of the Masta Gaunpalika ranges from 1257.51m. to 3926.82 m.

2.5.2 Slope

Slope is influencing the soil formation controlling soil erosion and water movement in the soil along with the other soil forming factors and affecting the soil characteristics. To delineate the soil boundary, slope is used as the physiographic variation. Besides this, slope of the project area was used as the basic tool for the demarcation of landform, land types and land units. The Slope of this Masta Gaunpalika ranging from 0.0340 ^{0} to 77.2597^0 and covering the major portion of by less than 80^0 Slope.

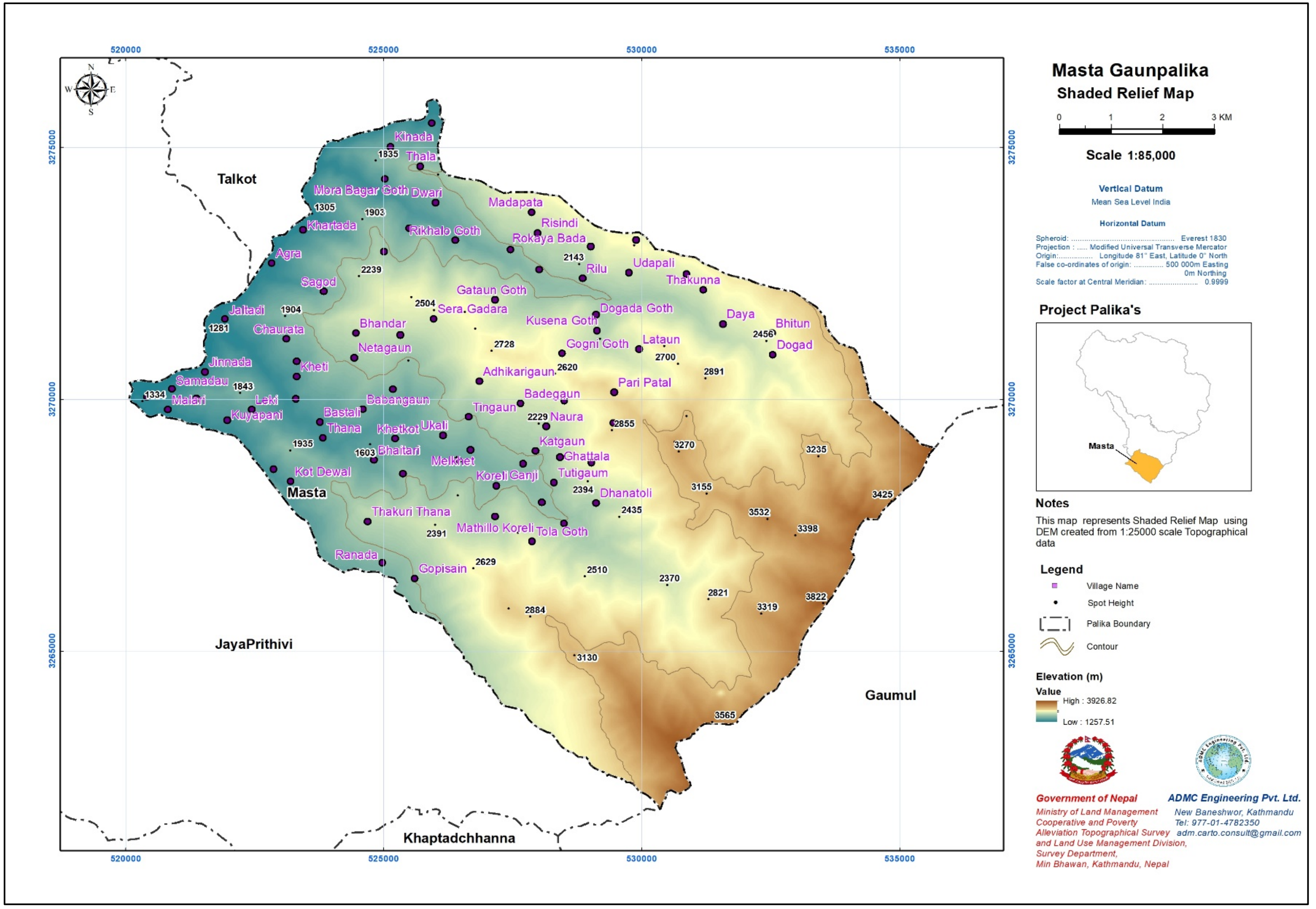

Figure 2.9: Elevation Map of Masta Gaunpalika

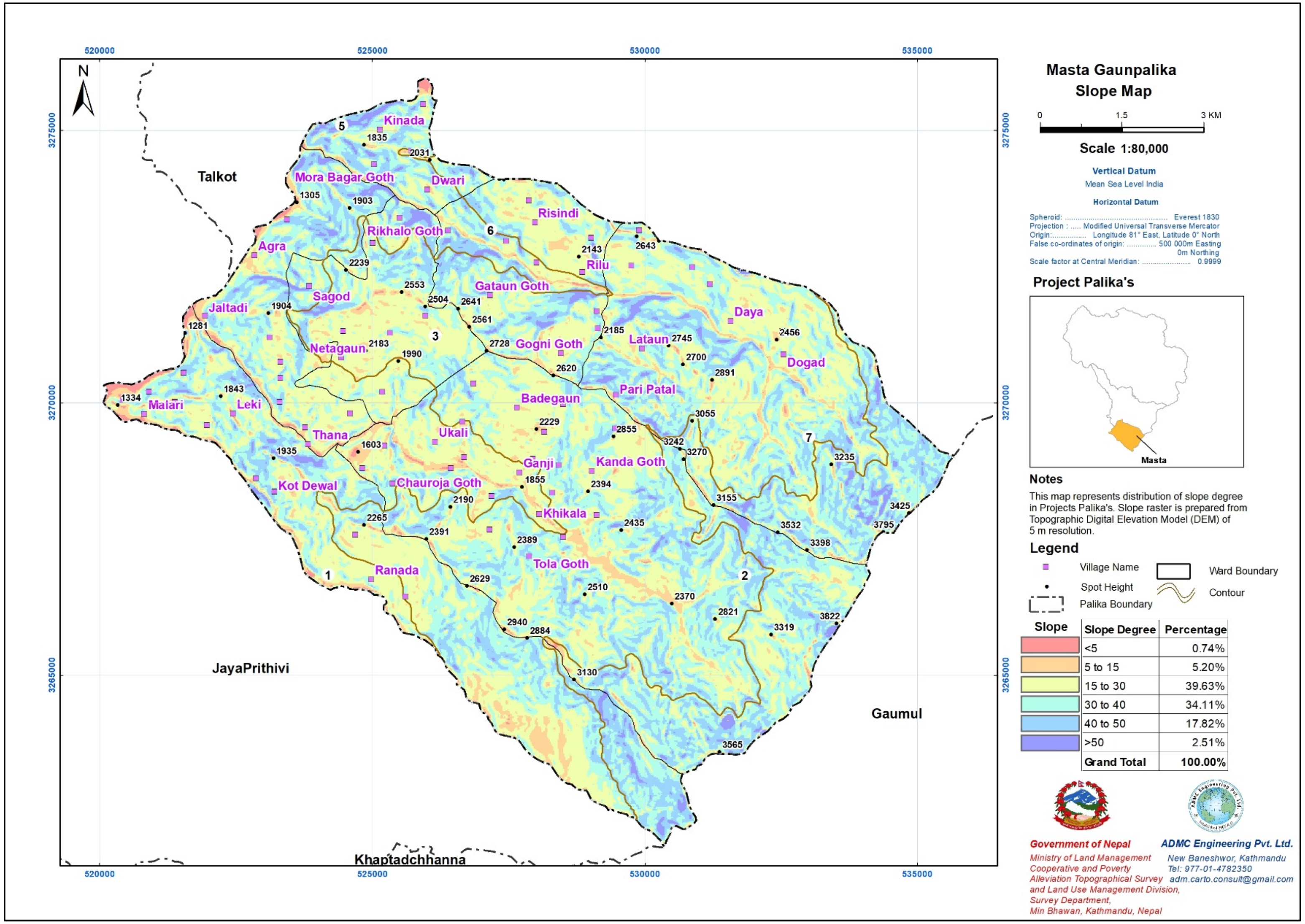

Figure 2.10: Slope Distribution Map of Masta Gaunpalika

2.6 Climate

Micro-climatic parameters like temperature, precipitation, humidity, and sunshine hours vary from each of the four seasons, Summer (Mar-May), Monsoon (Jun-Sep), Post Monsoon (Oct and Nov) and Winter (Dec-Feb). These microclimatic conditions have direct bearing on land use and agriculture. Mostly Sub Tropical Monsoon Climate is found this project area.

There is no hydrologic gauging station operated by Department of Hydrology and Meteorology in the district. However, Seti River is gauged further downstream at Banga near Belgaon at an elevation of 328 mamsl. There are two meteorological stations in Bajhang District, namely Chainpur (West) and Pipalkot in the designated areas.

Rainfall and temperatures are observed in Chainpur whereas in Pipalkot only rainfall is observed. For this Gaunpalika, Chainpur station is considered.

According to Chainpur station (West) at elevation 1,304 mamsl, the mean yearly minimum temperature is lowest (3.3^{0}C) in the month of January and it slowly rises from the month of Feb and attains highest (20.2^{0}C) in the month of July. Similarly, the mean yearly maximum temperature is the lowest (18.5^{0}C) in the month of January it slowly rises from the month of February and attains the highest (31.6^{0}C) in the month of June.

The Maximum recorded temperature is 25.4°C and Minimum recorded temperature is 10.9°C. Also, Yearly Mean Rainfall at Chainpur station (West) is maximum of 404.85 mm in the month of July and lowest rainfall is 10.53 mm in November. Table 2.1 shows the Yearly Mean Temperature in ^{0}C at Chainpur station (West) (1984-2013).

Table 2.1 Yearly Mean/Minimum Temperatures in ^{0}C and Rainfall at Chainpur (West) at elevation 1,304 mamsl (1984-2013)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean Min. temp. (°C)	3.3	5.3	8.9	12.3	15.8	19.2	20.2	19.7	17.6	12.1	7.3	4.0
Mean Max. temp. (°C)	18.5	20.5	24.9	28.7	31.0	31.6	29.5	29.2	28.7	27.0	23.3	19.9
Mean temp. (°C)	10.9	12.9	16.9	20.5	23.4	25.4	24.8	24.4	23.2	19.5	15.3	11.9
Mean Rainfall (mm)	44.92	73.41	56.38	42.74	69.32	177.18	404.85	396.89	221.26	44.25	10.53	23.87

Source: Department of Hydrology and Meteorology

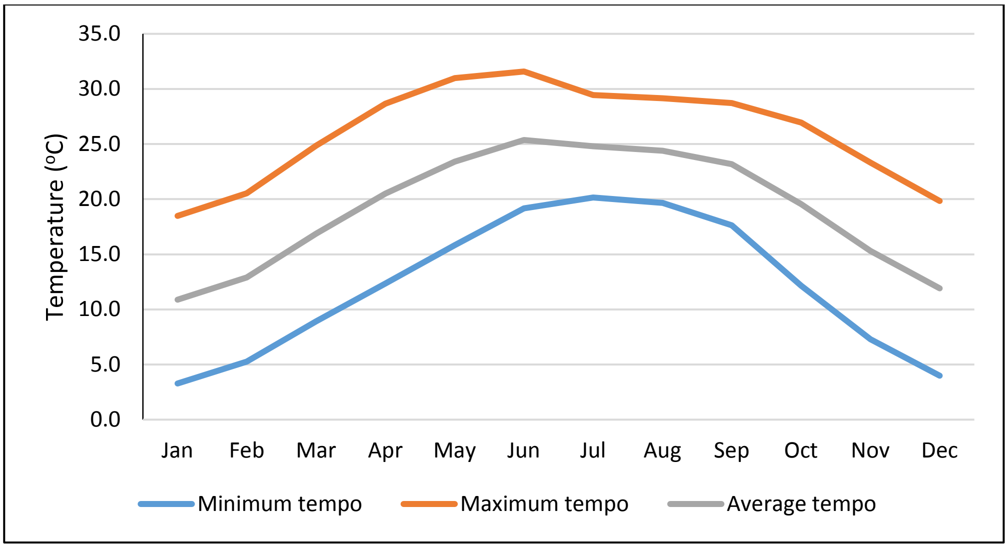

Figure 2.11: Mean Monthly Minimum and Maximum Temperatures and Mean Monthly Temperature of Chainpur (1984-2013)

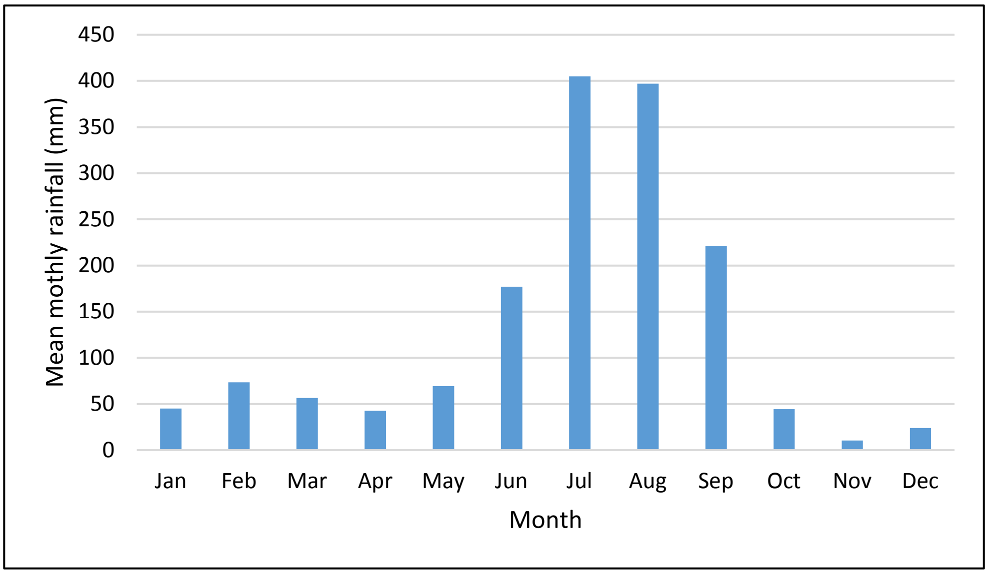

Figure 2.12: Mean Monthly Rainfall of Chainpur (west) from 1984-2013

Referring to Fig 2.11, the lowest mean monthly temperature of Chainpur is observed as 10.9ºC in the month of January and the highest mean monthly temperature as 25.4ºC in the month of June.

Bajhang is influenced by the Western Disturbances in the winter season and receives substantial amount of snowfall and rainfall. From Fig 2.11, mean monthly rainfall of 44.92mm is received in January

During the summer season, convective cells with thunderstorm bring rainfall. Rainfall of 69.32mm is received in the month of May, whereas heaviest rainfall of 404.85mm is received in July during the monsoon season.

The seasonal rainfall at Chainpur is presented in Table 2.2, depicted in Fig 2.13, Fig 2.14 respectively.

Table 2.2: Seasonal Rainfall at Chainpur

Season	Rainfall (mm)	Percent of seasonal rainfall with respect to annual rainfall (%)
Summer (Mar-May)	56.15	13.03
Monsoon (Jun-Sep)	300.05	69.62
Post Monsoon (Oct and Nov)	27.39	6.36
Winter (Dec-Feb)	47.40	11.00
Total rainfall	**430.98**	**100.00**

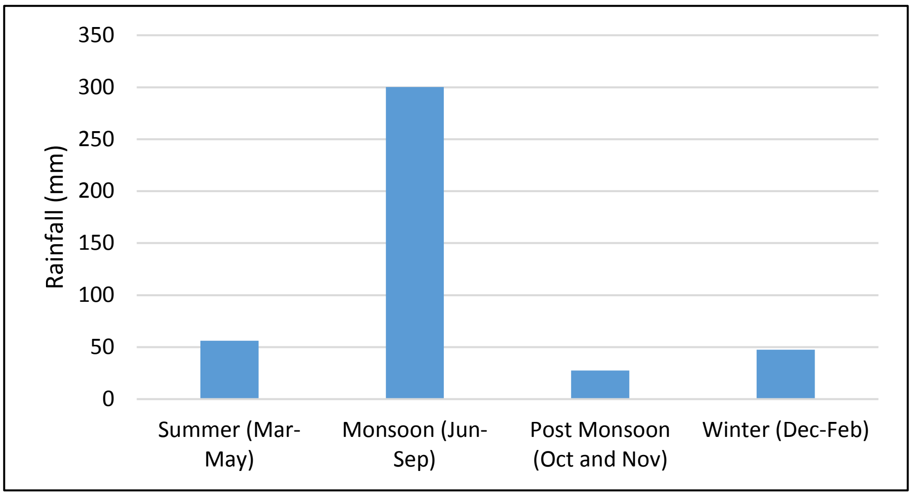

Figure 2.13: Seasonal Rainfall (mm) at Chainpur

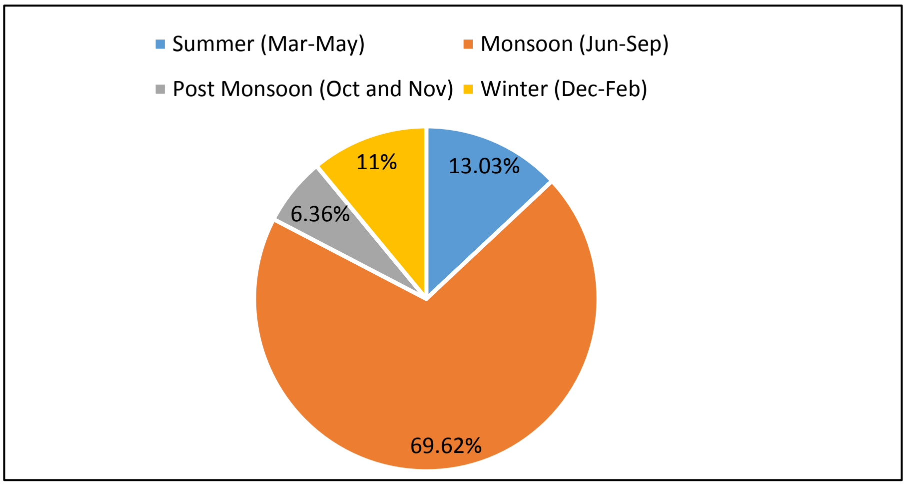

Figure 2.14: Seasonal Rainfall (%) at Chainpur

Fig.2.13 & Fig.2.14 indicate that Chainpur receives 69.62 % of annual rainfall in the monsoon season followed by 13.03 %, 11 % and 6.36 % of annual rainfall in summer, winter and post monsoon seasons respectively.

2.7 Forest and Biodiversity

Forest land accounts for about one-sixth of Nepal's area. There is great diversity of forest types across different altitudes and microclimates, each having specific uses in Masta Gaunpalika Forest covers 65.3% land of this Gaunpalika out of which certain percentage of forest is allocated as dense, some degraded and other sparse. The important NTF of the forest area are Nigalo, Lokta and Allo. Similarly, important medicinal herbs are Guchhichyau, Pakhanbed, Satuwa and others. The dominating timer trees species is pine. Other species composition and distribution of plants are about the same as of the district. The potential forest-based enterprises are Resin (Khoto) collection, Lokta paper industries and allo fibers industries. Road network has connected most of the settlement and having hydropower furniture industries is a potential enterprise.

As biodiversity is defined as the diversity of fauna and flora in the zone, there are lots of diversities observed in Bajhang districts. Sub-tropical climatic vegetation zone has Schima wallichii, Castonopsis indica, Alnus nepalensis and Pinus roxburghii as dominant species and Ritha, Tuni and Darim as sparse. Whereas temperate climatic vegetation zone has Loth salla, Thingre salla, Quercus incana-Q. lanuginose Forest (Qq) and Quercus dilata as dominant species and Forest (Qd)Rhododendron Forest (Rh) as dense. And Sub-alpine climatic zone has Cedrus deodara Forest (Cd) as dominant species Cupressus torulosa Forest (Ct), Picea smithiana Forest (Ps) and Abies pindrow Forest (Ap) as dense.

2.8 Natural Hazards and Environment

Every year in the project area there is the risk of natural hazards that threaten lives and livelihoods. The atmospheric, hydrologic, geologic (especially seismic), and wildfire phenomena that, because of their location, severity, and frequency, have the potential to affect humans, their structures, or their activities adversely.

There are three types of major hazards in the Gaunpalika. These are river cutting, flood hazard and landslide hazard. Flood hazard is the major one that seeps fertile agriculture land. According to the Gaunpalika Profile and the discussion with local representatives, 2070 households are prone to various types of disasters. The houses and settlements located in steep slopes as well as nearby river bank and stream are more vulnerable. Location of cutting was at ward no. 4 at different location. The recorded number of households that were affected after this event (flood and river cutting) was about 528 households.

Another hazard, Landslide Hazard, has caused some land damage and destruction of road in ward no. 1, 2, 3 and 4. A large quantity of private properties, public infrastructures and common properties damage every year during the summer season. The recorded number of households that were affected after this event was about 383 households.

The Risk of Fire hazard and seismic hazard is low compared to that of previous hazards (flood, river cutting and landslide). Forest fire usually takes place during dry season in each year. Domesticated animals in the grazing land and wild animals, both are affected by the forest fire especially in the upper part of Masta Gaunpalika. However, these hazards are being considered and addressed these challenges through appropriate environment management. A crucial effort is necessary to manage overall environment in a sustainable manner.

In addition to those, windstorm, thunderstorm, epidemics, droughts etc. are also frequently occurring here.

CHAPTER- 3

SOILS AND LAND CHARACTERISTICS

3.1 Land System and Soil Characteristics

Soil is considered as the integral part of the landscape and their characteristics are largely governed by the landforms in which they are developed. Physiography influences soil formation affecting the climate, vegetation of an area as if it is considered as passive factor of soil formation. Moreover, there is a close relationship between physiography and soil development which ultimately affects the availability of nutrients (Verma et al., 2005). The physiography has influential role in soil formation through slope and exposure. The flat topography has more depth of soil as compared to the steep slopes because the steep slopes are more prone to the erosion (Sehgal, 2002).

Soil properties like profile development, texture, structure, color, acidity, cation exchange capacity, base saturation etc are related to land form. There is a close relationship between physiography and soils. The formation of the diverse group of soils can be attributed to the variation in topography causing erosion, leaching, sedimentation and other pedogenic processes modified by water table (Mini *et al.,* 2006). Thus, physiographic influence of soil properties has been recognized which ultimately leads to evolution of the soil-landscape relationship. Topographic maps, aerial photographs stereo-capability and remote sensing data provide useful tool for geomorphic analysis of the region and help in soil survey and mapping.

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 3.1). Physiography in study area is further divided into land system according to recurrent pattern of landforms, geology and slope and arable agriculture limits and then land units based on map able 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 were determined by detailed field soil survey. These observations were further studied on *Soil Association* for classification. Digital Terrain Model (DTM) is employed for delineation of landform, land units and land types for detailed soil survey at local level planning.

3.1.1 Land System

The project area lies in the Middle mountain and High Mountain range. It encompasses land system units of 9a, 13b, 13d, 14a, 14b and 15b basically differentiated based on geology and geomorphology. Physiography is further subdivided into landforms basically defined by the position of land surface in landscape and it is characterized by slope and its direction, elevation, rock exposure and soil type.

3.1.2 Land form/Type

Landform is further subdivided into land units basically defined by the mappable size of land surface for demarcation in landscape by the user. And it is characterized by landscape features. The land units in the project area are shown as below:

- Intermediate position level.
- Depressions

- Khola, sandbar and flood plain

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 soil classes based on their texture are sand, clay and loams with intermediary class such as sandy loam. The texture is the relative proportion of sand, silt and clay particles in the soil. Soil texture of top layer is used for land system classification, soil suitability and classification of soil at family level. The soil textures found in project area are given with symbol in Table 3.1.

Table 3.1: Soil Texture and Symbol

Texture Classes	Symbol
Clay	Cl1
Clay loam	Cl2
Loam	Lo1
Loamy sand	Lo2
Sand	Sa1
Sandy clay loam	Sa2
Sandy loam	Sa3
Silt	Si1
Silty clay loam	Si2
Silty loam	Si3

3.1.3 Description of Individual Land Type Units (Masta Gaunpalika)

The land units defined by LRMP are further subdivided based on local field variation associated with the different land use practices. Altogether eight land units identified in the project are associated with the local micro-relief variations. The spatial extent covered by the Gaunpalika area is presented in Table 3.2 and distribution of the land units are shown in Figure 3.1

Table 3.2: Land System/ Land Type

Region	Land System	Landform	Land unit	Description	Dominant slopes°	Area (Ha.)	Area (Sqm.)	Percent
High Mountain (Hm)	13	Alluvial plains and fans	13b	13b-Recent alluvial plain	<2	12.82	128182.31	0.1
			13d	13d-Ancient alluvial terraces	<5	19.84	198368.62	0.2
	14	Past glaciated mountainous terrain below upper altitudinal limit of arable	14a	14a-Moderate to steep slopes	<30	2886.76	28867565.61	26.5
			14b	14b-Steep to very steep slopes	>30	4466.11	44661146.43	41.0
	15	Past glaciated mountainous terrain above upper altitudinal limit of arable	15b	15b-Very steep slopes	>40	3364.18	33641785.64	30.8
Middle Mountain Region (Mm)	9	Alluvial plains and fans(depositional)	9a	9a-River channel	<1	155.48	1554750.56	1.4
Grand Total						**10905.18**	**109051799.17**	**100**

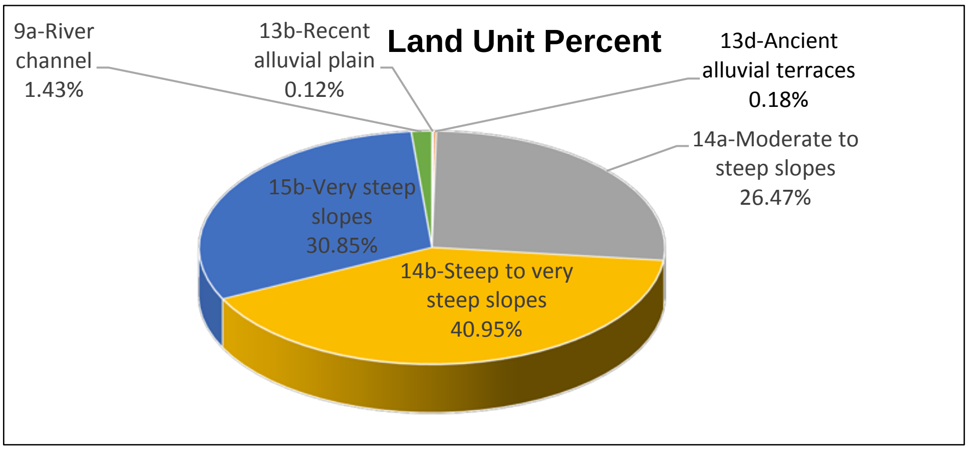

Figure 3.1: Distribution of Land Units

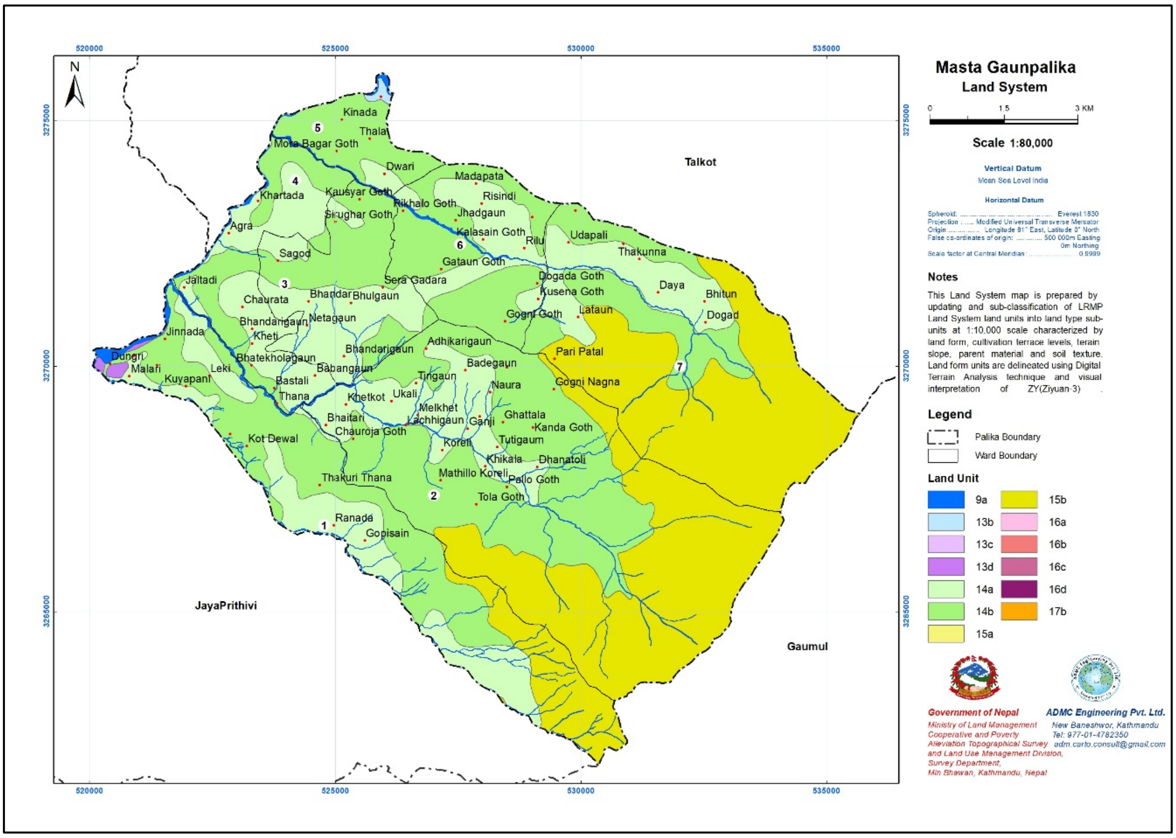

Figure 3.2: Spatial Distribution of Land Units of Masta Gaunpalika

The soils of Nagarpalika/Gaunpalika of Bajhang district are classified based on the morphological, chemical and physical properties of soil acquired from the soil profile study by digging the soil pit and soil mapping unit level. USDA soil taxonomy system of soil classification was adopted for the classification of soil in which soils are classified into order, sub-order, great group, sub-group, family and series levels. The soil classification of Gaunpalika is presented in the Table 3.3 and Figure 3.3, Figure 3.4.

The Masta Gaunpalika has two soil orders, three sub-orders, four great groups and eleven sub-groups were found from the survey of the soils. The detail descriptions of soil category are explained as below.

Table 3.3: Soil Taxonomy Classification of Masta Gaunpalika

Order	Sub Order	Great Group	Sub-Group	Area (Ha.)	Area (Sqm)	Percent
Entisols	Orthents	Torriorthents	Lithic Torriorthents	196.86	1968624.38	1.8
		Ustorthents	Lithic Ustorthents	192.79	1927873.15	1.8
			Typic Ustorthents	365.83	3658316.63	3.4
Inceptisols	Cryepts	Dystrocryepts	Humic Dystrocryepts	253.76	2537625.93	2.3
			Humic Lithic Dystrocryepts	216.80	2167983.90	2.0
	Udepts	Dystrudepts	Lithic Dystrudepts	124.03	1240266.82	1.1
			Calcic Lithic Dystrudepts	407.71	4077116.4	3.7

Order	Sub Order	Great Group	Sub-Group	Area (Ha.)	Area (Sqm)	Percent
					9	
			Fulventic Humic Dystrudepts	0.03	317.18	0.0
			Humic Dystrudepts	5043.56	50435601.23	46.2
			Humic Lithic Dystrudepts	642.58	6425798.76	5.9
			Lithic Dystrudepts	1819.11	.8191109.51	16.7
			Typic Dystrudepts	1562.54	.5625370.52	14.3
Unclassified			Riverine Area	79.58	795795.57	0.7
Grand Total				**10905.18**	**09051800.06**	100

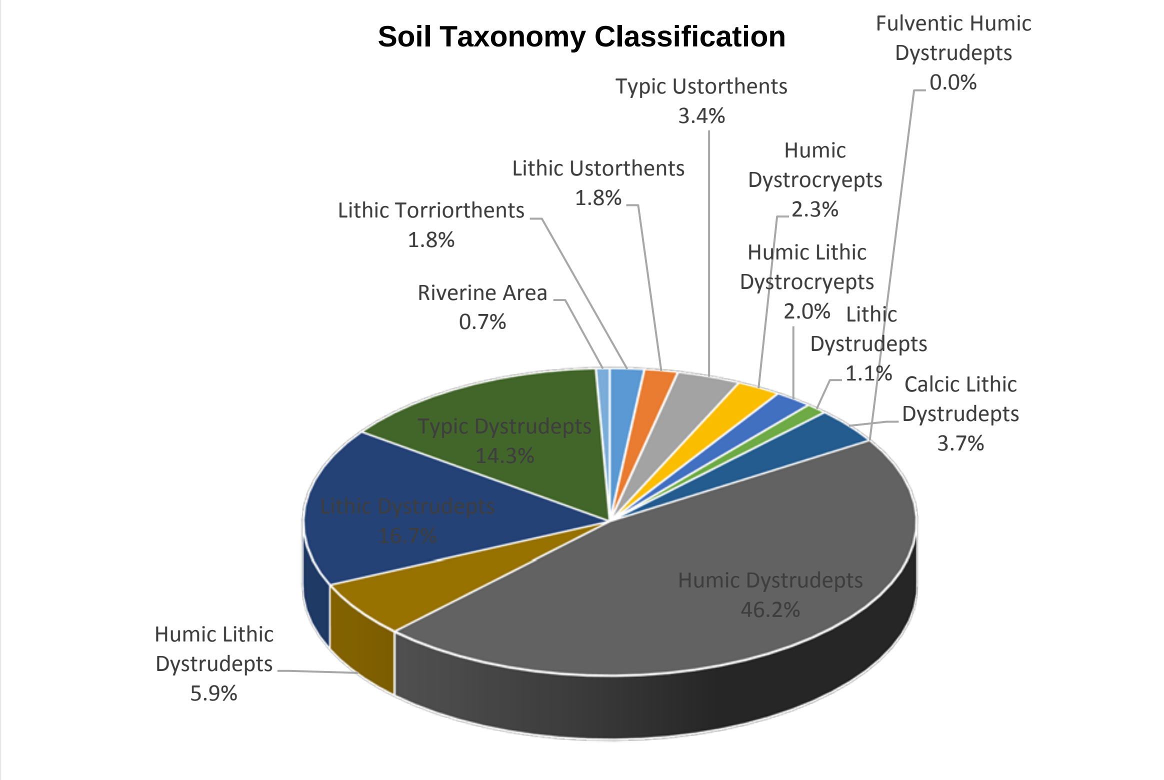

Figure 3.3: Distribution of Soil Taxonomy Classification

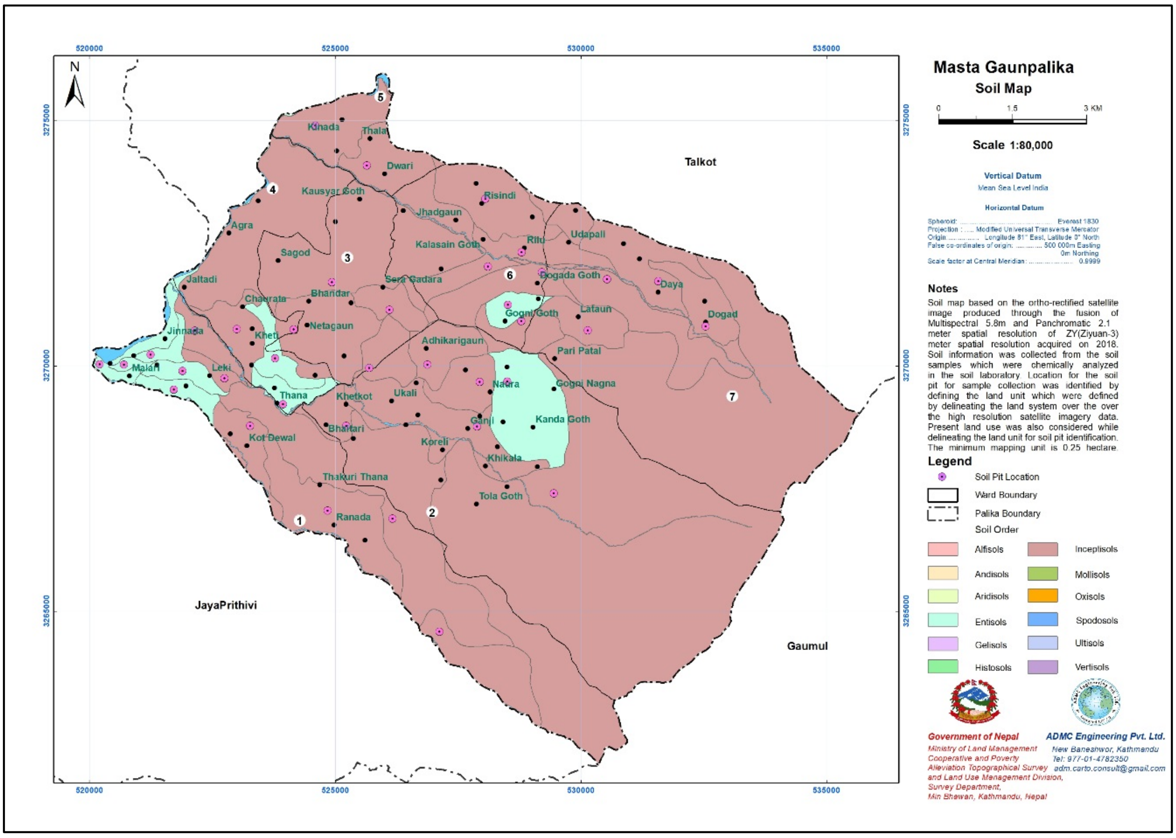

Figure 3.4: Soil Types of Masta Gaunpalika

3.2 Land Capability of Masta Gaunpalika

Land capability classification of the land type units was conducted on the basis of various criteria of soil and other parameters. This chapter presents the result of land capability class coverage in Masta Gaunpalika. The chapter also presents the summary of each type of management limitations as represented by the capability sub-class and units.

Land Capability of Masta Gaunpalika was conducted on the basis of the soil properties, terrain slope, erosion and drainage characteristics. The land capability class distribution in the Gaunpalika is presented in the Table 3.4 and Figure 3.5 and spatial distribution of land capability class of the Gaunpalika is shown in the map Figure 3.6. Majority of land (51.4%) consists of land capability class IIIAh/2, 46.9% land has IVCh/5 class and 0.9% land has Non-Arable Land class. These classes are fairly suitable for irrigated farming crops and Terracing is compulsory to control erosion when used for agriculture and some lands consists of lands with moderately severe limitations that limit the choice of crops and/or require very careful management practices.

Table 3.4: Land Capability Classes of Masta Gaunpalika

Land Capability	Area (sqm)	Area (Ha.)	Percent	Description
IIIAh/2	56058486.57	5605.85	51.4	Lands characterized as moderately to steeply sloping (5-30 degrees) slopes, Subtropical Climatic Zone, Humid moisture regime, diversified crops and moderately suitable for arable agriculture.
IVCh/5	51175270.19	5117.53	46.9	Lands characterized as too steep (>30°slopes), Cool temperate Climatic Zone, Humid moisture regime, lands are tentatively classified as non-arable.
Non-Arable Land	1818043.09	181.80	0.9	Non-Arable
Total	**109051799.86**	**10905.18**	**100**	

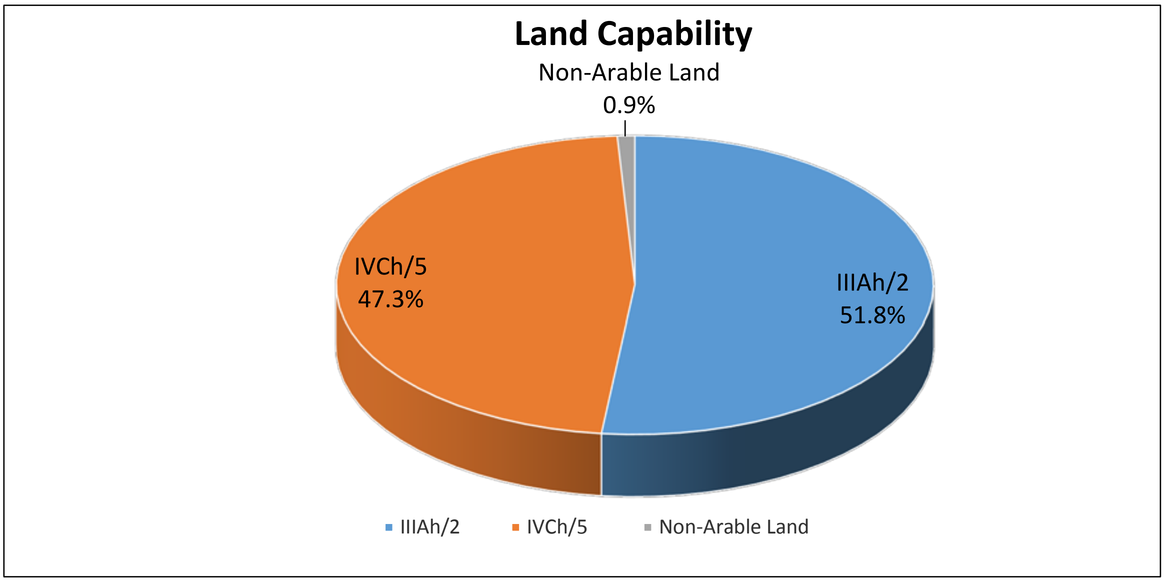

Figure 3.5: Distribution of Land Capability Classes

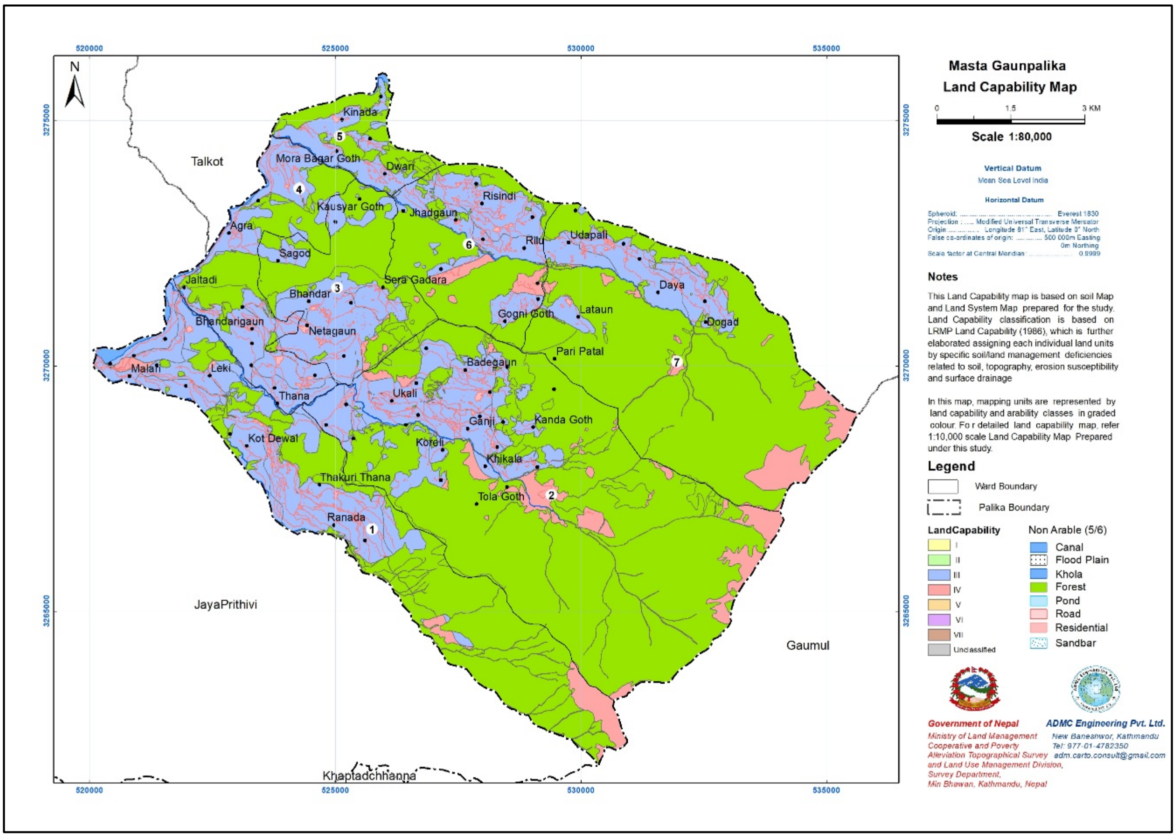

Figure 3.6: Spatial Distribution of Land Capability Classes of Masta Gaunpalika

3.3 Present Land Use

General land use of the Masta Gaunpalika at first hierarchical level of classification is provided in Table and Figure below. Out of total 10905.18-hectare land, 63.4% area is covered by forest, 30.9% area is covered by agriculture followed by Riverine and lake area which covers 1.1% area of the Gaunpalika. Public services cover about 0.4% and Residential covers 0.6% of the total area. However, Commercial, Mine and Minerals, Cultural and archeological & Industrial sectors cover small portion which are noticed below 0.01% of total area. Respectively, Other Land use area covers less than 3.6% of total area in this Gaunpalika. Whereas significant Mine & Minerals and Industrial land use distribution were not found in this gaunpalika.

Table 3.5: Present Land Use in Masta Gaunpalika

S.No	Landuse Class	Area (sqm)	Area (ha)	Percent
1	Forest	69184718.60	6918.47	63.4
2	Agriculture	33725206.37	3372.52	30.9
3	Other	3875438.03	387.54	3.6
4	Riverine, Lake and Marsh Area	1154027.14	115.40	1.1
5	Residential	669225.09	66.92	0.6
6	Public Service	438306.18	43.83	0.4
7	Commercial	3501.12	0.35	0.003
8	Cultural and Archeological	1372.00	0.14	0.001
	Grand Total	**109051794.53**	**10905.18**	**100**

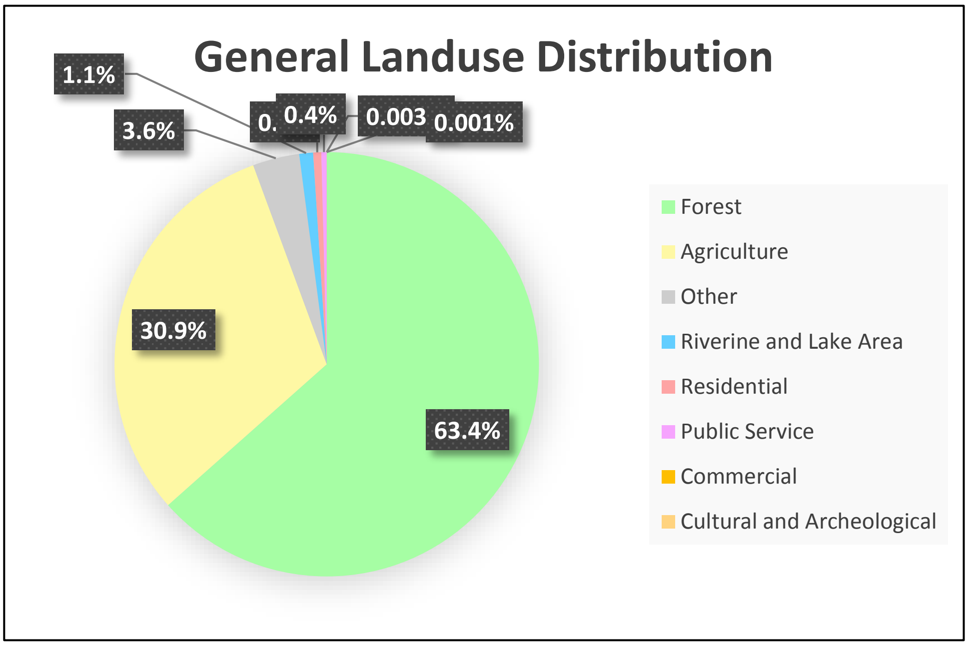

Figure 3.7: General Land Use Distribution in Masta Gaunpalika

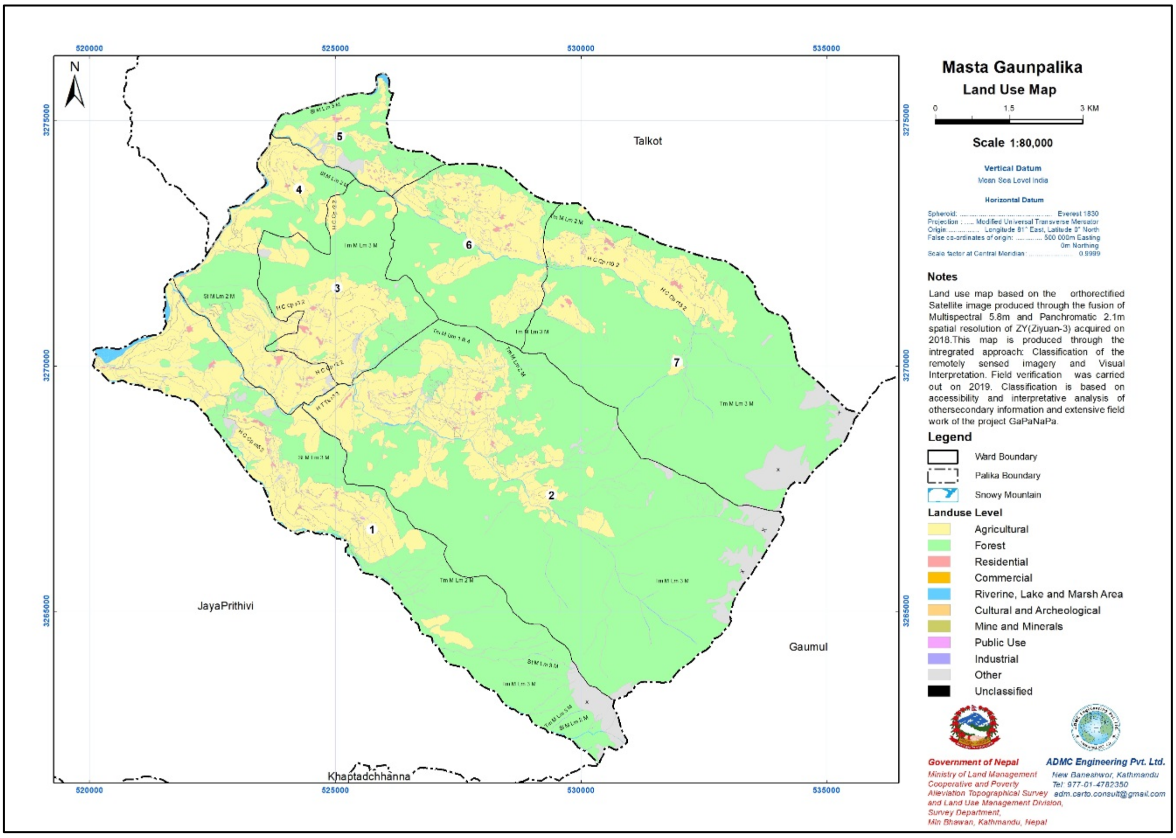

Figure 3.8: Land Use Map of Masta Gaunpalika

3.4 Agricultural Pattern

Agricultural Land Use: Almost all agricultural land of the Masta Gaunpalika is classified as Hill cultivation based on the physiographic region.

Agriculture level 3 is further divided into Slopping terraces and level terraces cultivation. About 86.2% of level 3 of agriculture are on Slopping terraces cultivation category.

Table 3.6: Agriculture Land Use Level 3

S.No	Agricultural Landuse (Level 3)	Area (sqm)	Area (ha)	Percent
1	Slopping Terraces-C	29084718.13	2908.47	86.2
2	Level Terraces-T	4640488.24	464.05	13.8
	Grand Total	**33725206.37**	**3372.52**	**100**

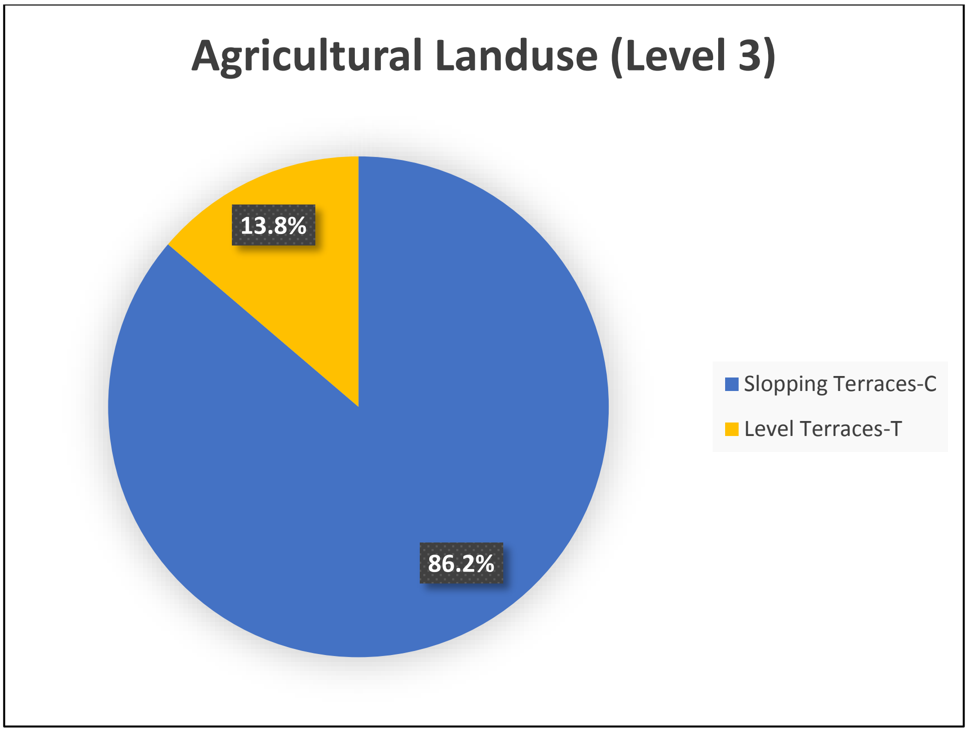

Figure 3.9: Agriculture Land Use Level 3

Table 3.7: Agriculture Land Use Level 4

S.No	Agricultural Landuse (level 4)	Area (sqm)	Area (ha)	Percent
1	Slopping Upland/ Pakho Land Cultivation-Cp	29084718.13	2908.47	86.2
2	Level Terraces Khet Land Cultivation-Tk	3965329.11	396.53	11.8
3	Level Terraces Upland/Pakho Land Cultivation-Tp	675159.13	67.52	2.0
	Grand Total	**33725206.37**	**3372.52**	**100**

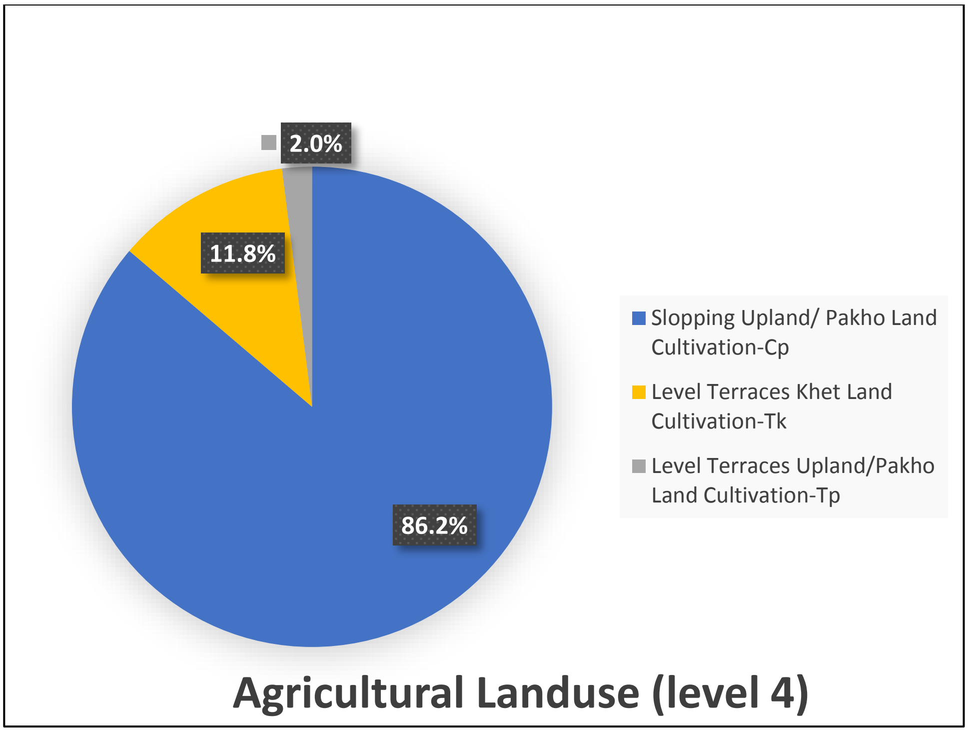

Figure 3.10: Agriculture Land Use Level 4

The cropping pattern of this Gaunpalika varies according to agricultural land types, irrigation and precipitation. The Level Terraces and Slopping Terraces cultivation comprises of crops such as Rice, Wheat, Maize, Millet, fruits, Pulses and vegetables. Rice, Wheat, Maize are the dominant crops. The table below presents the cropping pattern of the Masta Gaunpalika.

Table 3.8: Cropping Pattern

S.No	Cropping Pattern	Area (sqm)	Area (ha)	Percent
1	Maize-Millet-m7	7076923.22	707.69	21.0
2	Rice-Wheat-Pulses-r3	6476620.61	647.66	19.2
3	Rice-Wheat-r2	6163271.05	616.33	18.3
4	Maize-Wheat-m5	3820271.31	382.03	11.3
5	Rice-Wheat-Maize-r15	3033890.42	303.39	9.0
6	Rice-Maize-r10	2860376.12	286.04	8.5
7	Shrub from non-forest area-s3	2250665.94	225.07	6.7
8	Barren Cultivable land-b5	916387.73	91.64	2.7
9	Livestock Grazing area-g2	722440.26	72.24	2.1
10	Fruit-Others-f3	401921.43	40.19	1.2
11	Vegetables-Others-v4	2438.28	0.24	0.01
	Grand Total	**33725206.37**	**3372.52**	**100**

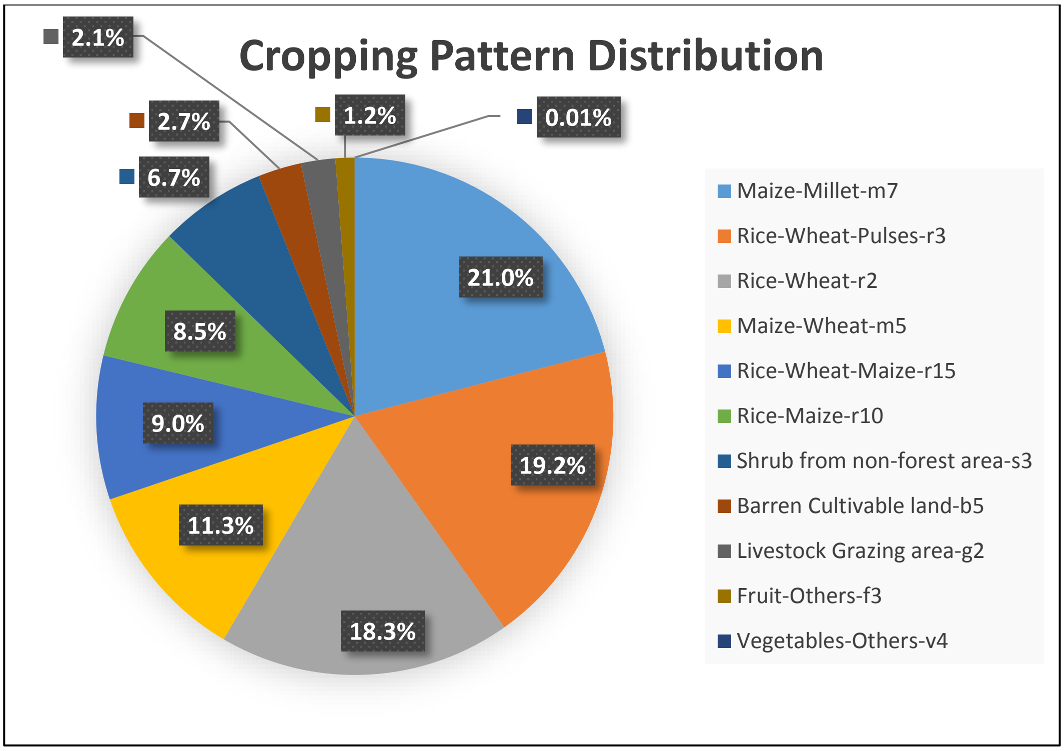

Figure 3.11: Cropping Pattern in Agricultural land

The Gaunpalika witness 85.7% of agricultural land having Medium cropping intensity, 11.3% of arable land of intense cropping intensity and 3% of land as of Light intensity. Although, orchard and pond areas do not directly relate themselves with cropping intensity, these have been included in the table as they also bear some degree of agriculture area related production. The following figure shows the distribution of cropping intensity including orchard-pond.

Table 3.9: Cropping Intensity

S.No	Cropping Intensity	Area (sqm)	Area (ha)	Percent
1	Medium-2	28909996.08	2891.00	85.7
2	Intense-3	3819530.58	381.95	11.3
3	Light-1	995679.72	99.57	3.0
	Grand Total	**33725206.37**	**3372.52**	**100**

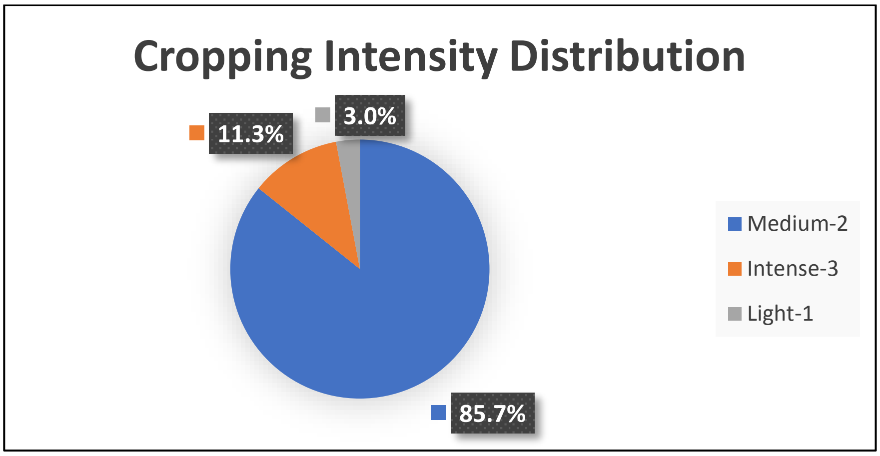

Figure 3.12: Cropping Intensity

3.5 Land Use Zones

Land use zoning of the Gaunpalika under study was carried out based on the present land use data, land capability taking the witnesses of current remotely sensed image with the help of ground-based information. As the Gaunpalika showed different degree of variability in land use pattern, minimum with agriculture and maximum on forest, it rendered same degree of variation in the spatial distribution of land use zones.

The study shows that the most of the part of the Gaunpalika, about 68.60% is forest and hence categorized as Forest zone. The present land under residential use and potential residential use for future is about 0.70%. The land suitable for commercial activities is almost 0.02%. Within the agricultural land, most of the land is found suitable for cereal crop, agro-forestry, animal husbandry, horticulture and cash crop production. For public utility uses, about 0.65% of the land is identified. In existing riverine and lake area, about 1.06% land is identified.

Proposed Land Use Zones are presented for this is shown on map.

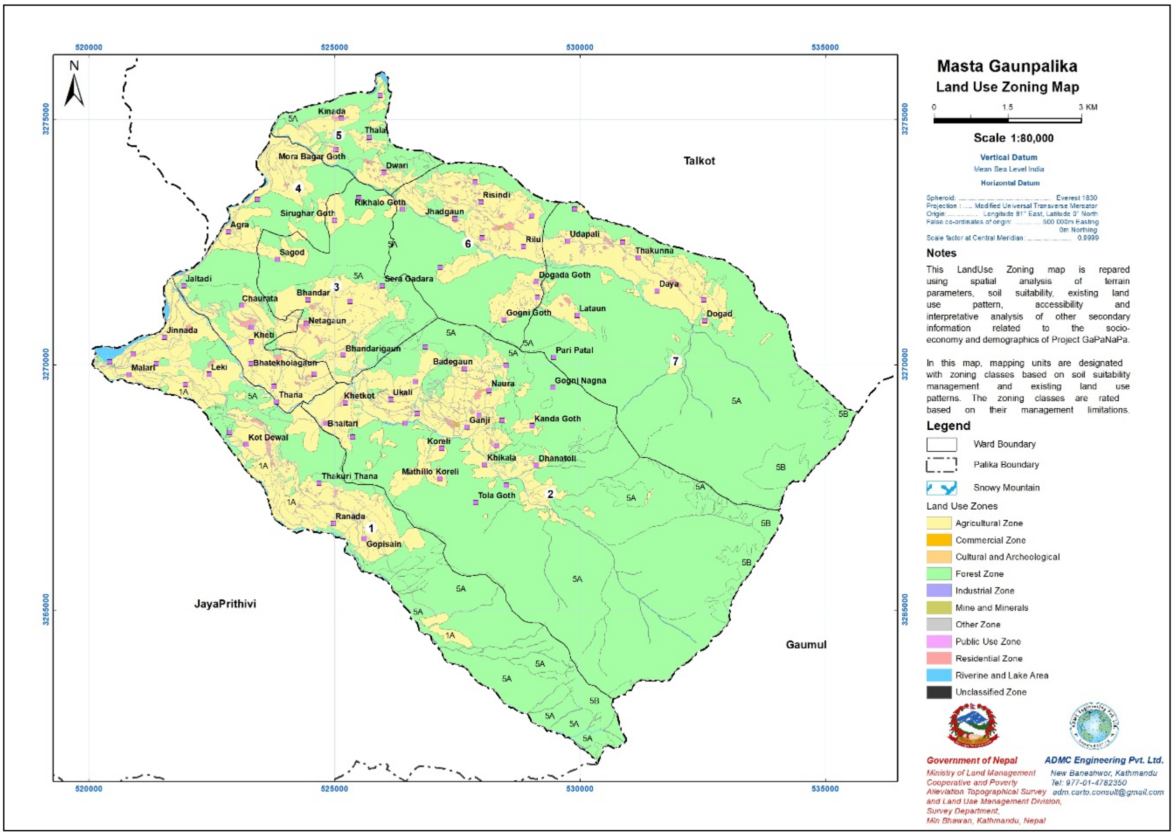

Figure 3.13: Land Use Zoning Map of Masta Gaunpalika

Table 3.10: Land Use Zones of the Study Area

Zone Type	Zone Sub Types	Area (Sqm.)	Area (Ha.)	Zone Type Area (Ha.)	Percent
Agricultural Zone	1A-Cereal crop production area	29122698.04	2912.27	3363.96	30.85
	1B-Cash crop area	2286.73	0.23		
	1C-Horticultural area	395353.84	39.54		
	1D-Animal husbandry area	713572.30	71.36		
	1F-Agro forestry area	2282427.03	228.24		
	1G-Other Agriculture Area	1123295.97	112.33		
Commercial Zone	3A-Service areas	3241.46	0.32	2.55	0.02
	3B-Business area	22299.76	2.23		
Cultural and Archeological Zone	9A-Existing Cultural and Archeological Area	1372.00	0.14	0.14	0*
Forest Zone	5A-Existing forest	69151800.18	6915.18	7276.27	66.72
	5B-Potential area for forest including barren lands, wet lands	3610869.67	361.09		
Public Use Zone	6A-Areas under roads, railways etc	681036.24	68.10	70.71	0.65
	6C-Open spaces, picnic spots, recreational etc	1690.10	0.17		
	6E-Public health, education library, police station, fire station, telephone, electricity areas etc	24421.40	2.44		
Residential Zone	2A-Existing residential zone	661437.13	66.14	76.32	0.70
	2B-Potential area for residential zone	101730.77	10.17		
Riverine, Lake and Marsh Area	10A-Existing Riverine and Lake Area	1152261.91	115.23	115.23	1.06
Grand Total		**109051794.53**	**10905.18**	**10905.18**	**100.00**

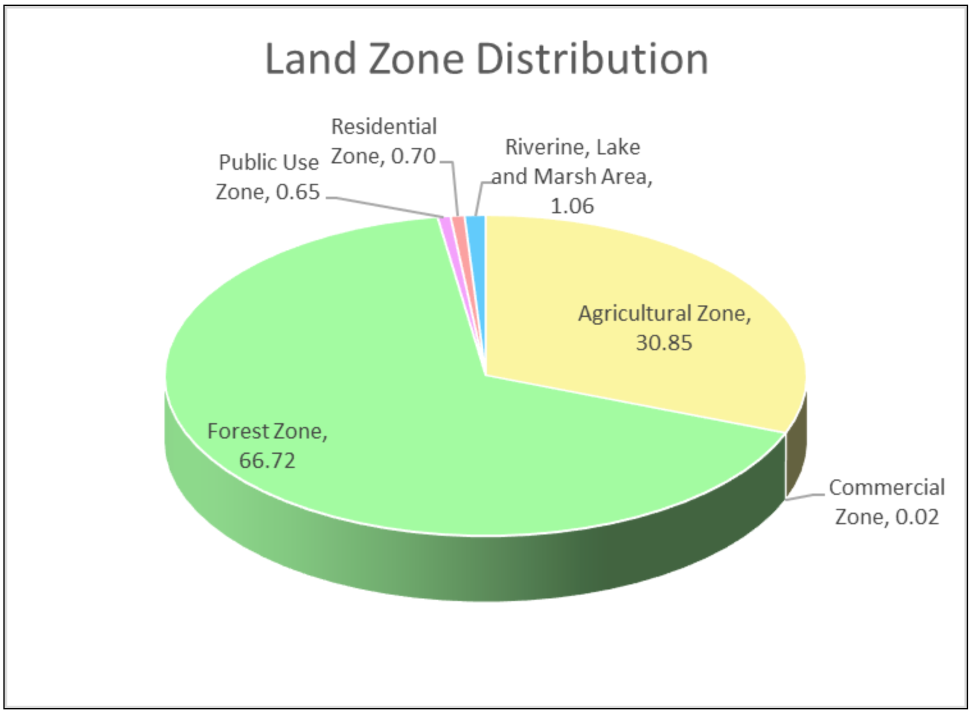

Figure 3.14: Details of Land Use Zoning of Masta Gaunpalika

3.6 Cadastral Data

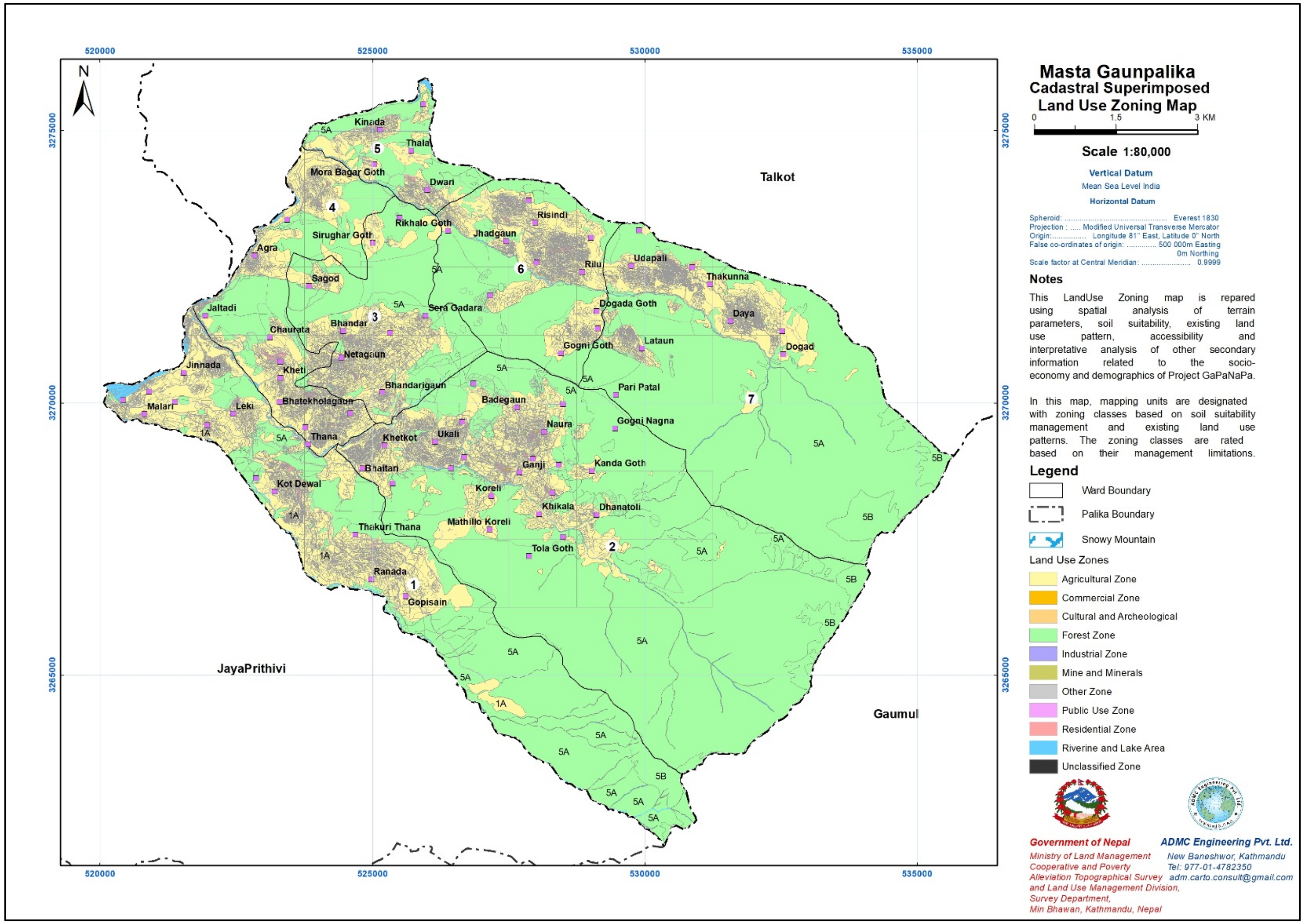

Figure 3.15: Cadastral Superimpose Map of Masta Gaunpalika

3.6.1 Cadastral Land Parcel Based on Land Use

The Cadastral Survey in Bajhang District was carried out during 2021 B.S. Due to lack of a land use zoning regulations the parcel size and use have undergone random conversions over the years. Similarly, due to the lack of strict regularizations on maintenance of public and government land some changes have undergone in their uses as well. Accuracy of the original plane table survey should as well be considered while assessing on the figures on the database, however this will have limited implications on the scale of the map 1:10,000.

At the time of digitization, the Gaunpalika had 45232 land parcels and area covered in the survey was 7213.31 ha.

Following table shows present characteristics of cadastral parcels that falls in the Gaunpalika under study.

Table 3.11: Parcel Characteristics of Present Land Use

Present Landuse Class	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest	39459432.32	3945.94	356	54.70%
Agricultural	31557846.96	3155.78	41501	43.75%
Riverine, Lake and Marsh Area	562934.20	56.29	328	0.78%
Residential	430056.16	43.01	2936	0.60%
Other	109414.48	10.94	44	0.15%
Public Service	12968.07	1.30	62	0.02%
Cultural and Archeological	210.59	0.02	2	0.0003%
Commercial	200.53	0.02	3	0.0003%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

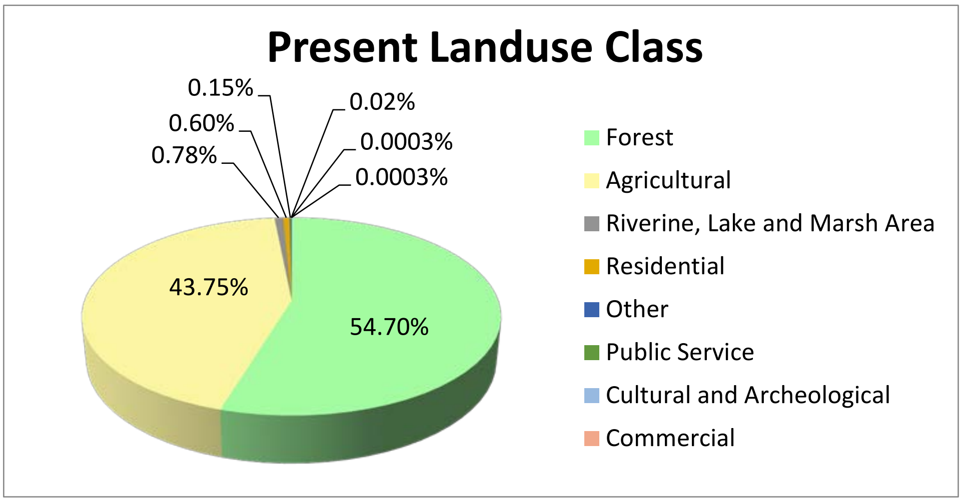

Figure 3.16: Distribution of Parcels over Present Land Use (%)

3.6.2 Cadastral Land Parcel Based on Land Use Zoning

Table 3.12 shows the characteristics of cadastral parcels superimposition on Land Use Zoning for the Gaunpalika under study of Bajhang district of Nepal. In the cadastral area of the Gaunpalika out of the designated 10 classes, zoning for all seven classes except other specially designated classes were planned. The distribution of parcels over proposed landuse zone is shown on table and chart below.

Table 3.12: Parcel Characteristics of Land Use Zoning

Proposed Landuse Class	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest	39504983.43	3950.50	360	54.77%
Agricultural	31455535.18	3145.55	40978	43.61%
Riverine, Lake and Marsh Area	562941.46	56.29	328	0.78%
Residential	528906.00	52.89	3194	0.73%
Public Service	58410.10	5.84	281	0.08%
Commercial	22076.55	2.21	89	0.03%
Cultural and Archeological	210.59	0.02	2	0.0003%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

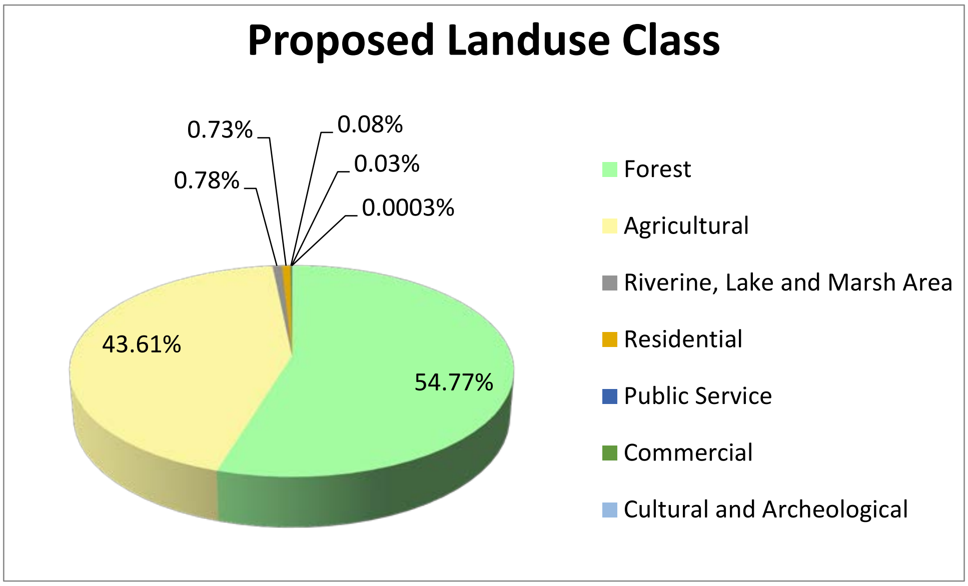

Figure 3.17: Distribution of Parcels over Land Use Zoning (%)

Parcel Characteristics: This could be assessed from the superimposition of present land use and proposed land use given in the land use zoning maps. The parcel characteristics could be analyzed with this superimposition. Table 3.13 gives the details.

Table 3.13: Parcel Characteristics of Present Land Use Land Use Zoning Superimposition

Present Land Use/ Proposed Land Zoning	Area(Sq.m)	Area(ha.)	Parcel Count	Percentage
Forest/Forest	39451614.36	3945.16	355	54.69%
Agricultural/Agricultural	31350092.20	3135.01	40936	43.46%
Riverine, Lake and Marsh	562857.56	56.29	327	0.78%

Area/Riverine, Lake and Marsh Area				
Residential/Residential	427577.70	42.76	2910	0.59%
Agricultural/Residential	101328.30	10.13	284	0.14%
Other/Agricultural	97625.03	9.76	41	0.14%
Agricultural/Public Service	42824.74	4.28	191	0.06%
Agricultural/Forest	41579.61	4.16	2	0.06%
Agricultural/Commercial	21938.21	2.19	87	0.03%
Public Service/Public Service	12968.07	1.30	62	0.02%
Other/Forest	11789.46	1.18	3	0.02%
Forest/Agricultural	7817.95	0.78	1	0.01%
Residential/Public Service	2478.46	0.25	26	0.003%
Cultural and Archeological/Cultural and Archeological	210.59	0.02	2	0.0003%
Commercial/Commercial	138.34	0.01	2	0.0002%
Agricultural/Riverine, Lake and Marsh Area	83.90	0.01	1	0.0001%
Riverine, Lake and Marsh Area/Public Service	76.64	0.01	1	0.0001%
Commercial/Public Service	62.19	0.01	1	0.0001%
Grand Total	**72133063.32**	**7213.31**	**45232**	**100%**

Note: Conversion from Forest to Agriculture or Public Service or Residential is due to unavoidable geometrical inconsistencies and therefore requested to be read as negligible and ignored.

CHAPTER- 4

SOCIO-ECONOMIC SETTINGS

4.1 Social Settings

Social settings reveal the social condition of the society that consist population distribution of ward-wise, migration, caste/ethnic composition, age composition, linguistic composition, religious composition, literacy etc. The major ethnic group living in this Gaunpalika is Brahmin/Chhetri followed by Damai/Kami/Sarki. However, these different ethnic groups are living in peace and harmony without any discrimination. The major source of income is Agriculture, major people are involved in the agriculture followed by other occupation.

4.1.1 Population Distribution and Density

Ward-wise population by sex is presented here. According to the Rural Municipality profile, the total population of this Rural Municipality is 17909 with 2798 households in which the male population is 8537 (47.66 percent) and the female population is 9372 (52.34 percent). Ward number one has the largest household size but second position in the context of population size.

Ward number two has the highest population, 4134 with 563 households followed by ward number one with 3294 and ward three with 2783 populations and 567 and 333 households respectively. The detail information has been shown in Table 4.1

Table 4.1: Ward-wise Population by Sex

Ward No.	No. of HHs	Male	Female	Total	Average family size	Sex ratio	Handicapped Person
1	567	1597	1697	3294	5.81	94.11	19
2	563	2148	1986	4134	7.34	108.16	50
3	333	1409	1374	2783	8.36	102.55	22
4	290	1100	1013	2113	7.29	108.59	24
5	322	953	961	1914	5.94	99.17	23
6	323	983	1099	2082	6.45	89.44	22
7	400	860	729	1589	3.97	117.97	26
Total	**2798**	**8537**	**9372**	**17909**	**6.45**	**102.85**	**186**

Source: Village profile Masta Rural Municipality, 2075; Bajhang District Profile, 2070.

Mother Tongue: Mother tongue is also an important aspect of social dimension of population. Nepal is known as multi-lingual country. But, in the case of Masta Gaunpalika of Bajhang, there is no such kind of scenario. However, there are basically two lingual groups in Masta Gaunpalika. The largest lingual group is Nepali which shares nearly 72.86 percent of the total population followed by Bajhangi (26.78 percent. The other language groups and not identified groups of the village are negligible in this Rural Municipality. Table 4.2 shows status of mother tongue in Masta.

Table 4.2: Population Distribution by Mother Tongue

S.N.	Mother tongue	Number	%
1	Nepali	13050	72.86
2	Bajhangi	4794	26.78
3	Other	24	00.13
4	Not stated	41	00.23
		17909	**100**

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2075.

Age Group: The population of the Gaunpalika is categorized into broad three age groups for this purpose. The table shows that a large number of populations falls under the 15-59 years of age group which shares about 54 percent population. This is the economically active age group which indicates to the plenty of productive manpower in the village.

Table 4.3: Population Distribution by Age Group

Age-group	Total	Female	Male
0-14	7077	3260	3817
15-59	9730	5350	4386
60 and above	1102	587	509
Total	**17909**	**9197**	**8712**

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2075.

Migration: Both types of migration, internal and international migrations are prevalent in this Masta Gaunpalika. Many people from this area out-migrate to city area especially in Dhangadhi, Mahendranagar, Nepalganj, Kohalpur and other small cities of hilly and Tarai region of Nepal for the searching of permanent and temporary jobs. Some people move seasonally in leisure periods especially winter season to earn cash for sustaining daily livelihoods of family. Moving towards India for the purpose of cash income is traditional way of livelihood of this area from very beginning. In the recent days, a large number of people migrate to Dhangadhi and Kathmandu for the purpose of new residence too. In the same way, a large number of young people migrate to Gulf Countries and Malaysia for searching employment. The process of in-migration is very negligible in this place. Some people shift their residence to the newly built market centre and from old settlement to new settlement nearby road for the purpose of business in Masta Gaunpalika.

4.1.2 Population by Caste/ethnicity

Nepal is considered as the multi-ethnic nation. However, Masta Gaunpalika is predominated by Brahmin and Kshetri which are included under caste group. Nearly 81 percent people are belonged to this group. The second largest group is Dalit community which. Kami, Damai and Sarki are main Dalit castes in this category in Masta. The other group i.e. Janajati that has sis population with only one household.

Table 4.4: Population Distribution by Caste/Ethnicity

Ward No.	Brahmin/Chhetri		Damai/Kami/Sarki		Others	
	HHs	Population	HHs	Population	HHs	Population
1	463	2570	104	724		
2	487	3554	76	579		
3	221	1825	111	957	1	6
4	271	1882	19	231		
5	275	1627	47	287		
6	272	1470	81	608		

Ward No.	Brahmin/Chhetri		Damai/Kami/Sarki		Others	
	HHs	Population	HHs	Population	HHs	Population
7	400	1589	0	0		
Total	**2359**	**14157**	**438**	**3386**	**1**	**6**

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2075.

4.1.3 Population by Religion

In Masta Gaunpalika, people follow mainly Hindu religion. According to the Gaunpalika Profile, 2075, Hindus are the dominant social group which account more than 99% of the total population of this Masta Gaunpalika. There are Buddhist and Christian language group in limited number i.e. 0.03 and 0.01 percent respectively.

Table 4.5: Population Distribution by Religion

Ward No.	Religion				
	Hindu	Bauddha	Christian	Others	Total
1	3294	0	0	0	**3294**
2	4116	1	17	0	**4134**
3	2782	1	0	0	**2783**
4	2113	0	0	0	**2113**
5	1913	0	0	1	**1914**
6	2081	0	0	1	**2082**
7	1585	4	0	0	**1589**
Total	**17884**	**6**	**17**	**2**	**17909**
Percent	**99.86**	**0.03**	**0.09**	**0.01**	**100**

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2075.

4.1.4 Literacy Status

In every community, education is one of the fundamental forces to the social change and development ultimately. The degree of education in a community indicates the standard of living and civilization. It is also a powerful instrument of social and individual change.

Literary status of the Gaunpalika is given in Table 7 Of the total population of 6 years and above age group, 7% population is still illiterate. Altogether, 93 percent people are literate. The proportion of male illiteracy is high comparing with females. Out of the total illiterate population, the number of females is more than the male. On the other, the situation is right opposite in the case of other different levels of education in this village. Or, the proportion of male, obtaining different levels of education is more than female.

Table 4.6: Literacy Status

Ward No.	Literate (%)			Illiterate (%)		
	Male	Female	Total	Male	Female	Total
1	91.61	68.83	80.22	8.39	31.17	**19.78**
2	96.93	92.09	94.51	3.07	7.91	**5.49**
3	91.98	82.82	87.40	8.02	17.18	**12.60**
4	90.82	66.24	78.53	9.18	33.76	**21.47**
5	90.45	80.44	85.44	9.55	19.56	**14.56**
6	94.68	94.04	94.36	5.32	5.96	**5.64**
7	93.84	86.97	90.40	6.16	13.03	**9.60**
Total	**92.90**	**81.63**	**87.27**	**7.10**	**18.37**	**12.73**

Source: Masta Gaunpalika Profile, 2075; Bajhang District Profile, 2075.

The rate of literacy is seen high in ward number two (96.93 percent0 followed by ward number six (94.68 percent) in case of male. The situation of literacy is same in the context of female. Comparatively, the position of female is low in the all wards of this Gaunpalika.

4.2 Economic Settings

Economic settings refer to the whole situation of an area. It consists of ward-wise status of crops, irrigation facilities, production of high value crops, livestock farming, types of food production, major crops, livestock farming, poultry and fish farming, industry, occupation/employment sources of income of this Gaunpalika.

4.2.1 Agriculture

Agriculture is the major economic activity of this Gaunpalika. The agriculture system is subsistence and traditional. Both cereal and cash crops are produced here. Major cereal crops include paddy, wheat, millet, barley and phaper. Major cash crops include potato, apple, lentil and oilseeds. In addition to these crops, orange, walnut and vegetables are other cash crops produced in small scale in the Gaunpalika. The pulses like *mass,* soybean, lentil and *gahat* are produced here.

Table 4.7: Status of Crops

Ward No.	Cash crops	Cereal crops	Vegetable	Mustard
1	Apple, potato	Rice, wheat, maize, millet, barley, buckwheat	Spinach, cauliflower, potato, tomato	Maas, soybean, lentil, gahat
2	Potato, banana, lemon, orange, walnut	Rice, wheat, barley, buckwheat, Millet	Tomato spinach, Cauliflower, Cabbage, radish, potato,	Maas, soybean, lentil, mustard
3	Potato	Rice, wheat, maize, millet, barley, buckwheat	Spinach, cauliflower, cabbage, radish, potato	Maas, soybean, lentil, mustard
4	Potato	Rice, wheat, maize, millet, barley, buckwheat	Cabbage, spinach, cauliflower, radish, potato,	soybean, lentil, mustard
5		Barley	Spinach, cauliflower, cabbage, radish, potato, tomato	
6	Apple, potato, pomegranate, orange, walnut	Rice, wheat, maize, millet, buckwheat	Spinach, cauliflower, cabbage, potato, tomato	soybean, lentil, mustard
7	Apple, potato, pomegranate, orange, walnut	Rice, wheat, maize, millet, barley, buckwheat	Cauliflower, spinach, cabbage, radish, potato, tomato	soybean, musuro, mustard

Source: Masta Gaunpalika Profile, 2075; Field Survey, 2076, District Agriculture Office, 2072/73

4.2.1.1 Food production

The major crops producing in this Gaunpalika are rice, maize, millet, wheat, oilseed, Musuri, bean etc. The agriculture system is subsistence and traditional. Commercialization in agriculture is essential in this area. Attraction towards agriculture has been decreasing day by day due to shortage of man power as well as negligence of government towards agriculture. Comparatively, the production of grain farming is high in ward number five and followed by one. Ward number three has the lowest production and area followed by seven. Production of oil seeds in all wards is very low quantity. The details of agriculture production and area is given in Table 4.8

Table 4.8: Food production by Wards

Ward No.	Grain		Pulse		Oil seeds	
	Arrea	Production	Area	Production	Area	Production
1	4301	5591	129	77	0	0
2	2388	3104	193	116	0	0
3	866	1126	105	63	16	6
4	2830	3679	203	122	2	1
5	9969	12960	75	45	2	1
6	2288	2974	23	14	0	0
7	2252	2928	613	368	19	8
Total	24894	32362	1341	805	31	16

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075; District Agriculture Office

Irrigation Facilities

Irrigation is the most important factor for the development of agricultural sector. The irrigated area is limited in Masta Rural Municipality. Irrigation is mainly from the small river's rivulets originating from the Mountain ranges. There are at least four to five kulos in each ward. Irrigation facility is relatively higher in ward no 5 and ward 6 of the Gaunpalika. The details of the irrigation source river and approximate irrigated area is given in Table 4.9

Table 4.9: Irrigation Projects

S.N.	Name of canal	Ward No.	Irrigated Area (ha)	Household
1	Ramdev Sichain	1	5	26
2	Ata Sichain	2	10	62
3	Agra Sichain	4	2	90
4	Dwari Sichain	5	40	160
5	Dogade Sichain	6	80	200

Source: Field survey, 2076; Masta Rural Municipality Profile, 2075;

4.2.1.2 Production of High Value Crops

Many vegetable and fruits are grown in the Gaunpalika. But the production is mainly for own consumption as they produce in small quantity. Major vegetables grown in this Gaunpalika area potato, cauliflower, lady finger, yam, cabbage, tomato, pumpkin, and broad leaf mustard (sag). These vegetables are grown in all wards.

The Gaunpalika has different types of climate mainly sub-tropical to temperate which are suitable for producing different types of fruits. Apple, and Okhar, are produced in upper parts of this Gaunpalika. Naspati, Aru, lemon, banana, litchi, papaya is mainly produced in low land lower areas. These crops are grown for household consumption at present. However, there is high potentiality of producing these crops for commercial purpose.

Table 4.10: Status of High Value Crops

Ward No.	Vegetable		Fruits	
	Area	Production	Area	Production
1	153	459	121	666
2	134	402	155	853
3	199	597	125	688
4	132	396	137	754
5	120	360	221	1216
6	128	384	130	715
7	229	687	143	787
Total	1095	3285	1032	5676

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075; District

4.2.1.3 Livestock Farming

Livestock farming is considered as the important occupation in Nepal. It is an important component of the farming system in this area. Basically, it is carried out together with agriculture. So, it is called complementary of agriculture. The major livestock, raised in Nepal are cattle (cow and ox) buffaloes, goat, pig, duck/hen and pigeon etc.

In Bajhang, livestock raising has been remained as an indispensable to the farming system and hence both farming are practiced as an integrated farming system. By this system, farmers are able to manage farmland ecology. Both cow and buffalo are raised for soil preparation, milk and manure. A huge proportion of livestock fodder comes from crop-residues and green fodder from the farm fields. Farmers get various products such as milk, meat, egg and ghee by raising livestock for household use as well as for an additional income.

Based on interaction with local representatives, there are altogether 4803 cattle, 1830 buffaloes and 3226 goat/sheep in this Gaunpalika. From the table, it becomes clear that cows and goats are in the large number compared to other buffalos, goats, and sheep. The details of livestock rearing are shown in Table 4.11.

Table 4.11: Livestock farming in Masta

Ward No.	Cattle	Buffaloes	Goats/sheep
1	838	319	864
2	989	377	306
3	603	230	424
4	510	194	481
5	498	190	340
6	596	227	425
7	769	293	386
Total	4803	1830	3226

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Looking at available data, all wards are about same position for livestock raising. The practice of raising cattle is more popular than buffalo in this area which is reflected in the number of its total population. Similarly, goat is also more common in this Rural Municipality. It is raised especially for the purpose of cash earning.

4.2.1.4 Poultry and Fishing

Not only domestic consumption, poultry is an important source of livelihood in Masta Gaunpalika like whole rural parts of Nepal. Most of the households are practicing poultry farming in small-scale in this Gaunpalika. Poultry plays important roles for the social and cultural aspect of rural people. Poultry farming in the village have many advantages in the mixed farming systems as they are small, reproduce easily, do not need large investments and can scavenge for food. Chickens are the most common species, but mixed flocks including species such as ducks, geese also often exist. The rearing households of poultry in this Gaunpalika is 2287 which produces 2847 chicken and 17082 eggs and 2135 kg chicken meat annually.

According to Gaunpalika record and local informants, there is no fish farming as traditional way and for commercial purpose. As suggested by informants, there is possibility of commercial trout farming in the upper part of the Gaunpalika.

4.3 Employment/occupation

There are five major employment sectors. These sectors are agriculture, service, wage labor, business and foreign labor migration. A large number of people (31 percent) are associated with non-productive sectors such as student and housewife. Nearly 25 percent people are young age who are not able to do any work. Out of total population, 4863 people of the Gaunpalika are partly or fully employed in agriculture sectors with livestock farming together. Similarly, 11.54 percent people engage in foreign employment. The major destination countries are India then it comes Gulf countries and Malaysia. Service, wage labor, business and industry are other sectors of employment in this Gaunpalika. This is shown in Table 4.12.

Table 4.12: Major Occupations

Ward	Agr.	Service	Industry& Business	Wage	Foreign labor	Std/house wife/old	Small age	Total
1	502	111	39	88	489	1435	630	3294
2	1251	67	18	20	681	978	1119	4134
3	675	86	9	19	512	770	712	2783
4	596	89	12	20	217	682	497	2113
5	848	35	17	8	11	499	496	1914
6	432	25	21	42	143	776	643	2082
7	559	53	20	39	14	413	491	1589
Total	**4863**	**466**	**136**	**236**	**2067**	**5553**	**4588**	**17909**
%	**27.15**	**2.60**	**0.76**	**1.32**	**11.54**	**31**	**25.62**	**100**

Source: Masta Gaunpalika Profile, 2075 and Field Survey, 2076.

4.4 Industries

No large industries are found in this Gaunpalika. Small and cottage industries based on agriculture and forest such as rice mills, saw mills, khoto sankalan are found here. Some small poultry farms can be seen in Masta. Local people have reported slat mines in Badegaun in ward 2, Lataun in ward 7 and Thakunna in ward 7. Local people have reported Slat mines in talpurana, kangarkot, kayan goth and seto dhunga in ward 4 and 5 and iron ore in ward 4.

Table 4.13: Distribution of Different Types of Industries by Ward

S. N.	Name of Industry	Establish Year	Location (Ward no, settlement)	Name of Produced goods	Production Quantity	Number of employments
1	Rice mill		2	Rice, flour		2
2	Saw mill		3	Furniture		2
3	Kagaj uddyog			Nepali kagaj	700 quintals	12
4	Allo uddyog			Kapada	415 quintals	15
5	Khoto sankalan			Khoto	4110 quintals	40
6	Poultry farming			Chicken		4
7	Silai bunai (Tailoring)			Clothes		3

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075; Gharelu tatha Sana Udoug Bikash Samiti, 2075

Different types of small industries are found in this Gaunpalika. Most of the industries are based on skill such as tailoring, poultry farming etc. Women are engaged in this sector as self-employment. Vegetable farming is also widespread in this area as small industry. Similarly, the training related with pig farming, goat farm, bee keeping and mushroom have taken for establishing small industries in Masta. There are some rice mills, allo udyog, kagaj uddyog and saw mills. The importance of such industries is great for the local development by using local skill and resources. The demand of local goods such as Nepali kagaj and clothes of allo is very in Kathmandu as well as abroad. Such products from kagaj uddyog and allo uddyog are exported to Kathmandu.

4.5 Remittances

Foreign employment has become significant component of Nepalese economy. Remittances from forign employment is considered as the backbone of the country. It is also an important source of employment of Nepalese youth. Based on interaction with local representatives and personnel, participation of youth people of this area is increasing in foreign employment in the recent days. Among the total migrants, about 95 percent people move to India. Moving to India for seasonal employment is a traditional practice of this area. In one season, one worker earns 40000 to 50000 Rs in India. Beside India, most of them move in Gulf Countries i.e. Saudi Arab, Dubai Qatar and Bahrain as well as Malaysia. Remittance has played a vital role for sustaining livelihood of this Gaunpalika. About 70 people are migrated to these countries in foreign employment and in an average, they earn about Rs. 150000-200000 annually. Out of the total population involved in this sector, male is dominant position which occupies 94 percent and only 6 percent by female.

4.6 Source of Income

Diversification of the sources of income indicates that the people are engaged in different sectors of livelihood options. Similarly, multiple sources of income mean secured livelihood of the households. As suggested by local. representatives and officials on discussion, remittance is the largest source of income in the recent days which contributes 53.58 percent followed by agriculture with livestock farming (30.25 percent) in this Masta Gaunpalika. The detail is shown in Table 4.14

Table 4.14: Sources of Income in Masta

S. N.	Sources	Percentage
1	Agriculture & livestock	30.25
2	Wage labour	2.75
3	Remittances	53.58
4	Service/pension	4.48
5	Industry & business	3.30
6	Others	2.00
Percent		100.00

Source: Field Survey, 2076

The share of remittance is increasing in the present days because of growing foreign employment especially Gulf countries and Malaysia. But India occupies more volume of remittance due to larger number of seasonal migrants there for earning. Likewise, service and pension accounts 4.48 percent income. Wage labor, industry and business are also some of the important other sources of income in Masta.

4.7 Potential Income Opportunities

This Gaunpalika is situated in rural area of mountain region. Hence, there have been established a number of small agriculture-based industries, i.e. rice mill as well as oil mills. These types of activities provide employment opportunities to the local people. Similarly, commercial agriculture activities will be another potential source of income of the people. In this Gaunpalika some of the farmers have been working for commercial farming. So, in the near future, they will be able to earn more money than today. Besides this, off-season vegetables could be the major sources of income of the people in this Gaunpalika.

CHAPTER -5

INFRASTRUCTURE AND SERVICES

Infrastructure development is essential for development. In this section, infrastructure and services including road, electricity, health facility, educational institutions, communication, etc. are dealt. Among the various infrastructure, road is considered very important for further development. In the recent days, more financial resources are invested for the extension of road construction in this Gaunpalika like other area of the country.

5.1 Road Transportation

Among the seven, altogether four wards are connected by local road as well as village road. The roads connecting with district headquarter and regional market center and highway are black topped. Most of the village roads are kachchi. Therefore, the road service is not available all the year. Basically, road service is stopped in summer season due to greater water volume in Seti river. In the winter season, temporary bridge (wood bridge) is constructed over the Seti river then starts road services through local jeep about 4 to 6 months. Lacking of permanent bridge over the Seti river seems very urgent for this village. The details of road name are given in Table 5.1.

Table 5.1: Status of Transportation

Ward No.	Road name	Connected settlements		Length	Type
		From	To		
1	Chhagri Chiuri Dewalkot	Masta R. M.	Ward 1	14	Kachchi
	Ranada Bhusya Sadak	Kotdewal			Kachchi
3	Pankot Bhaneli Sadak	Dungi	Bhaneli		Kachchi
4	Seti Saipal Sadak	Doti	Bajhang-Saipal		Kachchi
	Pankot Bhaneli Sadak	Dungi	Bhaneli	35	Kachchi
	Pankot Bhaneli Sadak	Dungi	Bhaneli	35	Kachchi
5	Bhimdhunga Malika Sadak	Kimada	Dwari	6	Kachchi

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

5.2 Health

Health is wealth. It is known as fundamental thing for human life. But education and awareness are prerequisite for this purpose. It requires more government investment for infrastructure. For the promotion of accessibility of health facility, government has also added more investment in health sector in those days. Nevertheless, the access of health service in this Gaunpalika is not so fine. The availability of health institution is given in Table 5.2.

Table 5.2: Status of Health Service

Ward No.	15 minutes	30 minutes	1 hour	Over 1 hour
1	214	277	0	0
2	117	335	99	0
3	40	87	108	41
4	186	312	50	113
5	0	0	258	0
6	0	262	0	0
7	0	0	299	0
Total	**557**	**1273**	**814**	**154**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Out of the total household, 74 percent households have got health post facility at their first attempt. Similarly, 7 percent households get hospital/nursing home facility for this purpose. About 19 percent household has access of traditional local healer until todays at their first attempt. Lama, Dhami, Jhankri and Bijuwa are recognized as traditional healer.

There are altogether four health posts in Masta Rural Municipality, one health post available in each four wards (2, 4, 5 and 6). There is no primary health post in ward one, three and seven. Hospital is available in district headquarter, Chainpur. Out of the total population, 45 percent population have got access of primary health post service within 30-minute distance. And, in the total, about 29 percent people should move one hour for taking primary health service.

Toilet is very important for health and sanitation. In Masta, 98 percent households have toilet facility with normal structure. Very limited people have access of flush toilet, only 15 household. In the total, about two percent people have no access of toilet facility in all wards. The highest percent of toilet unavailability is in ward no 4 (14.9%), followed by ward 1 (13.9%), ward no 5 (11.7%) and ward no 9 (11.6). The detail is given in Table 5.3

Table 5.3: Toilet Facility

Ward No.	With flush	Normal	No available	Total
1	5	557	5	567
2	1	557	5	563
3	9	317	7	333
4	0	289	1	290
5	0	321	1	322
6	0	292	31	323
7	0	385	15	400
Total	15	2718	62	2798
Percent	0.54	97.14	2.32	100

Source: Field survey, 2076; Masta Rural Municipality Profile, 2075

5.3 Drinking Water Services

Drinking water is known as basic needs of human life. Without clean drinking water, nobody can imagine healthy life. There are different kinds of sources of drinking water in Masta Gaunpalika i.e., piped tap, spring, well, river/stream etc. The detail is given in Table 5.4

Table 5.4: Source of Drinking Water to Households by Ward

Ward No.	Private Piped tap	Public Pipe	Spring	River/ stream	Covered well	Total
1	5	520	4	33	5	**567**
2	4	545	14	0	0	**563**
3	15	308	8	1	1	**333**
4	68	191	12	8	11	**290**
5	308	14	0	0	0	**322**
6	2	201	120	0	0	**323**
7	15	385	0	0	0	**400**
Total	**417**	**2064**	**158**	**42**	**17**	**2798**
Percent	**14.90**	**77.34**	**5.65**	**1.50**	**0.61**	**100**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

A large number of households use public tap water in all wards of this Rural Municipality. Likewise, about 15 percent households of seven wards use private piped water as their drinking water in Masta Rural Municipality. Similarly, spring water is used by nearly 5.65 percent people. This source of water is not considered secured for drinking due to the containing different bacteria. Although, the people of this place are compelled to use this kind of source. About two percent households use open source of water i.e. river, stream for drinking. Ward number six has the lowest access of safe drinking in this place.

5.4 Electricity

There are major two sources of light in this Masta Gaunpalika. The largest source for light is solar power in the this Gaunpalika. Out of the total (2798) household, 1361 households use kerosene for light. Solar power plants have been joined through the donation of governmental and non-governmental organizations. About 44 percent people use hydroelectricity for lighting. Ward number two has the highest rank in this regard. Electrification from national grid has been done in Masta. Small hydro power projects have also constructed in Masta and those projects generate 346 KW power. (Table 5.5).

Table 5.5: Modern Sources of Lighting at Household by Ward

Ward No.	Electricity	Kerosene	Bio-gas	Solar	Others	Total
1	153	0	0	288	126	**567**
2	434	0	0	128	1	**563**
3	42	9	1	250	31	**333**
4	146	4	0	139	1	**290**
5	46	5	1	268	2	**322**
6	210	0	0	112	1	**323**
7	204	1	0	176	19	**400**
Total	**1235**	**19**	**2**	**1361**	**181**	**2798**
Percent	**44.14**	**0.62**	**0.07**	**48.64**	**6.47**	**100**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

The users of kerosene for light are 0.62 percent in Masta. And, some households are the users of other sources such as biogas, peltry set etc. for this purpose.

Sources Fuel for Cooking

There are various types of fuels available for cooking in Masta Gaunpalika of Bajhang district i.e. firewood, biogas, LP Gas, kerosene, dung-cake etc. Among them, firewood is dominant fuel in this Masta Gaunpalika which occupies nearly 99 percent followed by LP gas (1 percent). The users of others for cooking are negligible percent in this Masta Gaunpalika.

Table 5.6: Availability of fuel for cooking

Ward No.	Fire wood	L.P gas	Bio gas	Others	Total
1	560	4	0	3	**567**
2	561	0	0	2	**563**
3	329	1	0	3	**333**
4	282	8	0	0	**290**
5	306	15	0	1	**322**
6	323	0	0	0	**323**
7	397	2	0	1	**400**

Ward No.	Fire wood	L.P gas	Bio gas	Others	Total
Total	**2758**	**30**	**0**	**10**	**2798**
Percent	**98.57**	**1.07**	**0**	**0.36**	**100**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Small Hydro and Solar Power Plants

There are several small river and streams in Masta which flow originating from different mountain ranges. Those rivers permanently flow and the discharge rate also high due to the fast speed in steep slope. Therefore, the potentiality of hydroelectricity generation is high in the area. Comparatively, the cost of production is also low. There are eleven small hydroelectricity projects in operation in six wards except ward seven of Masta. The capacity of projects ranges from 18 to 65 Kilowatts. Now a days, Masta has been connected with national grid. So, there is no problem of electricity in Masta.

Table 5.7: Situation of small hydro projects

S.N.	Project Name	Location	Capacity (KW)
1	Bhairani Chhana Small Hydro project	Masta-1, Kotdebal	22
2	Sai Dhunga Small Hydro project	Masta-1, Kotdebal	45
3	Dugri Gaun Khoia Small Hydro project	Masta-1, Kotdebal	19
4	Lachhi Gaun Small Hydro project	Masta-2, Lachhi Gaun	18
5	Dogade Gaun Small Hydro project	Masta-2, Tuti	46
6	Lachhi Gaun Khoia Small Hydro project	Masta-3 and 4	21
7	Agra Small Hydro project	Masta-4, Agra	15
8	Dwari Gaun Small Hydro project	Masta-5, Dwari	65
9	Tallo Rilu Gaun Small Hydro project	Masta-6, Rilu	42
10	Mathillo Rilo Gaun Small Hydro project	Masta-6, Thakunnan	22
11	Saurya Urja (solar power)	Masta-3 and 4	31
Total			**346**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

5.5 Educational Institutions

The pre-primary and basic schools are in all wards of this village. Secondary schools are established only in four wards (one, two, four and six) of this Gaunpalika. There are thirty-five educational institutions altogether in Masta. Out of total schools, thirty-three are community-based school. Nepal Government has categorized school education in three level i.e. Pre-primary, Basic and Secondary level education. There are thirty-one Pre-primary and Basic level and only four of Secondary school in this Masta Gaunpalika. The condition of educational service in this Gaunpalika is presented here.

Table 5.8: Number and types of school by ward

S.N.	School name	Ward No.	Pre. Pri.	Basic	Sec.	Total
			Std. No.	Std. No.	Std. No.	
1	Malika Ba. Sch.	1	12	45	0	**57**
2	Maitiban Ba. Sch.	1	0	188	0	**188**
3	Ghataldevi Ba. Sch.	1	0	46	0	**46**
4	Durgadevi Ba. Sch.	1	23	78	0	**101**
5	Betal Ba. Sch.	1	0	73	0	**73**
6	Surmadevi Ba. Sch.	1	22	90	0	**112**
7	Nepal Ra. Ba. Sch.	1	23	23	0	**46**
8	Dandabagh Ba. Sch.	1	20	58	0	**87**
9	Mangalamaya Ba. Sch.	1	0	66	0	**66**
10	Bhawani Ba. Sch.	2	39	189	0	**228**
11	Masta Ba. Sch.	2	37	242	0	**279**
12	Ghataldev Mangal Ba. Sch.	2	19	36	0	**55**
13	Shanti Ba. Sch.	2	0	55	0	**55**
14	Gaurishankar Ba. Sch.	2	20	65	0	**85**
15	Bhairabi Ba. Sch.	2	25	57	0	**82**
16	Balbikash Ba. Sch.	2	21	63	0	**84**
17	Malika Ba. Sch.	3	40	217	0	**257**
18	Girsain Ba. Sch.	3	0	90	0	**90**
19	Youbabarsa Ba. Sch.	3	0	84	0	**84**
20	Bhawani Ba. Sch.	3	30	64	0	**94**
21	Ekwar Ba. Sch.	4	31	30	0	**61**
22	Phulanandev Ba. Sch.	4	30	73	0	**103**
23	Kalika Ba. Sch.	4	20	171	0	**191**
24	Dwarikanath Ba. Sc.	5	34	258	0	**292**
25	Janaki Ba. Sch.	5	27	167	0	**194**
26	Kalika Ba. Sch.	6	0	238	0	**238**
27	Himalaya Ba. Sch.	7	45	152	0	**197**
28	Kailash Ba. Sch.	7	32	93	0	**125**
29	Malika Ba. Sch.	7	58	169	0	**227**
30	Ghachaya Sec. Sch.	1	0	255	65	**320**
31	Sharada Sec. Sch.	2	0	156	105	**261**
32	Kulamastajan Sec. Sch.	4	25	317	263	**605**
33	Riluchaur Sec. Sch.	6	0	312	154	**466**
34	Sraswati Bi. Ma. (community)	1	13	164	41	**218**
35	Ekta Eng Boarding (community)	3	49	65	0	**114**
Total			**695**	**4449**	**628**	**5772**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

The total student, studying in all level is 5772 which represents 32 percent of the total population of Masta. Most of the students (77 percent) belong to basic level (1-8 class) followed by pre-primary level (12 percent) and secondary level holds 11 percent students. The participation of girls seems good in the all level of education. There are no opportunities of university level of education in this Masta Rural Municipal

Communication and Media

The role of communication and media is important in this modern age. The major means of communication are radio, television and mobile/telephone in these days which are common all over the country. These things are used as the means of facilities and entertainment both. Mobile and Telephone are used by 2180 households (49%) as main mode of communication throughout Masta Gaunpalika followed by Radio 1849 households (41.49%) and TV 270 (6.07%). Out of the total, very limited household have access of computer and email/internet.

5.6 Financial Institutions

Banking and financial institutions have a greater role in socio-economic development and employment. As a banking institution, Rastriya Banijya Bank was established in this Gaunpalika which is providing banking facility to the inhabitants of this area.

Beside this, there are five cooperatives and saving and credit co-operatives in the village. These all work as financial institution like saving and credit for only own members. There are various informal groups such as Ama samuha, Kishan Samuha, Ban samuha and Mahila Samuha which functions saving and credit in group basis. They play important roles in urgent time and for the development of saving habit of common people especially women in rural areas.

Table 5.9: Financial Institutions by ward

S.N.	Name of Bank/cooperative and other financial institution	Members	Ward No./ Settlement
1	Mahila Bachat Samuha	260	1
2	Dalit Sahakari		1
3	Janabikash Gramin Bachat Samuha	605	2
4	Masta Sana Kishan Krishi Samuha	482	2
5	Yakikrit Krishi Sahakari	203	4
6	Pragatisil Sahakari		5
7	Malika Sahakari Bachat Samuha	400	
8	Yakikrit Sahakari Sanstha		3,4

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Access to Various Services

Access to various services such as radio, T.V. mobile/telephone, computer, internet, motorcycle, motor/cars, refrigerator, bus etc. play important role for the development of any community and region. The spatial concentration of access of such services and facilities in this Gaunpalika seems no more differences in all wards. Among the total people, 41 percent people have got access of radio and 49 percent in mobile. Likewise, in the total population 6 percent people have access of T.V. facility. In the case of T.V., ward number 6 has low access than another ward. The facilities such as motor/car, refrigerator, internet, computer is limited to the people of this area.

Table 5.10: Household access to various services

Ward No.	Radio	T.V.	Mobile/ Telephone	Computer	Internet	Motorcycle	Motor/ Cars	Refrigerator	Bus/ truck
1	418	84	541	29	3	25	5	1	6
2	321	98	531	20	0	0	0	0	5
3	260	24	297	4	0	1	0	0	4
4	250	32	262	2	0	0	0	0	2
5	259	11	96	2	0	0	0	0	4
6	151	6	255	0	0	0	0	0	8
7	190	15	198	13	2	2	0	1	11
Total	**1849**	**270**	**2180**	**70**	**5**	**28**	**5**	**2**	**40**
Percent	**41.56**	**6.07**	**49.00**	**1.57**	**0.11**	**0.63**	**0.11**	**0.04**	**0.90**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Governmental and Non-Governmental Organizations

The role of non-governmental organizations has become significant for the development of community in Nepal. Several non-governmental organizations are actively working in different fields of community. The organizations related with forest are more in Masta than others followed by youth club and cooperatives. Similarly, the number of bal club, Ama samuha and NGOs are also considerable in this village.

Table 5.11: Governmental and Non-Governmental Organizations in Masta

S. N	Organization types	Number	Participant Member	Working sector
1	Government (Local units, health post, post office, agriculture office	15		Government
2	Community Forest	31		Community, forest
3	Youth club	13	260	Youths, community
4	Bal club	8		Bal
5	Ama samuha	9	800	Community, women
6	NGOs	8		Community
7	Cooperatives	9	1111	Community

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

CHAPTER-6

HERITAGE, CULTURE AND TOURISM

6.1 Heritage

Heritage is the important property of the society. It is handed over to new generation from ancestors. Heritage refers culture, history and identity of any community and society. Although heritage is by no means uniformly desirable, it is widely viewed as a precious and irreplaceable resource, crucial to personal and collective identity and necessary for self-respect. So, it is our common property. There are some common heritages in Masta Gaunpalika which are as following in the table. There are altogether 14 temples related with different gods and goddess located in Masta. Not only religious, the cultural value of those religious places is notable. Hindu people perform worship regularly in such places during different religious ceremonies and festivals.

Table 6.1: Name of Heritage by Types and Ward

S.N.	Temple/Heritage Site	Location (Wards)	Importance/Characteristics
1	Mastadev Rajbhandar	3	Religious/cultural
2	Surma Devi Mandir	2	Religious
3	Kalika Bhawani Mandir	2	Religious
4	Kalasila	2	Religious
5	Bathapali Mandir	3	Religious
6	Malika Maitiban	1	Religious
7	Simpandu Patala Khikala	2	Reliious
8	Lawadev Nilakhari Bhawani	3	Religious
9	Baithajada Masta	3	Religious/cultural
10	Tapoban Tirthasthal	4	Religious/Tatopani
12	Mastadev Nandev Bathapali	4	Religious
13	Malika Tirthasthal	7	Religious
14	Kalasain Bathapali	4	Religious

Source: Field Survey, 2076; Masta Gaunpalika Profile, 2075

6.2 Culture

Culture has been called 'the way of life for an entire society. The statement holds particularly true in case of this village as elsewhere of Nepal where every aspect of life, food, clothing and even occupations are culturally classified. There are different castes and ethnic groups living in this Masta Gaunpalika. 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.

Masta Gaunpalika is the mixed type of village where various types of castes/ethnicities are found residing here. So, different types of culture and custom as well as feast and festivals are prevalent in each and every community. Dashain, Tihar, Maghe Sakranti, Saune Sakranti, Phagu Purnima, Chaite Dashain are celebrated commonly by all people like other parts of Nepal. In addition to those parbas (national festival), many other local parbas which are celebrated in the western mountain parts of Nepal such as, Bishu

Parba, Ganga Dasahara, Maghi, Gaura Parba, Bhuwo Parba, Deuda, Takaselai, Baishakh Sankranti Mela etc. are also popular in this area.

6.3 Tourism

Not only internal tourism, there is decent prospect of international tourism development in this area. 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. If they prefer a cool climate in summer, they can visit in this area. Tourists can enjoy unique cultural varieties of western mountain region of Nepal. People of this area regard guests as god. They are courteous and hospitable to the tourists.

Table 6.2: Major Tourist Places and Their Importance

S.N.	Major Places	Location	Major Characteristics (Importance)
1	Mastadev Rasbhandar	3	Religious/cultural/touristic
2	Baithajada Masta	7	Religious/cultural/touristic
3	Pugra kot	1	Religious/cultural/touristic
4	Leki Bhumka	1	Historical /touristic
5	Jarim Kot	1	Historical /touristic
6	Malika Maitiban	1	Religious/touristic
7	Tapoban	3	Religious/ touristic
7	Khaptad Rastriya Nikunj		Touristic/natural scene

Source: Field Survey, 2076; Masta Gaunpalika Profile, 2075

Mastadev and Khaptad Rastriya Nikunjare known as most of the attractive destination in western region of Nepal. Infrastructures such as roads, hotel, electricity, communication, drinking water and dissemination of tourism products of this area is very necessary things for the development of tourism industry in this area.

Chapter-7

RISK IN THE STUDY AREA AND SAFE AREAS FOR SETTLEMENT

7.1 Flood Risk

Nepal is highly vulnerable to natural disasters. The country has been facing different types of disaster such as earthquake, landslide, flood, thunderstorm, GLOF, avalanche, fire, drought, and epidemics every year. These disasters are found to occur in different parts of the country due to various reasons such as rugged and fragile geophysical structure, very high peaks, high angle of slopes, complex geology, variable climatic conditions, active tectonic processes, unplanned settlement, increasing population, weak economic condition and low awareness.

Basically, there are three types of hazards in this Rural Municipality. The main hazards are landslide, river cutting and flood which are common in this area. In addition to those, fire, windstorm, thunderstorm, epidemics, droughts etc. are also frequently occurring here. According to the Rural Municipality Profile and the discussion with local representatives, 2070 households are prone to various types of disasters. The houses and settlements located in steep slopes as well as nearby river bank and stream are more vulnerable. Landslides, river cutting and floods are considered most of the problematic hazard in this area due to several river and stream.

Table 7.1: Natural hazards in Masta

Ward No.	Location	Natural hazards				
		Landslide	River Cutting	Flood	Others	Total
1	Kadesain, Kojyakhal, Tusharpani, Dadabhir, Gaithi Ban, Jaltadi, Maljhuli, Samadeu				944	944
2	Badegaun, Bhattekhola, Ramalikhola, Khikala	80			50	130
3	Rithepatha, Dalit Basti, Tal Bojyadi, Bhimani-Bhawani Primary School, Paneri Khola, Bhaise Khola	150		150	100	400
4	Sagaud, Khatad, Hile-Namasi Khola, Khada-Kuri Kol	153	233	145	65	596
Total		**383**	**233**	**295**	**1159**	**2070**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

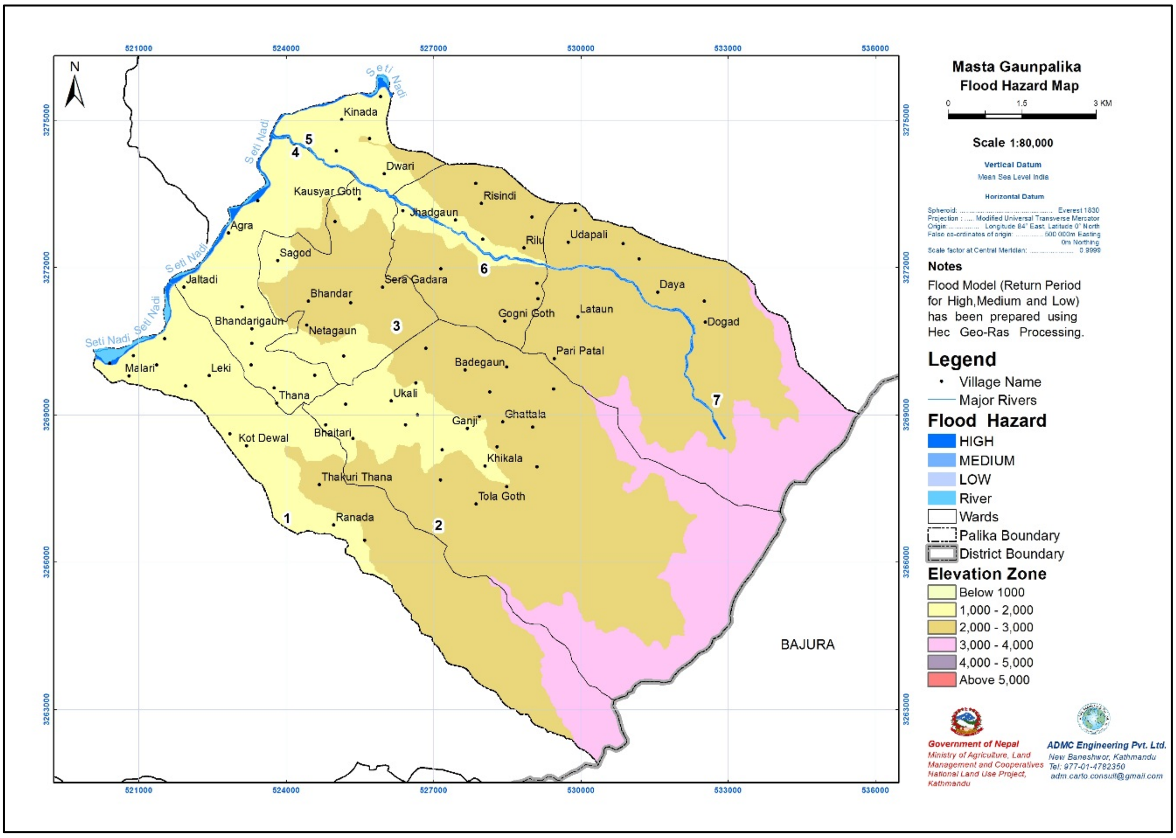

Figure 7.1: Flood Hazard Model for High, Medium and Low

In the summer season, landslide, flooding and river cutting events occur regularly. A large quantity of private properties, public infrastructures and common properties damage every year during the summer season. According to obtained information, ward number two, three and four are more vulnerable from landslide and three and four from flooding and four from river cutting. In the total (383 households), 80 households of ward number two, 150 of ward number three and 153 of ward number four are more affected by landslide. Similarly, out of the total (295 households), 150 households from ward number three and 145 households from ward number four are at risk to the flooding point of view.

The flood damaged the physical infrastructures such as school buildings, canal, drinking water projects, roads, bridges etc. in this area. As reported by local people, local representatives and personnel that the road situation during monsoon is very poor due to continuous flooding, erosion and landslides. The flood caused losses of school building and damage of roof from windstorm and its total disaster estimated value is 0.9 million NRs. Currently, there are eleven hydroelectricity projects located along the different streams which are also prone to flash flood.

Table 7.2: Loss/Damage of public properties

Hazard	Ward No.	Schools		Canal/drinking water		Road/bridges	
		Number	Loss (Rs)				
Landslide		1		2	40,000	1	50,000
Flood	3	1	400, 000	3	105,000		
Windstorm	1	1	500, 000				
Fire							
Total			**90,000**		**1,45,000**		**50,000**

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

Result

This delineated flood model is later used for the evaluation of land use planning by using overlay analysis in GIS environment. This process is discussed in the following section. The present land use information in the study area renders the following statistics.

Table 7.3: Present Land Use under Flood Risk

Land Use Type	Area (Sq. m.)	Area (Hectares)	%
Agriculture	596445.8244	59.644583	37%
Forest	489921.153	48.992114	30%
Riverine and Lake	527494.6231	52.749463	32%
Other	10568.1394	1.056813	1%
Public	7302.996229	0.730303	< 1%
Res	2170.452158	0.217045	< 1%
Grand Total	**1633903.188**	**163.390321**	100%

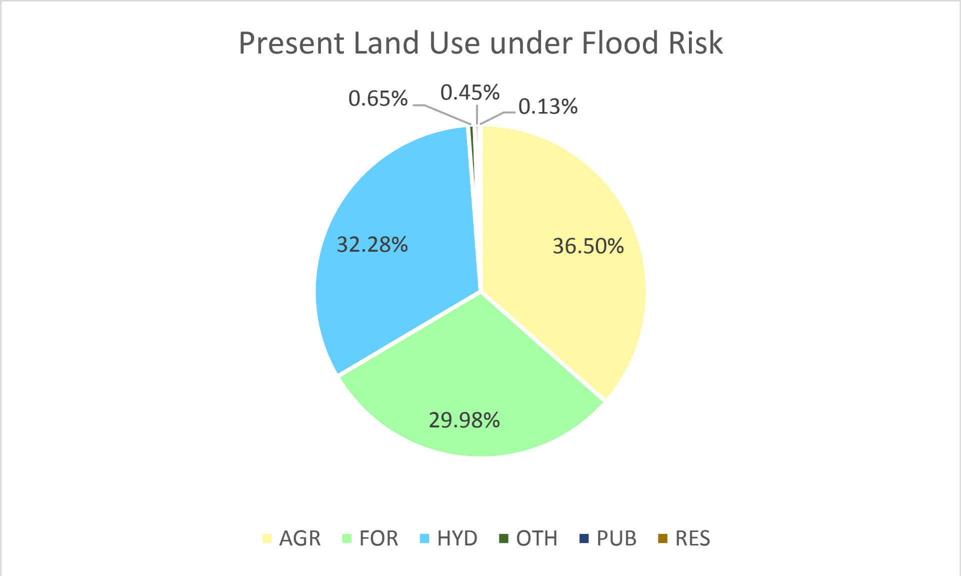

Figure 7.2: Classified land use under flood Risk

Table 7.4: Land Use Class and Flood Prone Area

Landuse	Low (ha)	Medium (ha)	High (ha)
Agriculture	9.13	8.77	41.74
Forest	10.52	10.39	28.09
Other	0.23	0.23	0.60
Public Use	0.18	0.14	0.41
Residential	0.01	< 1	0.21
Grand Total	**20.06**	**19.53**	**71.05**

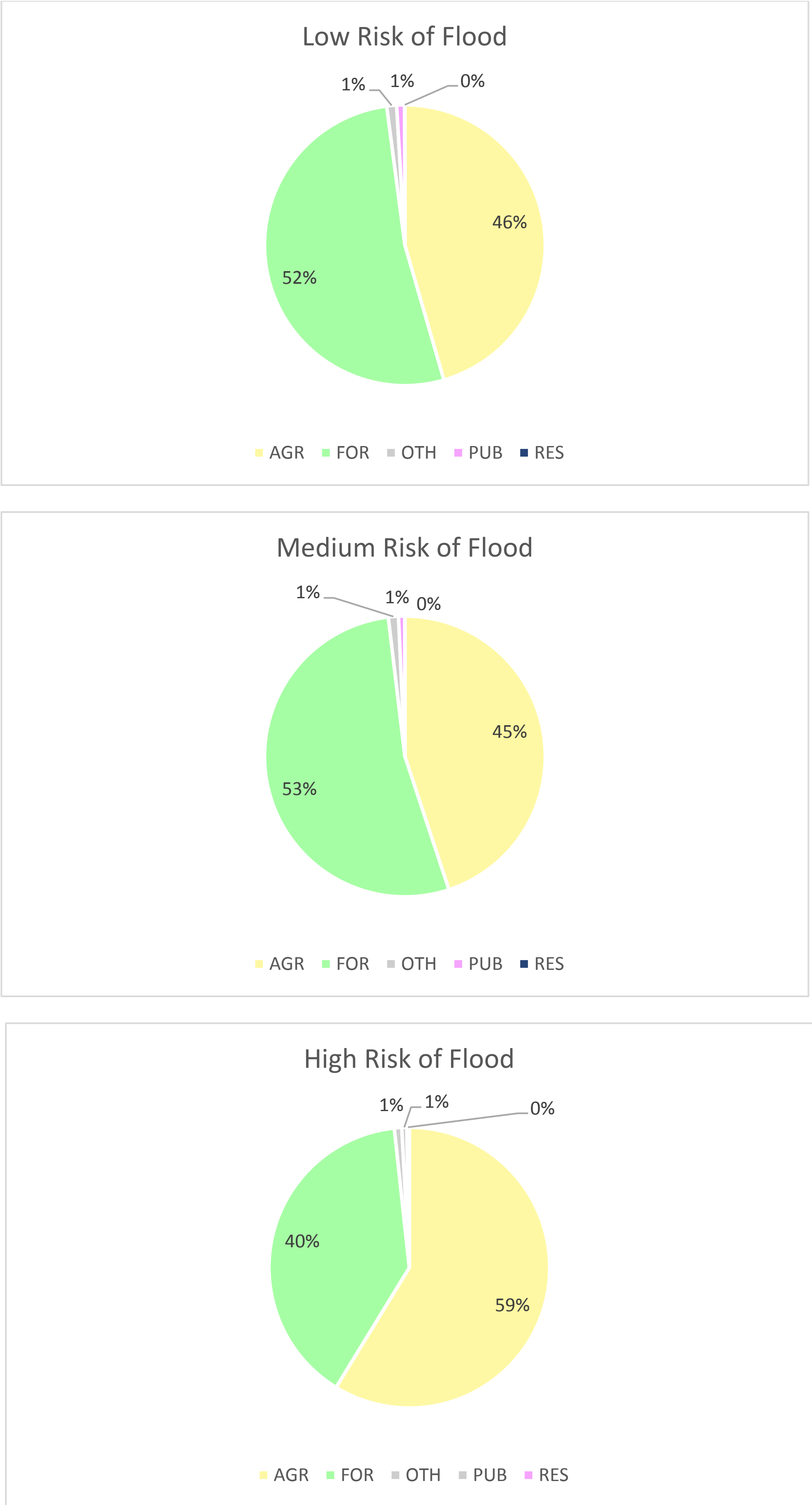

Figure 7.3: Flood Prone Zone for Masta Rural Muncipality

7.2 Fire Risk

Fire hazard is another most common natural hazard in Nepal. Fire disaster occurs mainly in the dry season between April to June. During this season the temperature in the Tarai region rises above 35° Celsius and it rains seldom. Fire disaster takes place mostly in the rural areas of the Tarai, middle Hill as well as mountain region of Nepal. Fire hazards are significantly increased with hotter dry seasons, which add to the frequency, and the intensity, of bush and forest, creating a greater hazard to life and property.

Fire hazard is also common problem in this area. The problem of fire hazard in the spring season makes very serious in the villages. Kachchi houses made by woods and thatch of roof make easy for catching and spreading fire. Most of the households use firewood for their cooking fuel which results fire spreading problem. Forest fire usually takes place during dry season in each year. Domesticated animals in the grazing land and wild animals, both are affected by the forest fire especially in the upper part of Masta Gaunpalika.

7.3 Landslide Risk

Disaster such as floods, landslides, thunderstorm, fire, hailstorm, windstorm and epidemic bring a huge loss in life and properties every year in Nepal during summer season. Due to diverse geographical coverage, Nepal is prone to various geological and hydro-meteorological hazards. Nepal’s geographic location also makes it extremely susceptible to such activity. Here, it is tried to show type of disaster, losses and damages induced by different kinds of disaster.

Landslide is the second important hazard though it is not common in this Gaunpalika. There are many small landslides all over the villages. Major landslides which are more sensitive, located in ward no two, three and four by which 40 households are affected by losing their private land, houses and animals. Similarly, the flood and windstorm damaged private property such as house, and goth in ward number three which affected 23 households. The estimated total value of disaster (damages and losses) caused by the landslides, flooding windstorm is NPR 45,15,000.

There is significant risk of landslide in this Gaunpalika that damage settlement and agricultural land. Tola Goth, Dungrakot and Bhate kholagaun are the settlement areas which are under risk of landslide.

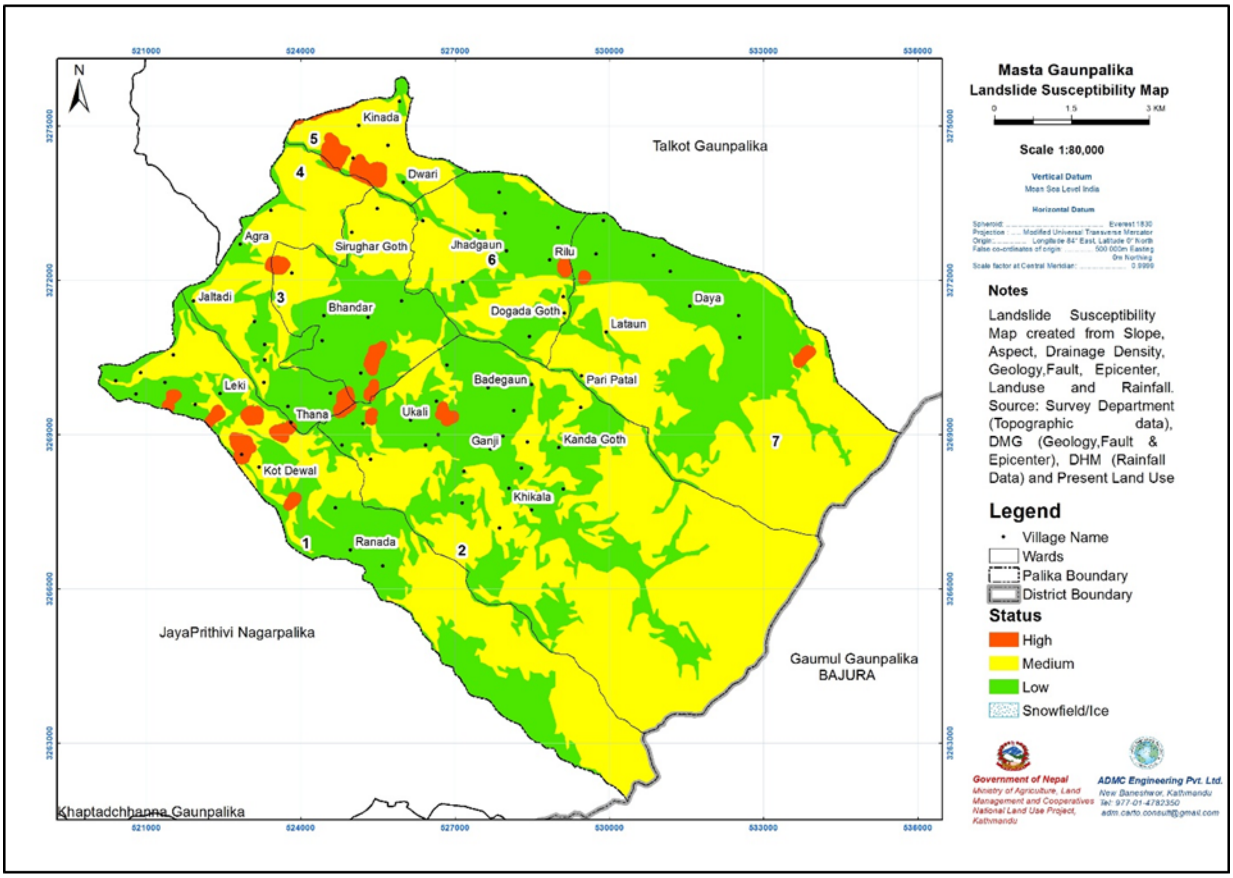

Figure 7.5: Landslide Susceptibility Map for Masta Gaunpalika

Table 7.5: Loss/damage of private properties

Hazard	Ward No.	Affected Households	Private land		Houses/goth		Animals	
			Area	Loss (Rs)				
Landslide	2,3,4	40		3,050,000	12	400,000	4	55,000
Flood	3	13		500,000				
Windstorm		10			10	450,000		
Fire							5	60,000
Total				35,50,000				1,15,000

Source: Field survey, 2076; Masta Gaunpalika Profile, 2075

7.4 Seismic Risk

Seismic Hazard is defined as the probabilistic level of ground shaking associated with the reoccurrence of the earthquakes. It is realized by depicting levels of chosen ground motion that likely will not be exceeded in specified exposure of time. (DMG, 2002)

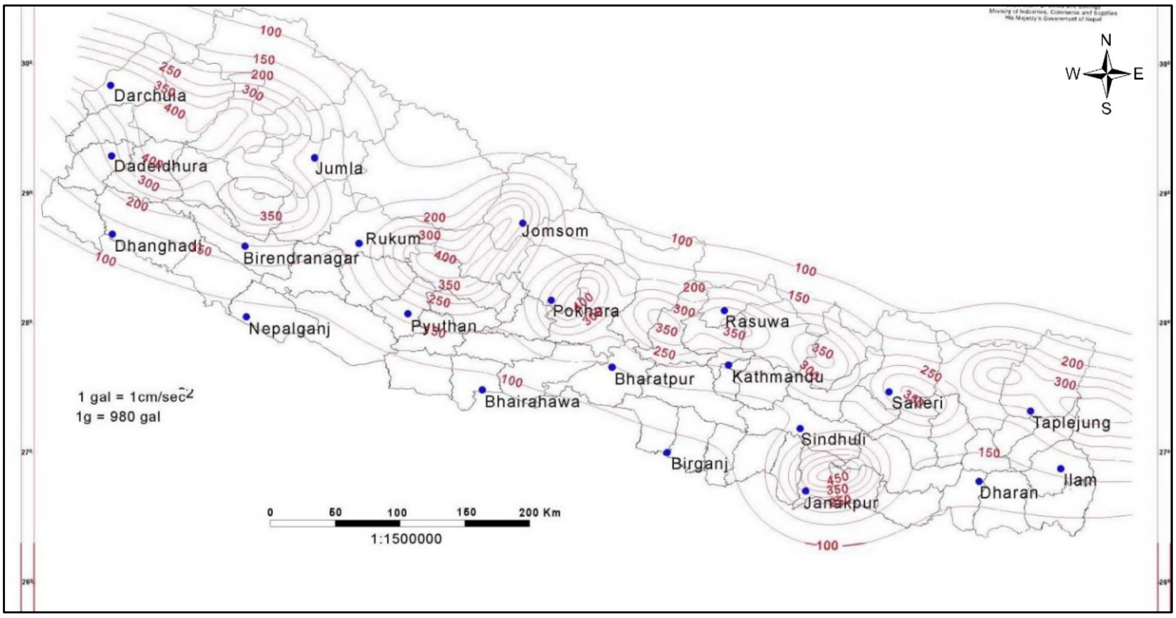

Figure 7.6: Probabilistic Seismic Hazard Assessment Map of the Nepal Himalaya

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.

For the minimum acceleration of 200-gal, reduction factor of 0.50 the calculated effective design seismic coefficient is approximately 0.10.
For the maximum acceleration of 400-gal, reduction factor of 0.50 the calculated effective design seismic coefficient is approximately 0.20.

Hence, the design horizontal seismic coefficient ranges from 0.10 to 0.20 (calculated values). The maximum and minimum value shows that the return period is between 100 to 200 years. In every 200 years, the area feels big earthquake with peak horizontal acceleration of between 0.10 to 0.20 g.

7.5 Industrial Risk

No major Industries were found in this Gaunpalika apart from small cottage with minimum risk to surroundings.

In future industries could grow in rapid way which could lead degradation of local environment. The proper control measures should be adopted to mitigate the risk of industrial pollution in the surrounding areas which are as follows.

a. Flora and fauna

- Support community based forest activities to conserve a habitat for flora and fauna.
- Allocated certain money to invest in conservation of biodiversity.

b. Water:

- Maintain and promote water bodies/wetlands and ponds.
- Prohibit polluted water discharge into rivers and any water bodies.
- Develop an irrigation facility in order to increase agricultural productivity nearby farms.
- Conduct a community-based watershed/lake management programme.

c. Air Quality:

- Maintain air quality controls in the surrounding areas as per the national standard.
- Prohibit polluted air emission directly into ambient environment.
- Adopt short-term and long-term strategies and equipment to control air pollution by the existing industries in the region.
- Adopt Polluter Pays Principle (PPP) to control the air pollution in the region.
- Monitor the air polluting industries and sources by the concerned authority.

d. Waste pollution and noise pollution:

- Make a green belt on both sides in industrial areas.
- Promote renewable energy for domestic use.
- Encourage 6R of solid waste.
- Adopt noise pollution control measures by the existing industries in the region

e. Soil Pollution:

- Prohibit the discharge of metal, hazardous material, dye, chemical and other into soil.
- Plantation of plants that absorbs pollutant of soil.

f. Legal framework:

- Ensure that the projects are accompanied by an evaluation of their impact on the environment. Include an alternative project to minimize the adverse effects (EIA/IEE).

7.6 Other Risk

Some parts of Masta face the problem of drought. Uneven and irregular monsoonic rainfall is the main factor of drought. The mountainous region (the northern belt) is generally dry. The lack of irrigation facilities makes the problem even more serious as prolonged drought condition has adverse effect in crop production.

Also, Windstorm occur mainly during the dry season between March to May. Thunderbolt occurs during the monsoon and hailstorm takes place during the beginning and end of the monsoon. Hailstorm causes heavy losses of agricultural crops though human life loss is seldom. Windstorm and thunderbolt cause the loss of human life as well as physical property.

7.7 Safe areas for resettlement

The study area holds major threat of Landslide along road, flood and inundation alongside the rivers and forest fire. Major rivers flowing though the study area are Seti Nadi and Dwari Gad. Mainly the agricultural area is under high threat from the flood and inundation. Other existing threats include the Forest Fire Hazards. Natural Forest Fire risk is seen in dry season. In case of Seismic risk, MCT is the fault line passes through the study areas. Some occurring of earthquakes as epicenter falling in the area has been seen. The area is prone to landslide mostly in the sloppy terrain alongside road in monsoon season. The intensity of the damage is moderate to high and proper management practice can help reduce to prevent further damages.

The identification of potential risk areas is very difficult task because nature may not follow the hazard model developed by the human beings. However, the modelling of the existing risk areas could be used to estimate or predict the future potential risk areas. Based on the existing risk in the project areas it can be concluded that the existing hazard risk areas are prone to future potential risks as well. 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 or as the open spaces.

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Annexes

Annex 1:

Photographs

DGPS Receiver at Base Station

The view of Trig 106-109

Expert Visit

Draft Presentation with Palika Members

Soil Semple Collection

Soil Semple Collection

Annex 2:

Minute of Meeting in Gaunpalika

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~~पेज - १५~~

मिति :- २०८३।०५।२८

आज मिति २०८३।०५।२८ मा भूमि व्यवस्था, सहकारी तथा गरिबी निवारण मन्त्रालय अन्तर्गत स्थलगत नापी तथा भूउपयोग व्यवस्थापन महाशाखाबाट सम्बन्धित भू-उपयोग नक्साङ्कन कामको लागि ए.डी.एम.सी. (ADMC) इन्जिनियरिङ प्राइभेट लि. बाट आएको टिम समूह र सहरा गाउँपालिका- का अध्यक्ष, उपाध्यक्ष लगायत अन्य जनप्रतिनिधि- हरु तथा विभिन्न क्षेत्र र तहका सरोकारवाला महा- नुभावहरुबीच यस गा.पा.को भू-उपयोग [illegible] जस्तो भन्ने [illegible] कार्यक्रममा उपस्थित सहभागीहरुको निम्नानुसार रहेको छ।

उपस्थिति :-

	नाम	पद	दस्तखत
१.	कर्ण ब. कठायत	अध्यक्ष	
२.	भगवती कु. बोहरा	उपाध्यक्ष	
३.	अम्मर राज जोशी	प्रमुख प्रशासकीय अधिकृत	
४.	अमर ब. जेठारा	कृषि प्राविधिक संयोजक	
५.	ई. दिपक ब. बोहरा	इन्जिनियर	
६.	दिलीप राना	सूचना प्रविधि अधिकृत	
७.	टिक्का टाल	लेखापाल	
८.	रमेश कुमार खड्का	स्वास्थ्य संयोजक	
९.	भिम ब. बोहरा	स्वास्थ्य शि. संयोजक	
१०.	ईश्वर ब. खड्का	ना. प्रा. प्र.	
११.	धर्मराज बोहरा	ने.पा.पा गाउँ सभाको अध्यक्ष	
१२	जगी ब. औजी	सर्वसाधारण	
१३.	~~[illegible]~~ गगन सिंह धियाल	हलुका सवारि चालक	
१४	~~रमेश कुमार खड्का~~	~~स्वास्थ्य संयोजक~~	
१५	शंकर बहादुर कामी	पशु सेवा शाखा प्रमुख	
१६	विरबहादुर बोहरा	प्राविधिक सहायक	
१७	ठाकुर प्रसाद त्रिपाठी	सिनियर सर्भेयर	Thakur
१८	डा. ओ.पी. कुमार पाठक	टोली प्रमुख	
१९.	डा. [illegible]	[illegible]	
२०	विनोद कुमार गुप्ता	Soil Surveyor	
२१.	शिव यादव	Soil Sample collector	Shiva

DATE: ....

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२२-	निरञ्जन कुमार गिरी	– GPS operator
२३-	डमल रावल	– field
२४.	प्रा. अशोक कुमार मल्लिक	Ag. ~~Expert~~ Expert
२५	डा. नारायण प्रसाद पौड्याल	Socio-Economics
२६.	विशाल ज्ञवाली	field data collection
२७	अमरध्वज सिंह	Forestry Expert
२८.	नारायण प्र. गौतम	Hydrologist
२९.	रिता राई	GIS Expert
३०.	सृजना पौडेल	Geologist
३१-	प्रेम गोपाल श्रेष्ठ	ADMC
३२	डिल्ली प्रसाद त्रिपाठी	CEO, ADMC

DATE: ....

DATE: ....

आज मिति २०७६/०९/०९ गतेका दिनको १०:०० बजे यस मष्टा ~~गाउँ~~कार्यपालिकामा, नापी बिभाग, स्थलरुप नापी तथा भू-उपयोग व्यवस्थापन महाशाखाको आ.व. २०७५/७६ को लागि स्वीकृत बहुवर्षीय कार्यक्रम अनुरुप गाउँपालिका/नगरपालिका स्तरीय भू-उपयोग नक्शा/डाटा तयार गर्ने कार्यको लागि ADMC Engineering Consultant Pvt. Ltd., Shreenagar, Shankhamul सँग प्याकेज नं:- TSLUMD/CS/QCBS/01/19/2075/76 को लागि सम्झौता भए अनुसार उक्त प्याकेजको Draft Report सम्बन्धीत परामर्शदाताबाट प्रस्तुत Draft Report, Presentation कार्यक्रम र बैठक यस गाउँपालिका प्रमुख श्री कर्ण बहादुर कठायत ज्यूको अध्यक्षतामा तपसिल बमोजिमका महानुभावहरुको उपस्थितीमा बसी निम्नानुसार निर्णय गरियो।

उपस्थिती :

सम्बन्धित स्थानीय तहको तर्फबाट :

अध्यक्ष ज्यूहरु/उपाध्यक्ष ज्यूहरु तथा कर्मचारीज्यूहरु :

१) राजेन्द्र ब० खड्का मष्टा गा.पा. वडा नं. १ वडा अध्यक्ष

धुरे बट खड्का मष्टा २ वडा अध्यक्ष

भगवती बोहरा मष्टा गा.पा. ६ उपाध्यक्ष

४ [illegible] मष्टा गा.पा. ५ वडा अध्यक्ष

५ कर्ण बहादुर कठायत गा.पा. प्रमुख मष्टा अध्यक्ष

टेक बहादुर कठायत ,, २

अमर ब. जेठारा मष्टा गा.पा. नि. प्र. प्र. अ.

प्रयागराज उपाध्याय मष्टा गा.पा. ४ वडा अध्यक्ष

दिपक बहादुर बोहरा मष्टा गा.पा. ईन्जिनियर

रमेश ब. बोहरा मष्टा गा.पा. सब-इन्जिनियर

धन ब. बोहरा मष्टा गा.पा. [illegible]

DATE: ....

नाम	ठेगाना	कार्य
१) कमल रावल	रम्भा धाना गा.पा	Surveyr (अमिन)
वडा नं. वीदार माध्य ५		

सम्बन्धित परामर्शदाता कम्पनिको तर्फबाट :

डिल्ली प्रसाद त्रिपाठी, प्र.का.अ. एडिएमसी इन्जिनियरिङ् प्रा.लि.
भिम खतिवडा, GIS Expert एडिएमसी इन्जिनियरिङ् प्रा.लि.
डा० गोविन्द प्रसाद जोशी त्रि०वि०(टी) ले प्रयुक्त एक्सपर्ट
प्रा० अशोक कुमार मल्लिक - कृषि विशेषज्ञ
लीना कोइराला Land Use Planner
सृजना पौडेल भुगर्भशास्त्री एडीएमसी इ.प्रा.लि.
हिमालय राई सामाजिक-लैंगिक विशेषज्ञ ADMC

नापी विभाग, मिनभवन, का०म.न.पा. १० तर्फबाट :

प्रेम थापा - सर्वेक्षक

निर्णयहरु :

१) काभ्रे जिल्लाको मण्डन गाउँपालिकाको प्याकेज नं - TSLUMD/CS/RCBS/01/19/2075/76 को गाउँपालिका स्तरीय भू-उपयोग नक्शा/डाटा तयार गर्ने कार्यको सम्बन्धित परामर्शदाता संस्था ADMC Engineering pvt. Ltd को Team Leader बाट प्रस्तुत गरिएका विभिन्न Theme हरुका नक्शा/डाटा/रिपोर्टहरुको Draft र जमिनलाई गरेको वर्गीकरण समेत सन्तोषजनक पाइयो।

DATE: ....

नापी बिभाग, मिनभवन, काठमाडौंको तर्फबाट :

प्रेम थापा - सर्वेक्षक

(signature)
०७५।०९।०१

२) राजनैतिक गाउँपालिकाका तथा वडाहरुको सिमानाहरुमा केहि सुधार गर्नुपर्ने महसुस भएकोले सम्बन्धित निकायमा पुर्‍याउने निर्णय समेत गरियो ।