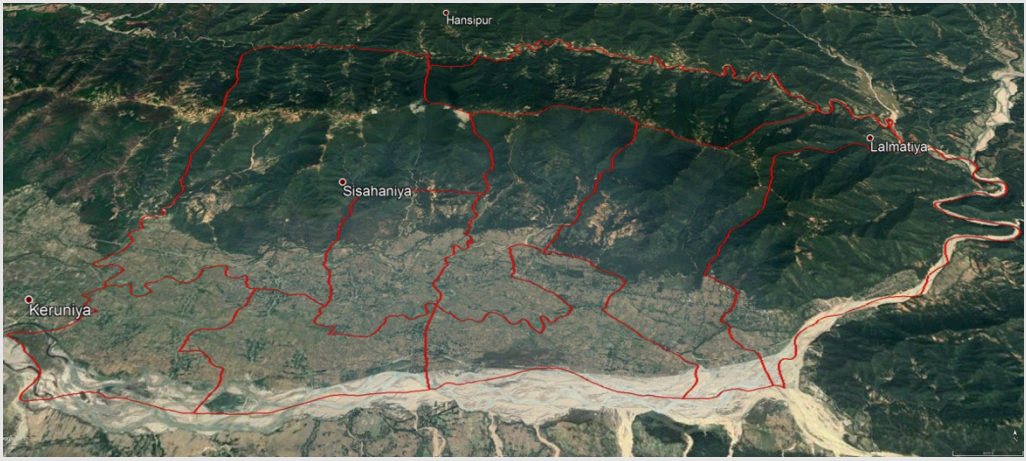
GEOLOGICAL STUDY OF RAPTI RURAL MUNICIPALITY, DANG

December 2020



Submitted to

Rapti Rural Municipality, Dang

Submitted by

Embark Engineering Services Pvt. Ltd.

Contents

CHAPTER-1

1.1 Introduction

Geological information is a key resource for national to local level government's infrastructure development. Local development planning must rely on accurate and relevant geological information that will lead to effective decision making for different physical development. The information helps to identify situations and problems that should be emphasized and focused. Data of earth science are basic information to study, investigate, analyze and document different development projects. A preliminary geological study was conducted in Rapti Rural Municipality to generate basic geological information of the area and aim to assist on decision making for local and national level development plans and projects. Likewise, this information may be useful for natural risk management and natural (mineral resource) evaluation.

1.2 Background

Recently, Rapti Rural Municipality has been declared as the part of the capital of the Lumbini Province. This may cause rapid pace of urbanization in this area and it need to bring sustainable urban development plan to the forefront development agenda. Assessment of natural hazard and

preparation of inventory of mineral resource and construction material is basic need for different aspect of development program. The goal of the study is to support the municipality to identify and capture opportunities of natural resources. The report is designed to assist long-term local government development.

An initial program activity was the carrying out of geological and natural risk analysis in different part of municipalities which are shown in Figure 1. This report is preliminary geological report that presents the findings of basic geological study of the Rapti Municipality in Dang District.

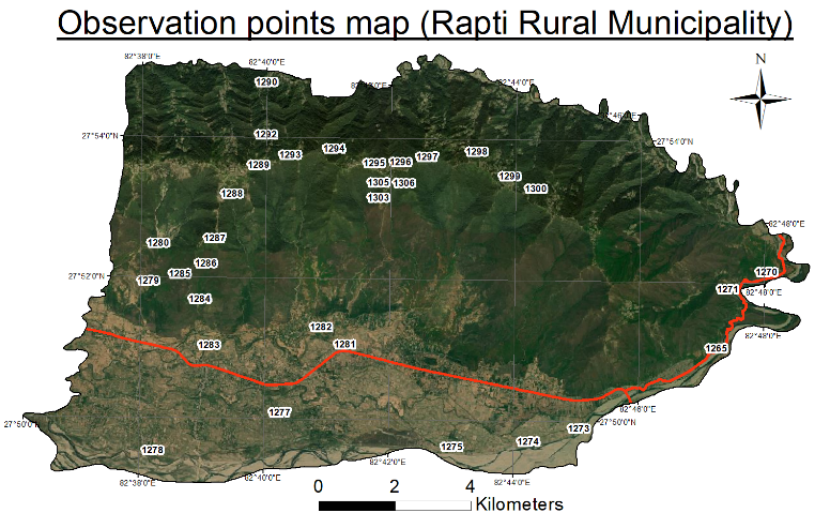


Figure 1:Observation points in the study area

1.3 Objective

The general objective of this study is to understand the geology of the area and its control on physical environment of the area.

The speicific objetive are :

- Prepare the geological map of the municipality

- Analyze and assess the geological condition
- Analyze and assess possibilities of natural resources (minerals) and construction material
- Analyze and assess the landslide hazard
- Analyze and assess the flood hazard
- Identify and formulate practical, operational and strategic findings based on the assessments.
- Advise on priority sectors, policy and planning interventions and possible projects that could be pursued in the municipality

1.4 Methodology

This geological report was prepared through the following steps and inputs:

• Studied secondary geological informations about the rural municipality and surrounding area from authentic sources and published papers.

• Conducted geological route mapping in different sections of the study area (Rapti river section and newly excavated road section)

• Combined preliminary geological findings with published geological maps and papers

• Geological map was prepared and lithological characters were analyzed for the assessment of mineral possibilities and natural hazard

1.5 Limitation

- Relatively shorter duration of geological field study
- Basic geological instruments (hammer, compass, acid, GPS) were used for study. Advanced geophysical instruments or drilling are suggested for further study.
- Geotechnical study in sedimentary deposit has not been carried out.

CHAPTER-2

2.1 Location

Rapti Rural Municipality lies in Dang District of Lumbini Province, Nepal.This rural municipality was formed by merging the previous VDCs namely Sisahiniya, Lalmatiya and Ward No.1 & 2 of Hansipur. In the Eastern and Southern part of Rapti Rural Municipality lies Rapti River, Lamahi Municipality in the West, and Ghoshkhola in the North.

2.2 Accessibility

It lies 365 km west of the capital city Kathmandu and is easily accessible via the Mahendra (East-west) Highway. The East-West Highway runs through the center of the municipality. The East-West Highway crosses this rural municipality. Hence the area is well accessible .

Kathmandu —146 Km (Prithvi highway)→ Narayanghat

Narayanghat —219 Km (east-west highway)→ Rapti Rural Municipality (Study area)

Number of road has been made inside the Rapti Rural Municipality (study area). Several north-south aligned road to reach the ridge top and village such as Devikot

village have been opened which ease for geological studies. One road parallel to ridge has been made which connects several villages of ridge top.

2.2 Physiography and Drainage

The main river course that drains out the area is the Rapti Khola flows from east to west and collects water from its tributaries. The main river and its tributaries form a dendritic drainage pattern. The watershed is surrounded by the Chure hills. The Rapti (West) river is formed by joining Mari Khola with Jhimruk Khola. It flows through Deokhuri valley towards west. Based on the measured data at Kusum hydrological observation station (HOS of Government of Nepal), the average and maximum discharge have been found 136 m3/s and 7279 m3/s.

The main populated area of Rapti Rural Municipality is surrounded to the north by east-west elongated ridge. Along the ridge and northern slope there several settlements such as Devikot, Rupakot, Muslimtole, Karangge, Bagasoti etc.

South of the Rapti Rural Municipality is characterized by lowlands whereas northern part is covered by rugged mountains (Figure 2,3).

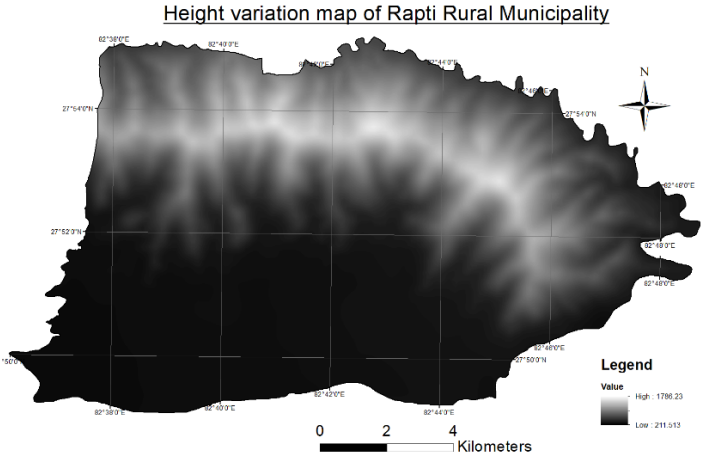


Figure 2:Elevation map of the Rapti Rural Municipality

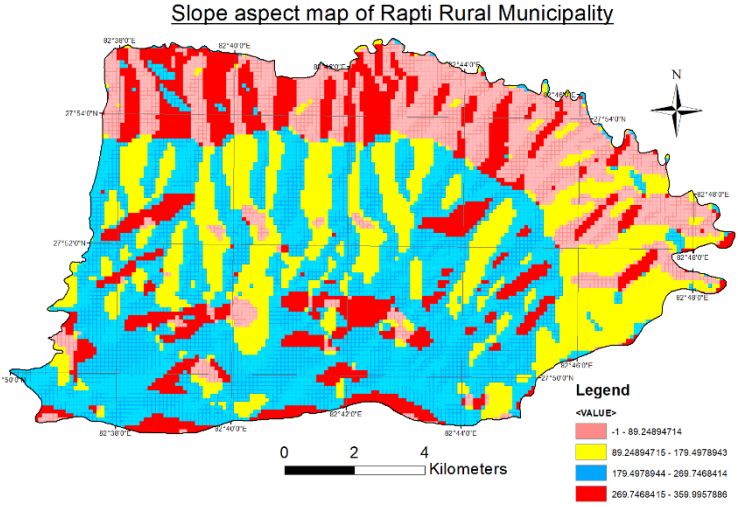


Figure 3:Slope aspect map of the Rapti Rural Municipality

CHAPTER-3

3.1 Regional Geology

The Himalayan crust is made up of the Tethys Himalaya with Neoproterozoic to Eocene sedimentary sequence, crystalline core of the Greater Himalaya and Paleoproterozoic to Miocene metasedimentary sequence of the Lesser Himalaya. The Siwaliks is Neogene to Quaternary synorogenic sedimentary sequence of the Himalayan foreland basin. Each of these lithotectonic unit are bounded by major fault system of the Himalaya (Figure 4)

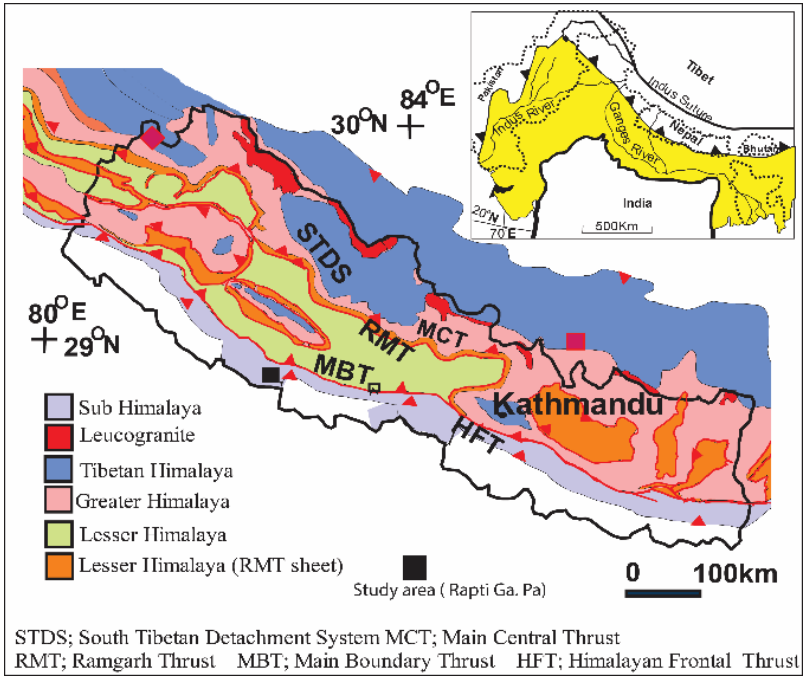


Figure 4 : Regional Geological Map

The Tethys domain is sedimentary to very low-grade metasedimentary rock sequence deposited in both marine and fluvial environment. It is the northernmost fossiliferous lithotectonic unit with rift to passive margin sedimentary sequence with some volcanic rock intercalation. The lower boundary of this unit is the STDS whereas the upper part is delineated by ITSZ. It is hard to distinguish protolith age of the Tethys Himalaya from the Upper Lesser Himalaya and the Greater Himalaya.

Greater Himalaya is the metamorphic core of the Himalaya. Granulitized eclogite have been reported from the Greater Himalaya of eastern Nepal, Bhutan and Tibet. Emplacement mechanism of such high-pressure rock is still unknown. Two popular school of thoughts for the extrusion of the Greater Himalaya are critical taper model and Channel flow. The observed burial and extrusion path obtained from PT profile do not match exactly to the predicted path of both of these models. Hence, some hybrid models are also proposed.

The Lesser Himalaya is divisible into Paleoproterozoic Lower Lesser Himalaya, Mesoproterozoic to Early Paleozoic Upper Lesser Himalaya, Late Paleozoic to Mesozoic Gondwana sequence and Tertiary Foreland Basin Sequence. Each of these units are separated by unconformities whereas the whole Lesser Himalaya is bounded to the north by the Main Central Thrust and to the south by the Main

Boundary Thrust. Patches of the Eocene and Miocene strata are reported from different locations of the western and central Nepal Himalaya. The Tertiary sedimentary sequence of the Himalaya has got more research attention throughout the Himalaya and many implications have been made from these units. These units are extended even in the inner windows and large extension of these units has been predicted. The Siwaliks is about 5 km thick Middle Miocene to early Pleistocene fluvial succession. This youngest lithounit of the Himalaya belongs to post-collisional Himalayan foreland basin. It comprises mudstone siltstone and conglomerate. This lithotectonic belt is situated between the Main Boundary Thrust (MBT) and the Himalayan Frontal Thrust (HFT).

The Siwaliks of the Dang region form the widest foothill belt in the country, and surround 2 beautiful intermontane valleys, Dang, and Deukhuri. The incompetent Siwalik strata have yielded to a variety of folds and number of imbricate faults. The rocks of the area are divided into two units the Lower Siwaliks and Middle Siwaliks by geoscientists.

3.2 Local Geology

Geology of the Rapti Rural Municpality can be described into two subtopics :

1. bedrock geology which covers about 101 km^2 and
2. Sedimentary succession of about 60km^2 distribution.

3.2.1 Bedrock geology

The area is characterized by Siwaliks sedimentary unit. Only Siwaliks lithounits cover the whole municipality area (Figure 5). They are made up mainly of mudstones, sandstones, varying proportions. These lithounits can be divided into two lithological formations based on lithology, depositional environment, sedimentary facies. Figure 6 represents the Geological Map of Rapti Rural Municipality.

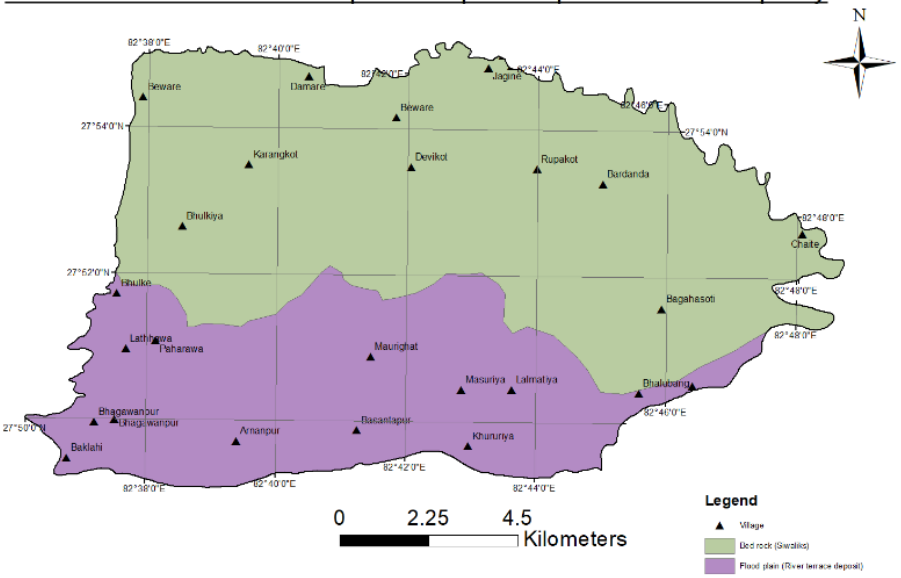


Figure 5 :Bed rock-River terrace deposit map

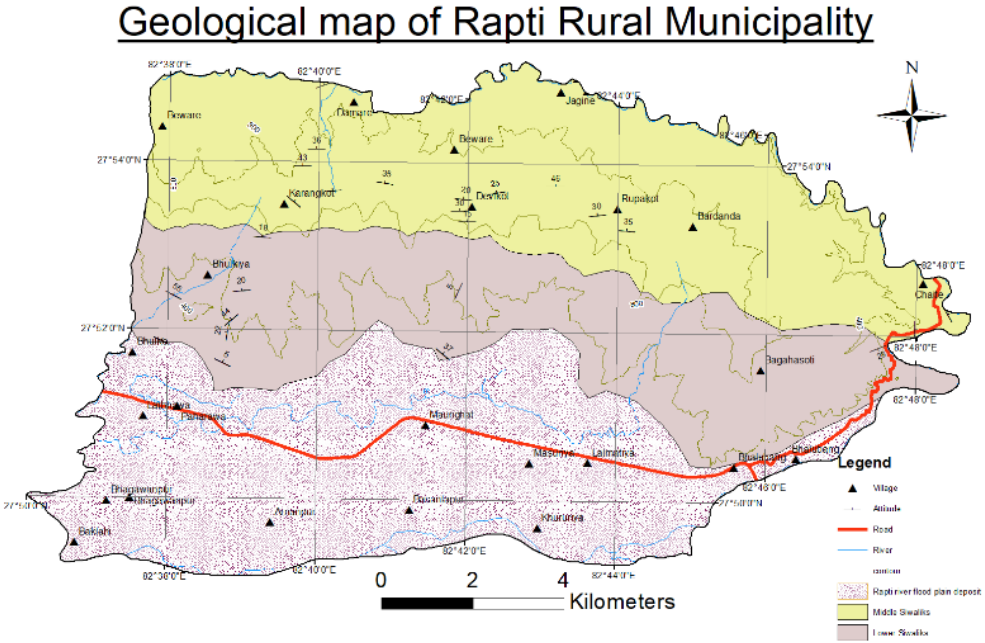


Figure 6 : Geological Map of Rapti Municipality

a) Lower Siwaliks

After crossing the alluvial deposit of Deukhuri valley mudstone beds of Lower Siwaliks can be observed at the foothill of the Siwalik mountain range. The lithounit is composed of variegated (i.e., pale yellow, orange, graygreen, and dark gray) mudstone alternating with medium to fine-grained sandstones, siltstones. Infrequently of shales and calcretes can be observed. This formation exposes along the Lalmatiya-Devikot road section and Lathwa-Karnkot road section, south of Devikot village.

Lower Siwaliks consists of interbedding of red purple brown verigated mudstone and grey green, Sandstone bed is of thinly bedded and spheroidically weathered. The minerals present in sandstone are Quartz, Muscovite, Biotite and Feldspar but presence of Muscovite is higher. Calcareous leaching is abundant in sandstone. Figure 7 to 9 show the characteristic features of mudstone.

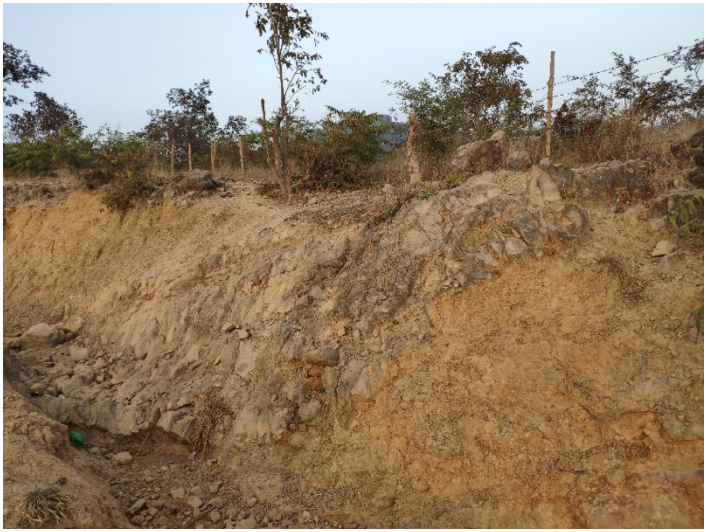


Figure 7:Highly weathered mudstone with few siltstone beds

Figure 8:Varigated mudstone of different color

Figure 9:Mudstone almost weathered show soil like nature

b) Middle Siwaliks

The Middle Siwaliks Formation comprises sandstones and mudstones. Infrequently calcrete, marl, and shale can be observed. Strong predominance of sandstone over mudstone is characteristic feature of this unit. The coarse sandstones of the Middle Siwaliks are recognized by appearance of pepper-and-salt color. It depicts preponderance of detrital biotite and quartz. Sandstone beds are massive, calcareous, and jointed and fractured. They are more than 5 of meters thick.

The Middle Siwaliks is well exposed around Devikot, Karanggekot-Bardada ridge road (ridge) section and

Karanggekot-Punkhola Gau section. Figure 10 to 12 shows the characteristics feature of the Middle Siwaliks.

Figure 10:Massive bedded sandstone of Midle Siwaliks from Dang-Pyuthan road

Figure 11:Sandstone boulders of the Middle Siwaliks

Figure 12:Pebbly sandstone beds of the Middle

3.2.2. Terrace Deposit

About 10 km wide Deukhuri Valley is extended morethan 50 km in the east–west direction. It comprises Plio–Pleistocene sand, pebble, mud deposits of the Rapti River, which flows from east to west. On the basis of their topographical position sediment deposit can be divided into high flood plain and low flood plain area although the sediment compositions are more or less same. Pebbles are of sandstone, quartzite, phyllite. They comprise sorted, loosely packed, gravel pebble with fine sediments. Near

the Rapti bridge at Bhalubang the thick (about 7m) and relatively consolidated gravel bed depicts the southward shifting of the Rapti river (Figure 13). Figure 13 to 15 shows characteristics of gravel beds.

Figure 13:Construction material are being extracted from river bed of Arghakhachi side

Figure 14:Terraace (flood plan deposit) at Bhalubang in Rapti river basin

Figure 15:Flood plain with possibilities of different kinds of building material in the Rapti river basin

3.3 Geological control and distribution of economic mineral deposit and construction material in Rapti Ru. Mu.

Unfortunately, Rapti Rural Municipality has very less possibility of economic mineral deposit. Since the whole area of this municipality is covered by young sedimentary rock of Siwaliks there is not any chance of finding metallic or non-metallic economic mineral deposit.

Nepal Himalaya is composed of four lithotectonic units; Tethys Himalaya Greater Himalaya, Lesser Himalaya and Siwaliks. Lesser Himalaya occurs in northermost part of Dang and Pyuthan district are having possibilities of nonmetallic (like limestone) and some metallic deposit. Greater Himalaya in Jajarkot district comprises various kinds of gemstone like kyanite, tourmaline, quartz.

Even for construction material this municipality should depend upon other municipality of northern part of Dang district or Pyuthan or Arghakhachi district.

Although there is not possibility of bed rock related mineral deposit there are two kinds of possibilities for natural resources.

1. Placer gold deposit
2. Construction material from river bed.

3.3.1. Placer gold deposit

The Lungri river is one of the important tributary the Rapti river. The Lungri river and surrounding area has been identified as the primary and placer gold prospect by department of Mines and Geology, government of Nepal. The process by which placer deposits form is much easier to understand, because it is a consequence of erosional processes that occur everywhere. The requirements for a placer deposit to form are:

1. Gold mineralization in the surrounding area in which the particle size of the gold is sufficiently large to be concentrated by fluvial action.
2. Active erosion of the mineralization
3. A river system capable of preferentially transporting the less dense material.

The simplest technique to extract gold from placer ore is panning. In panning, some mined ore is placed in a large metal or plastic pan, combined with a generous amount of water, and agitated so that the gold particles, being of higher density than the other material, settle to the bottom of the pan. The lighter gangue material such as sand, mud and gravel are then washed over the side of the pan, leaving the gold behind. Once a placer deposit is located by gold panning, the miner usually shifts to equipment that can treat volumes of sand and gravel more quickly and efficiently (Figure 16).

Hence, all of these conditions are favorable for the Rapti river placer gold deposit. Some Chinese companies had taken gold prospecting licenses from government of Nepal and conducted prospecting work in past. Local government can facilitate private companies to study gold possibilities cooperating with central government.

Figure 16:Machineries used for gold prospecting in Rapti river basin

3.3.2. Construction material from the Rapti river bed

Infrastructures development such as roads, highways, bridges, buildings isn't possible without basic construction material such as stone, aggregates and sand. They are the one used in huge amount in any construction work. For the development of the local level, it is important to identify source area for such materials. Since, there is not any possibility of finding bed rock suitable for

construction material in this municipality we must depend upon river bed or old terrace.

Huge quantities of weathered materials as sediment load are being deposited in the Rapti river's lower course. High intensity rains bring about landslides and high surface run -off in the upper catchment of the Rapti river. The Rapti river channel comprises such building material such as pebble, cobble, sand. Proper excavation and mining of the flood plains of the Rapti river of in the regular basis and with scientific study of the flood plains, load carrying capacity of the rivers etc. not only could produce construction material but also save the erosion of the fertile land of the municipality. Stones and aggregates could be obtained from the mining of the bed rocks and collection of flood plains and river course. Sand could be mined out from the sand mounds, terraces, flood plains and river course and the weathered rocks masses.

The prolonged bed -material extraction from the lower Rapti River will cause bed erosion. This erosion will migrate annually with variations in the channel gradient both upstream and downstream of the extraction sites. The river adjust with changes in its morphology and with maximum coarse materials (gravel and boulders) being extracted from the river bed. The balance between sediment transport and the supply capacity of the river can be altered. Human settlements near the banks and adjacent flood plains may get easy access to the river channel and

irrigation canal and road may get disturbed. Hence, extraction must be scientific and systematic (Figure 17).

Figure 17:Flood plain showing possibilities of construction materials of the Rapti river

3.4 Hazard and Risk Analysis

Since southern part of the municipality is at the right bank of Rapti river, the low land has high risk of flood. Likewise, northern part of the municipality belong to weak young sedimentary rocks of the Siwaliks and prone for landslide hazard.

3.4.1. Flood

The area of land adjacent to a river which stretches from the banks of its channel to the base of the enclosing valley walls, and which experiences flood during periods of high discharge is called flood plain. These flood plain terraces related to agricultural activities are of great importance along with human settlement.

The West Rapti River of Nepal is one of the most flood-prone rivers. Several villages in the lower part of The major causes of flooding in the West Rapti River basin are natural causes like. high rainfall, soil erosion, flat topography, debris flows and sedimentation, river channel migration, anthropogenic causes like blockage of drainage system, deforestation, poor planning, design and construction practices of roads, massive increase of settlements along East-West highway etc. Several embankments has already made to restrict flooding from Rapti river. However, municipality should monitor river channel annually and develop early warning system for flood.

3.4.2. Landslide

Several factors (i.e., slope, aspect, elevation, curvature, distance from road, distance form fault, distance from drainage, land use and lithology) control the possibility of landslide. Sub-Himalayan zone also called Siwalik is located between the Main Boundary Thrust (MBT) at north and the Main Frontal Thrust (MFT) at south. As a consequence of lithospheric plate dynamic between the Indian and Tibetan plate, the young and fragile sedimentary rock of the Siwaliks area are highly weathered and highly deformed. The Siwaliks range is made up of geologically very young sedimentary rocks such as mudstones, shale, sandstones, siltstones and conglomerates, due to such young and weak geological condition, trend of occurring different types of landslide is higher in the Siwaliks zone.

Highly weathered and easily erodible mudstone beds between thick sandstone beds are responsible for landslide in the Middle Siwaliks. The mudstones in the Lower Siwaliks are highly to completely weathered, which are in the form of residual soil in the surface at many places. These are less permeable but can be easily eroded by rain action due to soft nature. The eroded masses are soluble with water and moved through erosional gullies. So that, several gully erosion, erosion

induced landslide, mud flow and mud slide were occurred in Lower Siwaliks. Wedge failure, rock fall are common in thick to massive jointed Middle Siwaliks. Kinds of landslides are found majorly controlled by lithology in the study area.

Since, most of the settlements are in low land where there is not risk of landslide. There are not huge landslide which affect the human settlement. However, shallow landslides around road cut are frequent all over the highland of municipality. There are several of potentially damaging mass movements caused by informal road construction like, debris flows from excavated material stored on the downslope side of the road, deeper seated landslides that are accommodated by poor road drainage as water seepage can aid failures that include regolith, shallow failures close to the road caused by oversteepened road cuts. Moreover, meteorological, geological and geotechnical factors are the major factors accounting for frequent failures along the new road cut. Extensive rainfall during monsoon season also reduces the stability of cut slopes to great extent.
Along the Lalmatiya-Devikot and Lalmatiya-Karanggekot road section several shallow slides were observed (Figure 18 to 20).

The slope stabilization process need to be done by considering several factors such as stability grade, capital

to be invested, availability of raw material, availability of dumping sites. Detailed geotechnical study need to be conducted along the road cut slopes. rock slopes in the investigated rod section should be categorized and demarcated as unstable, marginally stable and stable in terms of mass failure. For each section suitable measure such as gabion wall, bioengineering, masonry wall, drainage management or re-alignment of road should be ensured.

Figure 18: Wedge failure and rock fall in Middle Siwaliks

Figure 19: Shallow landslide below Devikot temple due to new road cut

धरान उपमहानगरपालिका

नगर कार्यपालिकाको कार्यालय

धरान-१२, सुनसरी, कोशी प्रदेश नेपाल

आर्थीक प्रस्ताव खोलिने बारेको सुचना

प्रथम पटक प्रकाशित मितिः २०७७/०७/२०

प्रारम्भिक वातावरणीय परीक्षण (IEE) गर्ने सम्बन्धमा मिति २०७७।०६।०४ गतेको ब्लाष्ट टाइम्स राष्ट्रिय दैनिक पत्रिकामा प्रकाशित प्रस्ताव आव्हानको सुचना बमोजिम प्राप्त हुनआएका प्रस्तावहरुको प्राविधिक प्रस्ताव यस कार्यालय र प्रारामर्शदाता/फर्महरुको रोहबरमा खोली प्रस्ताव मुल्याङ्कन समितिबाट मुल्याङ्कन गर्दा तपसिलका ३ (तिन) वटा प्ररामर्शदाता/फर्महरु उत्तीर्ण भएको हुँदा सार्वजनिक खरिद नियमावली २०६४ (संशोधन सहित) को नियम ७९ बमोजिम उत्तीर्ण भएका प्रस्तावहरुको आर्थिक प्रस्तावहरु मिति २०७७।०७।२७ गते दिनको ११ बजे देखि यस कार्यालयमा खोलिने भएकाले सम्बन्धित प्रस्तावदाताहरुको उपस्थितिको लागि यो सूचना जारी गरिएको छ ।

सि.न.	प्रस्तावको नाम	उत्तीर्ण प्रस्तावकहरुको नाम
१	सेउती, सेहेरा, अँधेरी, सर्दु र पटनाली लगायतका खोलाहरुबाट नदीजन्य पदार्थ उत्खनन् तथा व्यवस्थापन गर्न प्रारम्भिक वातावरणीय परीक्षण प्रतिवेदन तयारी तथा स्वीकृत गराउने कार्य।	१. Ghar Nirman Pvt. Ltd.- Spiral Grid Solution Pvt. Ltd.- Systematic Engineering Associates Consultancy Pvt. Ltd. Joint Venture
		२. Home Plans Consultancy Pvt. Ltd., Dharan 12, Sunsari- Great Himalayan Research and Consult Pvt. Ltd., Basundhara, Kathmandu Joint Venture
		३. Public Engineering and Environment Consultant Pvt. Ltd., Inaruwa 5, Sunsari

२०७७।०७।२०

राजु चौहान

वातावरण निरीक्षक

Figure 20:IEE for extraction of construction material from river bed (exercised by other local level, Dharan) can be useful for Rapti RM

CHAPTER-4

This chapter aims to present conclusion of the geological investigation of the Rapti Rural Municipality and recommend lawmaking and implementing bodies for further action.

4.1 Conclusion

- The area is characterized by Siwaliks sedimentary unit. Only Siwaliks lithounits cover the whole municipality area (Figure 5). They are made up mainly of mudstones, sandstones, varying proportions.
- The rock unit of the area is divided into two lithounits, **Lower Siwaliks** with variegated variegated (i.e., pale yellow, orange, graygreen, and dark gray) mudstone alternating with medium- to fine-grained sandstones, siltstones and **Middle Siwaliks** with strong predominance of sandstone over mudstone.
- Since the whole area of this municipality is covered by young sedimentary rock of Siwaliks there is not any chance of finding metallic or non-metallic economic mineral deposit.
- Although there is not possibility of bed rock related mineral deposit there are two kinds of possibilities for natural resources, Placer gold deposit and Construction material from river bed.

- The Rapti River of Nepal is one of the most flood-prone river because of its extended flood plain and large catchment area.
- The Siwaliks range of the area is made up of young and weak sedimentary rocks such as mudstones, shale, sandstones, siltstones and conglomerates hence the occurrence of different types of landslide is higher in the Siwaliks zone. Shallow landslides around Lalmatiya-Devikot-Karankot-Punkholagau road cut are frequent all over the highland of municipality. There are several of potentially damaging mass movements caused by informal road construction.

4.2 Recommendation

- Engineering Geological study of sedimentary deposit of the Rapti River around Lalmatiya is necessary for urbanization, settlement plan and assessment of groundwater condition.
- Need geological and geotechnical studies of whole municipality for national level development program such as Western Rapti Multipurpose Bhalubang Dams.
- Geotechnical study for proposed Rapti Ring Road is recommended.

- Local government can facilitate private companies to study placer gold possibilities in Rapti river terrace cooperating with central government.
- Extraction of construction material from the Rapti river bed must be scientific and systematic. This rural municipality can learn the practice from other local level (Figure 19).ss
- Rapti Rural Municipality should monitor river channel annually and develop early warning system for flood hazard.
- For each new road cut section within the municipality suitable landslide prevention measures such as gabion wall, bioengineering, masonry wall, drainage management or re-alignment of road should be ensured.

Annex-1 : Photos of field works


हार्दिक स्वागत गर्दछौं।
बंगलाचुली गाउँपालिका, दाङ