Annual Report of
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FOREWORD

It is with great pleasure and pride that I present to you the Department of Mines and Geology's Annual Report, Volume 14. This bulletin is a testament to our department's relentless effort, unwavering dedication, and notable achievements over the past year.

As Director General, I have had the honor of witnessing firsthand our team's extraordinary progress toward fulfilling our organization's goals and ambitions. Our commitment to excellence, innovation, and sustainability has enabled us to not only meet but exceed our responsibilities in overseeing and promoting responsible mining and geological activities.

This report provides a comprehensive overview of our activities, initiatives, and outcomes across different aspects of our operations. From regulatory compliance and enforcement to research and development, every section highlights our continuous pursuit of operational excellence and dedication to the highest standards of integrity and responsibility.

Moreover, this report reflects our ongoing efforts to promote transparency and engagement with stakeholders, including government agencies, industry partners, local communities, and the general public. By sharing our successes, challenges, and future plans, we aim to build trust, collaboration, and mutual understanding in the pursuit of common goals.

I extend my heartfelt gratitude to all members of the Department of Mines and Geology for their dedication, hard work, and passion in advancing our mission. I also want to thank our partners and stakeholders for their unwavering support and collaboration throughout the year.

As we move forward, I am confident that with the same commitment and teamwork, we will make significant strides toward our vision of a sustainable and responsible mining and geological industry that meets the needs of current and future generations.

Thank you for your continued support and confidence in the Department of Mines and Geology.

Ram Prasad Ghimire
Director General

EDITORIAL

Department of Mines and Geology, DMG, is a sole government organization to carry out geo-scientific activities and to share the geological knowledge based on its field / research activities. On behalf of Editorial Board, I am delighted to bring out this Annual Report of Department of Mines and Geology, Annual Report No. 14, DMG, 2024. This annual volume of the department highlights the regular activities that the department has carried out in the last fiscal years as per its annual programs. This bulletin will cover the research activities on geological investigation, mineral exploration, seismology, landslide investigation, engineering geology, research on technology and many more on the data and information of department. There will be altogether 13 articles. These articles and the bulletin as a whole will be an important archive that will be useful for DMG personnel's, other likely stakeholders - Planners, Geo-scientists, mineral based enterprises, students and many more. Research and continued research will bring the results to an end that will uplift the overall goal of DMG. We are working in the principal "Work is God, Knowledge is Power" for the more than 5 decades. We have focused on the modern technology and tools for our research activities rather than the traditional techniques only. No doubt, more efforts and time are needed to maintain the quality of the articles that begins from the field / research activities. The quality research will, eventually, inspire the government and non-governmental stakeholders to collaborate with the DMG in the new realm of Geo-scientific research in future.

I, on behalf of the Board, want to thank all the authors, co-authors, field personnel's, laboratory persons and many more who were involved during the field / research activities. My thanks also go to all the members of the Editorial Board / Reviewers for the valuable contributions during finalization of this bulletin.

Thank You.

Jay Raj Ghimire
Chief Editor

TABLE OF CONTENT

Identifying area prone to landslides employing Random Forest Model in Raghuganga Rural Municipality of Myagdi District.

Dr. Suchita Shrestha (Sr. Div. Geologist), Bhawana Niraula (Geologist)

ABSTRACT

Landslides represent one of nature's most devastating hazards, capable of reshaping landscapes, demolishing structures, and endangering lives. Crucial for environmental management and urban planning, landslide susceptibility maps (LSMs) identify areas at higher risk, aiding in economic loss mitigation. This study crafted an LSM for Raghuganga rural municipality in Myagdi using the Random Forest (RF) model, known for its superior accuracy among machine learning methods. Eleven factors influenced susceptibility, including lithology, land cover, elevation, aspect, slope, curvature, topographic wetness index, Sediment transport index, Stream power index drainage proximity, and drainage density. 70% of known landslides formed the training dataset, with the remaining 30% for validation. The RF model underwent validation through the area under the receiver operating characteristic (ROC) curve, achieving success and prediction rates of 90.2% and 81%, respectively.

Keywords: Landslide Susceptibility; Machine Learning; Random Forest; Raghuganga Rural Municipality

INTRODUCTION

Worldwide, landslides emerge as a prominent and destructive threats in mountainous areas, consistently leading to casualties, agricultural losses, infrastructure damage, and structural collapse. Landslides occur because of unique and complex phenomena due to both internal and external causes. Internal factors like faults and thrusts render slopes vulnerable to movement, while external factors such as rainfall, earthquakes, and human activities serve as triggers for the displacement of earth materials.

This research was conducted as a component of the Department of Mines and Geology's annual program for the fiscal year 2078/79. The study encompassed the entirety of Raghuganga Rural Municipality (RRM) , situated approximately 17.4 km north of Beni Bazar within the Myagdi district of the Gandaki Province (refer to Fig. 1). All eight wards within Raghuganga RM were examined, revealing over 375 landslides, each characterized by its unique nature and geometry. Many of these landslides were attributed to activities such as road construction involving slope cutting and inadequate drainage systems.

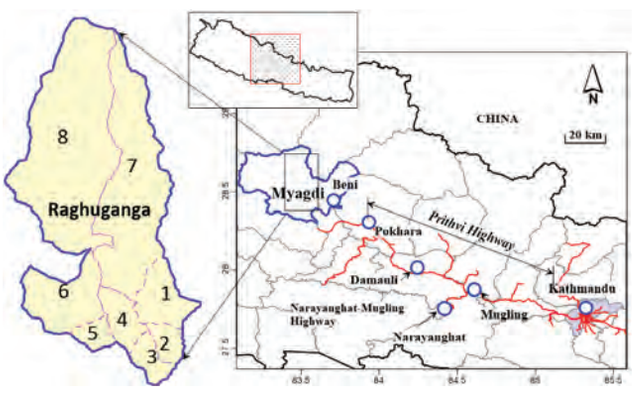

Fig. 1: Location map of the study area.

Numerous streams within the area converge to form the Kaligandaki River. Among these, Kali Khola and Myagdi Khola serve as primary tributaries of Raghughat Khola, which ultimately flows into the Kaligandaki River.

OBJECTIVES

- To identify the landslides and its impact employing the field survey.
- To detect and map landslides using high resolution imagery (Sentinel 2).
- To study the geological condition of the study area.
- To prepare a base map for landslide inventory.
- To prepare landslide susceptibility map of the study area.

METHODOLOGY AND MATERIALS

a) Desk Study

The desk study for the program involved analyzing high-resolution imagery (Sentinel 2) and examining existing topographical and geological data within and around the designated area. This included scrutinizing topographical sheets, geological maps, available landslide hazard maps, scientific literature pertaining to the area's geology and engineering geology, as well as relevant literature and similar resources.

b) Field Investigation

Field study includes mapping the existing landslide, the types of bed rock contributing to instability, the types of soil cover contributing to instability, and also mapping slope steepness or inclination, spring line / groundwater level condition. Some of the major landslide were studied in details by using landslide inventory form.

Data collected after the desk and field study were used to prepare the landslide susceptibility map using random forest method.

c) Landslide inventory

A Geographical Information System (GIS) based landslide inventory map was prepared using data from previous reports. The aerial images were orthorectified, and spatial data were obtained by extracting landslide zones by digitizing via visual interpretation using ArcGIS 10.2 software.

The precise delineation of landslide location is crucial for landslide susceptibility assessment of an area. Thus, it is necessary to prepare an inventory map of landslides. In this study, landslide locations were detected by compiling previous research and reports, and manual interpretation of Google Earth images. Google Earth provides a good alternative data source in inaccessible areas, and high-resolution imagery can be downloaded and combined with a GIS. To produce a detailed and reliable landslide inventory map of the study area, extensive field surveys and observations were performed in the study area. The dominant failures were shallow translational landslides, slope failures (Fig. 2) that sometimes resulted in the debris flows.

Fig. 2: Landslides observed during fieldwork.

A field survey was undertaken to rectify inaccuracies in the existing landslide inventory maps within accessible regions of the study area, thereby enhancing the maps' credibility. Fig. 2 shows the observed landslides during field survey. Local residents were consulted regarding the occurrence or absence of landslides in their surroundings. The majority of the identified landslides were categorized as rock falls and colluvium failures. Combining image analysis with the field survey, a total of 375 landslides were identified (Fig. 3), covering an area of 1.9 Km^2.

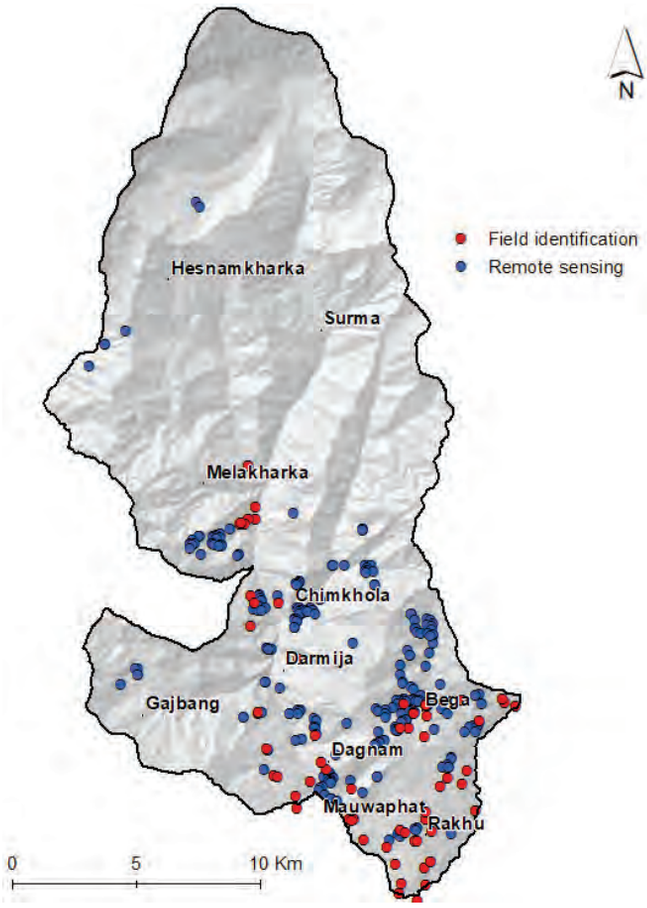

Fig. 3: Location of landslides in the study area.

d) Random Forest Model

Random Forest (RF) classification, which was originally developed by Breiman (Breiman 2001), is a machine learning algorithm for multivariate classification. RF is a popular ensemble learning method that is widely used for classification and regression. This can be used to determine the prediction of landslide occurrences in an area. This method has been widely used to identify disaster-prone areas such as floods, droughts and landslides due to its high accuracy and generalizability. This algorithm as several advantages, such as: able to avoid overfitting, has low bias and variance, low correlation of each tree due to forest diversity built using a number of variables/factors, strong error estimation using Out-Of-Bag (OOB) data, and higher predictive performance. In this study, the data set of identified landslide was randomly split into two subsets: (i) the training data (~70%); and (ii) model validation data (~30%). To ensemble with RF, the model needs landslide and non-landslide areas. Therefore, landslide initiation points were assigned a value of "1" and remaining pixels were assigned a value of 0.

CAUSATIVE FACTORS

Several studies have shown that these causative factors (CFs) are important in landslide analyses (Van Westen et al. 2003; Pradhan and Kim 2014; Shrestha

and Kang 2017), and they are used to prepare landslide susceptibility maps. In this study, 11 causative factors were collected from various sources and grouped into four types: geologic, landuse, topographic, and hydrologic as shown in Table 1. Among 11 CFs, geology and landuse are categorical variables while remaining variables are numerical. A 20×20m Digital Elevation Model (DEM) was prepared using contour and spot height data published by Department of Survey, Government of Nepal.

Table 1: List of Causative Factors

Type	Causative Factor
Geology	Geology
Landuse	Landuse
Topographic	Elevation
	Aspect
	Slope
	Curvature
Hydrologic	Topographic wetness index
	Sediment transport index
	Stream power index
	Drainage proximity
	Drainage density

a) Geology

It is widely recognized that geological parameters greatly influence the occurrence of landslides because different lithological units have varying physical properties, leading to variations in the permeability and strength of rocks and soils. In this study, the lithological layers were extracted by geological maps of Nepal. Geologically this area lies in Tibetan-Tethys Zone, Higher Himalayan and Lesser Himalayan Zone. The data were divided into 5 lithological units, namely Paleozoic (Pz), Higher Himalayan Crystalline (hx), Ghan Pokhari (Gp), Naudada Formation (Nd), Seti Formation (St) as depicted in Fig. 4. Grey to greenish grey phyllite, and thin layer to thick bed of quartzite found in the Seti Formation. Fine to medium grained white quartzite is intercalation of phyllites cover the area of Naudada Formation.

The overlay analysis shows that most of the landslides (369) are occurred in Seti Formation as presented in Fig. 5.

b) Landuse

The role of landuse in landslide susceptibility is significant, as it directly influences the stability of slopes and the likelihood of landslide occurrence. Landuse map with 10 classes was prepared as presented in Fig. 6 where cultivation and forest area has the highest number of landslide.

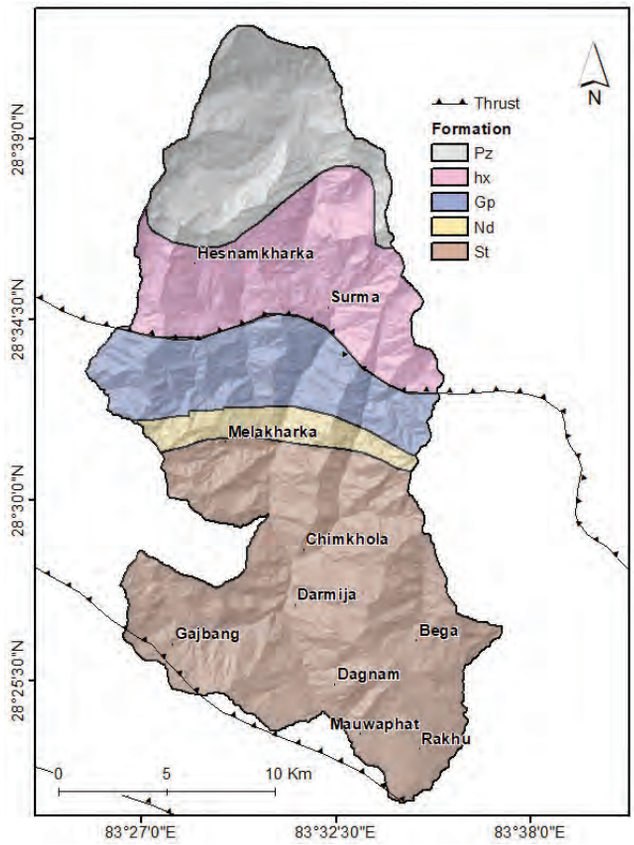

Fig. 4: Geological map of study area (From DMG 2020).

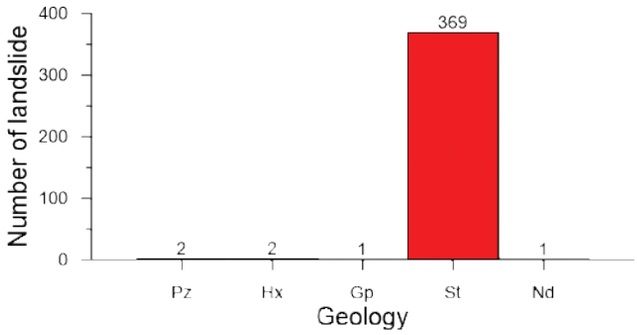

Fig. 5: Presence of landslides in different geological formations.

The overlay analysis of landslide and landuse pattern shows that 173 landslides occurred in the forest area followed by cultivation land (91), bush (58) and grass land (42) as depicted in Fig. 7

c) Topographic parameters

i) Elevation

Although there is no direct relationship between elevation and landslide occurrence, research has shown an increase in landslide occurrence at higher elevation. In the study area, the elevation ranged from 1060 m to 5060 m asl (Fig. 8).

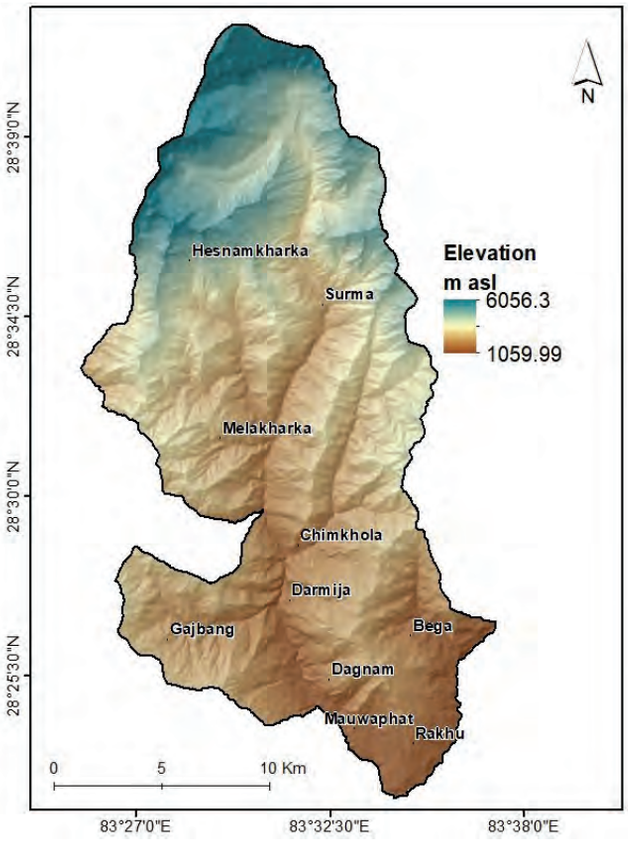

Fig. 8: Elevation distribution of the study area.

It is seen that most of the landslides occurs in confined to an altitude range of 1200–2400 m asl (Fig. 9).

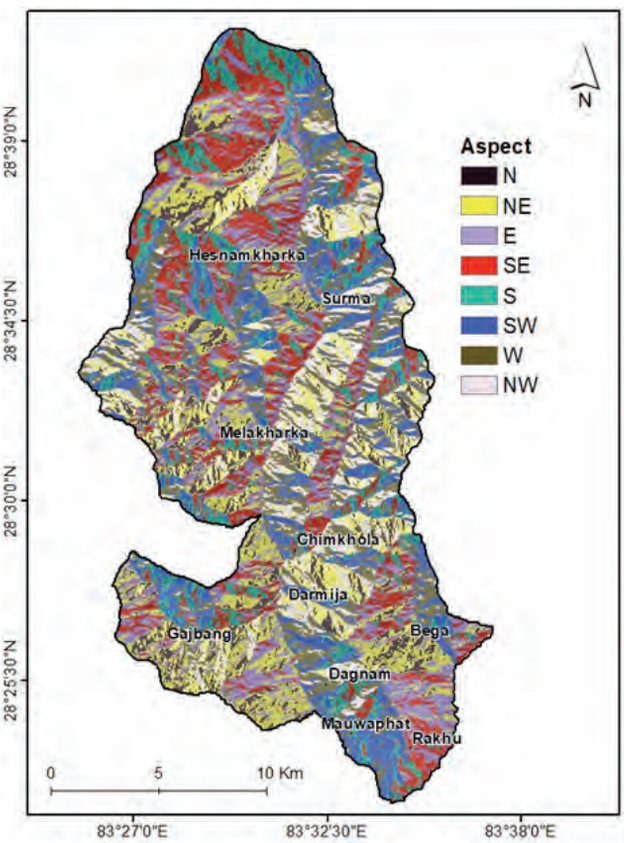

Fig. 9: Distribution of landslides in elevation.

ii) Aspect

Physically, the aspect is related to parameters such as vegetation cover, precipitation, soil moisture, wind impact and sunlight exposure. Although the relationship between the aspect and the mass movement has been thoroughly investigated, no consensus regarding the aspect–landslide relationship (Ercanoglu et al. 2004) has emerged. The slope aspect, or the direction of maximum slope of the terrain surface, was divided into eight classes (Fig. 10).

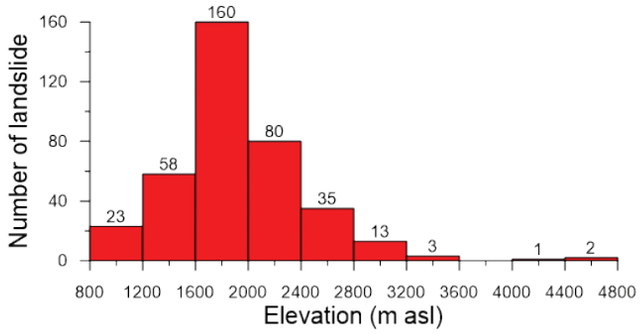

Fig. 10: Aspect map of the study area.

It is seen that the landslides are sparsely distributed. Most of the landslides has been occurred in North to South-East faces as presented in Fig. 11.

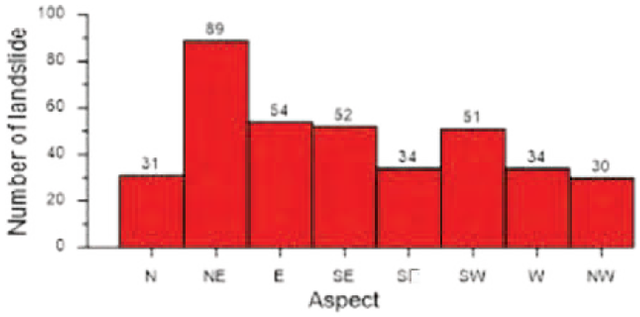

Fig. 11: Distribution of landslides in different Aspect of hillslope.

iii) Slope

Slope is a very important parameter in any landslide susceptibility mapping analysis. If the slope is great, there is an increased chance of landslide occurrence. The terrain slope calculates the gradient at any pixel on the surface which was derived from the first derivative function of the DEM. In this area, slope ranges from 0 to 75.3° as presented in Fig. 12.

The correlation between slope angle and landslide frequency indicates that landslides mostly concentrated on slope range of 10°–60° as shown in Fig. 13.

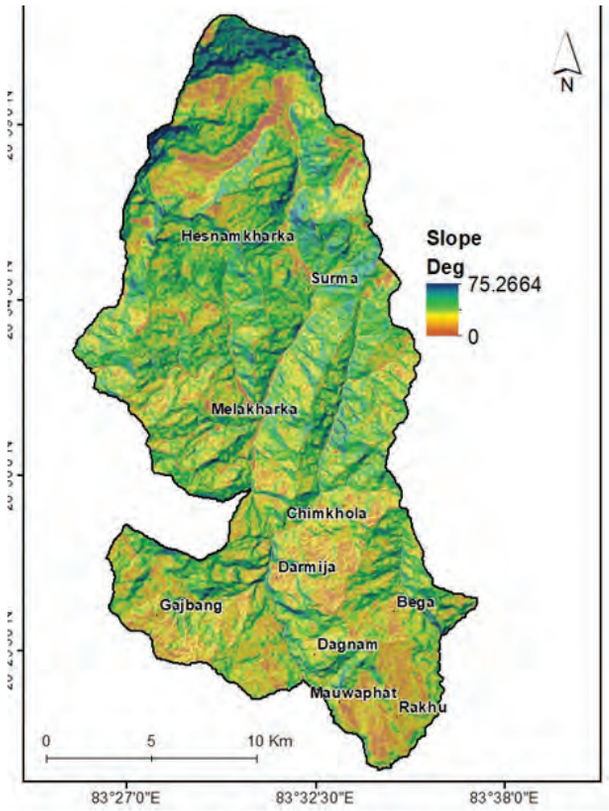

Fig. 12: Slope map of the study area.

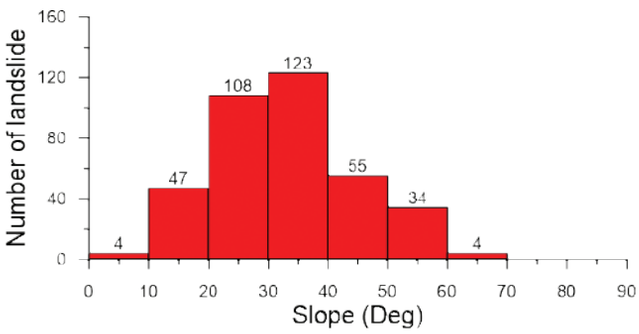

Fig.13: Distribution of landslides in different slope categories.

iv) Curvature

Another important CF is curvature, which measures the rate of change of terrain aspect angle measured in the horizontal plane. This can be used to differentiate between ridges and valleys. Curvature was calculated from a second-order derivative of the DEM as shown in Fig. 14. Generally, convex slopes are more stable as they disperse the runoff more equally down the slope, whereas concave slopes are considered potentially unstable because they concentrate water at the lowest point and contribute to the buildup of adverse hydrostatic pressure (Stocking 1972).

In case of curvature, both concave and convex slopes associated with planner slopes show high landslide frequencies (Fig. 15). The immediate slope shape change from planner to concave or convex can lead to concentrate groundwater (Reneau and Dietrich 1987).

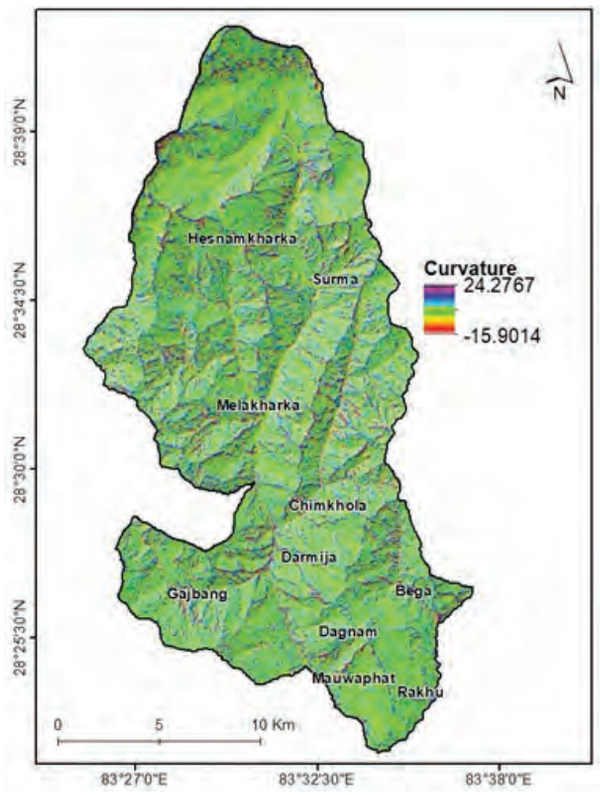

Fig. 14: Curvature map of the study area.

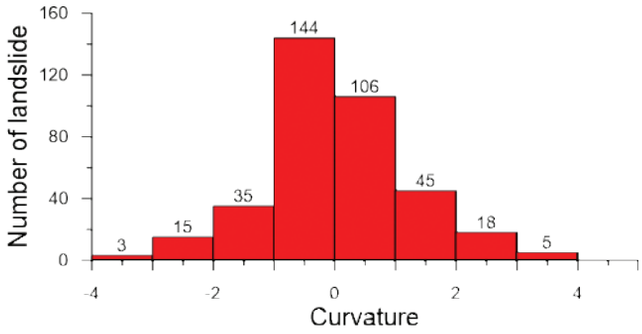

Fig. 15: Distribution of landslides in different curvature categories.

d) Hydrologic parameters

Topographic Wetness Index (TWI), Sediment Transport Index (STI), Stream Power Index (SPI) Drainage Proximity, are Drainage Density, are hydrological factors that play vital roles in slope instability.

i) Topographic Wetness Index

TWI is a steady-state wetness index that is commonly used to quantify topographic control on hydrological processes. TWI has been used extensively to describe the effect of topography on the location and size of saturated source areas of runoff generation. Moore et al. (1991) proposed Equation (1) for the calculation of TWI under the assumption of steady-state conditions and uniform soil properties.

$$TWI = \log\left(\frac{\alpha}{\tan\beta}\right), \quad (1)$$

where α is the cumulative upslope area draining through a point (per unit contour length), and tan β is the slope angle at that point. TWI is an indicator of the spatial distribution of soil moisture because groundwater flow often follows the surface topography. Higher value of TWI zone indicates possibility for groundwater in the rock flowing through the factures. The distribution of TWI in the study is shown in Fig. 16.

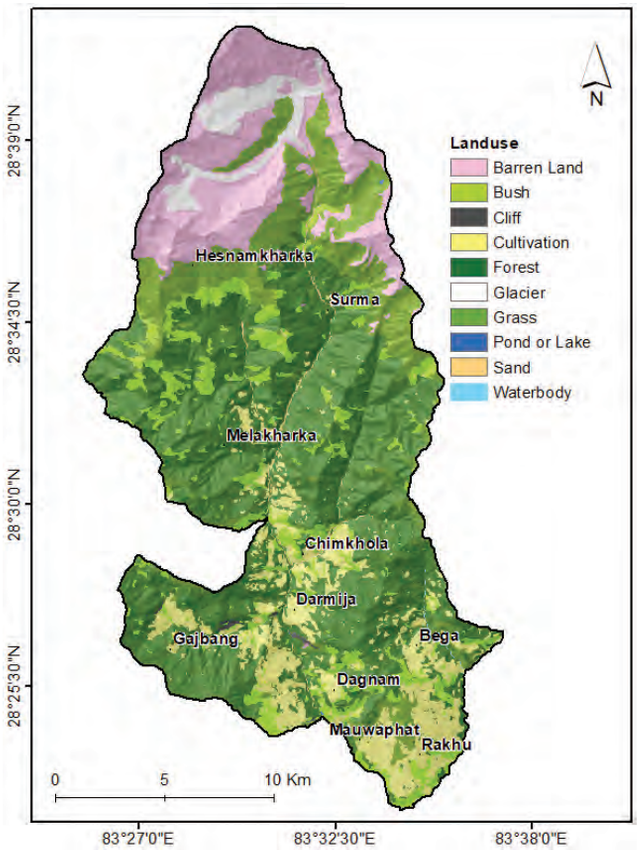

Fig. 16: TWI map of the study area.

Most of the landslides associated with low values of TWI because low values of TWI mean first order drainage pattern which as most erosive power (Fig.17).

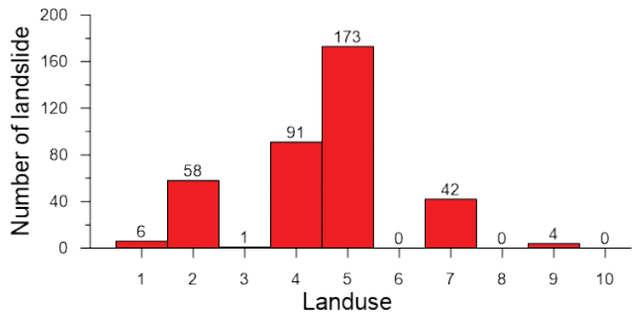

Fig. 17: Distribution of landslides in different TWI categories.

ii) Sediment Transport Index

By combining the length and steepness of slope, STI was calculated. It characterizes erosion and the deposition process. The sediment transport index (STI) depends on the catchment size and slope angle in a nonlinear fashion (Moore and Burch 1986), as shown in Equation (2):

$$STI = \left(\frac{A_s}{22.13}\right)^{0.6} \left(\frac{\sin\beta}{0.0896}\right)^{1.3} \qquad (2)$$

The distribution of STI is presented in Fig. 18.

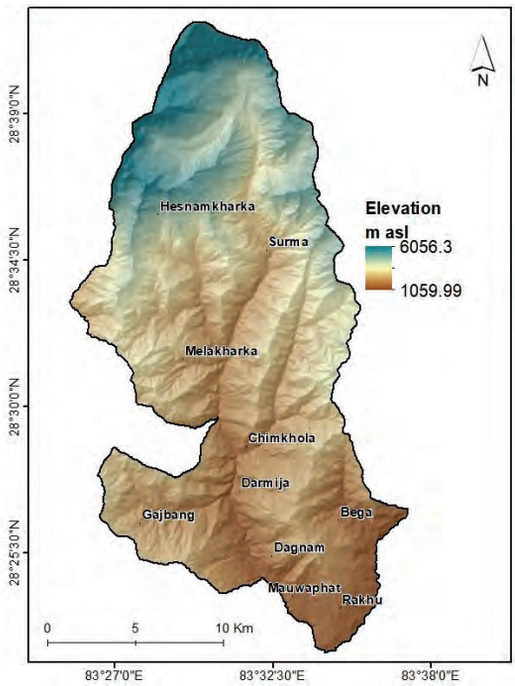

Fig. 18: STI distribution of the study area.

The correlation between landslides and STI shows landslides are mostly associated with the intermediate values of STI as shown in Fig. 19.

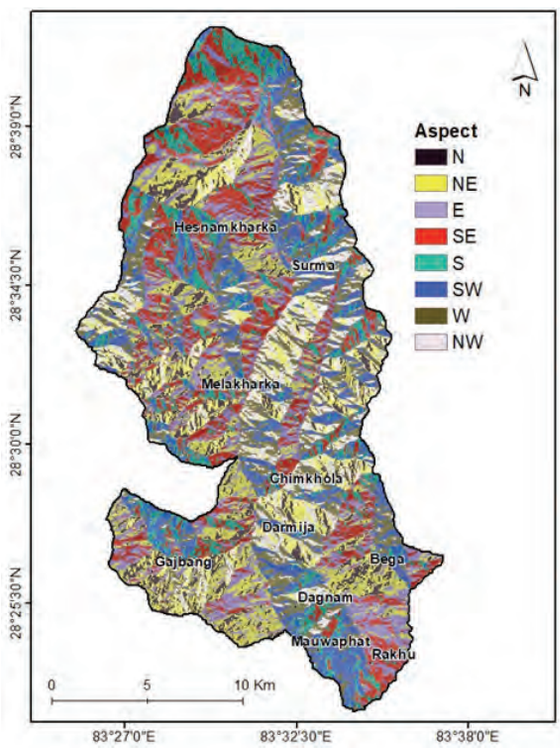

Fig. 19: Distribution of landslides in different STI units.

iii) Stream power index

The Stream Power Index (SPI) is a measure of the erosive power of flowing water. It's calculated based on slope and contributing area. This index is used to visualization potential flow erosion and related with landscape processes.

The SPI, an indicator of the stream's abrasive wear force, was calculated for the study area. SPI can be follows as defined in Equation (3):

$$SPI = A_s \times \tan\beta \quad (3)$$

where As is the particular catchment extent and β is the slope grade in degrees. The distribution of SPI is depicted in Fig. 20.

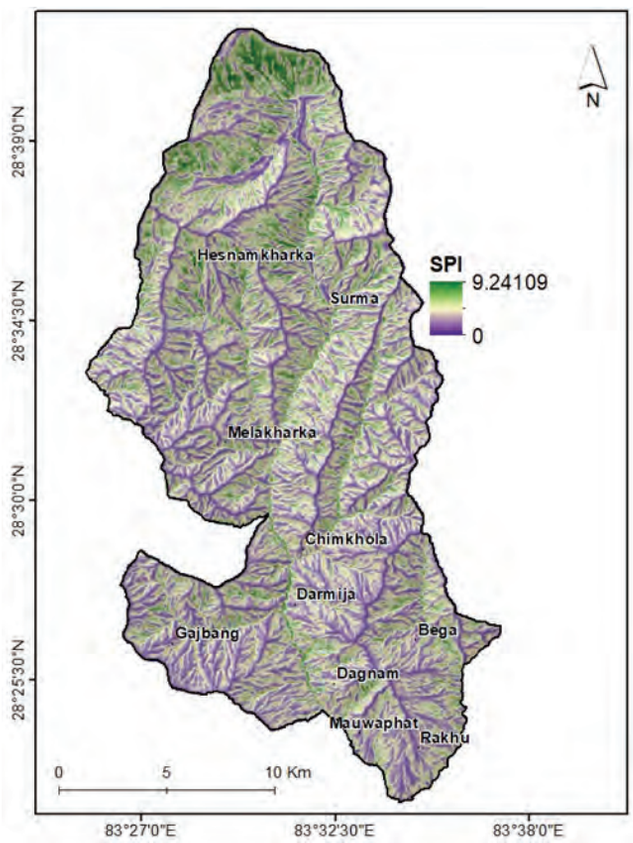

Fig. 20: SPI distribution map of the study area.

The overlay analysis of landslide distribution and SPI shows that most of the landslides has been occurred in the values ranges from 0.8 to 3.2 as depicted in Fig. 21.

iv) Drainage proximity

Terrain alteration may impact a region depending on its distance from a stream (Hua et al., 2021). Drainage proximity is a buffer distance from center of river/stream line (Fig. 22). The Euclidean function in GIS was used to calculate the drainage proximity. The landslide frequency is higher in the proximity of drainage. The river valleys have created steep slopes in its vicinity and water can adversely affect the slope by cutting the toe of terrain.

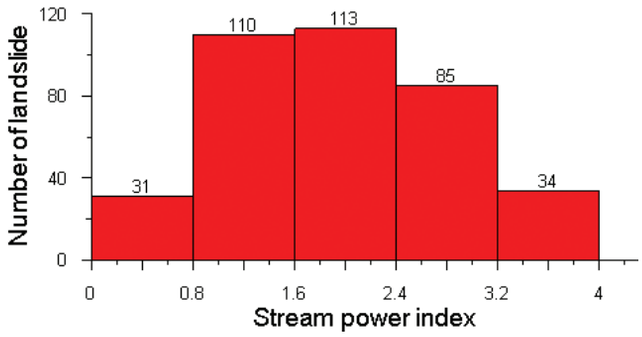

Fig. 21: Distribution of landslides in different SPI categories.

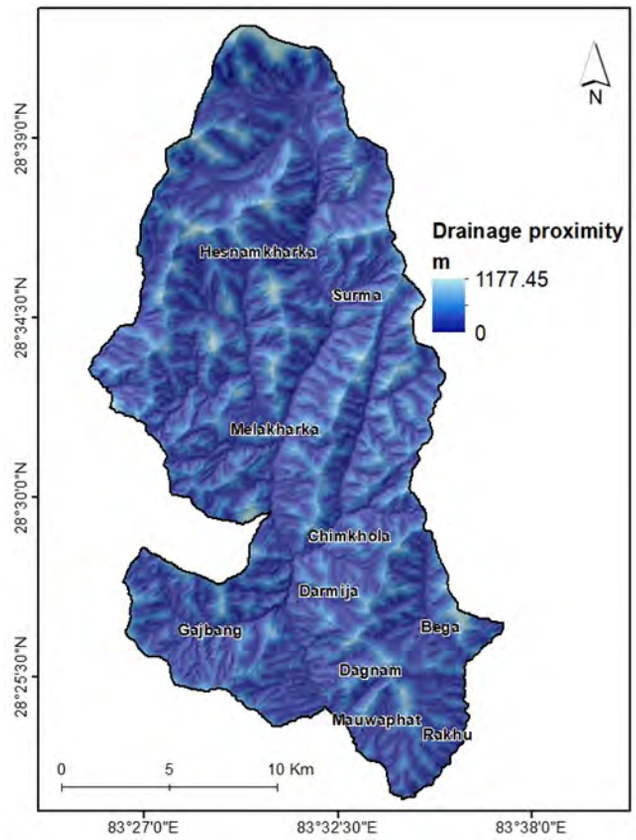

Fig. 22: Drainage proximity map of the study area.

The landslide frequencies are high up to a drainage proximity of 200 m but beyond that landslide frequencies become low (Fig. 23).

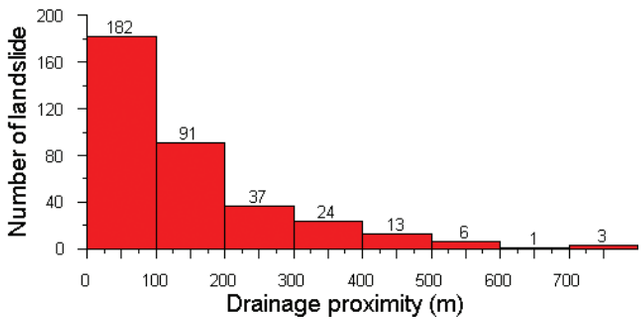

Fig. 23: Distribution of landslides in different drainage proximity categories.

v) Drainage density

Drainage density is a term used in geomorphology and hydrology to describe the relationship between the total length of streams and the area they drain (Dou et al. 2014; Kavzoglu et al. 2014). It is calculated as the total length of streams in a given area divided by that area. High drainage density indicates a well–developed drainage system with a large number of small streams. The drainage density illustrates the balance of erosive strength of surface runoff and resilience of surface geological formations (Fig. 24).

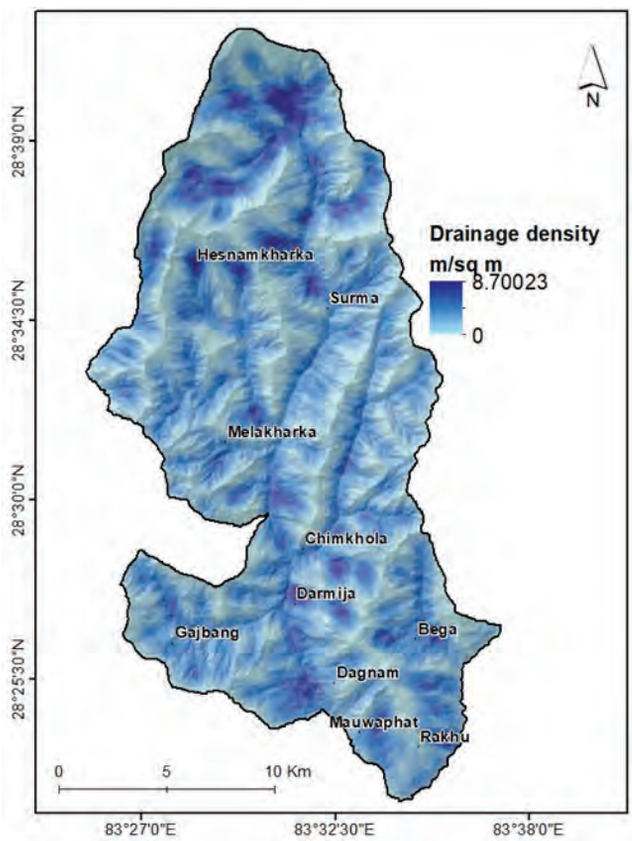

Fig. 24: Map showing drainage density of the study area.

In the present study, drainage densities ranging from 0.8 to 4 m/m² is correlated with landslide distribution as shown in Fig. 25.

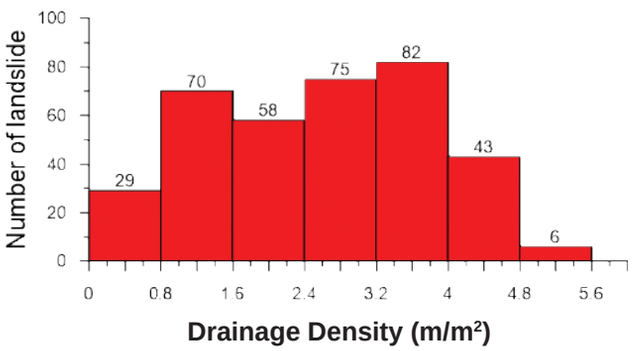

Fig. 25: Distribution of landslides in different drainage density classes.

RESULTS AND DISCUSSION

The landslide susceptibility map of the study area was prepared using the optimum input parameters and independent variables in the form of CFs using the RF in R Programming. Fig. 26 shows the landslide susceptibility map produced using the RF model and divided into five classes (Very Low, Low, Moderate, High, and Very High using the natural breaks classification method.

According to this map, 71.7%, 15%, 7.8%, 3.4 %, and 2.1% of the study area exhibit a very-low, low, moderate, high, and very high susceptibility to landslide, respectively. Although only of the study area is highly and very highly susceptible to landslides, approximately 91.9% of the existing landslides were in these two classes as shown in Table 2.

Table 2: Distribution of susceptibility and corresponding landslide area

Susceptibility classes	Terrain area %	Landslide %
Very Low	71.7	2.3
Low	15.0	1.9
Moderate	7.8	3.9
High	3.4	5.0
Very high	2.1	86.9

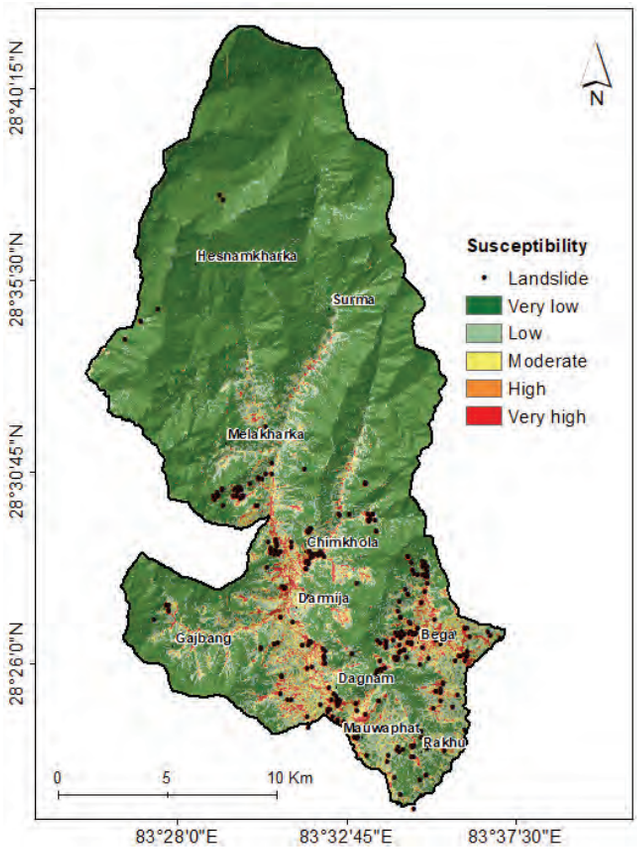

Fig. 26: Landslide susceptibility map of study area.

Evaluation metrics were employed to assess the proposed models utilizing contingency matrices, which include True Positives (TP), True Negatives (TN), False Positives (FP), and False Negatives (FN). A Receiver Operating Characteristic (ROC) curve is a graphical representation of the performance of a binary classification model (Hosmer, DW; Leseshow 2000). In ROC curves, the True Positive Rate (TPR: sensitivity) is plotted against the False Positive Rate (FPR: 1-specificity) at different classification thresholds. The quantitative–qualitative relationship between prediction accuracy and AUC could be categorized as follows: 0.5–0.6, poor; >0.6–0.7, average; >0.7–0.8, good; >0.8–0.9, very good; and >0.9–1, excellent. The RF model underwent validation through the AUC of, achieving success and prediction rates of 90.2% and 81.0%, respectively. In this study the value of AUC is 90.2% hence lies in the excellent group as shown in Fig. 27.

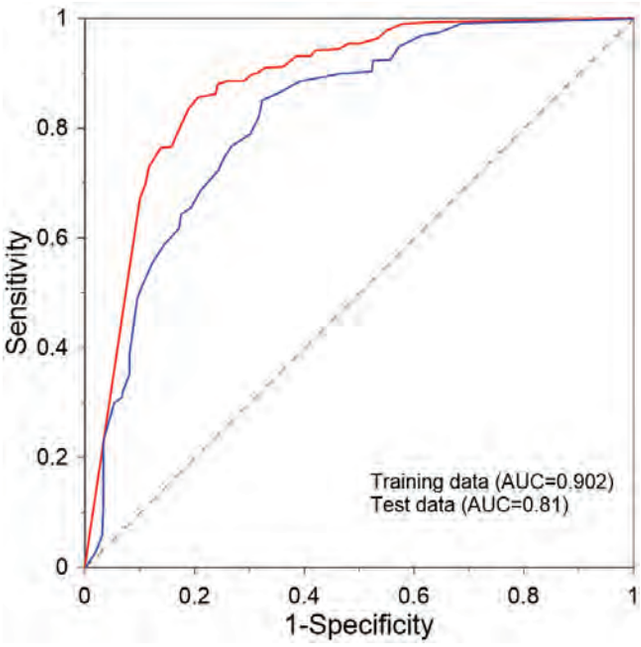

Fig. 27: ROC curve for evaluation the model.

CONCLUSIONS

Landslide susceptibility mapping is an essential tool for estimating the possibility of landslides in hilly terrain. For this accurate landslide prediction models are essential. A total 375 landslides were identified using remote sensing and field survey method. AUC of ROC is 90.2% hence show the result is excellent.

ACKNOWLEDGMENTS

We are grateful to Director General of Department of Mines and Geology for arranging the field program. Our sincere thanks to chairperson of Raghuganga Rural Municipality and all the members who help us during our field program.

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A Field Report on Engineering Geological study of parts of Damak Municipality and Kamal Rural Municipality of Jhapa District

Suresh Shrestha (Sr. Div. Geologist), Sulav Kayastha (Geologist)

ABSTRACT

The present study deals with the engineering properties of Quaternary sediments which gives information on more favourable ground condition for urban development. This study also deals with geological hazards, its impact in environmental and their mitigation. The field investigation was carried out by power driven auguring, hand auguring and Standard Penetration Test (SPT) equipments. Soil samples were taken from various depths to delineate different subsurface Quaternary geological units. A number of traverses were taken along rivers, tributaries and road alignments for delineating geological units and to identify the areas prone to geo-hazard such as flooding and river bank cutting. Natural resources such as sand, gravel and clay were assessed.

Keywords: (Geological Hazards; Standard Penetration Test; Flooding; Quaternary)

INTRODUCTION

Background

The rapid development of the urban areas in Nepal has generated concern with regard to the scope and extent of their infrastructural and environmental problems. There has been a significant increase in use of geological information in urban planning. The present "Engineering Geological Study" parts of Damak and Kamal Rural Municipality of Jhapa District, Eastern Nepal deals with the engineering properties of Quaternary sediments and gives information on favorable ground condition for urban development. Owing to the rapidly increasing population and accelerated economic growth, the demands on land and natural resources for housing, industry, road construction and other infrastructure developments are increasing rapidly. In this scenario, the present SPT test will provide a fundamental data for proper planning of settlements and other infrastructures. The present investigation works was conducted at the different locations within the Damak Municipality and Kamal Rural Municipality of Jhapa District for engineering geological study to find out bearing capacity of the soil and ultimately to classify the ground in regional scale.

Location

Damak is one of the growing cities of Jhapa District, Koshi Province. There are some small and medium scale industries within the study area. The proximity distance to this city from Kathmandu is about 420 km. The total area of Damak Municipality and Kamal Rural Municipality is about 76 sq.km and 105 sq.km respectively and population is about 75,743 and44,365 respectively (Census, 2068). The present study covers the parts of area of Damak Municipality and Kamal Rural Municipality. The total coverage of the present study is about 100 sq.km.

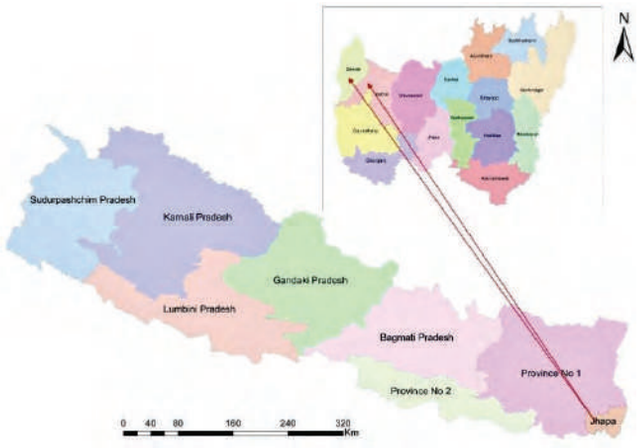

Fig. 1: Location Map of the Study area

Physiography and Climate

Physiographically the study area lies in the Terai region having low altitude ranges from 70m to175m from mean sea level (msl). The area represents vast alluvial Indo-Gangetic foreland basin in the southern flank and belongs to the southernmost tectonic division of Nepal. The northern part of the area consists of Siwaliks. The study area consists of sediments of Quaternary Deposits such as sand, silt, and clay etc. The climate of the study area is tropical and monsoon type.

Drainage

The study area lies in the southern-most part of the Nepal. The topography of this region is almost flat, so, river in this region flows in very low gradient or in the almost flat terrain. The major river shows the

meandering river pattern. The major rivers of this area are Ratuwa Khola and Mawa Khola.

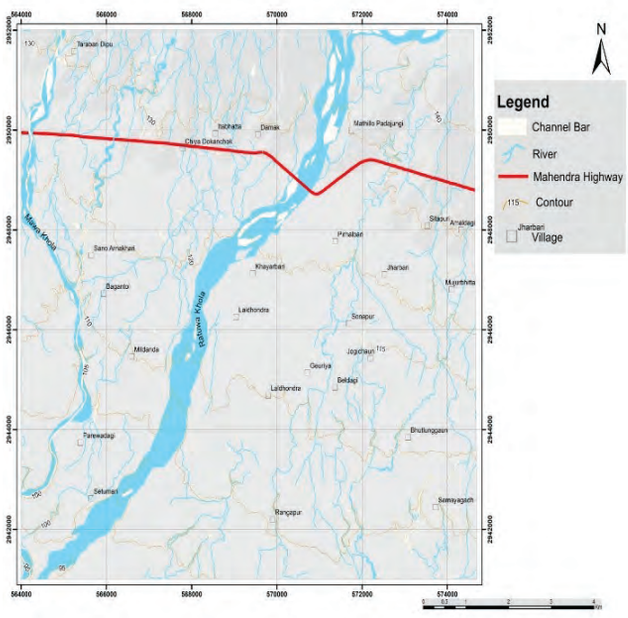

Fig. 2: Drainage map of the study area

Geological Setting of Damak

Physiographically, Damak area lies in the southeast direction from Kathmandu valley. It consists of Quaternary deposits of Terai Plain (Fig.3). The age of sediments of Terai Plain ranges from Pleistocene to Holocene. The sediments can be observed south of the Siwaliks. Generally, the Terai can be divided into three different zones from south to north (M.R. Dhital, Geology of Nepal Himalaya, 2015).

i) Lower Terai or Gangatic alluvium: It is the southernmost alluvial deposits of Terai. The most part of this zone lies the deposits of Terai rivers and its tributaries. It mainly consists of clay, silt and sand with some pebbles.

ii) Middle Terai or Marshy Land: This zone lies between the lower alluvial deposits and upper Bhabar Zone. It consists of silt and clay alternating with sand and gravel beds.

iii) Upper Terai or Bhabar Zone: It lies in the foothill of the Siwaliks. It consists of sand, pebbles, cobbles and boulders derived from the Siwalik. It is the groundwater recharge zone for the Terai Plain.

Previous Study

Geological Map of Central Nepal (1984) at 1:250,000 scale published by the Department of Mines and Geology shows the occurrence of recent sediments in the area and consisting of alluvium boulders, gravels, sands and clays.

Geological Map of Petroleum Exploration Block -10 (Biratnagar, Eastern Nepal, 2001) published by Petroleum Exploration and Promotion Project (PEPP) Department of Mines and Geology at scale of 1: 250,000 shows the occurrence of Quaternary deposit consisting of clay, sand, pebbles, cobbles, boulders alluvial deposits.

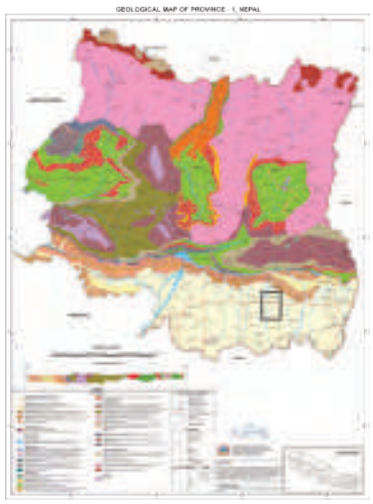

Fig. 3: Province Geological map showing study area

Objectives

The strength parameters of soil, unconsolidated sediment in the region are unknown. The major objectives of this study are enlisted below:

- To conduct detail engineering geological study of the Damak.
- To determine the N- value of the subsurface soil by SPT Method
- To classify the subsurface soil of the study area.
- To identify the geological hazard prone areas and recommend mitigation measures.
- To prepare engineering geological map of study area.

Limitations

- SPT is limited up to 8m depth as the test was performed manual.
- Power Auger is limited up to 7m depth due to constrain in equipment.
- The field survey can judge the susceptible to liquefaction hazard but cannot delineate its potential. There are various reasons to cause liquefaction which may not meet during field survey.
- The information contained in the map are intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. Therefore, the map cannot

replace detail site investigations. It also needs to be upgraded to integrate information according to changes.

- Bore holes were collapsed due to shallow water table, so difficult to penetrate the deeper depth.
- The collected soil/ sand samples were tested after 1 month or more from field works cause difficulties in weighing samples and to find moisture content.

METHODOLOGY

Desk Study

Existing relevant literature on geology, geo-hazard and other information like topo-maps, aerial photographs were collected and reviewed. Topo-maps and Google maps were studied to obtain the overall view and plan of the study area. Digital database of the topo-maps of study area is used for the preparation of final map.

Field study

Hand augering followed by Standard Penetration Test (SPT) and power auger machine were carried out in the field to obtain necessary data. SPT test on 108 bore holes and 98 Power Auger test were performed during the field. The location of the bore hole is shown in Figure below. Adequate soil samples were collected either from the hand auger boreholes or from the split barrel of SPT tests from various depths for laboratory analysis in the Geo-Technical Laboratory of DMG.

Field test

Standard Penetration Test (SPT)

The Standard Penetration Test (SPT) is the most commonly used in-situ test especially for cohesionless soils, which cannot be easily sampled. The test is extremely useful for determining the relative density, bearing capacity, and the angle of shearing resistance of cohesionless soils. It can also be used to determine the unconfined compressive strength of cohesive soils.

The Standard Penetration Test is conducted in a borehole using a standard sampling tube. It has mainly three parts (i) driving shoe made of steel tool about 75mm long, (ii) steel tube about 450mm long that split longitudinally into two halves, and (iii) coupling at the top of the tube about 150mm. The inside diameter of the split tube is 38mm and the outside diameter is 50m. When the borehole has been drilled to a desired depth the drilling tools are removed and the sampling tube is lowered to the bottom of the hole. The sampling tube is driven into the soil by a drop hammer of 63.5 Kg falling through a height of 750 mm.

The numbers of hammer blow required to drive first 150 mm of the sample is counted. The sampler is further driven by 150 mm and the numbers of blows are recorded. Likewise, the sampler is once again further driven by 150mm and the number of blows is recorded. The numbers of blow for the first 150 mm are disregarded. The numbers of blow recorded for the last two 150mm intervals are added to give the standard penetration number (N). In other words, the standard penetration number or N-value is defined as the number of hammer blows (hammer weight 63.5 kg, falling height of 750 mm) required to penetrate 300mm into the formation beyond a seating drive of 150mm. If 50 blows are reached before a penetration of 30 cm no further blows should be recorded. If the test is to be carried out in gravelly soils the driving shoe is replaced by the cone.

The SPT may be used in both sand and clays but the correlation between N-values and the shear strength of clays is very suspicious and should only be treated as a qualitative guide (Lee at al., 1983). On the other hand, a carefully conducted SPT in uncemented sands should give a reliable guide to in-situ density and hence the angle of shearing resistance. The N-values are extensively used in determining the bearing capacity and predicting the settlement of cohesionless soil and are described by a number of authors (Meyerhof, 1956; Teng, 1962; Terzaghi and Peck, 1967; Peck et al., 1974; Bowles, 1977; Lee et al., 1983).

Photo 1.Hand augering for the SPT test

Photo 2.SPT test using monkey hammer

Photo 3. Sample recovered from SPT test

Power Auger Drilling

Power auger drilling was carried out in the field to know the sub-surface geology of the study area. In this method a meter long sample tube rod that could hold sample was inserted in the ground with the help of power Auger machine and then that rod with the subsurface sample was pulled out and a log of sediment below the ground surface was prepared. In the similar manner again a meter long rod was added with sampler tube rod and sample from the 2-meter depth was extracted. The maximum depth that could be explored was 7 meters below the ground surface during the field study.

Photo 4. Power auger drilling at the site

Photo 5. Pulling out the rods after power auger

Photo 6. Materials as seen in sample tube after power auger

Description of Laboratory Tests

The soil samples collected during the field investigation are subjected to various tests in departmental geotechnical laboratory to determine their engineering properties, which are generally required for civil constructions. The laboratory tests are conducted in accordance with the standard test procedures. The following tests were performed in the geotechnical lab of the department.

a) Grain Size Analysis (Sieve curve)

b) Natural moisture content

c) Liquid Limit

d) Plastic Limit

a) Sieve analysis

Sieve analysis is carried on soil samples collected during fieldwork according to standard procedure. Both wet and dry sieving methods were adopted. Samples which contain considerable amount of fine materials like silt and clay wet sieving was carried out to ensure complete separation of fines for reliable assessment of their percentage. Grain size distribution curves are prepared for all sieve analysis results.

b) Natural Moisture Content

The Natural Moisture Content of all soil samples collected from auger boring, SPT split spoon sampler and undisturbed sample tubes are determined according to the standard procedure by drying the soil specimen of known weight under 105º centigrade for 24 hours and calculating the weight loss upon drying. The water content (Wn) of the soil was expressed as a percentage of the weight of oven dried soil as follows:

$$W_n = \frac{\text{Mass of water}}{\text{Mass of Oven dried samples}} \times 100\%$$

c) Liquid Limit

Liquid Limit of the soil samples containing high percentage of fine materials was carried out with ASTM method D423 standard using Casagrande cup. Water content of each sample is determined after oven drying the sample at 105ºC for 24 hours. Percentage of moisture content is plotted against the number of required drops counted during the test. The percentage of moisture content at the value of 25-drop number is taken as the liquid limit of the test sample.

d) Plastic Limit

Plastic Limit of the soil samples is determined as the water content in a soil thread that crumbles at a diameter of 3 mm. The test is carried out according to standard procedures for determination of Plastic Limit. The Plastic Limit values are used with Liquid Limit value of the same sample for determining plasticity index, which is the value, required for soil classification. The results of Plastic Limit Tests and the Liquid Limit Tests are shown in the Table.

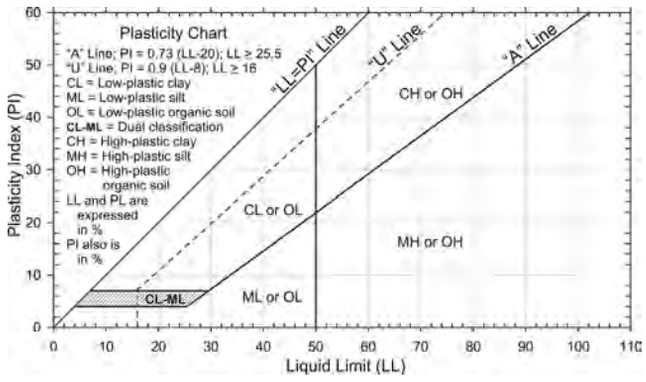

Fig. 4: Plasticity chart to classify fine grained soil

DATA ANALYSIS AND INTERPRETATION

Grain size analysis

Standard Penetration Tests (SPT) in 108 bore holes were performed during the field study. 344 samples collected and sieve analysis were done in the geo-tech lab. The study area consists of mainly medium to coarse grained sediments on visual inspection during the field study so both dry and wet sieving method was adopted. As from the sieve analysis of the collected sample shows mainly the medium to coarse grained sediments. Almost 70% sample consists of sand size particles and only 30% sample consists of fines (silt and clay) i.e., below 0.075mm size sediments. Generally, three types of grain size distribution graph represent the study area as in fig 5 a, b, c.

Moisture content

The Natural Moisture Content of all soil samples collected from auger boring, SPT split spoon sampler and undisturbed sample tubes are determined by

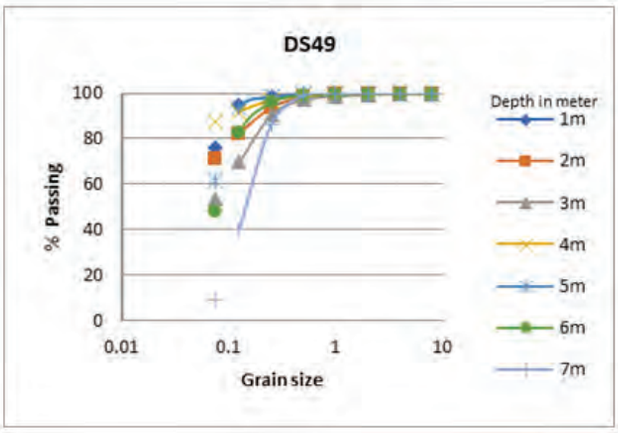

Fig. 5a: Grain size distribution curve representing the silt/clay dominant area.

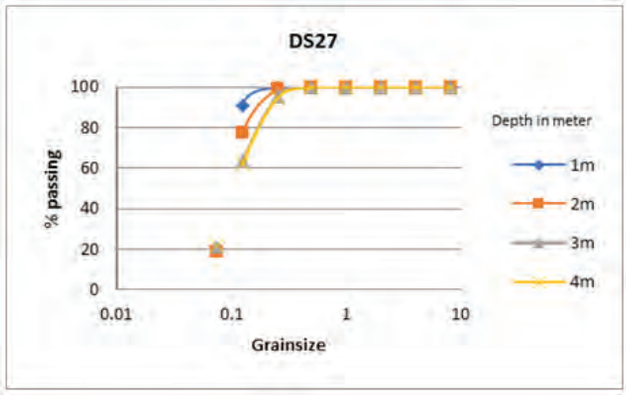

Fig. 5b: Grain size distribution curve representing the sand dominant area.

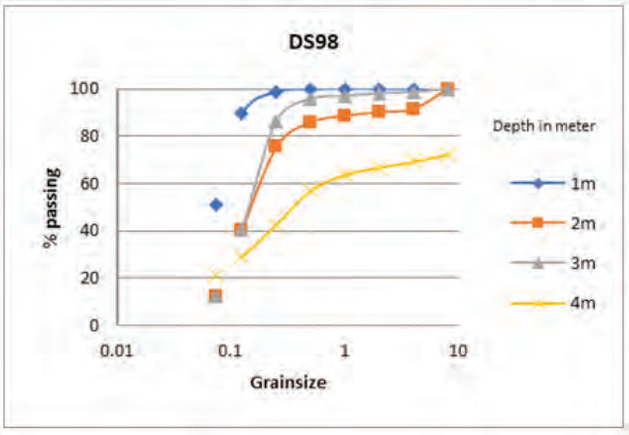

Fig. 5c: Grain size distribution curve representing the sandy gravel dominant area.

drying the soil specimen of known weight under 105º centigrade for 24 hours and calculating the weight loss upon drying. The moisture content of the tested samples was from 0.5% to 38%.

Liquid Limit and Plastic Limit

Liquid Limit and Plastic Limit of the 35 soil samples containing high percentage of fine materials was carried in the geo-tech lab. The Plastic Limit values are used with Liquid Limit value of the same sample for determining plasticity index, which is the value,

required for soil classification. The Liquid Limit of the tested sample is between 14 and 38. Similarly the Plastic Limit of the tested sample is between 15 and 38. The results of Plastic Limit Tests and the Liquid Limit Tests are shown in the Table.

Plasticity index

The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the Liquid Limit and the Plastic Limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. The soil was classified as

Table 1: Plasticity index to classify soil

Plasticity index		
0	non plastic	Sand
<7	Slightly plastic	Silt
7 to 17	Medium Plastic	Silty Clay
>17	Highly Plastic	Clay

Among the samples tested large number of samples lies in between medium plastic silty clay to highly plastic clay category and rest sample in non-plastic sand and slightly plastic silt categories. The data with Liquid Limit, Plastic Limit and Plasticity index is shown in the data sheet in the annex.

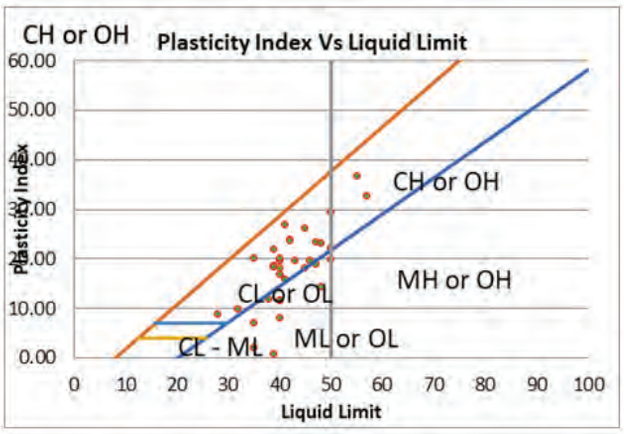

Fig. 6: Graphical representation of fine-grained soil classification

Subsurface geology and engineering properties of soil

The study area lies in the southernmost part of the Terai region and most of the area consists of fine to medium silt and sand with very few clays and gravels. The area lies in the flooding plain of Ratuwa and Mawa Khola. 108 SPT and 98 Auger boreholes were performed during the field survey. The test was carried up to the depth of 4 to 7 meters only because of the constraints in time and equipment. About 344 soil samples were collected from different auger holes and lab analysis was done in the Geotechnical laboratory of the Department.

Based on subsurface geological information (type, nature and size of the sediments) and N-values obtained by performing SPT tests, the study area is classified into 3 different deposits as Laldhondra deposit/unit, Sitapuri deposit/unit and Kharkhare Deposit/unit. They are briefly described below:

1) Laldhondra Deposit/Unit

Laldhondra deposit, clay dominant subsurface consists of grey to dark grey silty clay to clay deposit with alternation of clay silt and very few layers of fine sandy silt or sandy clay. The thickness of clay is about 3 to 5 meters with the alternation of silty clay or clayey silt with occasional sandy silt/clay interlayering of less than 1m thick.

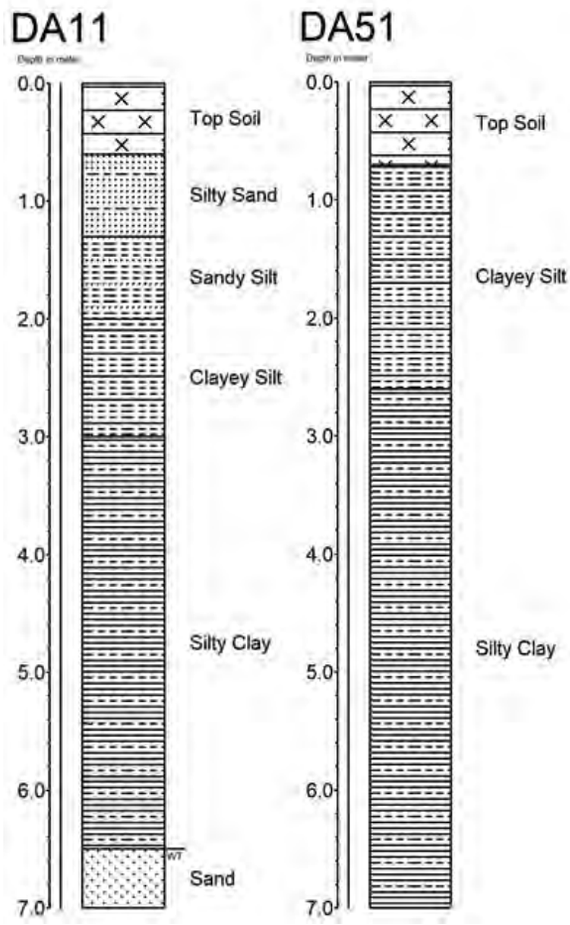

Fig. 7: Litholog representing Laldhondra deposit

2) Sitapuri Deposit/Unit

Sitapuri deposit, sand dominant subsurface consists of grey silty sand deposit with alternation of clayey sandy silt and few layers of silt layers. The thickness of sand is about 2m to 4m with the alternation of clayey silt or sandy/clay silt or silty clay.

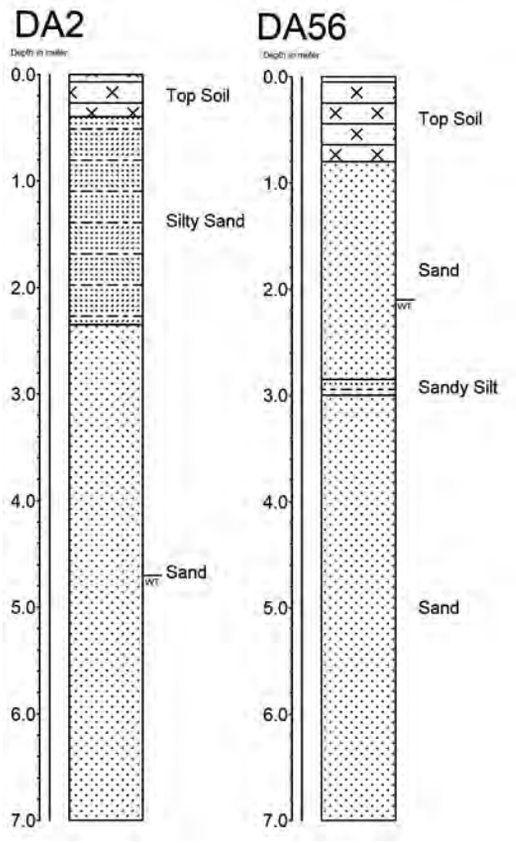

Fig. 8: Litholog representing Sitapuri deposit

3) Kharkhare Deposit

Kharkhare deposit, Pebble to cobble dominant subsurface consists of Pebbly to cobbly sand layers with silt and sand layers alternation. The thickness of sand deposits is about 0.5m to 4m with alternation of sandy silt/sandy clay/silty to clayey sand layers.

Liquefaction hazard analysis

Liquefaction is the tendency to loose shear strength of saturated soil layers under the stress of earthquake motion. Liquefaction mostly occurs in the saturated soil layers composed of coarse silt to fine sand particles. The liquefaction potential of the soil strata decreases as the particle size of constituting materials and the depth increases. Also, in the soil layers composed of fine materials like fine silt and clay size particles the liquefaction will be less likely to occur. For liquefaction to occur, the area should be prone to the earthquake.

Various methods of defining the susceptibility of material to liquefaction theories have been proposed. A simplified approach for liquefaction analysis using SPT value was used in present study given by Idriss and Boulanger,2006. For the assessment of liquefaction vulnerability Cyclic Resistance Ratio (CRR) and Cyclic shear Stress Ratio (CSR) values were computed to get the factor of safety. SPT N-value were obtained from the field by carrying the SPT test in about 60 bore holes and corrected N value $(N1)_{60}$ is obtained as from the given relation,

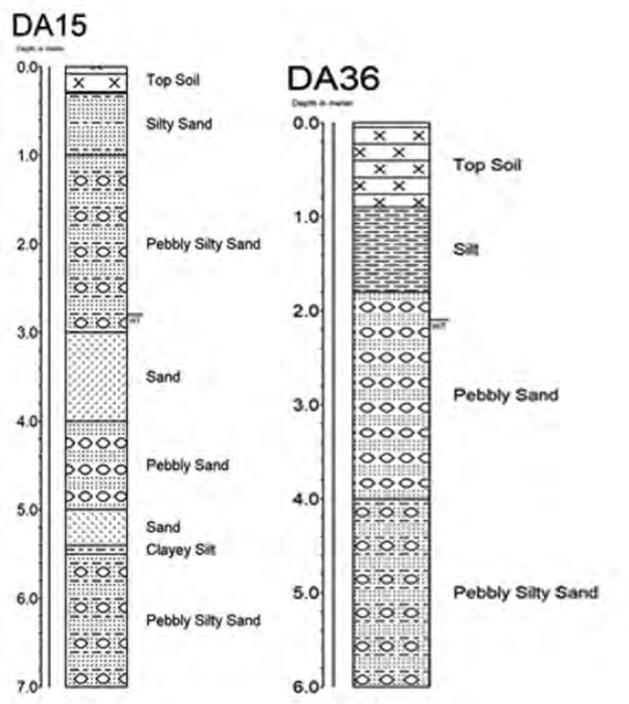

Fig. 9: Litholog representing Kharkhare deposit

$(N1)_{60}=N_M C_N C_E C_B C_R C_S$, where

$N_{M=}$N-value from field

C_N=Over burden correction factor

C_E=Hammer energy Ratio correction factor

C_B=Borehole diameter correction factor

C_R=Rod length correction Factor

C_S= correction factor for samplers with or without liners

Table 2: N-value correction parameters

S.N.	Correction parameter		correction factor
1	**Overburden correction (CN)**	$CN=(Pa/б_{vo})^{0.5}$ where Pa=100kpa(Standard overburden pressure, бvo=effective overburden pressure	0.4≤CN≤1.7
2	**Hammer energy Ratio correction(CE)**		
	Hammer type	Hammer Release Mechanism	Efficiency/ correction factor
	Automatic	Trip	0.7
	Donut	Hand drop	0.6
	Donut	Cathead+2 turns	0.5
	Safety	Cathead+2 turns	0.55-0.6
	Drop/pin	Hand drop	0.45

3	**Borehole diameter correction(CB)**	Equipment variables	correction factor
		65-115mm(2.5-4.5in)	1
		150mm	1.05
		200mm	1.15
4	**Rod length correction(CR)**	3-4m	0.75
		4-6m	0.85
		6-10m	0.95
		>10m	1
5	**Sampler correction(CS)**	Standard sampler	1
		Sampler without liner	1.2

Now the value of Cyclic Resistance Ratio (CRR) is computed using the below equation

$CRR_{7.5} = (1/34-(N_1)_{60cs}) + (N_1)_{60cs}/135+50 / (10.(N_1)_{60cs+45})^2-1/200$

Correction for fines ($(N_1)_{60cs}$) was done by using the following equation

$(N_1)_{60cs} = \alpha + \beta (N_1)_{60}$

Where α and β are the coefficients and determined by the following relationships:

α = 0, if FC ≤ 5%

α = exp (1.76-190/FC^2), if 5% <FC<35%

α = 5, if FC ≥ 35%

β = 1, if FC ≤ 5%

β = (0.99+$FC^{1.5}$1000), if 5% <FC<35%

β = 1.2, if FC ≥ 35%

Cyclic shear Stress Ratio(CSR) is average shear stress developed during earthquake divided by effective overburden stress (Seed and Idriss 1971) and is computed using the below equation (Idriss and Boulanger 2006)

$CSR=\{0.65 (a_{max}/g)*(\sigma_{vo}/\sigma 1_{vo})*(r_d)\}$, where

a_{max} is the peak ground acceleration, g is the acceleration due to gravity, a_{max}/g is the factor of zone, $\sigma_{vo\ is\ total}$ over burden pressure , $\sigma 1_{vo}$ is the effective vertical overburden pressure and r_d is the coefficient of stress reduction and given as

$r_d=(1.000-0.4113z^{0.5}+0.04052z+0.001753z^{1.5})/(1.00-0.4177z^{0.5}+0.05729z-0.006205z^{1.5}+0.001210z^2)$,

where z is the depth below ground level

After computing the values of CSR and CRR the factor of safety (FS) was calculated as

FS =CRR/CSR

If the value of FS is less than 1 than the soil might undergo liquefaction and if greater than 1 then there is no probability of liquefaction. The factor of safety only determines whether a soil layer will liquefy or not. The severity of liquefaction can be quantified and categorized spatially using the Liquefaction potential index (LPI).The LPI given by Iwasaki et al. is as follows

$LPI = \int_0^{20} F(z)W(z)d(z)$

F(z) = 1-FS for FS < 1

F(z) = 0for FS ≥ 1

W(z) = 10-0.5z for z < 20m

W(z) = 0 for z > 20m

Where, z is the depth of the soil layer from the ground surface in meters.

For the layers of the soil under 20m, LPI is computed as

$LPI = \sum_{i=0}^{n} W_i F_i H_i$

$F_i = 1-FS_i$ for $FS_i < 1.0$

$F_i = 0$ for $FS_i \geq 1.0$ Where

w_i = weighing factor

F_i = Liquefaction severity for i^{th} layer

H_i = soil thickness

n = layers numbers

FS_i = factor of safety for i^{th} layer

z_i = depth of ith layer

Table 3: Liquefaction severity (Iwasaki et al.)

S.N.	LPI	Liquefaction severity
1	LPI=0	Very low
2	0 < LPI < 5	Low
3	5 < LPI < 15	High
4	15 < LPI	Very high

The current liquefaction analysis was done using the N-value from SPT, grain size analysis data and ground water level data from the field study using peak ground acceleration value as 0.2 for 7.5 magnitude earthquake. According to the Liquefaction severity (Iwasaki et al.) the LPI obtained from the liquefaction analysis shows the area has low to high Liquefaction severity (Fig.10).

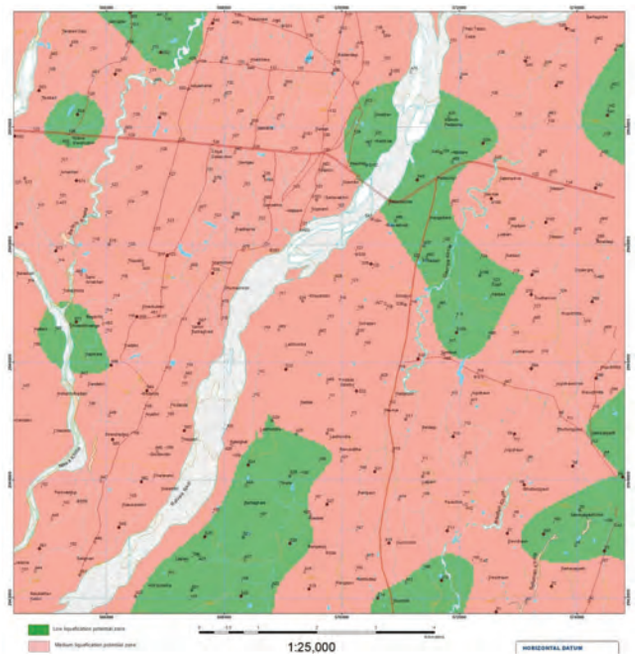

Fig. 10: Liquefaction severity map of the study area

Bearing Capacity

The load carrying capacity of foundation soil or rock which enables it to bear and transmit loads from a structure is known as Bearing Capacity.

There are different types of Bearing Capacity such as Net Bearing Capacity, Safe Bearing Capacity, Gross bearing capacity and Allowable Bearing Capacity. The Bearing Capacity of soil layers depends on the degree of its compaction or relative density. Higher the value of relative density greater will be its Bearing Capacity. There are many methods used for finding out the Bearing Capacity of soil layers on which the foundation of the engineering structures is to be constructed. SPT is one of such methods widely used for finding out the Ultimate Bearing Capacity of soil layers as correlation charts have been established between observed N values and corresponding relative density, stiffness and shearing strength of the soil strata at particular depths. Therefore, once the N values are obtained for any soil layers one can easily calculate its Ultimate Bearing Capacity using any one of the empirical formulas proposed by different authors. The Bearing Capacity of the granular soil depends on their relative density at particular level. Dense soil will have high N values and consequently high Bearing Capacity. Similarly with the increase of N value the compressive strength of cohesive soil increases giving to high Bearing Capacity. The Bearing Capacity analysis is carried out in this report according to Peck et al (1974) table 2. According to the analysis it is found that the Bearing Capacity of the study area is medium to very low. The soil condition in the study area varies from very low to very high with SPT value ranging from 0 to 45. The greater value is normally encountered at a greater depth, and hence the bearing capacity gradually increases with the increase in depth. The result shows that most of the areas have low to very low Bearing Capacity and very few areas have medium Bearing Capacity.

Peck et al (1974) have given for saturated cohesive soils, correlations between N value and consistency from which we can estimate the bearing capacity of the soil (Table 2). This correlation is quite useful but has to be used according to the soil condition met in the field.

Table 4: Correlations between N value and Consistency.

Condition	N-value	Bearing Capacity (Kpa)	Quality
Very soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	4 – 8	51 – 100	Low (L)
Stiff	8 – 15	101 – 200	Medium (M)
Very stiff	15 – 30	201 – 400	High (H)
Hard	>30	>400	Very High (VH)

Flooding

Since the study area lies in the Indo Gangetic Plain, the area is almost flat consisting mainly of silt, sand and clay materials. Because of its low to moderate permeability, less water is infiltrated during the rainy season and most of the water flows as surface run off.

The two main rivers Ratuwa Nadi and the Mawa Khola drains the study area. There are embankments in both bank of those rivers but during the monsoon sometimes water over flow the embankments flooding the Damak area.

Subsurface geological classification from the litho-log data and lab analysis data, liquefaction hazard analysis, N-value obtained from SPT test and bearing capacity analysis data were used for the preparation of engineering and environmental geological map.

Photo 7. River cutting

Photo 8. Bank erosion prone area due to small river in Kamal Rural Municipality

Photo 9. Bank cutting on right bank

Photo 10. Polluted river due to waste disposal.

Photo 11. Waste disposed in river near Damak

Photo 12. Waste being burnt by villagers nearby their house

Photo 13. Wide flood plain of Ratuwa Khola

Photo 14. Wide flood plain of Mawa Khola

NATURAL HAZARD AND ENVIRONMENTAL POLLUTION

The study area lies in the southernmost part of the Terai region of the country and the topography is almost horizontal or very gentle so there is very less probability of landslides but the study area is prone to flooding during monsoon. Although there are embankments at the both banks of Ratuwa Khola and Mawa Khola during monsoon season when there is heavy precipitation in the catchment area sometime the water in the channel over topped the embankments

or the natural depression flooding and inundating the settlement area destroying the lives and properties of the people.

The banks of Ratuwa and Mawa Khola is composed of loose silt and sand deposit in many places so those banks are prone to the bank erosion and river bank cutting problem. One can observe river bank cutting problem at all over Ratuwa, Mawa Khola area and other small streams. Most of the household wastes is either dumped in the stream or simply incinerate/ burned openly near the houses.

Although there are very few industries in the study area brick factories seems to be one of the industries that is creating air pollution. The waste from Damak and surrounding area is thrown and disposed near Bhutanese refugee camp northern part of Damak city.

Mitigation measures for the natural hazard and environmental pollution

The Damak area lies in the Terai region having very low elevation so during monsoon season there is high chance of inundation and flooding of the area. To prevent the inundation the water drain system should be properly managed. Proper maintenance of embankment of the river and early warning system for the flood could help to minimize the loss of properties and lives during the flood.

Similarly, sewage water from the house hold should be drained out to the proper place by closed sewage drain system which will help to maintain good hygiene within the settlement area and also helps to control the breeding of the mosquitoes and spreading of the diseases.

Damak Municipality and Kamal Rural Municipality up to now does not have permanent landfill site for the waste disposal. So, it is recommended to build the landfill site for the waste disposal and for that the suitable site will be the area with thick clay deposit which can prevent the percolation of the leachate in the groundwater. Similarly, the gabion wall and river training works could minimize the river bank cutting and erosion.

The factories should be located far from the settlement area and river system to minimize the effect of air pollution and water pollution.

CONCLUSION AND RECOMMENDATION

Conclusion

The preliminary investigation of the Engineering Geological fieldwork revealed that the study area mainly consists of alluvial and lacustrine sediments. On the basis of the power auger drilling and borehole drilling by manual augering the recent sediments of the Damak area is classified in to three types as Laldhondra Deposit/Unit, Sitapuri Deposit/Unit and Kharkhare Deposit according to the grain size of the sediments. SPT shows the study area have N-value from 1 to 20 having the bearing capacity very low to high. The preliminary Quantitative analysis of liquefaction hazard assessment shows the study area having the sandy deposits have high probability of liquefaction hazard and the deposits having clay and silts have low probability of liquefaction hazard. The engineering geological map was prepared on the basis of the N-value obtained from the SPT study, the data obtained from the auger log and data obtained from the lab analysis.

Similarly, the liquefaction analysis was done using the data obtained from SPT, ground water table and the grain size analysis data from lab. The Liquefaction Potential Index obtained from the study suggests that the study area falls in low to medium liquefaction potential zone.

The study area lies in the Terai region having flat terrain or having very gentle slope so the area is prone to flooding. River bank cutting and erosion along the banks of Ratuwa Nadi and Mawa Khola are commonly observed during heavy rain and destroys the cultivated land.

Recommendation

The study area consists of loose sedimentary deposits having the N-value 1 to 20 indicating very low to high bearing capacity and from the qualitative liquefaction hazard assessment shows medium to low probability of liquefaction hazard which should be considered during the infrastructure development. It is recommended to carry out proper site investigation before construction of any kind of heavy structures to make the structures safe and sustainable.

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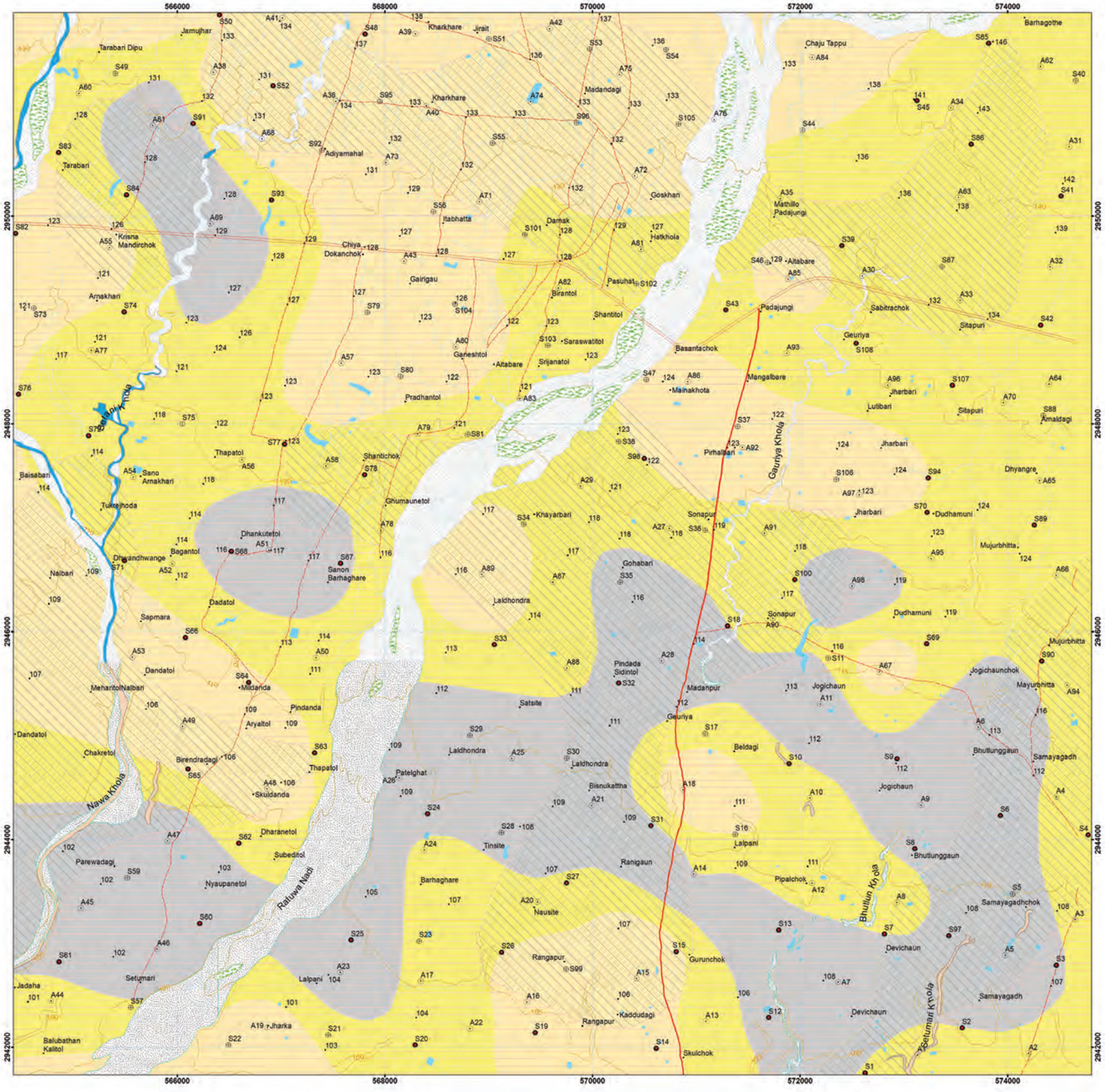
Engineering Geological Map of parts of Damak Municipality and Kamal Rural Municipality,Jhapa District (Parts of topo sheet no. 2687 07 B and 2687 07 D)



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EXPLANATORY LEGEND

Unconsolidated Sediments

Descriptions

Laldhondra Deposit/Unit (Fig. a)

Clay dominant subsurface consists of grey to dark grey silty clay to clay deposit with alternation of clay silt and very few layers of fine sandy silt or sandy clay. The thickness of clay is about 3 to 5 meter with the alternation of siltyclay or clayey silt with occasional sandy silt/clay interlayering of less than 1m thick.

Sitapuri Deposit/Unit (Fig. b)

Sand dominant subsurface consists of greysilty sand deposit with alternation of clayey sandy silt and few layers of silty layers. Thethickness of sand is about 2m to 4m with the alternation of clayey silt or sandy/clay

Kharkhare Deposit/Unit (Fig. c)

Pebble to cobble dominant subsurface consists of Pebbly to cobbly sand layers with silt and sand layers alternation. The thickness of sand deposits is about 0.5m to 4m with alternation of sandy silt/ sandy clay/silty to clayey sand layers.

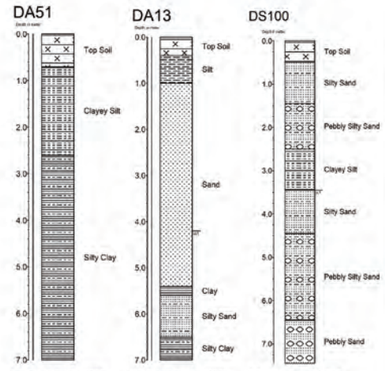


Fig. a: Log representing Laldhondra unit

Fig. b: Log representing Sitapuri unit

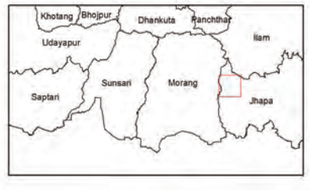
Fig. c: Log representing Kharkhare unit

Corrected N-values

SPT_i	depth(m)							
d	1m	2m	3m	4m	5m	6m	7m	8m
Ds1	3	5	6					
Ds2	2	2	2	6				
Ds3	1	2	3	5	4			
Ds4	1	4	6	10				
Ds6	3	3	2	10				
Ds7	1	2	4	8				
Ds8	2	3	3	3	5			
Ds9	2	3	3	6				
Ds10	2	3	3					
Ds12	2	3	3	3	8	5		
Ds13	2	3	1					
Ds14	1	3	6					
Ds15	2	5	5	6				
Ds19	1	2	5					
Ds20	1	1	3	10				
Ds24	0	3	3	3	4			
Ds25	1	3	5					
Ds26	1	6	6					
Ds27	4	3	5	10				
Ds31	2	5	6					
DS32	3	3	7					
Ds37	1	3	3					
DS39	3	4	6					
Ds40	2	2	4	3				
Ds41	2	2	6					
Ds42	1	3	2	9				
Ds43	1	3	7					
Ds45	1	2	2	3	6			
Ds48	1	7	3					
Ds49	1	2	5	6	5	9		
Ds50	1	4	4	6				
DS52	2	2	18					
Ds55	2	5	8					
Ds59	2	3	5					
Ds60	2	2	1	3	9			
Ds61	1	1	4	9				
Ds62	2	3	6					
Ds63	1	4	7					
Ds64	1	1	4	6				
Ds65	2	5	8					
Ds66	2	2	5					
Ds67	3	2	6					
Ds68	3	4	4					
Ds69	3	2	2	4	5	6		
Ds70	1	4	3	4	3	4		
Ds71	2	3	8					
Ds72	0	3	8					
Ds74	2	3	2	6	11			
Ds75	2	2	2	7				
Ds76	2	1	1	5	12			
Ds77	4	4	4					
Ds78	3	4	6					
Ds82	1	1	2	3	5			
Ds83	1	2	5	8	13			
Ds84	1	4	6	20				
Ds85	2	2	3	9				
Ds86	1	8	7					
Ds89	4	2	4	3	6			
Ds90	2	7	6					
Ds91	3	5	3					
Ds93	2	2	2					
Ds94	5	5	2	2	5	4	8	11
Ds97	7	4	4	17	4	19	17	21
Ds98	0	3	11	4	11			
Ds99	4	9	7	4	5	19	31	19
Ds100	3	3	1	13	17	17	20	
Ds104	1	3	4					
Ds107	2	3	3	7				
Ds108	1	4	6					

The maximum depth of SPT is limited to 8.5m. Bearing capacity analysis is carried out according to Peck et al, 1974. According to the analysis the bearing capacity of the study area mainly have low to medium bearing capacity with N Value ranging from 1 to 31.

Condition	N-Value	Bearing Capacity (Kpa)	Quality
Very Soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	5 – 8	51 – 100	Low (L)
Stiff	9 – 15	101 – 200	Medium (M)
Very Stiff	16 – 30	201 – 400	High (H)
Hard	> 30	> 400	Very High (VH)



Contour Intervals 10 Meters
Supplementary contours at 5 meters
Reference: Mean Sea Level (India)

Topographical Base:
Contours lines, villages, spot heights, roads and river/streams extracted from topographic base maps Published by Survey Department, Nepal

Note:
Field survey done in Dec , 2019

GENERAL SYMBOLS

- A4 Auger Location with ID
- S4 SPT Location with ID
- Village
- 85 Spot Height
- Main Road
- Branch Road
- River/Stream
- Sand
- Contour (Index/Intermediate)
- Contour (Supplementary)

Bearing capacity

- Area with medium bearing capacity
- Area with low bearing capacity

HORIZONTAL DATUM

Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 87° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9999

Prepared by : Senior Divisional Geologist: Suresh Shrestha
Geologist: Sulav Kayastha

DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2022

Engineering Geological Study of Bhadrapur Municipality, Jhapa District

Suresh Shrestha (Senior Divisional Geologist), Nabin Bishowkarma (Geologist)

ABSTRACT

An engineering geological study to know the geotechnical parameters of subsurface materials of Bhadrapur Municipality, Bhadrapur district was carried out according to the program of fiscal year 2078/79 by the Department of Mines and Geology. Standard penetration test carried out at 60 different places shows that the study area has N-value range from 1 to 49 with most of the area falling in medium bearing capacity zone. The collected samples from SPT, analyzed in the lab indicate the area consist of 70% sandy soil with 20% fine grained soil and 10% sandy gravel materials. A simplified approach using standard penetration test (SPT) N-value was used for liquefaction analysis given by Idriss and Boulanger, 2006. The Liquefaction Potential Index (LPI) obtained from the study suggests that most of the area falls in low to medium liquefaction potential zone. Incorporating the field data and the laboratory test data, an engineering Geological Map was prepared.

INTRODUCTION

Background

The Department of Mines and Geology (DMG) regularly conducts a field program to study the engineering properties of subsurface materials, focusing the rapidly developing cities of Nepal. In accordance with F.Y 078/079 program, an engineering geological field study was conducted in the Bhadrapur municipality of Jhapa district, Koshi Province (Figure 1) .Engineering properties of subsurface materials are very important parameters for the safe and sustainable infrastructural development. There has been a significant increase in use of engineering geological information in urban planning. Therrefore, this study specifically addresses the engineering properties of Quaternary sediments and gives information on favorable ground condition for urban development.

Location and accessibility

Bhadrapur Municipality is one of the old and fast growing cities of Jhapa district, Koshi Province. Situated approximately 440 km from Kathmandu, the city is accessible via various highways. One can travel through the BP Highway leading from Kathmandu to Bardibas, followed by the East-West Highway from Bardibas to Charali, and finally the Mechi Highway from Charali to Bhadrapur. Additionally, daily flights from Kathmandu to Bhadrapur airport provide convenient air travel access. . Bhadrapur and Chandragadhi are the two major old settlements of the Municipality, situated at the center of the study area. This municipality falls within the topo sheet no. 2688 05C and 09A. Notably, Mechi Nadi in the area serves as the international boundary between Nepal and India.

Geological Setting of Bhadrapur, Jhapa Area

Physiographically, Bhadrapur area lies in the southeast direction from Kathmandu valley. It is characterized by the Quatenary deposits of Terai Plain (Figure 2). The age of sediments of Terai Plain ranges from Pleistocene to Holocene and can be observed south of the Siwaliks. Generally, the Terai can be divided into three different zones from south to north (M.R. Dhital,, 2015).

Lower Terai or Gangatic alluvium: This is the southernmost alluvial deposits of Terai. This zone is mainly deposited from the Teraii rivers and its tributaries. It mainly comprises clay, silt and sand with some pebbles.

Middle Terai or Marshy Land: This zone lies between the lower alluvial deposits and upper BhabarZone. It consists of silt and clay alternating with sand and gravel beds.

Upper Terai or Bhabar Zone: It lies in the foothill of the Siwaliks. It consists of sand, cobbles, pebbles and boulders derived from the Siwalik. It serrves as the groundwater recharge zone for the Terai Plain.

Objectives

The main objective of this study is to determine geotechnical parameter of the subsurface materials and other objectives of this study are enlisted below:

- To determine the N- value of the subsurface soil by SPT Method.
- To identify the geological hazard prone areas and recommend mitigation measures.
- To prepare engineering geological map of study area.

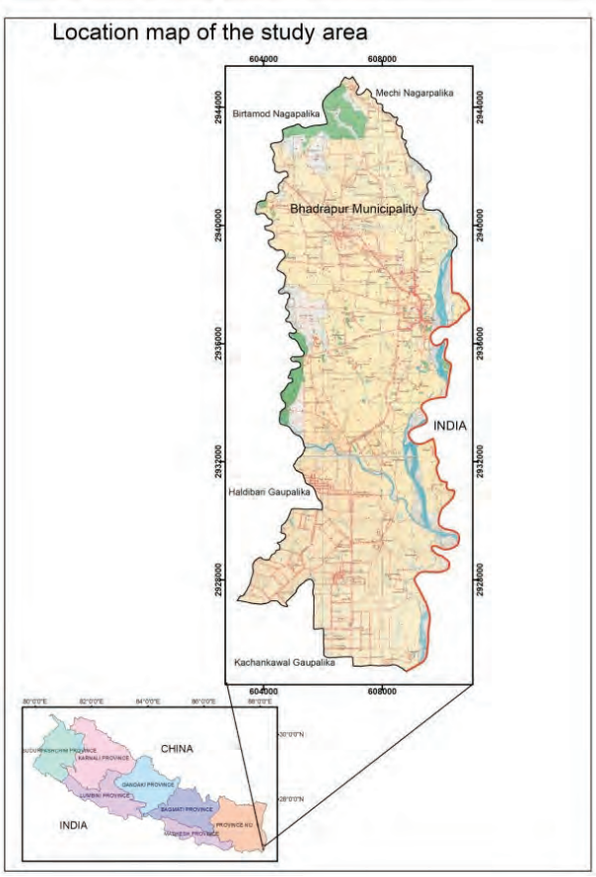


Figure 1: Location map of study area

Figure 2: Province Geological map showing study area

Limitations

- Standard penetration test is restricted to the depth as the test was performed manually and equipment used is very old.
- Power Auger usage is limited up to 7 m depth due to constrain in equipment.
- Shallow water tables have caused bore holes to collapse,, so difficult to penetrate the deeper depth manually.
- The information contained in the maps are intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. Therefore, the map cannot replace detail site investigations.

METHODOLOGY

Desk Study

Existing relevant literature on geology, geo-hazard and other information like topo-maps, aerial photographs were collected and reviewed. Topo-maps and Google maps were studied to obtain the overall understanding and plan of the study area. Digital database of the topo-maps and scan toposheet are used for the preparation of map.

Field study

Hand augering, followed by Standard Penetration Test (SPT) and power auger machine were carried out in the field to obtain necessary data. SPT test on 60 bore holes and 51 Power Auger test were performed during the field. Adequate soil samples were collected either from the hand auger boreholes or from the split barrel of SPT tests from various depths for laboratory analysis. Grainsize analysis, moisture content, liquid Limit and plastic limit, bulk density test, unconfined compressive strength, direct shear test and specific gravity analysis was carried out in geotechnical lab, DMG.

Standard Penetration Test (SPT)

The Standard Penetration Test (SPT) is the most commonly used in-situ test especially for cohesionless soils, which cannot be easily sampled (photo 1, 2, 3). The test is extremely significant for determining the relative density, bearing capacity, and the angle of shearing resistance of cohesionless soils. Additionally, it can be used to determine the unconfined compressive strength of cohesive soils.

The N-values derived from the test are extensively used in determining the bearing capacity and predicting the settlement in the cohesionless soil (Meyerhof, 1956; Teng, 1962; Terzaghi and Peck, 1967; Peck et al., 1974; Bowles, 1977; Lee et al., 1983).

Photo 1: Hand augering for SPT Test

Photo 2: SPT test using monkey hammer

Photo 3: Sample recovered from SPT test

Power Auger Drilling

Power auger drilling (Photo 4) was conducted in the field to know the sub-surface geology of the study area. In this method one- meter long sample tube rod, capable of holding sample, was inserted in the ground with the help of power Auger machine. Then the rod along with the subsurface sample was pulled out and a log of sediment below the ground surface was prepared. Similarly, again a meter long rod was added with sampler tube rod and sample from the two meter depth was extracted. This process continued incrementally, with additional rods. The maximum depth that could be explored was seven meters below the ground surface.

Photo 4: Power auger drilling at site

DATA ANALYSIS AND INTERPRETATION

Grain size analysis

Standard penetration tests (SPT) in 60 bore holes were performed during the field study. In the field, 344 samples were collected and sieve analyses were done in the geotechnical lab of DMG.

The study area consists of mainly medium to coarse grained sediments. However few samples of fine grained was observed on visual inspection during the field study. Therefore, both dry and wet sieving method was adopted. From the sieve analysis of the sample, it shows dominant of the medium to coarse-grained sediments. Most of the samples fall in either gravelly sand or silty sand categories i.e. about 34% and 33%. Similarly 11% of sample fall in sandy clay/silt and 11% in sandy clay categories (Figure 3). The detail of the grain size analysis of samples from one bore hole is presented in graph (figure 4).

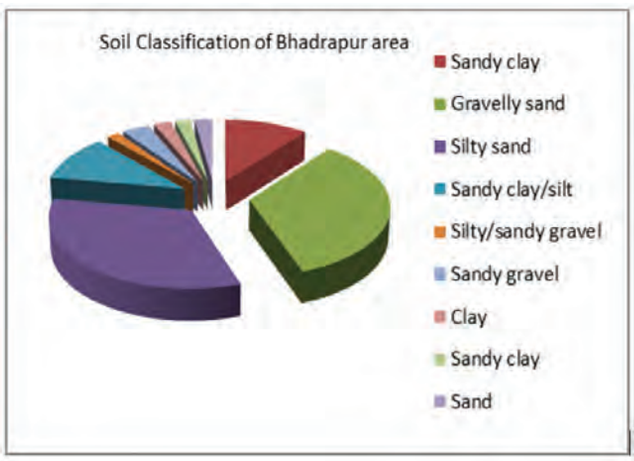


Figure 3: Summary chart of Soil classification by grain-size analysis

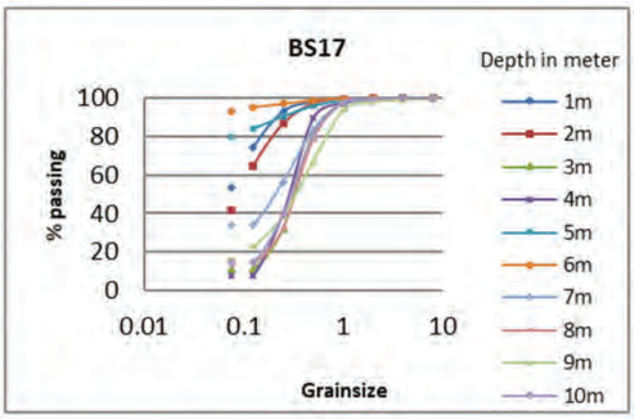


Figure 4: Grain size distribution showing the 10 sample in a bore hole

Moisture content

The Natural Moisture Content of all soil samples collected from auger boring, SPT split spoon sampler and undisturbed sample tubes are determined by drying the soil specimen of known weight under 105º centigrade for 24 hours and calculating the weight loss upon drying. The moisture content of the tested samples was from 0.5% to 38%.

Liquid Limit and plastic limit

Liquid limit and Plastic Limit of the 63 soil samples containing high percentage of fine materials was carried in the geo-tech lab. The Plastic Limit values are used with Liquid Limit value of the same sample for determining plasticity index, which is the value, required for soil classification. The liquid limit of the tested sample is between 32 and 58. Similarly the plastic limit of the tested sample is between 17 and 48.

Plasticity index

The plasticity index (PI) is a measure of the plasticity of a soil. The plasticity index is the size of the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and the plastic limit (PI = LL-PL). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. The soil was classified as in the Table 1.

Table 1: Plasticity index to classify soil

Plasticity index		
0	non plastic	Sand
<7	Slightly plastic	Silt
7 to 17	Medium Plastic	Silty Clay
>17	Highly Plastic	Clay

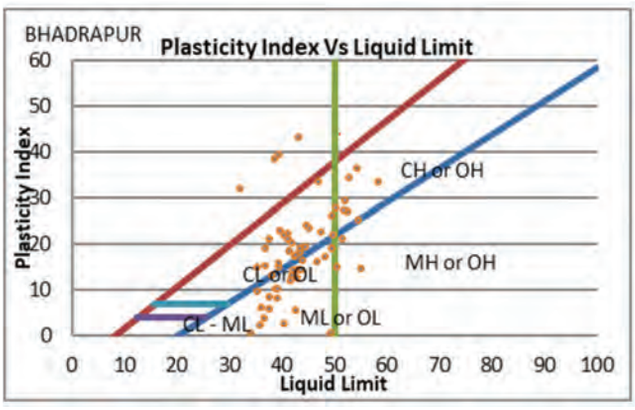


Figure 5: Graphical representation of fine grained soil classification

Among the samples tested large number of samples falls within low plastic clay and low plastic silt categories with few high plastic clay and high plastic silt/ organic soil (Figure 5)

Bulk density test

Bulk density of 25 undisturbed samples collected in tubes was tested in the lab. The result shows, bulk densities of tested samples ranges between 1.34 gm/cm^3 to 1.73gm/cm^3. Most of the samples tested are fine-grained sand, silt or clay which is somewhat cohesive.

Unconfined compressive strength

The sample tested for the unconfined compressive strength (UCS) are undisturbed samples collected in tubes and are mostly fine-grained or/and cohesive in nature. The tabulated result shows that the maximum UCS value is 1.27kg/cm^2 and minimum UCS value is 0.26kg/cm^3 (Table 3). In most of the case less compacted silty soil have low UCS. Shear strength of soil can be calculated from the value obtained from UCS value by dividing it by 0.5.

Specific Gravity

Specific gravity of more than 100 samples was tested in the geotechnical lab by pycnometer method for coarse grained samples and density bottle method for fine grained samples. The specific gravity varies from 2.4 to 2.78.

Direct shear test

Direct shear test of about 78 samples were conducted in the lab to find the cohesion value c and frictional angle value phi which will ultimately give the shear strength of the soil. Among the sample tested most of them are remolded sample and very few tests were conducted in undisturbed samples. The c values ranges from 0.001 to 0.3 and Phi value range from 2º to 51º. The test result shows that the fine grained silty and clay soils have low shear strength compared to sandy and gravelly sandy soil.

Subsurface Geology

The study area lies in the southernmost part of the terai region and most of the area consists of fine to medium silt and sand with very few clay and gravels. The area lies in the flooding plane of Mechi River and Devayani Khola. 60 Standard Penetration Test (SPT) and 51 Auger boreholes were performed during the field survey. The test was carried up to the depth of 4 to 10.

Based on subsurface geological information (type, nature and size of the sediments), the study area lithology can be generalized as 1 to 3m thick clay/silty clay/clay silt at the top followed by sandy layers mostly pebbly sand, rarely sandy pebble of 4 to 7m thick layer. At the bottom there is fine material like siltyclay to clay silt (Figure 6 &7). These observations are made on the basis of maximum depth of borehole i.e. 10m.

Liquefaction hazard analysis

Liquefaction is the tendency to loose shear strength

of saturated soil layers under the stress of earthquake motion. Liquefaction mostly occurs in the saturated soil layers composed of coarse silt to fine sand particles. The liquefaction potential of the soil strata decreases as the particle size of constituting materials and the depth increases. Also in the soil layers composed of fine materials like fine silt and clay size particles the liquefaction will be less likely to occur. For liquefaction to occur, the area should be prone to the earthquake.

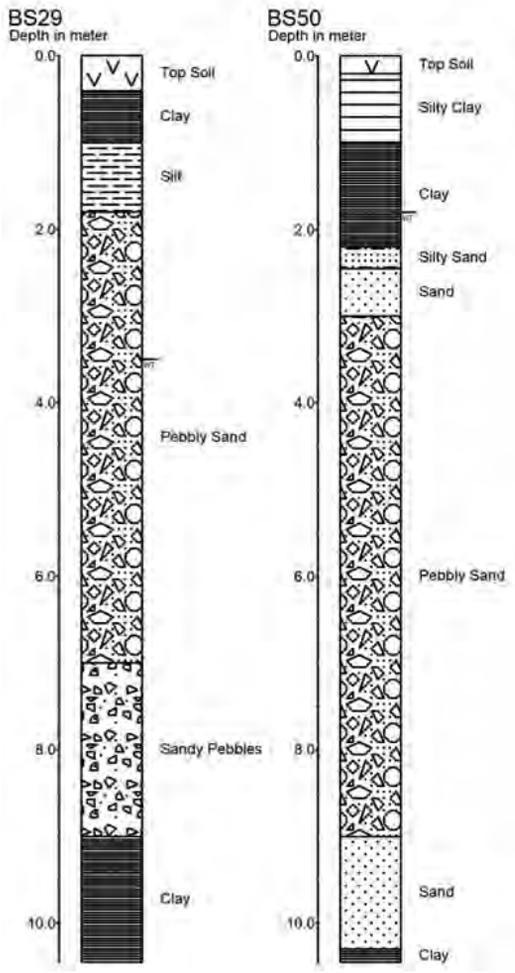


Figure 6: Lithologs (SPT) of the boreholes representing study area

Various methods of defining the susceptibility of material to liquefaction theories have been proposed. A simplified approach for liquefaction analysis using standard penetration test (SPT) value was used in present study given by Idriss and Boulanger, 2006. For the assessment of liquefaction vulnerability Cyclic Resistance Ratio (CRR) and Cyclic shear Stress Ratio (CSR) values were computed to get the factor of safety. Standard penetration Test N-value were obtained from the field by carrying the SPT test in about 60 bore holes and corrected N value $(N1)_{60}$ is obtained as from the given relation,

$(N1)_{60}=N_M C_N C_E C_B C_R C_{S\ ,\ where}$

$N_{M=}$N-value from field

C_N=Over burden correction factor

C_E=Hammer energy Ratio correction factor

C_B=Borehole diameter correction factor

C_R=Rod length correction Factor

C_S= correction factor for samplers with or without liners

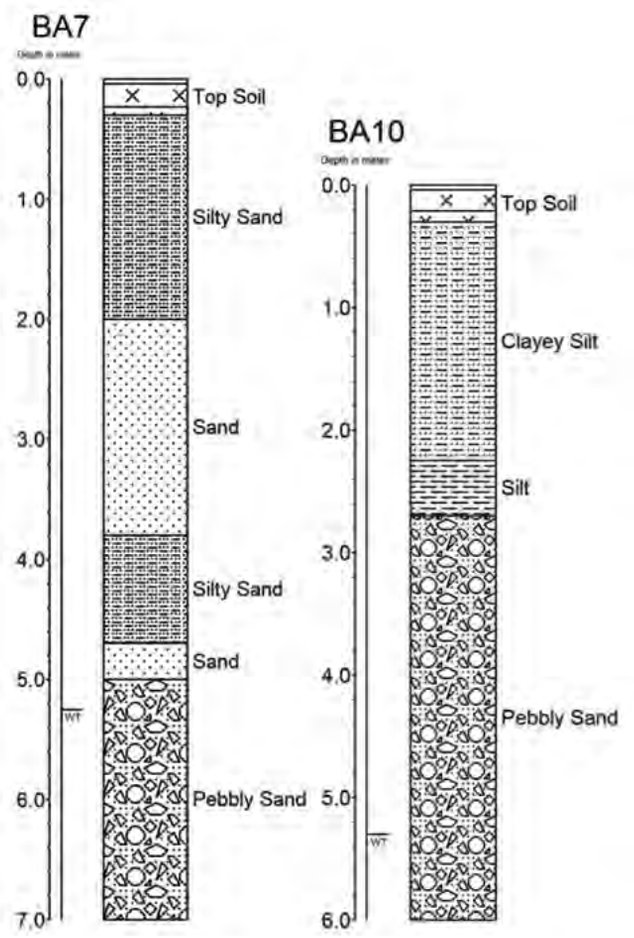


Figure 7: Lithlogs(from Power augering)

Table 2: N-value correction parameters

S.N.	Correction parameter		correction factor
1	**Overburden correction (CN)**	$CN=(Pa/\sigma_{vo})^{0.5}$ where Pa=100kpa(Standard overburden pressure, σvo=effective overburden pressure	0.4≤CN≤1.7
2	**Hammer energy Ratio correction(CE)**		
	Hammer type	Hammer Release Mechanism	Efficiency/ correction factor
	Automatic	Trip	0.7
	Donut	Hand drop	0.6
	Donut	Cathead+2 turns	0.5
	Safety	Cathead+2 turns	0.55-0.6
	Drop/pin	Hand drop	0.45

3	**Borehole diameter correction(CB)**	Equipment variables	correction factor
		65-115mm(2.5-4.5in)	1
		150mm	1.05
		200mm	1.15
4	**Rod length correction(CR)**	3-4m	0.75
		4-6m	0.85
		6-10m	0.95
		>10m	1
5	**Sampler correction(CS)**	Standard sampler	1
		Sampler without liner	1.2

Now the value of Cyclic Resistance Ratio (CRR) is computed using the below equation

$CRR_{7.5} = (1/34-(N_1)_{60cs}) + (N_1)_{60cs}/135+50 / (10.(N_1)_{60cs+45})^2-1/200$

Correction for fines ($(N_1)_{60cs}$) was done by using the following equation

$(N_1)_{60cs} = \alpha + \beta (N_1)_{60}$

Where α and β are the coefficients and determined by the following relationships:

α = 0, if FC ≤ 5%

α = exp (1.76-190/FC^2), if 5% <FC<35%

α = 5, if FC ≥ 35%

β = 1, if FC ≤ 5%

β = (0.99+$FC^{1.5}$1000), if 5% <FC<35%

β = 1.2, if FC ≥ 35%

Cyclic shear Stress Ratio(CSR) is average shear stress developed during earthquake divided by effective overburden stress (Seed and Idriss 1971) and is computed using the below equation (Idriss and Boulanger 2006)

CSR={0.65 (a_{max}/g)*($\sigma_{vo}/\sigma 1_{vo}$)*($r_d$)}, where

a_{max} is the peak ground acceleration, g is the acceleration due to gravity, a_{max}/g is the factor of zone, $\sigma_{vo\ is\ total}$ over burden pressure , $\sigma 1_{vo}$ is the effective vertical overburden pressure and r_d is the coefficient of stress reduction and given as

$r_d=(1.000-0.4113z^{0.5}+0.04052z+0.001753z^{1.5})/(1.00-0.4177z^{0.5}+0.05729z-0.006205z^{1.5}+0.001210z^2)$,

where z is the depth below ground level

After computing the values of CSR and CRR the factor of safety (FS) was calculated as

FS =CRR/CSR

If the value of FS is less than 1 than the soil might undergo liquefaction and if greater than 1 then there is no probability of liquefaction. The factor of safety only determines whether a soil layer will liquefy or not. The severity of liquefaction can be quantified and categorized spatially using the Liquefaction potential index (LPI).The LPI given by Iwasaki et al. is as follows

$LPI = \int_0^{20} F(z)W(z)d(z)$

F(z) = 1-FS for FS < 1

F(z) = 0for FS ≥ 1

W(z) = 10-0.5z for z < 20m

W(z) = 0 for z > 20m

Where, z is the depth of the soil layer from the ground surface in meters.

For the layers of the soil under 20m, LPI is computed as

$LPI = \sum_{i=0}^{n} W_i F_i H_i$

$F_i = 1-FS_i$ for $FS_i < 1.0$

$F_i = 0$ for $FS_i \geq 1.0$ Where

w_i = weighing factor

F_i = Liquefaction severity for i^{th} layer

H_i = soil thickness

n = layers numbers

FS_i = factor of safety for i^{th} layer

z_i = depth of ith layer

The current liquefaction analysis was done using the corrected N-value from SPT, grain size analysis data and ground water level data from the field study using peak ground acceleration value as 0.2 for 7.5 magnitude earthquake (Table 4). According to the Liquefaction severity as in Table 3 (Iwasaki et al.) the LPI obtained from the liquefaction analysis shows the area has Low to high Liquefaction severity (Figure 8).

Table 3: Liquefaction severity classification (Iwasaki et. al.1982)

S.N.	LPI	Liquefaction severity
1	LPI=0	Very low
2	0 < LPI < 5	Low
3	5 < LPI < 15	High
4	15 < LPI	Very high

Table 4: Liquefaction potential index (LPI) calculation for borehole BS17

Spt_ ID	Depth (m)	N Value	corrected N- value (N1) 60	%fines	rd	CSR, 0.2	α	β	N1(60) cs	CRR7.5	Factor of safety(FS)	Mid point of soil layer(z)	soil thickness (Hi)	W(z)	(Fi)	Fi* Wz* Hi	LPI
BS17	1	4	3.6	53.29	0.99	0.13	5.00	1.20	9.41	0.11	0.82	0.50	1.00	9.75	0.18	1.78	
	2	7	5.6	41.47	0.98	0.13	5.00	1.20	11.80	0.13	1.00	1.50	1.00	9.25	0.00	0.00	
	3	14	10.3	11.04	0.98	0.15	1.22	1.03	11.86	0.13	0.86	2.50	1.00	8.75	0.14	1.24	
	4	18	14.0	7.60	0.97	0.17	0.22	1.01	14.40	0.15	0.93	3.50	1.00	8.25	0.07	0.62	12.10
	5	3	2.2	79.88	0.96	0.18	5.00	1.20	7.63	0.09	0.51	4.50	1.00	7.75	0.49	3.83	
	6	5	3.8	93.16	0.95	0.19	5.00	1.20	9.64	0.11	0.58	5.50	1.00	7.25	0.42	3.05	
	7	13	9.5	33.95	0.94	0.19	4.93	1.19	16.28	0.17	0.90	6.50	1.00	6.75	0.10	0.68	
	8	20	14.0	14.13	0.93	0.20	2.24	1.04	16.89	0.18	0.91	7.50	1.00	6.25	0.09	0.54	
	9	31	20.8	16.87	0.92	0.20	2.98	1.06	25.08	0.29	1.48	8.50	1.00	5.75	0.00	0.00	
	10	22	14.2	14.80	0.90	0.20	2.44	1.05	17.35	0.18	0.93	9.50	1.00	5.25	0.07	0.37	

Bearing capacity

The load carrying capacity of foundation soil or rock which enables it to bear and transmit loads from a structure is known as bearing capacity.

There are different types of Bearing Capacity such as Net Bearing Capacity, Safe Bearing Capacity, Gross bearing capacity and Allowable Bearing Capacity. The Bearing Capacity of soil layers depends on the degree of its compaction or relative density. Higher the value of relative density greater will be its Bearing Capacity. There are many methods used for finding out the Bearing Capacity of soil layers on which the foundation of the engineering structures is to be constructed. Standard Penetration Test (SPT) is one of such methods widely used for finding out the Ultimate Bearing Capacity of soil layers as correlation charts have been established between observed N values and corresponding relative density, stiffness and shearing strength of the soil strata at particular depths. Therefore once the N values are obtained for any soil layers one can easily calculate its Ultimate Bearing Capacity using any one of the empirical formula proposed by different authors. The Bearing capacity of the granular soil depends on their relative density at particular level. Dense soil will have high N values and consequently high Bearing Capacity. Similarly with the increase of N value the compressive strength of cohesive soil increases giving to high Bearing capacity.

The bearing capacity analysis is carried out in this report according to Peck et al (1974) table 2. According to the analysis it is found that the bearing capacity of the study area is medium to very low. The soil condition in the study area N-values varies from very low to very high with SPT value ranging from 0 to 45. The greater value is normally encountered at a greater depth, and hence the bearing capacity gradually increases with the increase in depth. The result shows that most of the areas have medium bearing capacity and very few areas have high to low bearing capacity (Figure 9).

Correlations between N value and consistency from which we can estimate the bearing capacity of the soil is given by Peck et al (1974) for saturated cohesive soils, (Table 5). This correlation is quite useful but has to be used according to the soil condition met in the field.

Table 5: Correlation between N-value and Consistency

Condition	N-value	Bearing Capacity (Kpa)	Quality
Very soft	<2	<25	Extremely Low (EL)
Soft	2 – 4	25 – 50	Very Low (VL)
Medium	4 – 8	51 – 100	Low (L)
Stiff	8 – 15	101 – 200	Medium (M)
Very stiff	15 – 30	201 – 400	High (H)
Hard	>30	>400	Very High (VH)

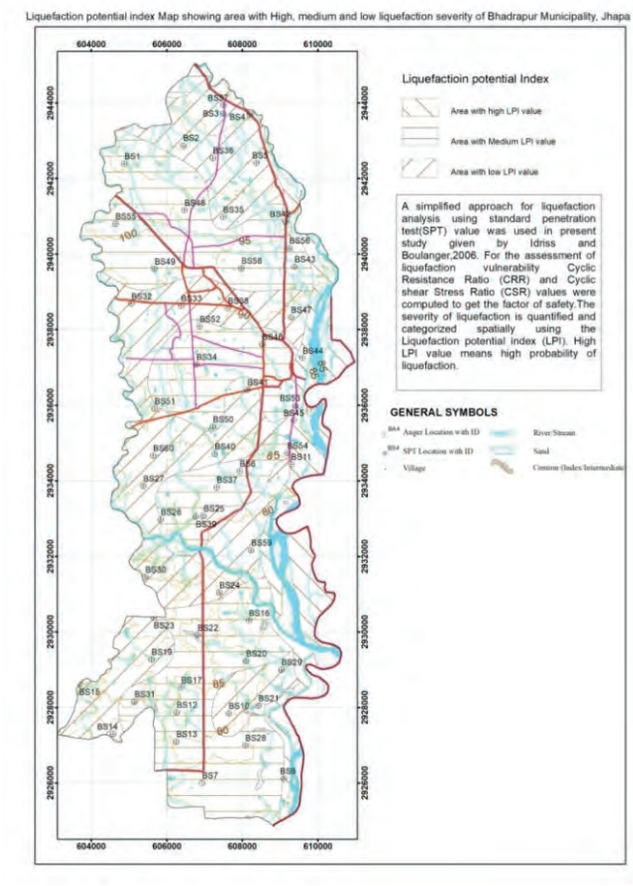


Figure 8: Liquefaction potential index map showing low to high liquefaction potential area

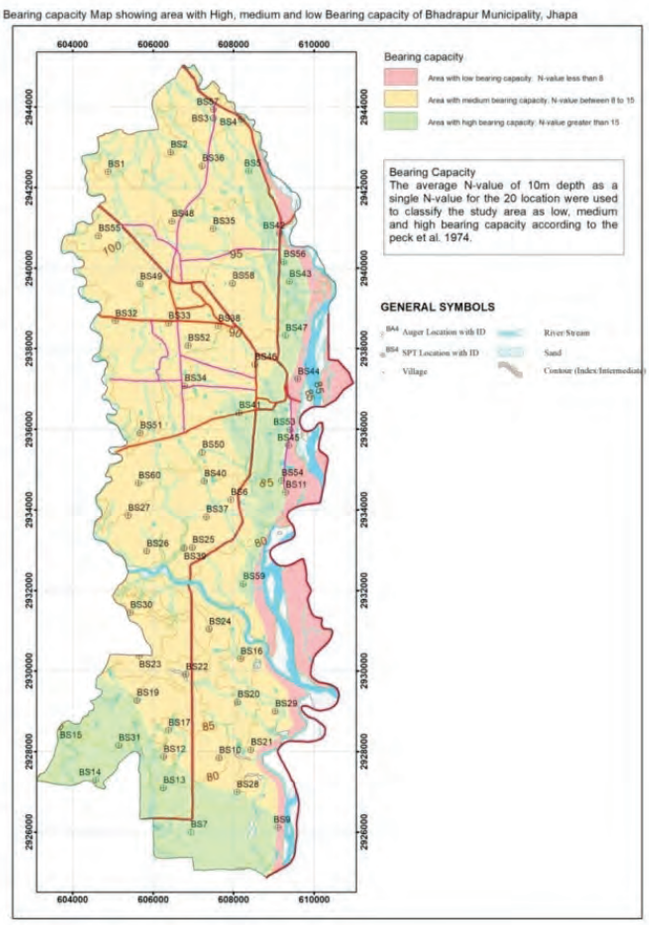


Figure 9: Bearing capacity map of the study area

Natural hazard and Environmental pollution

The study area lies in the southernmost part of the Terai region of the country and the topography is almost horizontal or very gentle. Therefore, the study area is prone to inundation and flooding during monsoon. Despite the presence of embankments along the Mechi Nadi and its tributaries, heavy precipitation in the catchment area can cause water levels in the channels to exceed the embankment heights, leading to flooding and inundation of settlements, resulting in loss of lives and property. The banks of composed of loose gravel, sand or silt deposit making them vulnerable to the bank erosion and river bank cutting problem (Photo 5&6) . One can observe river bank cutting problem at Deuniya, Phulbasa Khola area and in other small streams.

Bhadrapur Municipality collects waste materials from the urban area and dumped at the bank of Mechi Khola haphazardly (Photo 7). Besides that most of the household wastes is either dumped in the stream or simply incinerate/burned openly near the houses by the people.

Proper maintenance of embankment of the river and early warning system for the flood could help to minimize the loss of properties and lives during the flood.

Similarly, sewage water from the household should be drained out to the proper place Household sewage should be efficiently drained away using enclosed sewage systems to maintain hygiene within residential areas. This not only prevents the breeding of mosquitoes but also curbs the spread of diseases.

In and around Bhadrapur up to now does not have permanent landfill site for the waste disposal. So it is recommend to deliver and landfill site for the waste disposal and for that the suitable site will be the area with thick clay deposit which can prevent the percolation of the leachate in the groundwater. Similarly the gabion wall and river training works could minimize the river bank cutting and erosion.

Photo 5: Loose gravel at the bank of Devaniya Khola

Photo 6: River bank cut prone area

Photo 7: Waste disposal site of Municipality at the bank of Mechi Nadi

CONCLUSION

The preliminary investigation of the Engineering Geological fieldwork based on power auger drilling and manual borehole drilling suggests that the study area mainly consists of alluvial sediments. The recent sediments of the Bhadrapur area, mainly consists of fine sediments like silty clay to clay at the top followed by coarse sediments pebbly sand to sand and at the bottom again fine materials indicating the possibility of fluvial cycle Standard Penetration test shows the study areas have N-value from 1 to 48 and most of the area falls in the medium bearing capacity zone. The Liquefaction Potential Index obtained from the study suggests that most of the study area falls in low to medium liquefaction potential zone.

The study area lies in the terai region having flat terrain or having very gentle slope so the area is prone to flooding. River bank cutting and erosion along the banks of Deuniya Khola are commonly observed during heavy rain and destroys the cultivated land.

The litho-log data and lab analysis data, liquefaction hazard analysis, N-value obtained from SPT test and bearing capacity analysis data were used for the preparation of engineering geological map of Bhadrapur area (Figure 13, annex). Similarly the average shear wave velocity from microtremor analysis and vertical electric sounding survey data are only included in the map.

RECOMMENDATION

The information contained in the maps is intended for urban planning in regional scale and infrastructure development activities. It should not be used as only basis for any specific site investigation for individual buildings or any other major structures. The map cannot replace detail site investigations. It is recommended to carry out proper site investigation before construction of any kind of heavy structures to make the structures safe and sustainable.

ACKNOWLEDGEMENT

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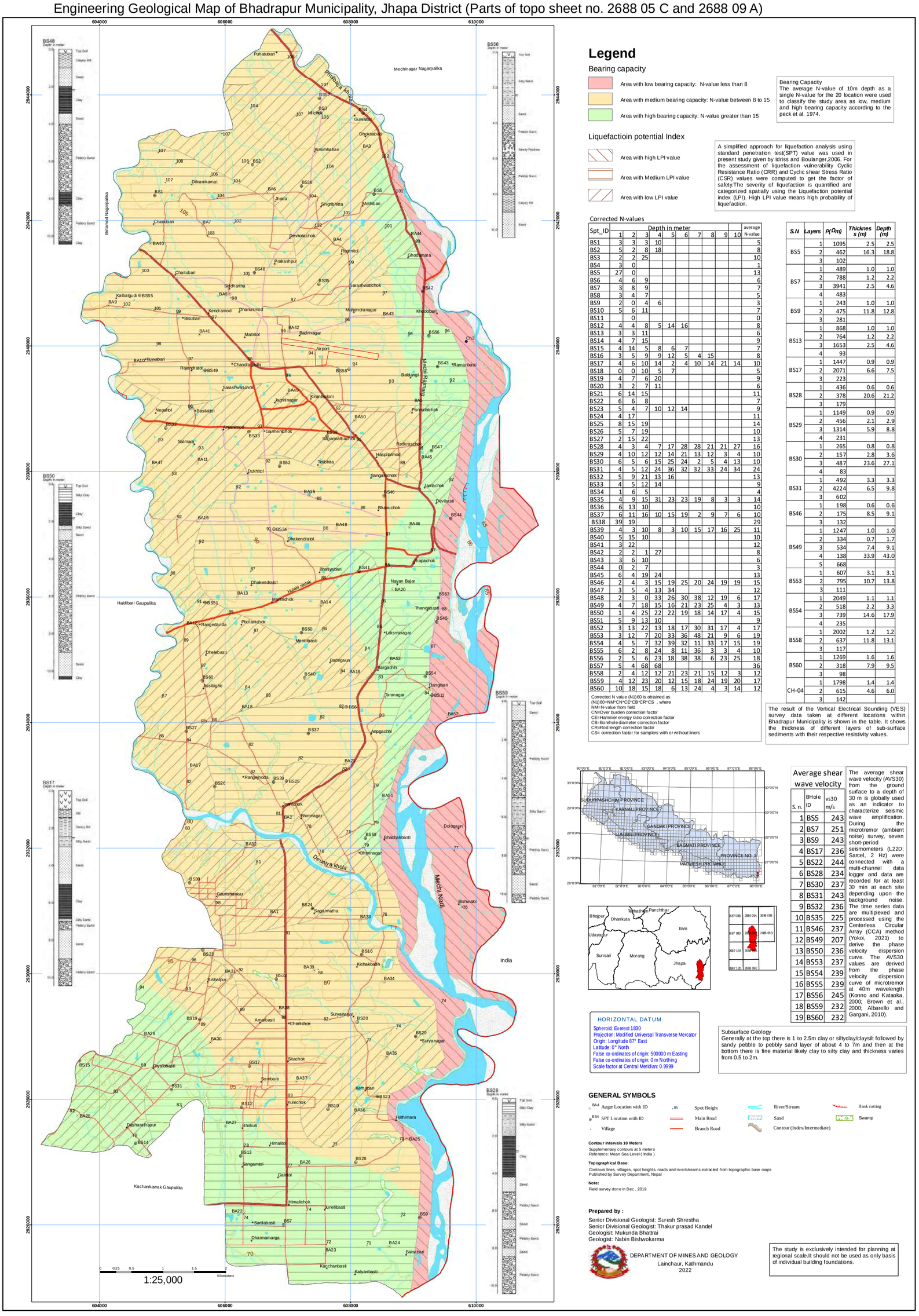
Engineering Geological Map of Bhadrapur Municipality, Jhapa District (Parts of topo sheet no. 2688 05 C and 2688 09 A)



Legend

Bearing capacity

- Area with low bearing capacity: N-value less than 8
- Area with medium bearing capacity: N-value between 8 to 15
- Area with high bearing capacity: N-value greater than 15

Bearing Capacity
The average N-value of 10m depth as a single N-value for the 20 location were used to classify the study area as low, medium and high bearing capacity according to the peck et al. 1974.

Liquefactioin potential Index

- Area with high LPI value
- Area with Medium LPI value
- Area with low LPI value

A simplified approach for liquefaction analysis using standard penetration test(SPT) value was used in present study given by Idriss and Boulanger,2006. For the assessment of liquefaction vulnerability Cyclic Resistance Ratio (CRR) and Cyclic shear Stress Ratio (CSR) values were computed to get the factor of safety.The severity of liquefaction is quantified and categorized spatially using the Liquefaction potential index (LPI). High LPI value means high probability of liquefaction.

Corrected N-values

Spt_ID	Depth in meter 1	2	3	4	5	6	7	8	9	10	average N-value
BS1	3	3	3	10							5
BS2	5	2	8	18							8
BS3	2	2	25								10
BS4	3	0									1
BS5	27	0									13
BS6	4	6	9								6
BS7	3	8	9								7
BS8	3	4	7								5
BS9	2	0	4	6							3
BS10	5	6	11								7
BS11		0									0
BS12	4	4	8	5	14	16					8
BS13	3	3	11								6
BS14	4	7	15								9
BS15	4	14	5	8	6	7					7
BS16	3	5	9	9	12	5	4	15			8
BS17	4	6	10	14	2	4	10	14	21	14	10
BS18	0	0	10	5	7						5
BS19	4	7	6	20							9
BS20	3	2	7	11							6
BS21	6	14	15								11
BS22	6	6	8								7
BS23	5	4	7	10	12	14					9
BS24	4	17									11
BS25	8	15	19								14
BS26	5	7	19								10
BS27	2	15	22								13
BS28	4	3	4	7	17	28	28	21	21	27	16
BS29	4	10	12	12	14	21	13	12	3	4	10
BS30	6	5	6	15	25	24	2	5	4	13	10
BS31	4	5	12	24	36	32	32	33	24	34	24
BS32	5	9	21	13	16						13
BS33	4	5	12	14							9
BS34	1	6	5								4
BS35	4	9	15	31	23	23	19	8	3	3	14
BS36	6	13	10								10
BS37	6	11	16	10	15	19	2	9	7	6	10
BS38	39	19									29
BS39	4	3	10	8	3	10	15	17	16	25	11
BS40	5	15	10								10
BS41	3	22									12
BS42	2	2	1	27							8
BS43	3	6	10								6
BS44	0	2	7								3
BS45	6	4	19	24							13
BS46	2	4	3	15	19	25	20	24	19	19	15
BS47	3	5	4	13	34						12
BS48	2	3	0	33	26	30	38	12	19	6	17
BS49	4	7	18	15	16	21	23	25	4	3	13
BS50	1	4	25	22	22	19	18	14	17	4	15
BS51	5	9	13	10							9
BS52	3	13	22	13	18	17	30	31	17	4	17
BS53	3	12	7	20	33	36	48	21	9	6	19
BS54	4	5	7	32	39	32	11	33	17	15	19
BS55	6	2	8	24	8	11	36	3	3	4	10
BS56	2	5	6	23	18	38	38	6	23	25	18
BS57	5	4	68	68							36
BS58	2	4	12	12	21	23	21	15	12	3	12
BS59	4	12	23	20	12	15	18	24	19	20	17
BS60	10	18	15	18	6	13	24	4	3	14	12

Corrected N (N1)60 is obtained as
(N1)60=NM*CN*CE*CB*CR*CS , where
NM=N-value from field
CN=Over burden correction factor
CE=Hammer energy ratio correction factor
CB=Borehole diameter correction factor
CR=Rod length correction factor
CS= correction factor for samplers with or without liners

S.N	Layers	ρ(Ωm)	Thicknes s (m)	Depth (m)
BS5	1	1095	2.5	2.5
	2	462	16.3	18.8
	3	102		
BS7	1	489	1.0	1.0
	2	788	1.2	2.2
	3	3941	2.5	4.6
	4	483		
BS9	1	243	1.0	1.0
	2	475	11.8	12.8
	3	281		
BS13	1	868	1.0	1.0
	2	764	1.2	2.2
	3	1653	2.5	4.6
	4	93		
BS17	1	1447	0.9	0.9
	2	2071	6.6	7.5
	3	223		
BS28	1	436	0.6	0.6
	2	378	20.6	21.2
	3	179		
BS29	1	1149	0.9	0.9
	2	456	2.1	2.9
	3	1314	5.9	8.8
	4	231		
BS30	1	265	0.8	0.8
	2	157	2.8	3.6
	3	487	23.6	27.1
	4	83		
BS31	1	492	3.3	3.3
	2	4224	6.5	9.8
	3	602		
BS46	1	198	0.6	0.6
	2	175	8.5	9.1
	3	132		
BS49	1	1247	1.0	1.0
	2	334	0.7	1.7
	3	534	7.4	9.1
	4	138	33.9	43.0
	5	668		
BS53	1	607	3.1	3.1
	2	795	10.7	13.8
	3	111		
BS54	1	2049	1.1	1.1
	2	518	2.2	3.3
	3	739	14.6	17.9
	4	235		
BS58	1	2002	1.2	1.2
	2	637	11.8	13.1
	3	117		
BS60	1	1269	1.6	1.6
	2	318	7.9	9.5
	3	98		
CH-04	1	1798	1.4	1.4
	2	615	4.6	6.0
	3	142		

The result of the Vertical Electrical Sounding (VES) survey data taken at different locations within Bhadrapur Municipality is shown in the table. It shows the thickness of different layers of sub-surface sediments with their respective resistivity values.

S. n.	BHole ID	vs30 m/s
1	BS5	243
2	BS7	251
3	BS9	243
4	BS17	236
5	BS22	244
6	BS28	234
7	BS30	237
8	BS31	243
9	BS32	236
10	BS35	225
11	BS46	237
12	BS49	207
13	BS50	236
14	BS53	237
15	BS54	239
16	BS55	239
17	BS56	245
18	BS59	232
19	BS60	232

Average shear wave velocity

The average shear wave velocity (AVS30) from the ground surface to a depth of 30 m is globally used as an indicator to characterize seismic wave amplification. During the microtremor (ambient noise) survey, seven short-period seismometers (L22D; Sarcel, 2 Hz) were connected with a multi-channel data logger and data are recorded for at least 30 min at each site depending upon the background noise. The time series data are multiplexed and processed using the Centerless Circular Array (CCA) method (Yokoi, 2021) to derive the phase velocity dispersion curve. The AVS30 values are derived from the phase velocity dispersion curve of microtremor at 40m wavelength (Konno and Kataoka, 2000; Brown et al., 2000; Albarello and Gargani, 2010).

HORIZONTAL DATUM

Spheroid: Everest 1830
Projection: Modified Universal Transverse Mercator
Origin: Longitude 87° East
Latitude: 0° North
False co-ordinates of origin: 500000 m Easting
False co-ordinates of origin: 0 m Northing
Scale factor at Central Meridian: 0.9999

Subsurface Geology
Generally at the top there is 1 to 2.5m clay or siltyclay/claysilt followed by sandy pebble to pebbly sand layer of about 4 to 7m and then at the bottom there is fine material likely clay to silty clay and thickness varies from 0.5 to 2m.

GENERAL SYMBOLS

BA4 Auger Location with ID
BS4 SPT Location with ID
Village
85 Spot Height
Main Road
Branch Road
River/Stream
Sand
Contour (Index/Intermediate)
Bank cutting
Swamp

Contour Intervals 10 Meters
Supplementary contours at 5 meters
Reference: Mean Sea Level (India)

Topographical Base:
Contours lines, villages, spot heights, roads and river/streams extracted from topographic base maps Published by Survey Department, Nepal

Note:
Field survey done in Dec , 2019

Prepared by :

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DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu
2022

The study is exclusively intended for planning at regional scale.It should not be used as only basis of individual building foundations.

Figure 10: Engineering geological map of Bhadrapur Municipaliy

Applicability of Vertical Electrical Sounding (VES) for Engineering Geological Prospecting in Bhadrapur Municipality, Jhapa District, Province 1, Nepal

Thakur Prasad Kandel (Sr. Div. Geologist), Prakash Luitel (Geologist)

ABSTRACT

A short geophysical field study was carried out in Bhadrapur Municipality, Jhapa district, eastern Nepal to study the sub-surface information of Bhadrapur Municipality, using Vertical Electrical Sounding (VES). The survey was carried out at 30 different locations within Bhadrapur municipality and 2 profile of 2D-ERT also carried out during this field. IX1D software was used to analyse the Vertical Electrical Sounding field data which provide the resistivity of the sub-surface layers of the sediments. Among the 30 VES conducted, 14 were filtered out due to high RMS error, and only 16 points were selected for data analysis Most of the profile area lies on fine to medium grained sediments whereas some are in dry red soils. The sediment layers are differentiated on the basis of resistivity contrast. These layers are useful for planning and design of structure thus forming and integral part of engineering geological investigation.

Keywords: Vertical Electrical Sounding, Resistivity Layers, Geophysical Method

1. INTRODUCTION

1.1 Background

A short geophysical field study was carried out in Bhadrapur Municipality, Jhapa district, eastern Nepal from 2077-12-25 to 2078-01-13, to study the sub-surface information of Bhadrapur Municipality, using Vertical Electrical Sounding (VES) for engineering geological prospecting. This study was equally focused within Municipality. The VES study focused to identify the sub-surface information, sand, clay and gravel layer. These electric parameters with depth are useful for designing earthquake resistant building for proper landuse plan.

The electrical Resistivity Tomography (ERT) technique is used as geophysical methods in this study. It is an indirect geophysical technique that can be used to find out the details on the sub-surface. Electrical methods rely on electrical resistivity contrasts (Telford et al., 1990). Loose sediments and saturated sediments comparatively have lower values of resistivity as they struggle to host sediments. ERT is a geophysical method more applicable to prospected ground water level. During this field research, the geophysical data were acquired using GD10- Geomative instrument and the 31 VES profiles and 2 2D profile were done in this period. Topographic data for each profile is also measured by using DGPS surveys.

1.2 Objectives

The main aims of this study are as follows:

- To find out the sub-surface geological information and sediment thickness.
- To find out the groundwater level in the study area.

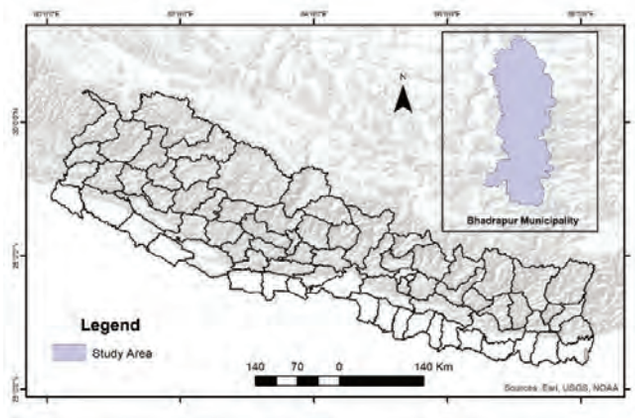

Fig. 1: Location map of the study area

1.3 Limitations

The field work was time-limited and thus the findings are not comprehensive. The VES study was concentrated in previously worked SPT and auger locations due to which the profile length was limited.

1.4 Methodology

The study comprises of desk study, field work, data analysis and interpretation. The published, unpublished papers and annual reports of the Department of Mines and Geology (DMG), related to engineering geological mapping was collected and reviewed. The regional geological maps, electrical resistivity techniques, topo-survey maps, and DMG annual program reports were reviewed before the field study.

The fieldwork mainly consists of geophysical survey for sub-surface information, mainly Vertical Electrical Sounding (VES). The sounding survey can detect different layers of unconsolidated materials (overburden), bedrocks, mineralization bands,

subsurface water channels due to the contrast of resistivity between subsurface materials. The ground resistivity is related to various geological parameters (Loke, 2004) such as sediments and fluid content, porosity, and degree of water saturation in the rock. The fundamental physical law used in resistivity surveys is Ohm's Law that governs current ground flow (Loke, 2004).

The apparent resistivity is expressed by ρ_s (expressed by R_0 in this machine) in Ω • m, which can be defined as:

$$\rho_S = K\frac{V_{MN}}{I}$$

Where, K is the device constant value, V_{MN} is the primary field potential difference between the potential electrodes M and N, and I is the current that is transmitted to the ground through the current transmitting electrodes A and B (fig. 2). The geometrical factor (K) is given by the formula:

$$K = \frac{2\pi}{\frac{1}{AM} - \frac{1}{AN} - \frac{1}{BM} + \frac{1}{BN}}$$

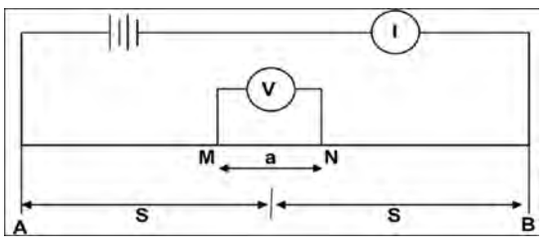

Fig. 2: Schematic diagram of Schlumberger configuration for data acquisition

2. OBSERVATION AND DATA COLLECTION

2.1 Geology and Land Use

Regionally, the study area lies in the Terai region of Easter Nepal. The study area mostly consists of cultivation area with heavy settlement at the present time (Fig. 3). The area is composed of alluvial sediments ranging from fine clay to coarse sand.

2.2 ERT Data Collection

The Vertical electrical sounding (1D ERT) survey was carried out at 30 different locations within Bhadrapur municipality and 2 profile of 2D-ERT also carried out during this field. Figures 4 shows the technique of VES data collection in the field. All sounding data were taken in Schlumberger array using GD 10 Geomative instrument. The figure 3 shows the landuse pattern of the study area and the red dots show the analysed VES points.

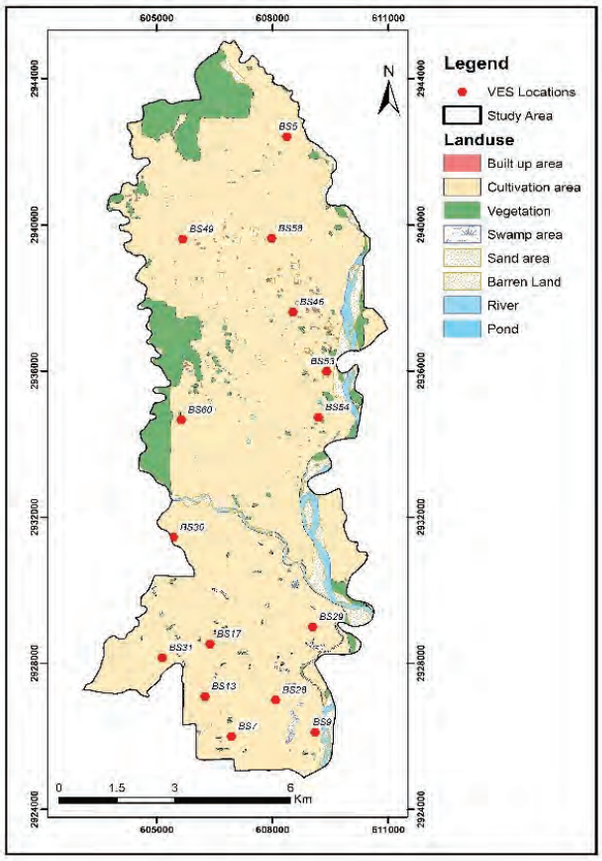

Fig. 3: Map of Bhadrapur municipality, Triangles shows the location point of Vertical Electrical Sounding (VES).

Fig. 4: Photograph showing the electrical data collection in Bhadrapur Municipality.

The location of the sounding is pre-defined (SPT/Auger Point). DGPS survey was also conducted for collecting the topographic data of each profile (Fig. 5). The profile length of the survey depended on the local conditions, such as buildings, cannels, black-topped road, and so on.

Fig. 5: Photograph showing the topographic data collection in Bhadrapur Municipality.

3. DATA ANALYSIS AND RESULT

IX1D software was used to analyse the Vertical Electrical Sounding field data which provide the different resistivity of the sub-surface layers of the sediments. This software is useful for 1-D Direct Current (DC) resistivity, Induced Polarization (IP), Magnetotelluric (MT) and electromagnetic sounding inversion program.

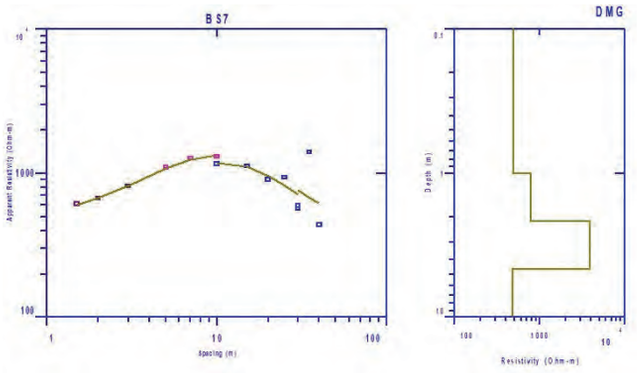

Fig. 6: Graphical representation of apparent resistivity from BS7. [rectangles represent the apparent resistivity and the line shows the best fitted curve.]

The sub-surface layers of collected data were estimated using IX1D software. Among the 30 VES conducted, 14 were filtered out due to high RMS error, and only 16 points were selected for data analysis. These selected points are shown in figure 3. Figure 6 shows the graphical representation of collected resistivity data using IX1D and figure 7 shows the sub-surface layers of these data by resistivity values.

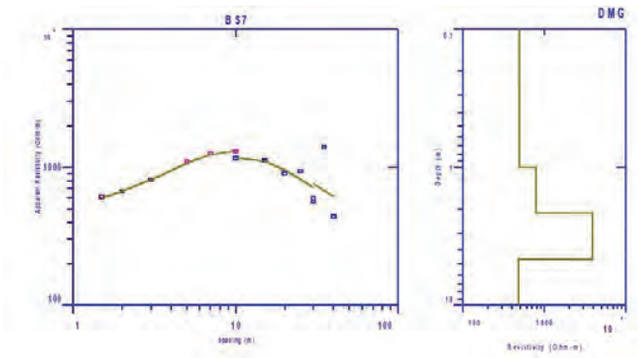

Fig. 7: Inversion result of apparent resistivity curve from BS7 showing different layers of subsurface sediments with respect to their resistivity values using IX1D

The collected data were processed using IX1D software and obtained resistivity inversion graphs with different resistivity layers. These inversion images show the final result of each VES data points. Due to noise (high residence, electrical lines) some VES points have high RMS error, which are excluded from the final analysis. The final result of VES data inversion is presented in Table 1.

Table 1: Final Result of VES survey in Bhadrapur Municipality, Jhapa

S. N	Northing	Easting	Layers	ρ (Ωm)	Thickness (m)	Depth (m)
BS5	2942344	608157	1	1095	2.5	2.5
			2	462	16.3	18.8
			3	102		
BS7	2925970	606932	1	489	1.0	1.0
			2	788	1.2	2.2
			3	3941	2.5	4.6
			4	483		
BS9	2925609	607772	1	243	1.0	1.0
			2	475	11.8	12.8
			3	281		
BS13	2927080	606326	1	868	1.0	1.0
			2	764	1.2	2.2
			3	1653	2.5	4.6
			4	93		
BS17	2928508.2	606393	1	1447	0.9	0.9
			2	2071	6.6	7.5
			3	223		
BS28	2926940	608120	1	436	0.6	0.6
			2	378	20.6	21.2
			3	179		
BS29	2928979	609046	1	1149	0.9	0.9
			2	456	2.1	2.9
			3	1314	5.9	8.8
			4	231		
BS30	2931418.8	605440	1	265	0.8	0.8
			2	157	2.8	3.6
			3	487	23.6	27.1
			4	83		
BS31	2928138	605117	1	492	3.3	3.3
			2	4224	6.5	9.8
			3	602		
BS46	2937615	608513	1	198	0.6	0.6
			2	175	8.5	9.1
			3	132		

S. N	Northing	Easting	Layers	ρ (Ωm)	Thickness (m)	Depth (m)
BS49	2939619.2	605696	1	1247	1.0	1.0
			2	334	0.7	1.7
			3	534	7.4	9.1
			4	138	33.9	43.0
			5	668		
BS53	2935947.5	609422	1	607	3.1	3.1
			2	795	10.7	13.8
			3	111		
BS54	2934718.5	609190	1	2049	1.1	1.1
			2	518	2.2	3.3
			3	739	14.6	17.9
			4	235		
BS58	2939629	607976	1	2002	1.2	1.2
			2	637	11.8	13.1
			3	117		
BS60	2934685	605698	1	1269	1.6	1.6
			2	318	7.9	9.5
			3	98		
CH-04	2939678	604230	1	1798	1.4	1.4
			2	615	4.6	6.0
			3	142		

4. DISCUSSION AND CONCLUSION

Different sediment layers based on resistivity contrasts, their thickness and depth from surface is shown in table 1. Most of the surface sediments are relatively dry during survey period due to the seasonal condition.

The resistivity of soil decreases significantly with increase in density (Seladji et al, 2010). Most of the profile area lies on fine to medium grained sediments whereas some are in dry red soils. The resistivity value at the top layer of sediments ranges from 198 (BS46) to 2049 Ωm (BS54) as shown in Table 1. This suggests the presence of unconsolidated and dry sediments at the top layer.

The lower resistivity value indicates the presence of the saturated condition in the unconsolidated soil while the higher values represent the dry and hard consolidated sediments (Drahor et al, 2006). In our observation, sites BS5, BS28, BS46, BS53, BS58 and BS60 have relatively low resistivity at the third layer whereas sites BS13, BS30, BS49 have lower resistivity in the fourth layer at different depths as compared to other layers (Table 1) suggesting the saturated condition. The resistivity of expected saturated layers ranges from 83 to 179 Ωm.

Relatively, clay sediment has lower resistvity as compared to sand and gravels (Telford and Sheriff, 1984, Keller and Frischknecht, 1996). The higher resistivity values at middle layers as compared to the top and bottom layers represent the coarse-grained sediments.

The result of geophysical investigation using Vertical Electrical Sounding (VES) is capable of finding different sub-surface layers on the basis of resistivity contrast. This information is useful in planning and design of engineering structure on any geological material and forms an integral part of engineering geological mapping.

ACKNOWLEDGMENTS

First of all, we are grateful to Mr. Ram Prasad Ghimire (Director General), and Dr. Rajendra Prasad Bhandari (former Deputy Director General), Department of Mines and Geology for providing us all support and guidance. We are extremely thankful to Dr. Mukunda Bhattarai, Seismologist for accompanying the field work.

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Microtremor Array Exploration in the Rapti Rural Municipality of Dang District

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ABSTRACT

Earthquakes are the most destructive geological phenomena in the Himalaya. The seismic waves that can cause destruction on the ground depend on the source effect including magnitude, rupture process, etc., the path effect governed by the propagation from the source, and the site effect controlled by ground conditions around sites. Each new destructive earthquake gives further proof of the importance of the site conditions in parallel with the other two. This site effect, i.e., how local geological or geomorphological conditions amplify the seismic waves, can be prospected before the disaster occurrence. The amplification of seismic waves due to local geological and geomorphological conditions is one indispensable component for seismic hazard assessment. Over the last decades, microtremors (ambient noises) have been used as an efficient tool for the spatial variability of seismic site response, as it is convenient and affordable for usage in urbanized areas, environment friendly as well as a more advanced array exploration technique.

The time averaged shear wave velocity for the upper 30 m depth (Vs30) is the most commonly used parameter to evaluate seismic wave amplification. Rapti Rural Municipality (RRM), the province capital of Lumbini province located in Dang district is a rapidly expanding city filled with fluvial sediments on the basement rocks of Siwalik sedimentary unit. The present study aims to access the seismic site effect of RRM based on microtremor array techniques.

We have conducted short and long period Microtremor array measurements in RRM with about 1 km by 1 km grid interval and analyse data using Spatial AutoCorrelation (SPAC) as well as Centerless Circular Array(CCA) methods. SPAC analysis gives the large uncertainty in the deep 1-D shear wave velocity profile whereas, the Vs30 of the study area falls between 243 m/s to 541m/s based on Konno and Kotaoka 2000. The sediments in the study area are characterized by site class D (180-360 m/s) and site class C (360-760 m/s) based on the provision in the National Earthquake Hazards Reduction Program (NEHRP)

Keywords: (Microtremor, Site effect, VS30, CCA, SPAC, Phase velocity dispersion curve)

INTRODUCTION

The Nepal Himalaya occupies one third of the whole Himalayan arc length, about 800 km of the Himalayan range. The Indian plate in the south is moving northward at a convergent rate of about 40 mm/yr relative to Eurasia, half being accommodated by shortening through the Himalayas (e.g., Lavé and Avouac, 2000; Jouanne et al., 2004; Bettinelli et al., 2006; Ader et al., 2012). However, its continental lithosphere is too buoyant to subduct so that it is colliding with the Eurasian plate in the north generating large earthquakes and forming steep mountains in the Himalayan region including Mount Everest (8,848 m). Historical earthquake shows that despite the earthquake source and path characteristics, site-specific geological and geomorphological conditions influence on the damage and severity caused by an earthquake. In addition, the local geological conditions strongly influence the seismic ground motion (amplification, deamplification) at a site, and the soil characteristics significantly affect the severity of ground shaking. The damage caused by an earthquake on the ground surface is called the site effect. A review of the early history of site effect studies was given by Sanchez-Sesma and Crouse (2015). The variation of ground motion with depth at various soil conditions were first investigated in Japan using ground displacement records (Milne, 1887). After the pioneering work by Japanese scientists/Engineers in the 19th century in Japan, microtremor has been used as an efficient tool for site characterization studies worldwide. The surface of the earth is always in motion without an earthquake. Microtremors (ambient noise/vibration) are the ground vibrations far below than human sensing having displacement amplitude (10-4 to 10-2 mm) and mainly caused by anthropogenic activities, machinery, traffic etc., that can be observed at anytime and anywhere by short and long period seismographs/geophones. Short period (high frequency) microtremors falls within the frequency range (1-10Hz) and beyond the upper frequency. They are mainly caused by anthropogenic activities, machinery, vehicle etc., whereas long-period (low frequency) type (0.1-1Hz) microtremors are mainly caused by the perturbation in oceans, tidal activities, atmospheric changes etc., and distant observations of long period waves are captured by broad band seismographs mainly at overnight

deployment. We performed microtremor observation in Rapti Rural Municipality (RRM) of DANG district to accomplish annual field program FY (2079/2080). For the observation, we choose the sites on both sides of the east west highway unevenly based on availability of open space, avoiding the wet land, running water, possible voids etc. The data collected from tri-axial seismographs are used to calculate the predominant period and site amplification; however, by the recent advancement in the geometry of seismographs in arrays give shear wave velocity structures and average share wave velocities from the ground surface to the depth of 30 m can be explored.

LOCATION, ACCESSIBILITY AND SURVEY POINTS

Dang district is located in Lumbini province and falls in the inner Terai of Midwestern Nepal. The bordering districts of Dang are Pyuthan, Rolpa and Salyan to the north, Uttar Pradesh of India to the south, Arghakhanchi and Kapilvastu to the east and Surkhet and Banke to the west. The district headquarter of Dang is Ghorahi. Dang district consists of two sub-metropolitan cities, one municipality and seven rural municipalities. Our study area lies in Rapti Rural Municipality (RRM) of Dang district (Figure 1). This Rural Municipality is divided in to 9 wards and some of the wards towards south have high risk of flood during monsoon along the Rapti River. Whereas, some sites in the northern part are covered by vegetation and not easily accessible by the motor able road. We can reach RRM by road travel in a single day from Kathmandu.

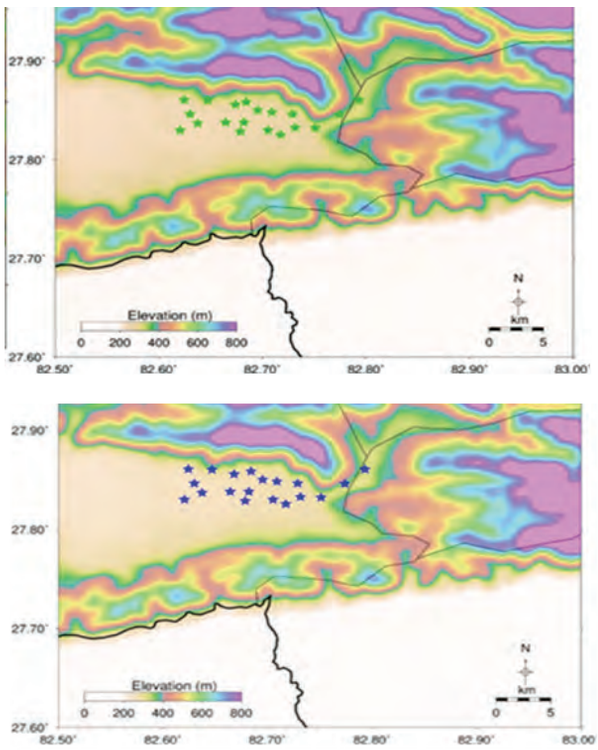

Figure 1: a) Location of microtremor survey taking into account for Centerless Circular Array (CCA) method; b) Survey location for Spatial Auto-Correlation (SPAC) method

OBJECTIVE OF THE STUDY

The main objective of this study is to estimate the time averaged shear wave velocity (Vs) up to the depth of 30 m beneath the surveyed sites (Vs30) and to classify the sites based on National Earthquakes Hazard Reduction (NEHRP) site classification. The auxiliary objective is to determine the deep shear wave velocity (Vs) structure up to the engineering and seismic bedrocks.

EQUIPMENT USED FOR THE SURVEY

During this study, the probable survey sites were plotted in the google earth map in approximately 2 km*2 km grid sizes. Before survey these sites were visited and if the site falls in the private property negotiation is done for the permission. The equipment and setting for SPAC and CCA observations are listed in Tables 1 and 2 respectively.

Table 1: Summary of the equipment used for the SPAC field observation

Seismometer	Data Logger
(CMG40T (Guralp Systems Ltd) , 3-components)	Data Mark (LS8800) Hakusan Co. Ltd Japan
Frequency range from (0.03 Hz) 33.3 s to (50 Hz) 0.02 s	3-components, GPS synchronized Clock,
Sensitivity: 2*400 V/m/s	A/D converter: 24 bits, Dynamic range: 128 dB

Table 2: Summary of the seismometer and setting of the digitizer for CCA field observation

Seismometer	Data Logger and setting
Sercel L22D vertical component	McSeis/SW 24 Channel
Frequency range 2 Hz	Sampling rate 2000 micro second
	Data length 16384 samples
	Record length 32.768 second
	Trigger level 10% or less

BASIC PRINCIPLE FOR SPAC METHOD

The Spatial Auto-correlation (SPAC) Method for regular shaped array is a method to estimate phase velocity of surface waves that come from various directions using bi-dimensionally deployed array of seismographs. The concept of the SPAC method is based on assumptions that microtremors are a spatiotemporally stationary stochastic process and also the wave field consists of dispersive waves propagating along the free surface (Aki 1957; 1965, Okada 2003, Yokoi and Margayan 2008). The SPAC method requires a circular array (Figure 2) that consists of evenly spaced sensors (usually three sensors) on the circumference of a circle and one sensor at the center point as shown

in Figure 2 based on the side length and radius. The SPAC coefficient is obtained by the azimuthal average of coherency between microtremor records observed by two sensors. According to Okada (2003), the SPAC coefficient at angular frequency ω between microtremors observed by two sensors in different

$$\rho(r_{AB},\omega)=\frac{1}{2\pi}\int_0^{2\pi}\exp\{irk\cos(\theta-\emptyset)\}\,d\theta=\frac{1}{2\pi}\int_0^{2\pi}\frac{Re\left(E\left[C_{A,B}(\omega)\right]\right)}{E\left[C_{A,A}(\omega)\right]}d\theta=J_0(kr) \quad (1)$$

locations A(0,0) and B(r,0) is written as:

where E[□] and Re in the third member of the equation denotes the ensemble average over time block and the real part of a complex coherence function, respectively. CA,A(ω)) is the power spectrum of sensor at A and CA,B(ω) is the cross-spectrum between sensors at A and B. J0(kr) in the fourth member of the equation is the Bessel function of the first kind of zero order. The Vs profile is finally estimated using the derived dispersion curve in the inversion analysis. The inversion take place by two different kinds of inversion methods (Yokoi, 2005): the downhill simplex method (DHSM, e.g., Press et al. 2007) and the very fast simulated annealing (VFSA) method (Ingber, 1989) to find optimal values of Vs and thickness of each sedimentary layer. The P-wave velocity (Vp, m/s) of each layer is estimated using the empirical relationship between Vp and Vs for sedimentary layers saturated by underground water (Ludwig et al., 1970).

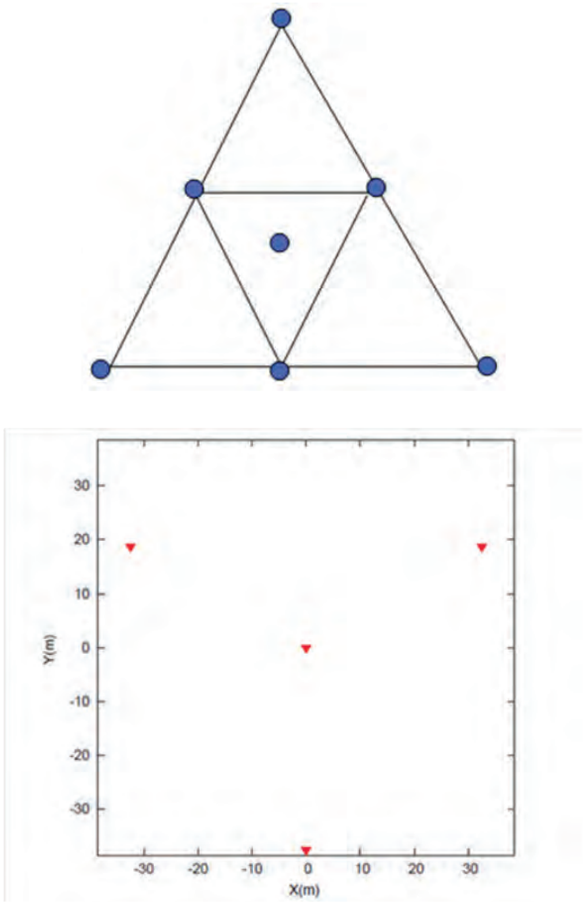

Fig. 2: Geometry of the equilateral triangular array for SPAC method (left) at site SPAC1 with 30 m side length (right). Broadband seismometer CMG40T (Guralp) and digitizer LS2200 (Datamark)

BASIC PRINCIPLE FOR CCA METHOD

The CCA method originally proposed by Cho et al. (2004, 2006) is based on the theory of circular array given by Henstridge (1979) and stands for the Fourier transform of microtremor wavefield over the azimuth. This method is quite similar to the circular array of the SPAC method, but without any sensor located at the center of the circle and based on a completely different principle. The CCA coefficient is given by the spectral ratio of the power of the zero order Fourier coefficient over azimuth to that of the first order. It is expected to converge to the known function as follows,

$$s(r,\omega)=\frac{PSD\left\langle\int_{-\pi}^{\pi}Z(t,r,\phi)\,d\phi\right\rangle}{PSD\left\langle\int_{-\pi}^{\pi}Z(t,r,\phi)\exp(-j\phi)\,d\phi\right\rangle}=\frac{J_0^2(r\omega/c)}{J_1^2(r\omega/c)} \quad (2)$$

where PSD<> denotes the power spectral density, J0 ( ) and J1( ) the zero and the first order Bessel functions of the first kind, r the radius of circular array, w the angular frequency, c the phase velocity of Rayleigh waves, j the azimuth from the center of the array to a station on the peripheral circle, Z(t, r, j) time history of vertical component of microtremor observed at distance (r,j) and time t. The calculation of the CCA coefficient was done in the frequency domain using the following formula:

$$s(r,\omega)=\frac{\sum_{i=1}^{M}\sum_{k=1}^{M}\left[C_{ik}(r,\omega)\right]}{\sum_{i=1}^{M}\sum_{k=1}^{M}\left[C_{ik}(r,\omega)\right]\exp\left[-j(\phi_i-\phi_k)\right]} \quad (3)$$

Where, Cik(r,w) denotes the cross spectra of the records obtained at the i-th and the k-th stations. During this study we set the geometry of seismometers as shown in Figure 3.

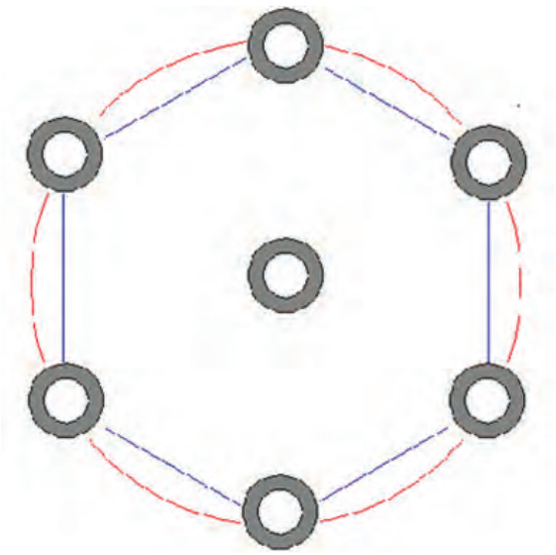

Fig. 3: Geometry of the field deployment is shown in a hexagonal array of 6 short period seismometers (Sercel L22D) with one seismometer at the center having radius 2m

DATA ANALYSIS AND RESULTS FOR SPAC METHOD

We analyzed the data using Spatial Auto Correlation (SPAC) method (Yokoi 2020). First the vertical component data from 4 individual seismometers were multiplexed (Figure 4a), resampled to the sampling interval 0.25 sec for reducing the file size and processing time too, and divided into the time blocks of 1024 samples. (Figure 4b) shows the power spectra. The time blocks were screened out if they contain impulsive noises caused by traffic or significantly big root-mean-square (RMS) amplitude. Then, the cross spectra were calculated for the selected interstation distances with padding zeros for having a sufficiently fine frequency interval. The coherence functions, i.e., the real part of the cross spectra of the same interstation distance averaged over azimuth gives the SPAC coefficient curve. The SPAC coefficient curves of the Site SPAC1 shows normal (Figure 4d) feature without any significant disturbance. The dispersion curve was determined by searching the minimum of the misfit function given by the L2-norm of the difference of these observed SPAC coefficient curves from the theoretical one J0(rw/c(w)) calculated over the frequency - phase velocity panel, where high misfit values are truncated and uniformly painted yellow (Figure 4e). The estimation of Vs structure was performed using a combination of the Very Fast Simulated Annealing (VFSA, Ingbar 1989)) and the Down Hill Simplex Method (DHSM, Nelder and Mead 1965), (Yokoi 2005) as shown in (Figure 4f).

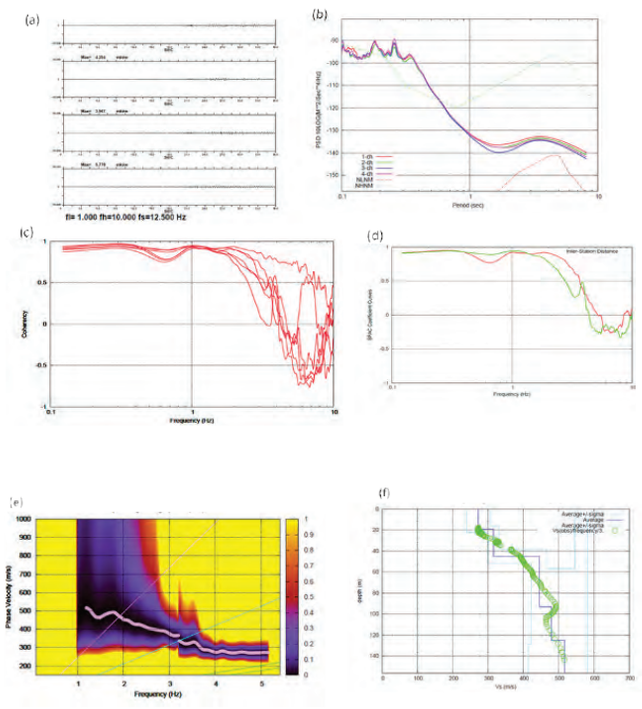

Fig. 4: (a) Multiplexed waveform , (b) power spectra (c) Coherence (d) phase velocity dispersion curve(e) SPAC coefficient (f) shear wave velocity structure obtained from SPAC1 site in an equilateral triangular array of side length 30 m

DATA ANALYSIS AND RESULTS FOR CCA METHOD

Wave forms from seven sensors are multiplexed and resampled to associate the seven channels together in a time sequential manner (Figure 5a). The fourier spectra and power spectra are shown in (Figures 5b abd 5c). The noisy part on the waveform is reduced by applying the screening techniques (ajude and a_ sigma) and the remaining blocks from screening are used for calculating the CCA coffecient to derive the phase velocity dispersion curve. (Figure 5d) shows the coherence of all seven channels used . The observed dispersion curve is shown in (Figure 5e), The shear wave velocity structure is constructed by applying the Heuristic search technique (inversion) on the assumed initial velocity model using the combined metods of DHSM (Down Hill Simplex: Nelder and Mead, 1965) and VFSA (Very Fast Simulated Annealing: Ingber, 1989) is shown in Figure 5f. multiplexed/resampled waveform (Figure. 2), Coherence (Figure.5d) dispersion curve (Fig. 5) and the derived structure (Figure. 5f) respectively are shown below.

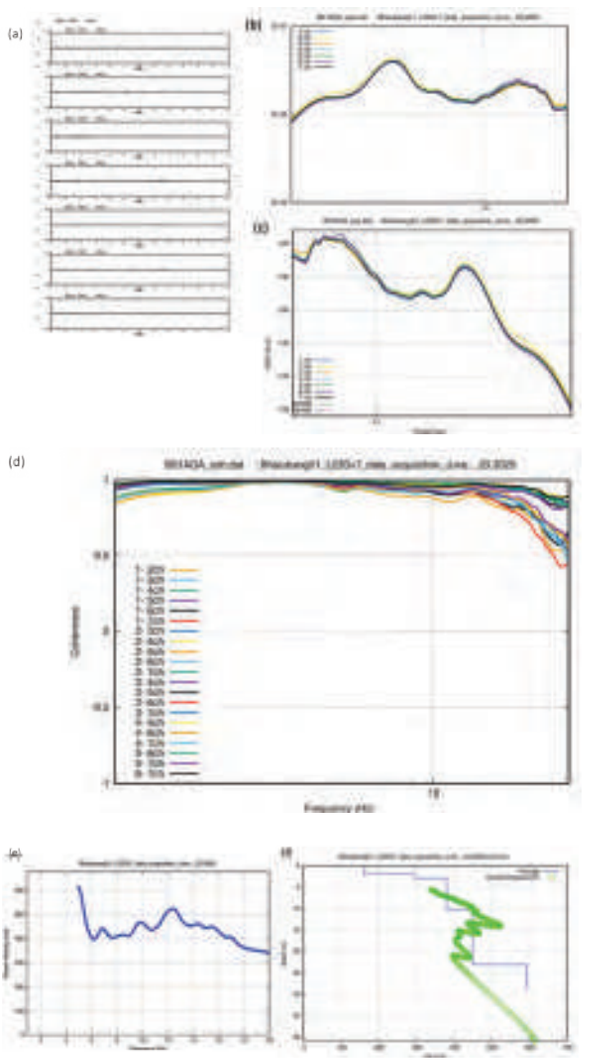

Fig. 5: (a) Multiplexed waveform (b) flourier spectra (c) power spectra (d) coherence (e) coherence (f) phase velocity dispersion curve (g) shear wave velocity structure of the site CCA1

Table 3. Results of the CCA analysis of all sites

Site No.	Latitude	Longitude	Vs30 (m/s)	NEHRP Class
CCA1	27.832857	82.731606	440	C
CCA2	27.848423	82.709115	329	D
CCA3	27.828805	82.678751	365	C
CCA4	27.838178	82.682241	454	C
CCA5	27.825816	82.661672	492	C
CCA6	27.824505	82.649061	475	C
CCA7	27.843632	82.649989	495	C
CCA8	27.858626	82.684423	243	D
CCA9	27.855718	82.668261	437	C
CCA10	27.860348	82.646997	440	C
CCA11	27.860851	82.624436	367	C
CCA12	27.830191	82.620696	367	C
CCA13	27.83712	82.637464	----------	----------
CCA14	27.860652	82.793341	466	C
CCA15	27.846175	82.774129	541	C
CCA16	27.838092	82.664507	474	C
CCA17	27.846504	82.729003	335	D
CCA18	27.838092	82.664507	474	C
CCA19	27.830135	82.705437	309	D
CCA20	27.825702	82.717605	418	C
CCA21	27.846499	82.630173	438	C
CCA22	27.850272	82.695507	444	C

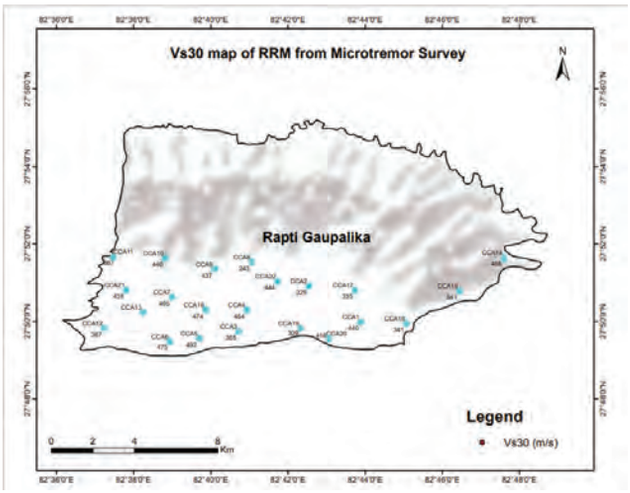

Fig. 6: Vs30 map of the study area obtained from CCA analysis

RESULT AND DISCUSSION

The long period microtremor measurement results for less than an hour during day time with side length 30 m in the geometry of equilateral triangle shape array at site SPAC1 did not grow the phase velocity in the dispersion curve above 500 m/s (Figure 5e). The inverted Vs structure shows huge uncertainty in the deeper structure below about 30 m depth (Figure5f).

From the CCA analysis we calculated the average shear wave velocity (Vs30) up to the 30m depth from the phase velocity dispersion curve without taking into account the geological information by using direct method of Konno and Kataoka 2000. Vs30 result (Table 3; Figure 6) demonstrates that the Vs30 values for the study area vary between 243 m/s to 541 m/s. Based on the NEHRP provisions sites 2, 8,17 and 19 are categorized into site class D (180-360 m/s) within the study area, whereas remaining other sites falls in site class C (360-760 m/s).

CONCLUSION AND RECOMMENDATION

Microtremor array analysis techniques mainly Spatial AutoCorrelation (SPAC) and Centerless Circular Array (CCA) methods (Yokoi 2020) have been applied for seismic site evaluation in Rapti Rural Municipality (RRM) of Dang district. Four three component broad band seismographs (Guralp CMG40T) and seven one component (vertical) short period seismometers (Sercel L22D, 2 Hz) were deployed in an array to measure the ground excitation by microtremors at approximately 1000 m × 1000 m grid interval. Some of the planned sites could not exactly reached due to rice planting time, running water, wet land, forest and bushes. The study area covered both North-South part of the RRM from the East-West Mahendra highway. Microtremor array data were analyzed to calculate the shear wave velocity structure and average shear wave velocity of upper 30 m depth (Vs30) of subsurface sedimentary layers, respectively. The Vs30 values from the phase velocity dispersion curves were estimated from (Konno and Kataoka 2000).

- The huge uncertainties in the underground deep structure is obtained from SPAC analysis at site SPAC1.
- The average shear wave velocity (Vs30) of the upper 30 m soil column falls in the ranges from 243 m/s to 541 m/s based on Konno and Kotaoka 2000.
- Based on this study the observed Vs30 values soil deposits of Rapti Rural Municipality of Dang district can be classified into site class D (180-360 m/s) and site class
- C (360-760 m/s) according to the provision in NEHRP.
- Majority of the study area falls in Site class D based on NEHRP classification.
- The Vs30 value at site CCA13 could not be reached, further studies are needed at around this site. It might be due to insufficient data recording, seismometers not well coupled on the ground or any other geological or geomorphological uncertainties.

It is recommended to gather subsurface information at some of the drill hole sites in and around RRM and revise the initial model for inversion to obtain fine structure. It is also recommended to have such surveys during the dry seasons to avoid the variations

in water table. Further interpretation is needed based on geological information.

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Tracing of Budar Fault and Neo-Tectonics Study in Dadeldhura and Doti District

Dr. Lok Bijaya Adhikari (Senior Divisional Seismologist), Mr. Bal Bahadur Tamang (Seismologist)

ABSTRACT

Himalaya was formed by the collision of the Indian Continent and the Eurasian continent about 40 million years ago i.e. Indian continent has been subducting underneath the Eurasian continent. Nepal lies in the central part of the Himalayas and one of the seismically active zones of the world where the Indian continent has been moving underneath of Eurasian continent by 21.5 ± 1.5 mm/yr in Central Nepal and 19 ± 6 mm/yr in Western Nepal. Neotectonics is the sub-discipline of tectonics, the study of the process of recent tectonic deformation and tectonic geomorphic evolution of the earth. Neotectonics and active tectonics for seismic hazard assessment a significant aspects of earthquake geology work. In Central Himalaya, MBT, MFT, blind thrust, and other transverse thrusts are active, which are the splays of active Main Himalayan Thrust (MHT). The study area lies between the Dadeldhura and Doti districts of Parshuram Na. Pa., Aalital Ga. Pa., Jorayal Ga. Pa., Chure Ga. Pa., Badikedar Ga. Pa., and Mohanyal Ga. Pa. and boundary area covered by 28.671˚, 80.288˚ to 29.113˚, 80.189˚ coordinates. The main objectives of this research are Budar Fault tracing, Neo-tectonic study, and charcoal collection in the Rangun Khola Terrace. There are five levels of terrace in the Rangun Khola area. The main lithology of this area is alluvial soil, and parent rocks are Granites, Quartzites, Phyllites, Sandstones, and Amphibolite. Lithological characteristics illustrate high current fluvial activity. The collected charcoal samples were tested, and the result hasn't been received yet. Geologically this area is covered by the lower Siwalik to Syangja formation. Budar fault is passed through Thuligad Khola, Thuligad Khola to NW direction of Kamala Khola, Chhattiwan Taal, Budar and Chainpur, Siradi, Sayen Gaun, and Aalital Pond.

Keywords: (Neotectonics, Active faults, Budar Fault, Charcoal Sampling)

1. INTRODUCTION

Himalaya is an Active Mountain in the world which is formed by the collision of the Indian Continent and the Eurasian continent 40 million years ago i.e. Indian continent has been subducting underneath the Eurasian continent. Nepal is lies in the central part of the Himalayas and one of the active zones of the world where the Indian continent has been moving underneath of Eurasian continent by 21.5 ± 1.5 mm/yr in central Nepal (Lavé and Avouac 2000) and 19 ± 6 mm/yr in western Nepal(Husson, Mugnier, and Leturmy 2004). The consequences of collision, four major tectonic structures formed along the East–West trend Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), Main Central Thrust (MCT), and South Tibetan Detachment System (STDS). Based on the major tectonic structures Nepal has been divided into five geological units from south to North such as Terai, Siwalik, Lesser Himalaya, Higher Himalaya, and Tethys Himalaya (Dhital 2015). Neotectonics are the sub-disciplines of tectonics, the study of the process of recent tectonic deformation and tectonic geomorphic evolution of the earth. Neotectonics and active tectonics for seismic hazard assessment a significant aspects of earthquake geology work(Wu and Hu 2019). Neo-tectonic movements deform or offset streams and river courses, they also dislocate river terraces, alluvial fans, and ancient erosion surfaces. In major east-west trending tectonic structures, MBT and MFT are tectonically active whereas the other two are passive. However, many transverse and blind faults and thrusts are active in the Nepal Himalayas. However, MHT is the main active fault in the Himalayas and Nepal. It occurs at a depth of 20 to 25 km and all other active faults are splays of the MHT (Nakata 1989). In addition, in the eastern and western Himalayas, consistent uplift of the Himalayas has taken place due to north-dipping imbricate thrust though in Central Himalaya MBT is relatively straight i.e. a steep dip near the surface. Nakata 1989 classified Nepal's thrusting and faulting system into the Main Central Active Fault System, Main Boundary Active Fault System, Main Frontal Active Fault System, and other individual active faults. The Main Boundary Active Fault System is one of the most conspicuous in the Himalayas. It stretches throughout the Nepal Himalayas along the border of the Siwalik and Lesser Himalayas. It is represented by a chain of discontinuous active faults of up to 100 km in length interrupted by active sections. The Rangun Khola and Surkhet-Ghorahi faults are some examples of the Main Boundary Active Fault System (Dhital 2015). Budar Thrust is a normal fault marked by many sag ponds and it affected by the Main Boundary Active Fault system (Dhital 2015). This trust is named in India by Krol Thrust, Main Boundary Thrust, Chail nappe, or Ramgarh Thrust and it extend across the Mahakali River upto Budar and beyond.

1.1 Location and Accessibility

The study area lies between Dadeldhura and Doti

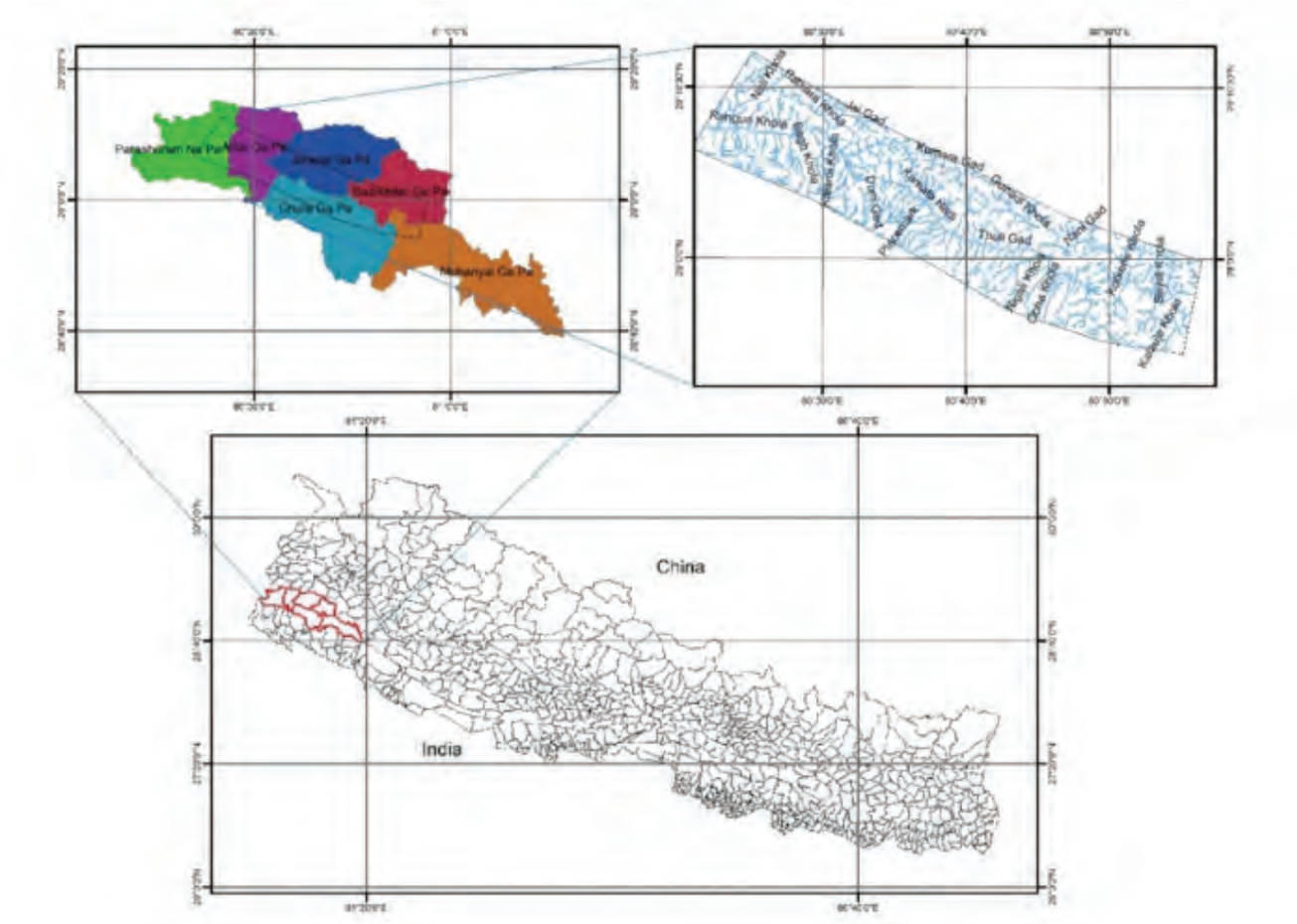

Fig. 1: Study area

districts of Parshuram Na. Pa., Aalital Ga. Pa., Jorayal Ga. Pa., Chure Ga. Pa., Badikedar Ga. Pa., and Mohanyal Ga. Pa. and boundary area covered by 28.671˚, 80.288˚ to 29.113˚, 80.189˚ coordinates. Bhimdatta highway is the main highway connected by Attariya kailali to Darchula. In addition, the gravel road is connected to the study area. The study area is shown in Figure 1. The altitude ranges from 402 m to 1274 m above mean sea level. The study area's climate falls within the subtropical zone. The primary drainage system comprises Rangun Khola, Thuli Gad Khola, and their tributaries. The overall drainage pattern of the study area is dendritic.

1.2 Geological Setting of the study area

Nepal Himalaya has been divided into five distinct tectonic units separated by major thrust faults. From south to north they are the Main Frontal Thrust (MFT), the Main Boundary Thrust (MBT), the Main Central Thrust (MCT), and the South Tibetan Detachment System (STDS) respectively (Upreti 1999). Among them, the South Tibetan Detachment System (STDS) is a low-angle normal, and all the remaining are reverse faults. These structures divide Nepal Himalayas into five major tectonic units from South to North, the major tectonic units are Terai, Siwalik, Lesser Himalaya, Higher Himalaya, and Tibetan-Tethys Himalaya. Geologically this study area covered the lower Siwalik to Syangja Formation (DMG 1985). Most of the faults in this study area passed along the Lower Siwalik, Sangram Formation, and Syangja Formation as shown in figure 2. Lower Siwalik is made up of dark brown to greenish brown or bluish grey sandstones, and sandstones are interbedded with purple, dark reddish brown, and green-grey shales. The study area of lower Siwalik consists of fine-grained sandstones and mudstone, ranging in thickness from a few meters to tens of meters, in almost equal proportions. Similarly, just above the lower Siwalik it continues lesser Himalayan rock sequences and in the study area, it consists of pale green to white Quartzites alternating with green Phyllites.

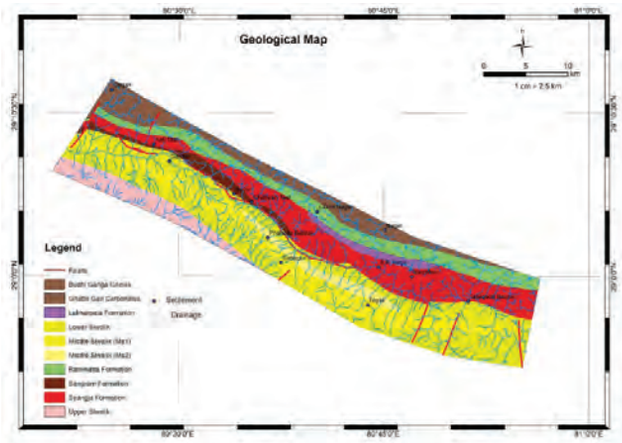

Fig. 2: Geological Map of the study area with drainage system.

2. OBJECTIVES

The main objectives of this research are Budar Fault tracing, Neo-tectonic study, and charcoal collection in Rangun Khola terrace.

3. MATERIALS AND METHODS

During this study, budar thrust was first mapped based on topographic maps, geological map, areial photographs, and google earth maps. Further evidence was collected by detailed field investigations from B P nagar Doti to Aalital gaunpalika Dadeldhura. To varrifing the Budar thrust and geology of this area was carried out by field obsservations around those area and traverse mapping along the budar thrust. During the field, efforts were specially made to clarify the mode and sense of active faulting through observation of tectonically produced landforms and other evidence of late quaternary faulting. In order to verify the active fault system in this area we traced quaternary deposited terraced mapping in Rangun Khola valley. The amount of fault displacements was also measured in the fields. Charcoal samples for radiocarbon dating were collected from every terrace by pit logging.

4. OBSERVATION

The fieldwork was done from B P Nagar, Doti to Aalital gaun palika Dadeldhura. Geologically this area is covered by the lower Siwalik to Syangja formation. During Budar fault tracing field work we observed 33 points of various places in Dhadeldhura, Kailali, and Doti districts as illustrated in table 1. Budar fault passes through Thuligad Khola, Thuligad khola to NW direction of Kamala khola, Chhattiwan Taal, Budar and chainpur, Siradi, Sayen Gaun, and Aalital Pond. We observed Greyish coloured highly crushed brecciated rocks, various sag ponds, mylonite, saddles, piggy bag structures, terraces etc. Some of the photographs taken in the field are shown in figure 3.

Table 1: Field observation data along Budar Fault

S.N	Location	Latitude	Longitude	Attitude		Lithology
				Dip Direction	Dip Amount	
BF01	Belbhadi	29.108232	80.530478			Greyish Color, fine grained to medium grained highly crushed breccia
BF02	Rajauda	29.103284	80.540284	74	42	Greyish Color, fine grained to medium grained highly crushed shale
BF03	Rangun Khola	29.13051297	80.49819096	-	-	Terrace
BF04	Aalitaal Pond	29.13983671	80.47046002	-	-	Highly Crushed Quartzite and Phyllite
BF05	Sayen Gaun	29.12637826	80.50331302	-	-	The fault line, Shaddle With - 39.90 m
BF06	Sayen Gaun	29.12338764	80.505202	-	-	The fault line, Shaddle
BF07	Sayen Gaun	29.12210545	80.50675898	-	-	Highly crushed breccia
BF08	Sayen Gaun	29.11792617	80.51240014	-	-	greyish coloured, fine grained mylonitic rock
BF09	Siradi Gaun	29.11665928	80.51561223	-	-	highly crushed greyish coloured phyllite
BF10	Siradi Gaun	29.11373062	80.51968533	-	-	Phyllite/ old Sag pond
BF11	Siradi Gaun	29.1136476	80.5244276	-	-	highly crushed phyllite breccia /fault line
BF12	Belbhadi	29.1100126	80.52782812	-	-	highly crushed phyllite breccia /fault line
BF13	Budar Bazzar	29.08445737	80.56261784	-	-	Highly crushed, purple Shale/ greyish color fine to medium-grained brecciated rocks, and Sac Pond
BF14	Chainpur, Budar	29.08194414	80.57151247	-	-	Light reddish color fine-grained silty gravel/ Fault line passed
BF15	Chainpur, Budar	29.08177974	80.5761539	-	-	Greyish colour highly fracture shale
BF16	Chattiwan Tal	29.0787307	80.58542428	0	50	Purple colour highly fractured shale alternates with light greyish colour highly fractured shale
BF17	Taliya, Godam	29.02449053	80.65241676	356	26	Purple colour highly fracture Quartzite
BF18	Taliya, Godam	29.02616973	80.64467002			Terrace
BF19	Shera Village	29.025108	80.64082	262	25	Greyish color fine-grained Sst. Alternate with mudstone (Lower Siwalik)
BF20	Matsya Village	29.03315423	80.63695435			Terrace
BF21	Confluence of Kamla and Thuli gad Khola	29.04229689	80.63056467	315	72	Purple colour highly fracture & crushed shale with brecciated rock

S.N	Location	Latitude	Longitude	Attitude		Lithology
				Dip Direction	Dip Amount	
BF22	The right bank of Kamala Khola	29.04883557	80.62352661	-	-	Greyish colour highly crushed brecciated rock
BF24	Left bank of Kamala Khola	29.06126719	80.6160894	60	42	Greyish colour highly fractured Phyllite alternate with quartzite band
BF25	Taliya, Godam	29.0212095	80.65273326	-	-	Purple colour highly fractured shale
BF26	The right bank of Thuli Khola, BP Nagar	29.00783878	80.74603672	-	-	Greyish color highly crushed brecciated rocks and greenish Phyllite
BF27	Right bank of Thuli Khola, BP Nagar	29.00965033	80.73557029	-	-	Terrace/ Fault could be passed
BF28	Right bank of Thuli Khola, BP Nagar	29.00454671	80.71741294	-	-	Terrace
BF29	Thuligaad Khola	29.0097882	80.70234593	300	84	Purple color highly fractured & Crushed shale with brecciated rocks
BF30	Right bank of Thuli Khola, Milannagar	29.01121568	80.69851122	350	85	Greenish color, highly fractured shale with brecciated rock
BF31	Right bank of Thuli Khola	29.0133274	80.6869065	-	-	Purple color highly crushed
BF33	Right Bank of Thuli Khola, Santipur	29.01824769	80.67255227	-	-	Terrace, Fault passed

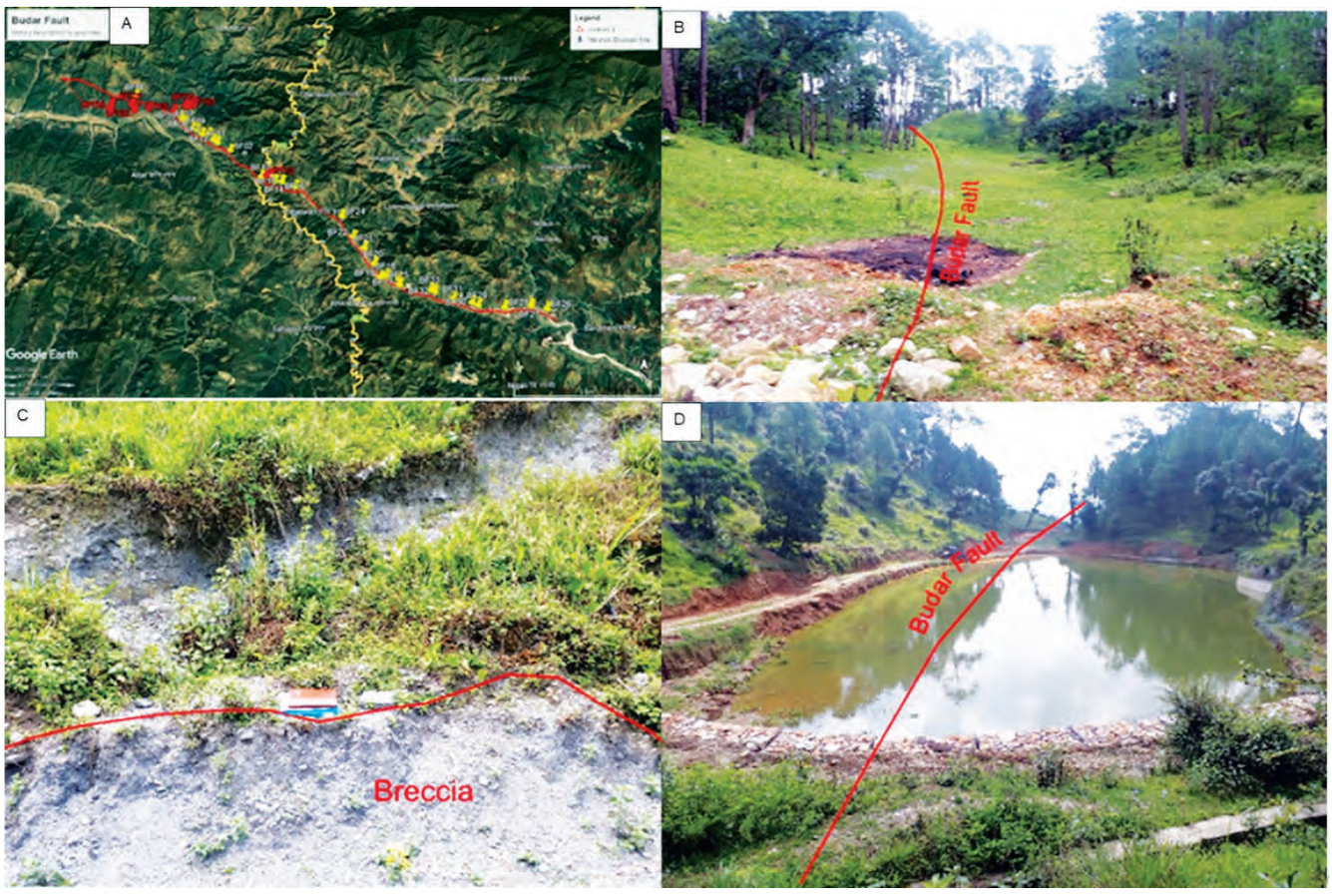

Fig. 3: A. Budar Fault Tracing location, B and D. Sag Ponds, C. Breccia

Generally, for a better understanding of Neo-tectonics, terrace differentiation would be suitable for research work. Rangun Khola and its tributaries covered the whole watershed area which flows toward SW from NE direction. Rangun Khola is a perennial stream and it has made good terraces and fan deposits. Therefore, the study area, specifically Ward No. 5 of Aalital Gaunpalika, features an alluvial deposit terrace, including a terrace level. Budar fault passes across Rangun Khola. At the place the Rangun Khola directly shifts toward the Northwest direction from the Southwest direction. The final fourth terrace is crossed by the Budar fault, and we can easily see height differentiation between them. In addition, the southern terrace is uplifted as compared to the northern terrace which is nearly 7 m high. In the fault line area, a wide gully, and some cultivation land constructed for paddy crops were observed. This gorge width is nearly 25 to 30 m. Five levels of terraces were observed in the study area which are marked from T0 to T4 figure 4. We collected charcoal samples from each terrace for carbon dating from the pit holes as shown in table 2.

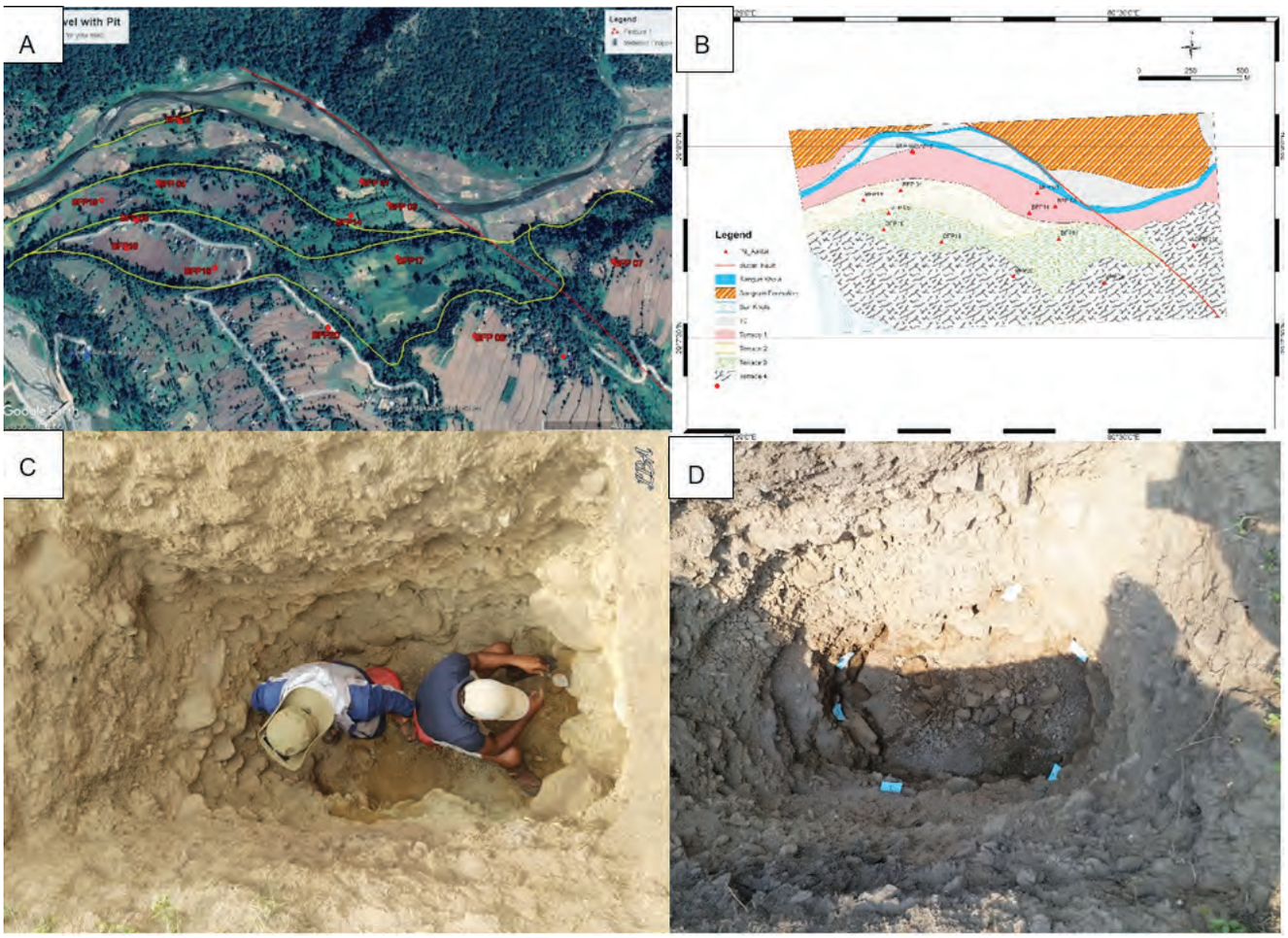

Fig. 4: A. Terrace mapping using google earth, B. Terrace map of Rangun Khola, C and D. Pit hole for charcoal sampling.

Table 2: Charcoal sampling from terrace

S.N.	Pit logging (m^3)	Depth (m)	Lithology
BFP01	2 m^3×2×2	0.74	Light brownish color fine grained Silt
		0.28	Black color fine grained Silty Sand
		0.2	Greyish white color Sandy gravel
		0.3	Pebble to boulder
		0.4	Greyish to white color sandy gravel
		0.1	Pebble to boulder
BFP02	3 m^3×2×2	0.5	Black color Silty Sand
		1.05	Sandy gravel
		1.45	Greyish color Silty Clay

S.N.	Pit logging (m^3)	Depth (m)	Lithology
BFP03	2 m^3×2×2	0.6	Silty Clay
		0.4	Sandy Gravel
		1.05	Pebble to Boulder
		0.4	Sandy Gravel
BFP04	2 m^3×2×2	0.95	Silty Clay
		0.65	Sandy Gravel
		0.4	Sand to pebble
BFP05	2 m^3×2×2	1.45	Silty Clay
		0.33	Sandy Clay
		0.22	Silty Clay
		0.5	Gravel to Pebble
BFP06	2 m^3×2×2	0.9	Brownish Color Silty Clay
		0.75	Cobble to Boulder
		0.5	Sandy Soil
BFP07	2 m^3×2×2	1.6	Brownish Color Silty Clay
		0.8	Sandy Gravel with Pebble
BFP012	2 m^3×2×2	0.61	Black colored Silty Sand
		1.49	Grayish colored Sandy Gravel to Cobble Layer
		0.5	Dark grayish color Silty Sand
BFP018	3 m^3×2×2	1.3	Greyish colored Silty Clay
		1.5	Sandy Gravel With Boulder
BFP019	3 m^3×2×2	1.4	Greyish colored Silty Sand
		1.3	Sandy Gravel With Boulder
BFP020	3 m^3×2×2	2	Raddish colored Sandy Gravel
		1	Sandy Gravel with Boulder

5. RESULT AND DISCUSSION

Neo-tectonics refers to the study of recent and ongoing deformations of the earth's crust and the associated tectonic activities. In the context of the Nepal Himalayas, it is very active and large mega earthquakes are faced frequently. The main cause of an earthquake in the Himalayas is the subduction of the Indian continent underneath the Eurasian continent every year by nearly 21.15 ± 1.5 mm/yr (Lavé and Avouac 2000). This research's main objective is the study of Neo-tectonics, Budar fault tracing, and the collection of charcoal for radiocarbon dating in Rangun Khola terrace of Aalital Gaunpalika Dadeldhura. To recognize the Fault zones in the field, it should consist of volumes of intensely fractured rocks associated with numerous closely spaced fault surfaces (Billi 2005). Thus, during the field study we observed highly crushed, fractured, and dissected rocks for instance mylonite, breccia, and gouge. Investigation of geological, geomorphological, and archeological signatures of past earthquakes plays an important role in paleo-seismology. Similarly, Late Quaternary geological data is more useful to understating earthquakes processes (Micheiti and Hancock 1997). In the study area there are five levels of terraces made by the Budar Fault and Rangun Khola which are quaternary deposited. Therefore, this area would be very suitable for the study of Paleo seismology and output of the results would help to understand Neo-tectonics and earthquake activities in this area and western Nepal itself. The main lithology of this area is alluvial soil, and the terrace has been made with high current fluvial activity, therefore, the charcoal available possibility is very low though we collected some samples from each terrace. Some of the collected charcoal samples are we for the dating and we are still waiting for the report. Therefore, when we get the dating report then we can continue our further work for data interpretation. However, based on the geological, geomorphological, and structural data illustrated the Budar fault is splay of an active fault of Main Boundary Systems because this fault is trending SE to NW and continuation on MBT fault systems(Nakata 1989).

6. CONCLUSION

Budar fault is the Main Boundary System fault which is trending SE to NW and is still an active fault in Nepal Himalayas. For the analysis of observational data and deskwork, we have prepared the fault map. Similarly, four levels of the terrace were observed in

Rangun Khola Valley which has been made by Rangun Khola and Budar Fault. The lithology of this research area is alluvial deposit sediment, and its parent rocks are Granites, Quartzites, Phyllites, Sandstones, and Amphibolite. Terrace lithological features indicate the high current fluvial activity in the past; therefore, we couldn't find samples easily. The result of charcoal dating is on the process. To complete the study, there is a need to prepare high resolution DEM of the area and complete the fault mapping of the area west to Aalital.

Acknowledgement

We are grateful to the Director General of DMG for supporting the field program, guidance, and encourage to write this report. I would like to thank all the members of the National Earthquake Monitoring and Research Center (NEMRC) and the staff of DMG for their kind help during the field period and others for their supporting roles

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Follow-up Exploration of Dhuseni limestone Deposit, Benighat Rorang Rural Municipality Dhading District, Bagmati Province, Nepal.

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ABSTRACT

Mahadevstan-Dhusa area consists rocks of Bhimphedi Group of Kathmandu Complex and Upper Nuwakot Group of Nuwakot Complex, the two being separated by the Mahabharat Thrust (MT). The rocks around MT are folded into an east-west trending Mahabharat synclinorium, with the rocks of Bhimphedi Group in the core. The Markhu Formation consists essentially of marble interbedded with siliceous marble, schist and rare quartzite beds. The crystalline limestone (Marble) bands extend roughly northwest to southeast with low to moderate dip amounts with dip towards north. The cement grade limestone zone is mapped almost continuously in the southern limb of the syncline. However, due to longitudinal and transverse faults, the zone is largely obliterated in the northern limb. The possible geological reserve of limestone in Dhuseni area is calculated about 65.6 million tons.

Keywords: (Limestone; Marble; Reserve; Sampling)

INTRODUCTION

The present target exploration area of limestone was already recognized and mapped by DMG at scale of 1:50,000. This study shows the presence of limestone around Mahadevstan and Brushaban area of Dhading district. Similarly, a preliminary and detail study of limestone prospecting work was also carried by DMG in last two years around this location. Geologically the exploration area falls to the Markhu Formation of Bhimphedi Group of Kathmandu Complex. For detail exploration of Dhuseni limestone deposit, field were conducted from 2074/11/27 to 2075/01/08 for duration of 42 days and follow up field was conducted in 2079/80 for the duration of 14 days where 100 hector topo survey and other geological studies were carried.

LOCATION AND ACCESSIBILITY

The prospecting area lies south of Malekhu Bazar of Dhading district in Mahabharat Lek range. The limestone prospecting area can be approached by the under-construction Malekhu- Lothar Road. The road runs almost parallel to Malekhu Khola for about 14 km. The distance from Malekhu to Kandrangadi (near by the study area) is about 21 km. From Kandrangadi it takes about 1 hour to reach the study area on foot. Similarly the study area can be accessed from Charaudi Bazar of Prithivi highway via Charaudi-Chauki-Dovan-Bumrang. But the road approach is only to the Chauki-Dovan which is 6 km north from Charaudi Bazar.

OBJECTIVES

- To collect the necessary data to prepare limestone resource map of the area in 1:1,000 scale
- To study the overall potentiality of Cement grade Limestone in proposed area
- To collect the representative channel samples (300 m) in different profiles and topo survey of 100 hector area of limestone deposit.

GEOLOGY

Geologically, the area lies in Lesser Himalayan Crystalline Nappe. It consists of relatively low to medium grade metamorphic rocks of Kulekhani Formation, Kalitar Formation, Bhainsedoban Marble, Markhu Formation and Tistung Formation of the Bhimphedi Group of Kathmandu Complex. The rocks in the area generally extend in northwest-southeast direction with northeast dip directions. They have moderate to high dip amounts towards north.

Fig 1: Location Map, Benighat Rorang R. M, Dhading

Table 1: Stratigraphy of Bhimphedi Group, (Stocklin and Bhattarai (1977).

Complex	Group	Formation	Thickness (m)	Main lithology
Katmandu Complex	Bhimphedi Group	Tistung Fm	300	Meta-sandstone, Phyllite
		Markhu Fm	1000	Crystalline limestone, schist
		Kulekhani Fm	2000	Quartzite schist
		Chisapani quartzite	400	quartzite
		Kalitar Fm	2000	Schist, quartzite
		Bhainsedovan Marble	800	Crystalline limestone
		Raduwa Fm	1000	Garnet-schist, Quartzite

Tistung Formation

Tistung Formation is composed of fine-grained Metasandstone with phyllite and some carbonate bands. The formation attains a thickness of about 300m (Stocklin and Bhattarai, 1977). The rocks of this formation are distributed in the northern part of present study area.

Markhu Formation

Markhu Formation is composed of schist, micaceous marble and massive marble (crystalline limestones) in varying proportions. Cystalline limestone is the distinctive lithology of this formation (Stocklin and Bhattarai 1977). The rocks of this formation are distributed at the middle part of the present study area. The average thickness of this Formation is about 1000m.

Kulikhani Formation

Kulikhani Formation is composed of fine-grained biotite-schist and impure strongly micaceous quartzite of dark and light green grey color. The formation attains a thickness of about 450m. The rocks of this formation are distributed in the southern part of present study area.

LIMESTONE PROSPECT

The Markhu Formation is found to be important from limestone prospecting point of view. The formation consists of gray to dark gray schist with interbeddings of massive marble beds. However, two distinct bands of marble are mapped with the formation. The marble found in the area are medium to thick-bedded, coarse crystalline, and gray to white in color. They are highly fractured and jointed. Therefore, the marble shows no possibility of being used as dimension stone. But, their optimal use can be for cement manufacturing and accordingly the study was carried out in the area.

In the Dhuseni Limestone Deposit, the limestone can be divided into four different horizons on the basis of color, crystailinity and texture of individual beds. From the field observation, the limestone is classified as zones I, II, III and IV.

Zone I: The limestone is milky white with light grey shades, medium to coarse grained. Well-formed calcite crystals are also developed in some beds. The rocks are generally medium to thick bedded (20cm- 1m) and vigorously react with dilute HCI. Pyrite and muscovite grains frequently occur in these limestone beds. This type of rock is exposed in three horizons showing possibility of high grade limestone for cement exploration. Very thin layers of siliceous brown limestone and parting of schist are also noticed occasionally with the white crystalline limestone. In this zone, proportion of white limestone is more than 90%.

Zone II: This zone comprises light grey medium to coarse-crystalline limestone. Well-formed calcite crystals are developed in some beds. Similarly, the rocks are generally medium to thick bedded (30 cm-1 m) and vigorously react with dilute HCI. This type of rock is exposed in two horizons showing possibility of high grade limestone for cement exploration. Very thin layers of siliceous brown limestone and parting of schist are also noticed occasionally with the light grey crystalline limestone. In this zone, proportion of light grey limestone is more than 95%.

Zone III: This zone also comprises interbedding of brownish siliceous limestone with white and grey, medium to fine grained limestone. The siliceous rocks are dominant over the crystalline limestone. The light gray to brown siliceous limestone reacts so smoothly with the 10% dilute HCL. The proportion of crystalline white limestone is very low. This type of limestone is found in top part of Channel Sampling profile III.

Zone IV: This zone comprises interbedding of light grey to white coarse crystalline marble with schist. These types of rocks are found at the base of zone I and Zone II type of Limestone. It seems low grade limestone. So, Channel sample was taken only above this type of limestone.

Channel Sample

There are three different channel profiles, which are taken from west to east. At the basal part channel sample is not taken because it seems low grade i.e. limestone are of as zone IV.

Table: 2 Sample Profile with Sample No. and Length

S. N.	Profile	Sample no.	Length (m)
1.	DH/P-I	99	128
2.	DH/P-II	119	150
3.	DH/P-III	76	90

QUALITY OF LIMESTONE

Quality of limestone is controlled by the parameters like presence of CaO, MgO, SiO_2, Al_2O_3 and Fe_2O_3,. On the basis of presence of such parameters limestone is standardized by cement grade or not. The collected samples of limestone is partially analyzed in DMG lab and most of the samples were analyzed in Aastha Scientific Research Service Pvt. Ltd. Dillibazar, Kathmandu. The Chemical analysis shows the limestones in the area is of cement grade. But some samples are of high MgO content. So those high MgO content samples should be considered as overburden while mining. The analysis of chip samples in profile II and III are not included in quality assessment of limestone deposit. Since some bands of limestone show dolomitic nature, MgO content seems little bit high in this analysis report. If those high MgO content samples with MgO value more than 6% is discard, the MgO will remain below 3% in the area.

Table: 3 Average quality of limestone.

S.N.	Profile	Weighted Average CaO %	Weighted Average MgO %
1.	DH/P-I/Ch-1 to Ch-99	45.90	3.41
2.	DH/P-II/Ch-1 to Ch-119	46.62	3.41
3.	DH/P-III/Ch-1 to Ch-76	44.66	3.88

Table: 4 Average quality of limestone discard samples with MgO value more than 6%.

S.N.	Profile	Weighted Average CaO %	Weighted Average MgO %	Remarks
1.	DH/P-I/Ch-1 to Ch-99	45.12	2.99	Discard samples with MgO value more than 6%.
2.	DH/P-II/Ch-1 to Ch-119	47.19	2.99	
3.	DH/P-III/ Ch-1 to Ch-76	45.89	2.81	

GEOLOGICAL RESERVE

The geological reserve is estimated simply by taking the geological cross sectional method, strike length, average dip length and average density. The total geological reserve of Dhuseni Limestone deposit is about 65.6 Million Tones and the reserve in this phase of study in Dhuseni limestone deposit is Probable geological reserve.

CONCLUSION

The studies carried till now indicate the presence of cement grade limestone (marble) in Dhuseni area which can possibly be used for manufacturing of cement and probable geological reserve is 65.6 MT.

The chemical analysis shows the average CaO% is about 46% while MgO is about 3%.

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PHOTOGRAPHS

Ph 1: Overview of Dhuseni Limestone deposit (west)

Ph 2: Overview of Dhuseni Limestone deposit (east)

Ph 3: sampling in field

Ph 4: Collecting of samples

Ph 5: Close view of grey marble

Ph 6: Close view of White marble

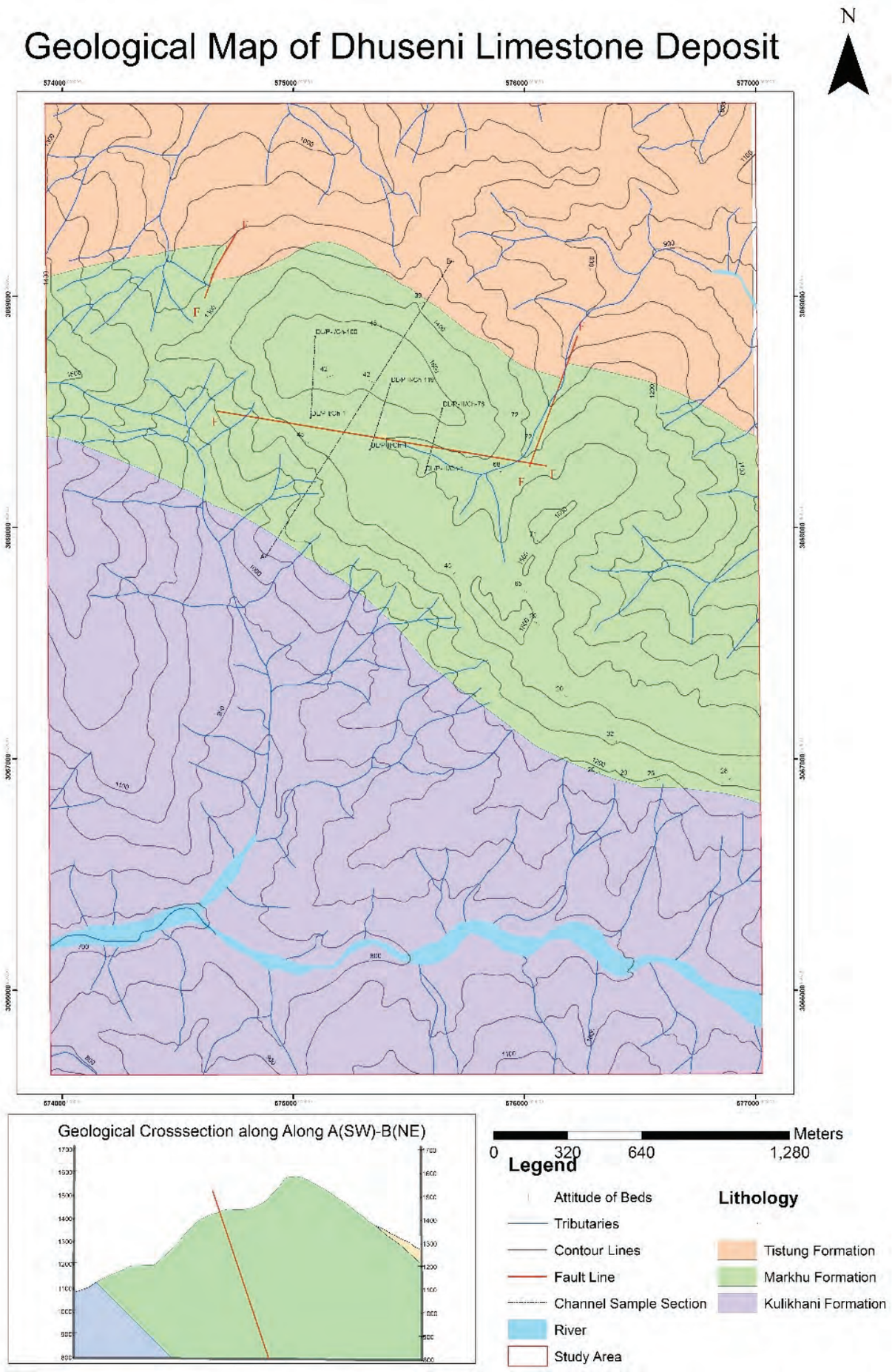
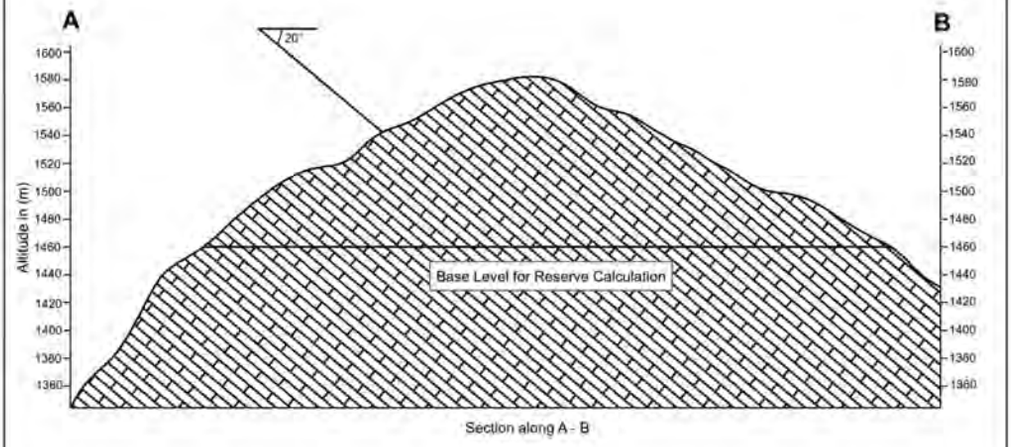
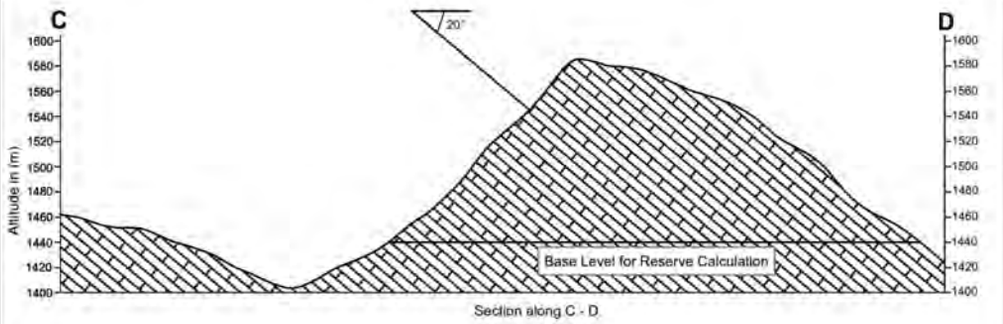


Fig 2: Geological Map of Dhuseni Limestone Deposit

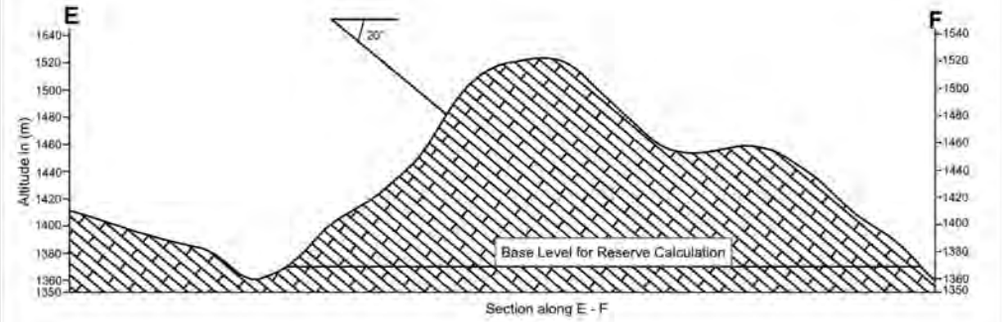
Geological Cross-Section of Dhuseni Limestone Deposit, Benighat R.M. Dhading District



Section along A - B

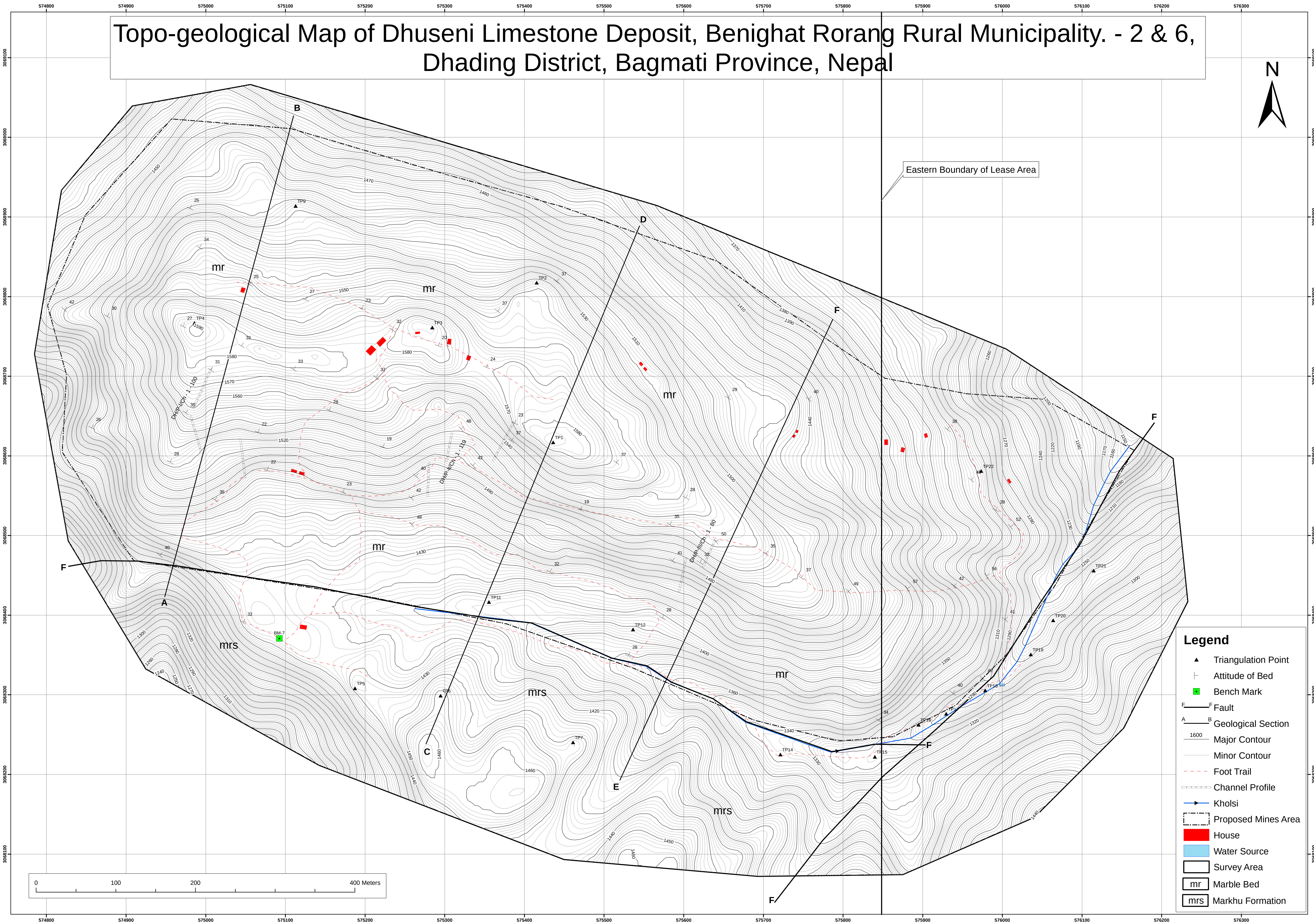


Section along C - D



Section along E - F

Topo-geological Map of Dhuseni Limestone Deposit, Benighat Rorang Rural Municipality. - 2 & 6, Dhading District, Bagmati Province, Nepal



Orogenic Primary Gold Prospecting in Parts of Sunchhahari RM, Rolpa District

Dharma Raj Khadka (Senior Divisional Mining Geologist), Naresh Maharjan (Geologist)

ABSTRACT

A 36 sq. km geological mapping and sampling for gold prospecting was carried out for primary gold around Dhokadhunga and Phuliban areas of Sunchhahari RM, Rolpa for the Fy 2077/78. The upper parts of Chaurjhari Formation green schists and quartzite host rocks cross cut with quartz veins, magnetite injection veins/pods/bodies, and copper sulphide veins has gold association. The lower part of Telkhola Formation altered marbles intercalated with pelites shows gold content. A broad shear zone lies in between them forms the pathways for hydrothermal mineralization. Tectonically, this zone lies within the southern part of Jajarkot Klippe which is mentioned to be the south extended klippe of GHS and THS. The gold is associated with copper and iron ores. The HC samples show majority of concentrate consists of magnetite major, chalcopyrite and pyrite intermediate and epidote less. Finally, it is noteworthy that some samples collected during field session 2076/77 show 0.02 to 4.76 gm/ton gold. The style of mineralization might be hydrothermal and type “Orogenic Gold” based on field evidences.

Keywords: (Orogenic primary gold, prospecting, sampling, analysis)

INTRODUCTION

As per the Departmental program of primary gold exploration for the fiscal year 2077/78 a preliminary follow-up gold prospecting in Lungri Khola area of Rolpa District has been carried out. The study area is a part of Sunchhahari RM-6 (Fig-1). The road connectivity from Bhalubang to Sulichaur is 82.9km and Sulichaur to Philiban is 23km. The target area is 36 sq.km in toposheet no 2882-12A and C, 1:25000 scale.

Joshi, 1984 first identified presence of primary gold mineralization in Lungri khola areas. Thirty-three primary gold occurrences with 1.5 to 40.0 m thickness were located. These occurrences are identified in Damphutar, Dokadhunge, Phuliban, Seram, Bargo and Gam of Rolpa district covering a stretch of 30.0 Km length. The observed lateral continuity of the individual gold bearing zone up to 120 m width with gold content from 0.1 to 4.0 gm/ton are identified. Possible reserve is calculated only in two localities namely Damphutar and Phuliban. Possible reserve of Damphutar and Phuliban is 0.4million tons with o.1 to 1.7 gm/ton Au, 0.2 to 0.4% Cu and 0.38 million tons with 0.1 to 0.4 gm/ton Au respectively (Joshi, 1985-1991).

Joshi, 1991 concluded that the primary gold mineralization occurs in Pre-Cambrian green schist facies and Lower Paleozoic micaceous marble and limestone. The Pre-Cambrian green schist facies comprising mainly of sericite and chloritic quartzite, chlorite schist, quartz-chlorite schist, chloritic phyllite and schistose pebble beds include a discontinuous auriferous zone. The auriferous host rocks are found confined close to the contact with the overlying Lower Paleozoic carbonates. So far minor quartz-carbonate veins have indicated the presence of gold. Finely disseminated gold with minor amount of pyrite, chalcopyrite and rarely arsenopyrite occurs in the above hosts.

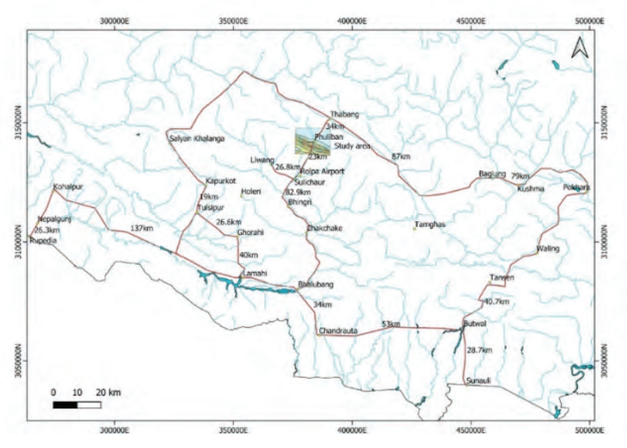


Fig. 1: Location map of the study area

Khadka, 2019 did an assessment of the prospect considering the present condition. The results found so far in the collected samples are encouraging which ranges from 0.02ppm to 4.79ppm gold in 7 out of 32 rock samples from Phuliban and Dokadhunga areas.

OBJECTIVE

The main objective of the study is to prospect primary gold in parts of Rolpa district covering over an area of 36 sq.km including geological mapping of the area, heavy concentrate examination in crushed rock samples and rock chip and grab sampling for chemical analysis.

METHODOLOGY

Desk study

It covers library consultation, website data collection, study of material published in reports etc.

Field study

It covers geological mapping in which the geological map of the area was prepared at the scale of 1:25000. The rock crushed heavy concentrate sampling was prepared with the help of 2mm sieve nest, large and small pans, digging tools, sample bags, gloves, marker pen and had lens. The Heavy concentrate sampling methods were followed as per the mineral exploration practice at DMG. The sampling method consists of hammer and mortar hand crushing of rock samples collected in the field and panning. 2mm sieve concentrate, careful rubbing and shaking, washing concentrate with water for clay particles until water remains clear, still water panning, near circular swirling motion of water, examine the concentrate with hand lens, sampling 50 gm sample for lab analysis. The site selection was considered following the available ore samples in the field. GPS data were collected for each sampling site. The filed examination was performed using hand lens.

Lab study

The collected grab and rock chip samples were directly delivered to the Chemical Lab of Department of Mines and Geology (DMG), Nepal for Au, Cu and Fe analysis. The Atomic Absorption Spectrometry (AAS) method was employed for chemical analysis.

GEOLOGY

Geologically, the study area comprises of Chaurjahari Formation of Greater Himalayan Sequence (GHS) and Telkhola and Thabang Formations of Tethys Himalayan Sequence(THS) separated with a thick shear zone, Fig 2, Table-1.

Table 1: Litho-units of the study area

Group	Formation	Lithology	Age
THS	Thabang Formation Telkhola Formation	Calc-schist and marble	Late Cambrian to Ordovician (Roche 2018)
Shear zone			
GHS	Chaurjahari Formation	Green schists, quartzites, feldspathic schist, psammitic schist, two mica schit, garnet schist, augen gneiss 493±25Ma.	Neoproterozoic (DeCelles et. al., 2020)

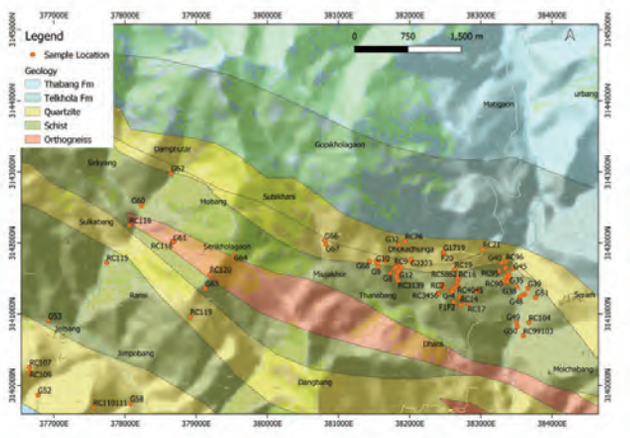


Fig. 2: Geology of the area, Rock Chip (RC) and Grab (G) sample location points

Greater Himalayan Sequence (GHS)

The GHS consists of Chaurjhari Formation in the study area. It consists of quartzite and schist bands, Fig-2.

Chaurjhari Formation

The formation name was coined by Sharma 1984, 1989. It also coincides with Jelbang Formation (Kansakar 1982, Joshi 1991). The Chaurjahari Formation consists of green schists, quartzites, augen gneiss, magnetite and hematite beds, copper old audits and chalcopyrite bearing schists and sericitic quartzites. The mineralization lies in the uppermost parts of the formation within a km of shear zone which are susceptible for in situ gold content. The beds are dipping due NE with moderate dip amount. The western part of Dhokadhunga area is covered with old slope collapsed material. The Phuliban and eastern part of Dhokadhunga has a large landslide. The Seram area has some surface float indications in Ghusban khola and Kap khola. The area is covered with green chloritic schists and gray quartzite. Seram itself lies in the old landslide. Subikhani area has augen gneiss, Damphu area has chloric schist and sericitic quartzite. There are also some magnetite floats in the stream beds and slopes. Jelbang area has chloritic schists and quartzite beds with iron old audits. Ruibang khola area has pyrite bearing green schist and some magnetite bearing floats. The area has inferior quality iron beds of about 1km length and old audits at the right slope of Phagum khola.

Quartzite

It consists of alternating quartzite and schist bands in most parts of the south of the study area. The lowermost quartzite unit exposures are cropping out around Jelbang village and its surroundings. This unit is represented with dominantly medium bedded white quartzite and interbanded with biotite schists. It also consists of ferruginous quartzite, alteration halos in which core part is injected with magnetite ore bodies in three places with 3 old audits associated with malachite staining and chalcopyrite mineralization. There is

another locality of ferruginous quartzite. The old audits for iron ore extraction has been recorded. The quartzite beds are dipping due N-NE with dip amount ranging from 250-600. Similarly, the middle quartzite band crops out around Ransi areas. It consists of quartzite, psammitic schist, sericitic white quartzite and gritty quartzite with subordinate chl-bt-schist. The quartzite beds are dipping due NE with dip amount ranging from 340-640. The uppermost quartzite bands are cropping out in Dhokadhunga, Damphu and Seram areas. The quartzite beds are massive, sericitic white with disseminated pyrite and chalcopyrite at places and most of the beds have disseminated magnetite grains. The beds are intercalated with chloritic schist. The quartzite beds are injected with magnetite veins. The quartzite beds have malachite staining at places. The interbanded psammitic schists have also magnetite veins around Phuliban area. The beds are dipping due N to NE direction with dip amount ranging from 500-600(Fig 2).

Schist

The lower schist bands are observed along the Jelbang to Ransi trail section. It consists of garnet biotite schist, psammitic schist, gritty psammitic schist, chloritic schist and sericitic white quartzite interbandings. Quartz veins in size ranging from mm to cm scale cross cut the foliation. The ferrogenous gritty schist are found at places. The beds are dipping due N-NE direction and dip amount ranging from 350-580. The upper schist bands are exposed around Damphutar consists of chloritic schist, gritty schist and pyrite, chalcopyrite and magnetite bearing quartzite interbandings. Gritty schist is also recorded in which consists of chlorite, biotite and feldspars. The schists bands in Phuliban area consist of chloritic schist in which three old copper audits are located. The chloritic schists are interbedded with psammitic schists in which magnetite injection are prolific, have been recorded in the massive magnetite veins in chloritic schists are located around Phuliban and Dhokadhunga school areas. The magnetite injection in pelitic and psammitic schists are observed along the trail from Phuliban to Dhokadhunga. The magnetite injected psammitic schists beds are traceable down slope within the jungle right NE of Phuliban area the psammitic schists, choritic schists intersected with quartz veins are noted in. A talcose schist is recorded. The beds are dipping due NW-NE direction and dip amount ranging from 600-800 in Phuliban areas. (Fig-2)

Augen Gneiss

The augen gneiss consists of feldspar augens that are surrounded by a finer ground matrix consisting of quartz, muscovite and biotite. The elongated feldspar augens have parallel orientation displaying gneissocity. The augens are eye shaped and lens shaped feldspar grains ranging in size from few mm to cm scale. The gneiss injections are parallel to the foliation of host schist rocks in Serikholagaon areas and first tributary towards north after Pobang areas. The augen gneiss itself has shown no mineralization in the observed sections. Fig-2)

Tethyan Himalayan Sequence (THS)

The THS consists of Telkola Formation and confirmably overlying Thabang Formation in the study area, Fig 2.

Telkhola Formation

The formation name was coined by Kansakar 1982. The formation consists of marble, quartzite, with pelite interbeddings in the lower part. The impure marble is dominant over sericitic schist in the upsection. The white crystalline marble is dominant in the upper section. The basal part of the formation consists of recrystallized calcite in the matrix of pelites. The calcite veins are seen in the pelites and marble itself with shear zone related magnetite injection veins, pods and bodies parallel to foliation. The similar scenario is seen in the upper part of the Chaurjhari Formation quartzite and schists which host injected magnetite veins and bodies. The lower part of Telkhola formation itself is a shear zone. The massive magnetite bodies which are seen at the tributary north of Phuliban along the road section are associated with chalcopyrite, pyrite, malachite and azurite mineralization in the impure marble hosts in the landslide area. This scenario tells that the mode of occurrence of the magnetite veins and pods in upper part of the Chaurjhari and lower part of the Telkhola Formation could be speculated as of Orogenic partly related to Himalayan Orogeny. The majority of gold mineralization is speculated to be related to this event.

Thabang Formation

The formation name was coined by Sharma 1984. It consists of impure marble, chl-bt-schist, muscovite-bitite schist, psammitic schist confirmably overlying Telkhola Formation marbles and pelites.

Geological structure and metamorphism

There is a profound shear zone in between Chaurjhari Formation quartzites and Telkhola Formation thin bedded impure marble and schists. The beds are adulterated due to shearing as seen in the recrystallization of calcite crystals, cross cutting calcite veins, ferruginous alteration zones. The shear zone is about 1km thick in the Telkhola Formation. This is accompanied with magnetite injection pods, lenses and bodies with association of chalcopyrite, pyrite, malachite and azurite mineralization which can be observed at the base of the Telkhola Formation around the first tributary from Phuliban towards north. This gives a clue of structural control of mineralization.

The metamorphic grade was mapped from upper-greenschist- to lower-amphibolite-facies pelitic and psammitic schist to lower-greenschist-facies marble and limestone with minor siliciclastic layers in Chaurjhari, Telkhola and Thabang Formation

respectively which is favorable for gold mineralization.

SAMPLING

The rock chip samples were collected from the fresh outcrops. They are represented with RC series, Fig-2. The grab samples were represented with G series, Fig 2.

A total of 29 HC samples and 186 rock chip samples have been taken from the investigated area (Fig-2). Previously, in FY 2076/77, a total of 32 rock chip and grab samples were taken from the area and their chemical results are assessed. The collected samples, this year, were crushed, graded and homogenized to dispatch to the chemical lab at DMG for analysis using AAS methods for Cu, Fe and Au and results are awaited.

GEOCHEMISTRY

Gold

The gold mineralization at Phuliban, Dokadhunga areas could have formed as a result of metamorphic processes, often associated with STDS shear zone and greenschist facies. The gold in these prospects is typically found in quartz veins or disseminated within altered host rocks. (Table 2).

Table 2: Au (ppm) chemical results

Sample	Grade, Au(ppm)	Gram/ton
RC-23	0.15	0.15
RC-10	0.02	0.02
RC-5	0.16	0.16
RC-11	1.68	1.68
RC-22	1.68	1.68
RC-16	4.79	4.79
RC-21	0.06	0.06

The description of the gold host rocks is as follow-

1) sericitic white quartzite(RC-23),

2) chloritic quartzite(RC-10),

3) py, cp, magnetite bearing chloritic schist(Rc-5),

4) chloritic-sericitic schist with quartz veins (RC-11),

5) psammitic magnetite schist (RC-22),

6) Malachite staining quartz veins (RC-16) and

7) Altered marble (RC-21)

Fig. 3: Gold host rock occurrences a) Cp, py bearing sericitic white quartzite, chloritic quartzite(RC-23,10) b) Shear zone, altered thin bedded marble and pelites (RC 21) c) Chloritic schist with quartz veins(RC11) d) Cu old audit, magnetite, cp, py bearing chloritic schist(RC5), e) Psammitic schist magnetite veins(RC22), f) Location of Au bearing samples

Cu-Au association

Old copper audits in Phuliban and Dhokadhunga areas are associated with magnetite veins, pods and bodies in schists and psammites cross cut with quartz veins. The malachite and azurite staining at the surface of the magnetite bodies associated with chalcopyrite and pyrite are observed in the Phuliban areas and tributary north of the Phuliban at the road side where a huge landslide occurred. The gold cannot be visualized with naked eye. The pyrite crystals are weathered and rim of it are replaced by fine gold and silver when observed under heavy concentrate sample with hand lens. The chloritic schists has both sericitic and chloritic alteration indicates the potential for gold mineralization. The quartzites at the Dhokadunga area has both sericitic

and chloritic alteration with disseminated pyrite and chalcopyrite crystals. This sulphide system indicates orogenic gold potential. The area is highly sheared and crushed forming irregular fractures. The schists are silicified with quartz veins accompanying with sulphide, malachite and azurite minerals indicating orogenic gold mineralization in the Phuliban areas. The overlying Telkhola formation impure marble beds are injected with magnetite veins, pods and bodies at the basal part with sulphide minerals. The same situation is observed on the upper part of Chaurjhari Formation schists and quartzite injected with magnetite veins, pods and bodies. This indicates that the both sides of the shear zone are altered and effected by hydrothermal system during shear zone formation. The Heavy concentrate sample shows majority of magnetite, pyrite and few sulphide minerals with minor epidote, this indicate that they are alteration products of hydrothermal system.

Cu, Au and Fe association

Magnetite is a common alteration mineral associated with hydrothermal system. Its presence can indicate both Au and Cu mineralization. Chalcopyrite is a high temperature mineral. Magnetite is an intermediate Temperature mineral. Gold mineralization favors low temperature. Co-precipitation of these minerals depends on geochemical factors, structural controls and proximity to intrusions. The presence of pyrite in the host rocks like sericitic quartzite and chloritic quartzite in Dhokadhunga indicates reaction between Fe rich and S rich metamorphic fluids and precipitate crystals in disseminated form or in veins. Magnetite veins, pods and bodies are injected in both schists and quartzites of Chaurjhari Formation and basal part of Telkhola Formation.

Au and carbonate rocks

Carbonatization can be seen along the road section altered marble zone of the basal part of the Telkhola Formation where introduction of carbonate rich fluid replaces original minerals and new carbonate minerals form during hydrothermal activity. It has buff colored alteration zone injected with magnetite veins, pods and bodies at the basal part. This zone has gold mineralization.

DISCUSSION

The present gold prospecting area falls under the Himalayan Orogen resulting from continent- continent collision between Indian and Eurasian plates, as shown in the schematic cross section of western Nepal, Fig-4. It could be related to collision tectonics. The host rocks are greenschist facies schists and quartzite of HHS and carbonate rocks of THS in the Jajarkot Klippe. The Chaurjahari Formation is separated from the overlying Thabang sliliciclastic and carbonate rocks by an ~1km thick shear zone. The broad shear zone between these group of rocks controls the pathways of hydrothermal fluid transfers during orogenesis as observed from the field evidences, Fig-4. The age of the formation of the shear zone is believed to be of Miocene.

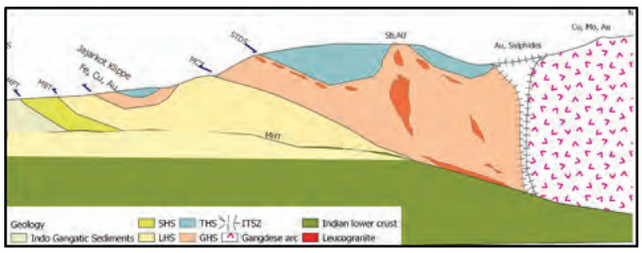


Fig. 4: Schematic cross section of western Nepal Himalaya depicting gold mineralization zones. [MFT (Main Frontal Thrust), MBT (Main Boundary Thrust), MCT (Main Central Thrust), STDS (South Tibetan Detachment System), ITSZ (Indus Tsangpo Suture Zone, MHT (Main Himalayan Thrust), SHS (Sub Himalayan Sequence), LHS (Lesser Himalayan Sequence), GHS (Greater Himalayan Sequence), THS (Tethyan Himalayan Sequence)]

It is noteworthy that the Phuliban and Dhokadhunga area has undergone following alterations based on the field observations-

1) Sericitization: It is the hydrothermal alteration product of feldspar, the sericite schist hosts gold bearing veins, and is an exploration indicator of gold, is an effect of low grade metamorphism.

2) Chloritizaion: It is the product of regional metamorphism, low grade, or hydrothermal alteration in quartzites and schists.

3) Silicification: It is the replacement by silica rich fluids, replacement by quartz, alteration indicator of mesothermal ore deposits, chloritic schist hosts cross cutting cu bearing quartz veins.

4) Carbonatization: It is the replacement of original minerals by carbonate minerals during hydrothermal activity. It can be seen in the alternation zone of Telkhola Formation.

The Dhokadhunga and Phuliban Au prospects are mostly related to the shear zone. The gold host rocks are sericitic white quartzite, chloritic quartzite, py, cp, magnetite bearing chloritic schist, psammitic magnetite schist, malachite staining quartz veins from upper part of Chaurjhari Formation and altered marble of Telkhola Formation.

The chemical result shows 0.02 to 4.76 gm/ton gold in the samples. The preliminary resource evaluation will be based on the chemical results of all samples and, their interpretation using IDW interpolation and field relations.

CONCLUSION

Primary gold prospecting around Dhokadhunga and Phuliban areas of Sunchhahari RM, Rolpa district

follows Chaurjhari Formation green schists and quartzites host rocks cross cut with quartz veins, magnetite injection veins/pods/bodies, and copper sulphide veins. Some of the chemical results shows gold content in those hosts.

The lower part of Telkhola Formation altered marbles intercalated with pelites show gold content.

A broad shear zone lies in between Chaurjhari and Telkhola Formations embodiment the pathways for hydrothermal mineralization. The gold is associated with copper and iron.

The HC samples show majority of concentrate consists of magnetite major, chalcopyrite and pyrite intermediate and epidote less.

Finally, it is noteworthy that some samples collected during field session 2077/78 show 0.02 to 4.76 gm/ton gold. The style of mineralization might be hydrothermal and type "Orogenic Gold" based on field evidences.

Further exploration work plan will be based on the availability and interpretation of chemical analysis results of the collected samples, preliminary resource assessment considering field relations.

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Detail Exploration of Granite Deposit at Kaphal Dada Area, Roshi Rural Municipality, Kavrepalanchok District, Bagmati Province

Deepak Basnet (Geologist), Dinesh Kumar Napit (Sr. Div. Geologist), Suresh Shrestha (Sr. Div. Geologist)

ABSTRACT

The granite deposit, located at Kaphal Danda at Roshi Rural Municipality Ward-02, Kavrepalanchock District, Bagmati Province, was initially investigated by the Department of Mines and Geology (DMG) team during the Fiscal Year 2063/64. Based on the recommendation, the exploration drilling programme was carried out in FY 2078/79. Geologically, this granite is part of the Naraythan Granite of the Mahabharat Range and is located in the Lesser Himalaya of Central Nepal. Locally, it is named as Kaphal Danda Granite deposit. Total of 150 m of exploratory drilling was carried out in three different drill holes to assess the deposit. Petrographic studies and mineral composition analysis on the drill core samples reveal that the granite is predominantly composed of quartz and feldspar, with minor amounts of tourmaline. Physio-mechanical study was conducted on five different core samples - that included cutting and polishing, resistance tests, discontinuities analysis in the granite. These test results indicated the possible block sizes ranging from 0.5 cubic meters to 1.5 cubic meters. The drilling data confirmed a proved granite reserve of 5,899,670 cubic meters of such block sizes. This investigation demonstrates that the granite deposit has significant potential for use mainly as dimension stone and secondarily as construction material.

Keywords: (Granite; Exploration; Mineralogy; Lab Analysis, Reserve Estimation)

INTRODUCTION

Granite and granitic gneiss intrusion are found distributed in about 7,500 sq. km areas in the Lesser Himalayan region of the country. Narayanthan granite of Kavre district is considered to be one of the largest deposit of granite (Mineral Resourses of Nepal, 2004, DMG). With growing demand of polished and dimension stone, Department of Mines and Geology (DMG) carried out several exploration of polished and dimension stone in the annual Programme of the F.Y 2063/64.The exploration target covers an area of 125 sq.km including preliminary and follow up investigation of the potential areas in some parts of Kavrepalanchock district (Ghimire, JR and Napit DK, 2008, DMG). Based on the DMG study, Special Prospecting License for granite prospecting at Roshi Rural Municipality-04, Kavrepalanchock district was issued in 2076 B.S. Based on the recommendation of the previous study, exploratory drilling at the Kaphal Dada area in Roshi Rural Municipality, Kavrepalanchock District was carried out in FY 2078/2079. This initiative aimed to meet the significant market demand for granite and took into consideration the deposit's easy accessibility and proximity to market (Kathmandu). The exploratory drilling was part of DMG's annual program and focused on assessing the granite deposit's viability for commercial use.

Locally named, Kaphal Danda granite deposit area has rugged mountainous terrain with altitudes ranging from a maximum of 2306 meters at Shikhar Ambote to a minimum of about 1482 meters at the valley bottom in Narayantar. The Roshi Khola serves as the primary drainage system for the region and the Tindhara Spring waterfall is the main source of drinking water for the surrounding area. Several major settlements include Purangau, Gumba Gaun, Narayantar Besi and Shikhar Ambote. The granite deposit itself is located in Kaphal Dada, within Roshi Rural Municipality Ward-02 in Kavrepalanchock District, Bagmati Province, Nepal. The area is included by the topographic map 2785 11A,in the scale of 1:25,000, published by the Department of Survey, Government of Nepal.

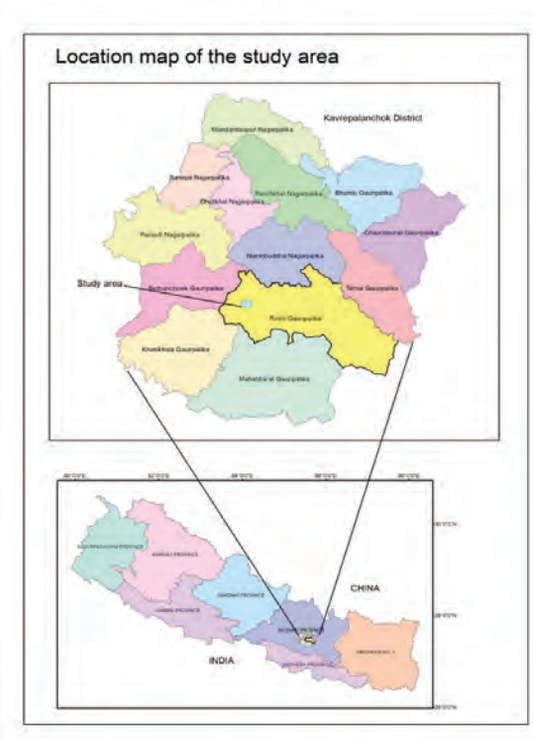

Fig 1: Location map of study area

GEOLOGY

Geologically, the prospect lies in the lesser Himalaya in Central Nepal. The rock types encountered in the investigation area belongs to metamorphic rocks of Bhimphedi Group and metasedimentary rocks of Phulchouki group of Kathmandu complex along with Naraythan Granite and Katungebeshi Gneiss as intrusive bodies of Pre-Cambrian age (Stocklin and Bhattarai, 1977). Geological Mapping of the area at the scale of 1:50,000 has been prepared by DMG (2063/64) as shown in Fig 2. The Naraythan granites within the Lesser Himalayan is intruded in the Kulekhani formation so contact metamorphism with the rocks of Kulekhani formation and Markhu formation could be observed in the field. The massive granitic body mainly consists of Biotite tourmaline and somewhere aplitic tourmaline granite rich in feldspar and quartz minerals.

The present area of exploration is based on the recommendation study over 125 sq.km. as follow up exploration of polished /dimension stone programme (J.R. Ghimire and D.K. Napit (2063/64). The southern part of the investigation area has gneiss intrusion within the Kulikhani quartzite. The Kulikhani Formation is a well-bedded alternation of fine-grained biotitic schist and impure, strongly micaceous quartzite, of dark and light green-grey color. The rocks of this Formation are essentially composed of fine-grained quartzite and mica in proportions varying from layer to layer, resulting in an alternation of more or less micaceous quartzite and more or less quarzitic schist

Marble bands belonging to Markhu formation are present around central part of the study area. The Markhu Formation is of mixed lithology, consisting of schists, quartzites and carbonates in varying proportions. The schist and quartzite between the marble bands are dark, biotitic and fine grained.

FIELD INVESTIGATION

During the field investigation altogether three holes were drilled using diamond bits to recover core of the granite deposit. The exploratory drilling works has been completed by using HGY -300 Drill Machine size of the core used was NX and NQ. A wireline mining exploration technique has been used by using a HGY-300 hydraulic rotary core drilling machine with capacity of drilling upto 300m depth.

The details of core recovery are presented in the table.

Table 1: Details of Diamond Core Drilling

SN	Drill hole	Days	Drill length (m)	Core length (m)	Core Recovery
1	KGDH-1	9	50.05	14.87	29.71
2	KGDH-2	9	50.15	17.07	34.03
3	KGDH-3	9	50.15	31.24	62.3
			150.35	63.18	

KGDH-1

The hole is located at 358910E and 3042090 N with elevation of 1836m and hole facing NE at Azimuth of 800 with isolated hill slope at Kaphal Dada. The dip of hole is at 600 and total drill depth of hole is 50.05m shown in (Table.1). The exposure of rock around the drill hole is moderately fractured rock and slightly weathered.

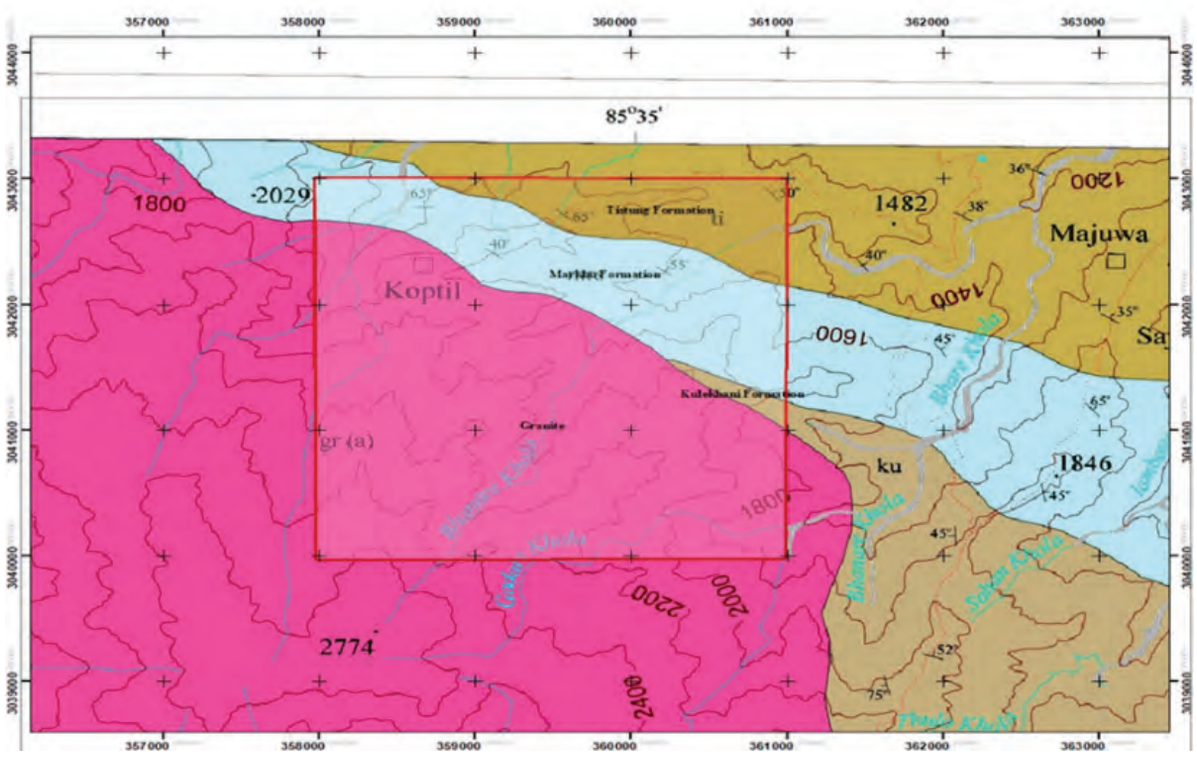

Fig 2: Geological map of study area showing the granite deposit (Map is prepared by DMG published in 2008)

KGDH-2

The hole is located at 359146E and 3042154 N with elevation at 1808m and hole is facing NNE at Azimuth of 1600. The inclination of hole is at 850 with almost vertical drive and total drill depth of hole is 50.15m shown in (Table no 1). The exposure of rock around the drill hole is moderately fractured, slightly weathered which leads to massive intact rock downwards.

KGDH-3

The hole is located at 359234E and 3042122 N with elevation at 1840m and hole is facing NNE at Azimuth of 1300 .The inclination of hole is at 600 with slight inclination drive and total drill depth of hole is 50.15m shown in (Table no 1). The exposure of rock at the surface is moderately fractured rock and slightly weathered while intact rock is in few meter depths. (Table 3).

RESULTS OF LABORATORY TEST

a) Mineralogy of granite

Petrographic study

The granite of the study area is fine to very coarse grained, slightly weathered, slightly fractured and jointed. Quartz, feldspar, tourmaline is major mineral constituent (Fig. 3). There are very rare mica minerals to few mica minerals in the observed granite. Petrographical analysis of the rock also shows similar mineral constituent like quartz, feldspar, tourmaline with very few grains of mica which signify the rock has less susceptible for weathering which increase the strength of rock significantly.

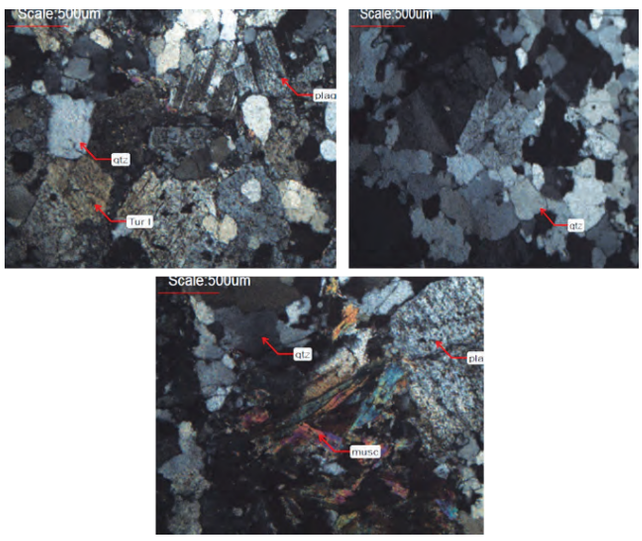

Fig 3: Thin section of granite under microscope

b) Physio-mechanical study

ASTM specified physio-mechanical tests of 5 granite samples were conducted. Bulk density (D), Water Absorption Test (Abs) @ 24 hours soaking within water and Point Load Strength test and Compressive strength were done in the lab. The results of the test are presented in the Table 2. The compressive strength of the granite in the Table 2 was calculated on the basis of point load strength.

Table 2: Geotechnical analysis result

Sample ID	Rock type	Bulk density (kg/ m3)	Absorption by weight (%)	Point load index (Mpa)	Compressive strength (Mpa)
KGDH3-a	Granite	2783	0.32	13	194
KGDH1-a	Granite	2759	0.6	20	126
KGDH3-b	Granite	2770	0.59	19	145
KGDH3-b	Granite	2767	0.38	16	145
KGDH1-a	Granite	2782	0.57	20	126

The above result is only valid for the fresh granite without fractures as the test were conducted in fresh samples recovered from core drilling. The results are compared with the ASTM standard. In our study, the average bulk density of granite obtained from core logging of 5 samples is 2772 kg/m3 and average absorption by weight percentage is 0.49. The results of Physio-mechanical tests done by (J.R. Ghimire and D.K. Napit DMG annual Report (2063/64) revels average of Bulk density of tourmaline granite is 2620 kg/m3.also, average water absorption by weight percentage is 0.67.

(i) Suitability Tests

Cutting and Polishing

The polished surface of aplitic granite shows good shining lusture and attractive appreances.Fig.4 shows the irregular crystal grains with abundant feldspar and some sample has more mica abundancy. Polished section of the granite core shows smooth shinning surface.

Fig 4: Polished sections of granite

(ii) Resistance Test

The aggregate properties of granite in terms of

Aggregate impact value, water absorption ratio, Slake Durability Test (SDI). The value obtained from the lab test is shown in the Table 3.

Table 3: Lab test result for aggregates

S.N	Tests	Average value
1	Aggregate impact value	19.20%
2	Water absorption ratio	0.72%
3	Slake Durability Test (SDI)	99.60%

The average value of aggregate impact and water absorption ratio shows the fractured granite is highly durable and suitable for construction materials.

(iii) Discontinuities analysis in granite

The granite rocks in the field have lots of joints and moderately to highly fractured nature. The joint analysis (Table 4) shows that the maximum size of the block is $2m^3$. But the size of the block of the granite is also dependent on the weathering condition of the granite rock below ground level and the nature of fracture in the rock.

Granite rocks are usually less susceptible for weathering and in the field, rocks are slight to moderately weathered. By the analysis of discontinues the possible block size is $0.5m^3$ to $1.5m^3$ of size.

RESERVE ESTIMATION

The geological reserve has been calculated up to the defined limit of survey area as demarcated in the surveyed map. The calculation has been made simply by vertical cross section method. Three geological cross sections A-B, C-D and E-F are drawn along S-N direction for each drilling hole, in the geological map of 1:2500 scale prepared in the field after topographic surveying. Following norms and assumption have been considered for reserve estimation field after topographic surveying. Following norms and assumption have been considered for reserve estimation:

a) Sectional Area: Sectional area of granite is delineated from geological mapping has been computed within survey map.

b) Influence Length: It is the summation of half the length in between section lines on either side of a section line and is taken differently for different sections.

- The influence length for section A-B is 60m on either sides.
- The influence length for section C-D is 45m on either sides.
- The influence length for section E-F is 50m on either sides.

c) Base level of Reserve Calcualtion: For each section base level for reserve calculation is determined by visual observation of topography of the influence area suitable for mining in future shown in Fig 5a, b.

CONCLUSION

Petrographical analysis of the rock also shows similar mineral constituent like quartz, feldspar, tourmaline with very few grains of mica. Polished section of the granite core shows smooth shinning surface.

Geotechnical analysis of granite sample shows satisfactory result for the use of granite as dimension stone, i.e. the unconfined strength, bulk density, water absorption ratio falls within the range to be used as dimension stone.

Discontinuities with in the granite rock decide the size of blocks and the maximum size of blocks that could be obtained is about 0.5 to 1.5 m3 but the un-even fracture and deep weathering in the rock might affect the size of block.

The total proved reserve of granite is about 5899670m3 and was estimated by using conventional vertical cross-section method.

The investigation confirmed that the deposit contains high-quality granite suitable for dimension stone and construction material. Given its location and the market's demand, the Kaphal Dada granite deposit presents a promising opportunity for development and utilization.

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Table 4: Discontinuities in granite

Location	KGDH1			KGDH2			KGDH3		
Major joint sets	J1	J2	J3	J1	J2	J3	J1	J2	J3
Dip direction/ amount	170/70	240/50	290/40	300/50	250/30	40/40	300/45	270/40	5/40
Spacing	0.5 to 1.3m	0.1m to 1m	0.20m to 5m	0.1m to 1.5m	0.2 to 1m	1 to 5m	0.5 to 5m	1 to 10m	0.3 to 2m
Wall surface	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures	Rough with fractures
Weathering grade	Slight to moderately weathered	Slight to moderately weathered	Slight to moderately weathered	Slight to moderately weathered	Slight to moderately weathered	Slight to moderately weathered	Slightly weathered	Slightly weathered	Slightly weathered
Possible block size	0.5 m^3 to 1.5m^3			0.3 m^3 to 1.5 m^3			1m^3 to 2m^3		

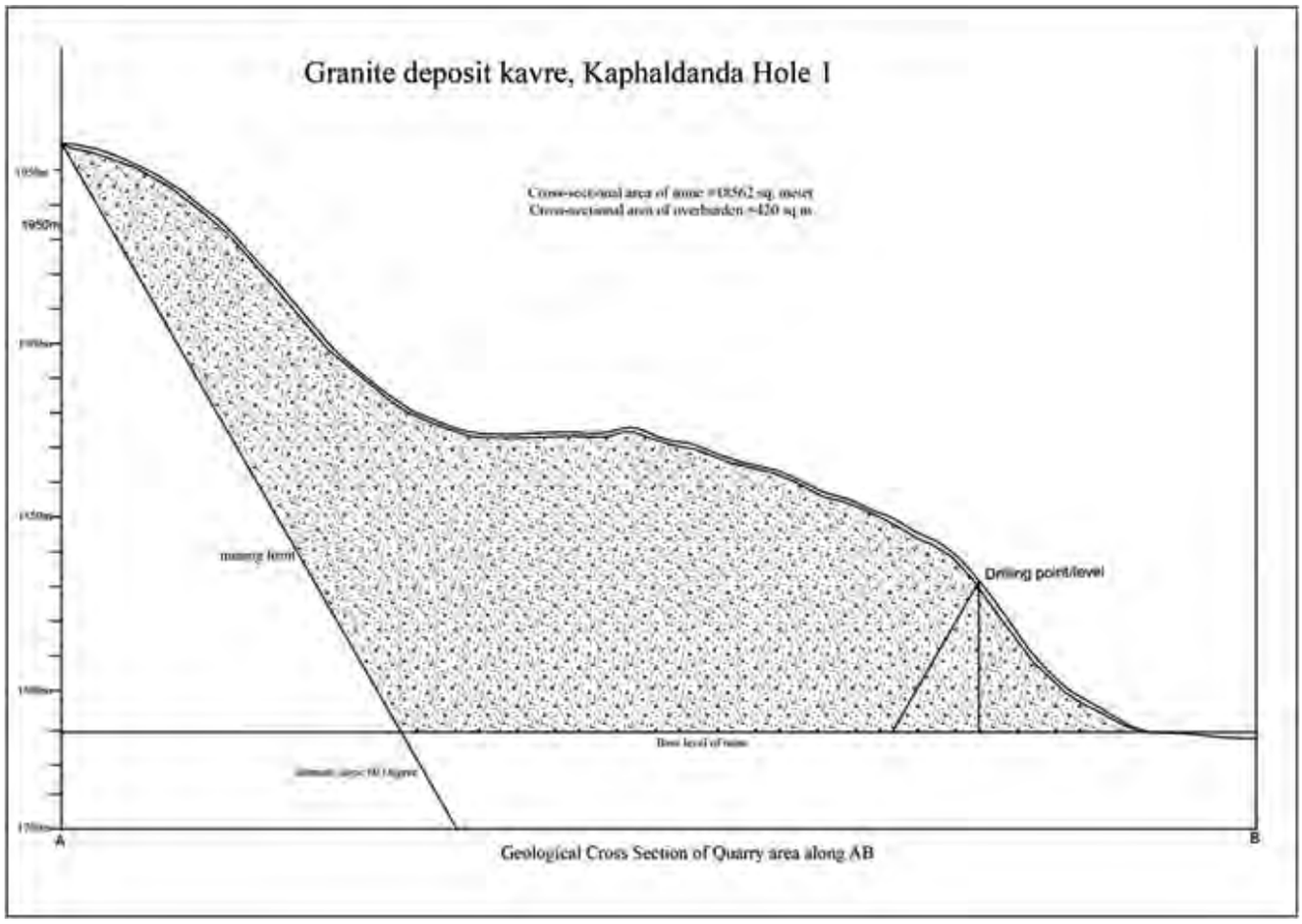


Fig 5a: Schematic Geological cross section

PHOTOGRAPHS

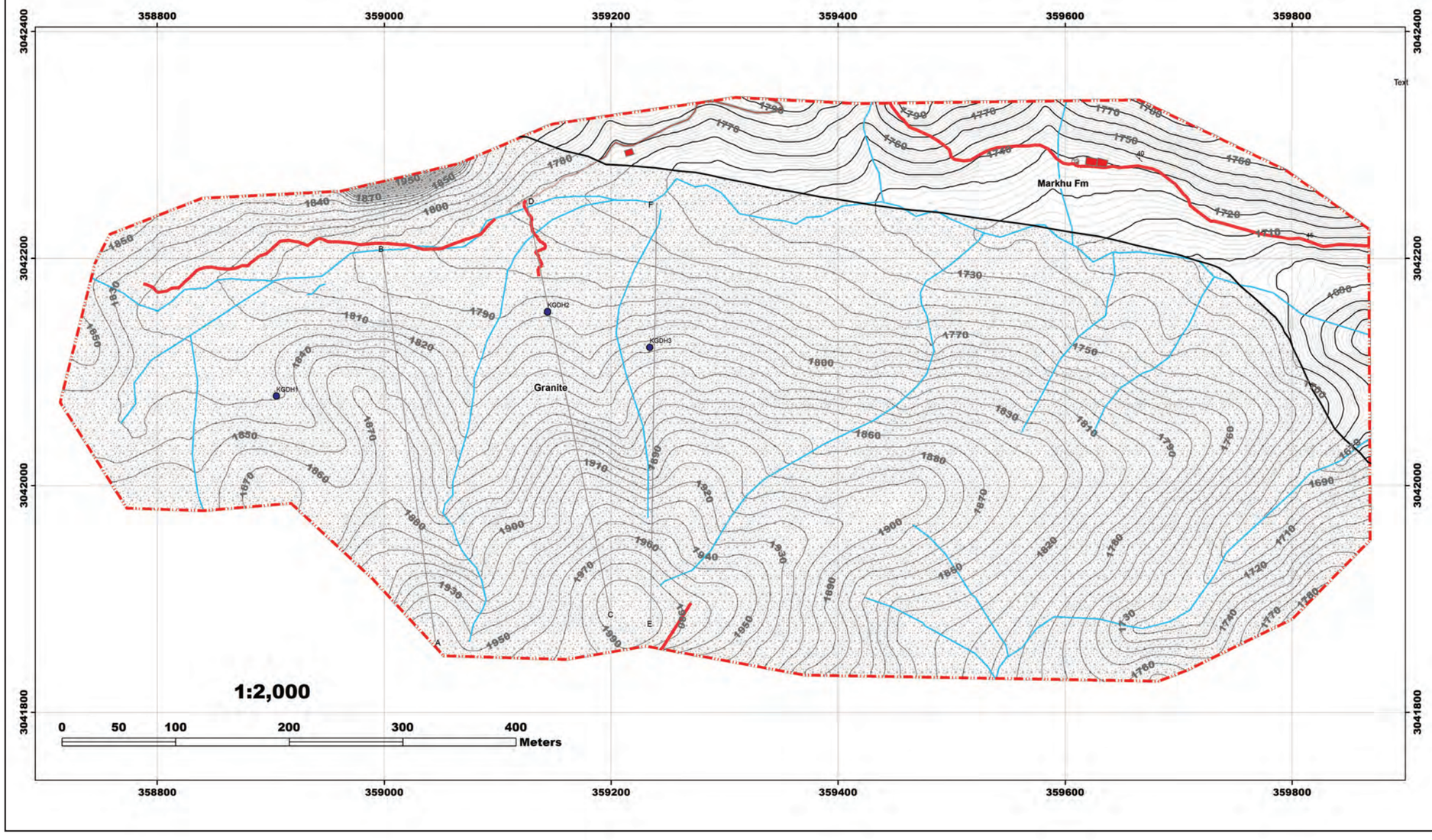
Photograph 1: Manpower involved from DMG for drilling

Photograph 2: Labors carrying the drilling equipment

Potograph 3: Core box and bore hole samples

Photograph 4: Supervision by the Deputy Director General of DMG

Geological Map of Kaphal danda Granite Deposit at Roshi Gaunpalika, Kabhreplanchwok



Topographic Legend

- Drilling point
- Geological contact
- Section line
- House
- Goreto
- Kholsi
- Road
- Survey Area
- Minor Contour
- Major Contour
- Goreto
- Road
- Kholsi
- <all other values>
- House

Geological Legend

- drilling_point
- Granite
- Markhu Fm

Co-ordinate system:Nepal MUTM
Central 87 Everest 1830
Projection:Transverse Mercator
Datum:Everest 1830
False Easting:5,00,000
False Northing:0.0000
Central Meridian:87.0000
Scale Factor:0.9999
Laltitide of Origin:0.0000

Government of Nepal
Ministry of Industry, Commerce and Supplies
Department of Mines and Geology
Lainchaur,Kathmandu ,Nepal

Fig 5b: Geological map with topo survey data

Adopting LC^3 Technology in Nepal

Gautam Prashad Khanal (Geologist), Sulav Kayastha (Geologist), Prakash Luitel (Geologist)

ABSTRACT

The cement industry in Nepal has evolved through different stages and now has reached its growth stage. A review of Portland cement and new alternative LC^3 in terms of components and production plant is presented. LC^3 technology has been put forward claiming better strength, durability and lower carbon emissions and sustainability. However, challenges remain in terms of Kaolinite resource exploration, standardization, production consistency, and market adoption. A cautious call is made to evaluate its resource capacity, suitability for industrial applications, as well as its economic advantages and disadvantages before fully embracing LC^3 technology.

Keywords: LC^3 (Limestone Calcined-Clay Cement); Portland Cement; Resource exploration

INTRODUCTION

Recently Nepal has become self-reliant in cement production with 55 operating cement plants having an annual production capacity of 15 million tons across the country (SAM, 2022). Being self-reliant in cement production, due to the availability of limestone resources has given optimistic sign for Nepal's construction and infrastructure sectors and ultimately to economy by reducing trade deficit. However, to maintain the present cement success, sound resource management through sustainable mining, long term planning, and continuous research on adopting efficient technology is essential. Particularly, a mine life of limestone is dependent on (1) size of the deposit and (2) the rate of extraction. As, the volume of limestone reserves are naturally limited (unless new deposits are discovered), the extraction rate plays vital role in determining mine life.

Despite having abundant limestone resources in the Lesser Himalaya, the primary challenge faced by the cement industry is sourcing high-CaO (calcium oxide) limestone (Bhanadari, 1976; Bhandari, 1985; Hetauda Cement, 1961; DMG, 1996). Here, LC^3 (Limestone Calcined Clay Cement) has been put forward as new alternative of the Portland Cement (PC) that can retain the limestone reserves without reducing the cement production volume. In this article a comparison is made between LC^3 and the portland cement production process.

HISTORY OF CEMENT PRODUCTION AND USES IN NEPAL

The growth of cement industry in Nepal started through its use, production and export. Before the introduction of cement, most of the houses were constructed using mud and wood using traditional architecture of Nepal. However, Bajra Plaster (a kind of lime plasters used in neoclassical designs of Singha Durbar and Bagh Durbar) with raw mix of lime, sand and surkhi (brick powder) have been introduced by Rana Rulers. So far, the history of cement production in Nepal can be broadly described into three different periods with ups and downs within each stage.

a) Perceive Period (before 1971)

Importance of modern cement industries was realized during this era. As a result, government formed feasibility committee for potential cement industry in Nepal which recommended establishing the Himal Cement Industry, the first Portland Cement manufacturing industry.

b) Infant Period (1972-2008)

During 1972-1987, abundant cement grade limestone reserves were discovered in different parts of the country and as a result government established Himal Cement Industry Ltd. (1972), Hetauda Cement Industry Ltd. (1976) and Udaypur Cement industry Ltd. (1987). As the nation witnessed a major political revolution in 1990, government formulated the Industrial Policy 1992, attracting private sectors. However, industrialization was halted during the insurgency period from 1996 to 2008. Nevertheless, during this period DMG (Department of Mines and Geology) has laid strong foundation of cement industry by exploring high grade limestone deposits in different parts of the country. In 2004, Nepal also became member of World Trade Organisation (WTO) which also opened door for free trade in international market and attracted foreign investment in Nepal.

c) Growth Period (after 2010)

The demand for cement rocketed after 2010 with introduction of mega projects and real estate boom. The 2015 earthquake; an unfortunate natural disaster also created massive market of cement in affected areas of central Nepal. During this period, the OPC (Ordinary Portland Cement) price reached over 1000 NPR/bag. Private sector grabbed the opportunity, and this led to self-reliance in Nepalese cement industries. However during 2019-2020 cement industry faced major shakeout because of the global pandemic COVID which halted the international movement, and created domino effect by significantly reducing foreign aids, remittance, foreign reserves, consumer buying power and cement demand. Furthermore, Nepalese government also introduced regulatory measures in

real estate sector which eventually reduced cement demand. As a result domestic demand reduced to 12 Million ton annually (half of the total production capacity) (CMAN 2024). On the other hand, the decline in demand and market competition has declined the cement price to around 650 to 800NRs/bag in domestic market (as per April 2024 market price). To maintain profit in the falling demand, cement industries began looking for foreign markets. In 2022, Nepal started its cement export to India and a gradual increase annual cement exports is seen in the recent years.

MANUFACTURING PORTLAND CEMENT

The traditional Portland cement production involves several steps (Figure 1).

Mining and Raw Material Preparation:

Limestone, clay, and other raw materials are quarried or mined, depending on their availability. These raw materials are then crushed, blended, and sometimes pre-calcined to prepare a uniform mixture known as "raw meal". In Nepal, the conventional raw mix design of cement contains Limestone (CaO)-85%, clay (SiO2, Al2O3 or Fe2O3)-13% other additive (SiO2, Al2O3 or Fe2O3) <1% (Pandey & Banskota, 2008) in such a way that the final chemical composition of the cement produced should not exceed 5% MgO but Al2O3/FeO should be at least 0.66 (NS 572:2076; Table 1).

Table 1: Chemical Requirements for OPC cement in Nepal. Source NS 572:2076

	Chemical properties		OPC43	OPC53
1	Lime saturation factor $\frac{(CaO)-0.7(SO3)}{2.8(SiO_2)+1.2(Al_2O_3)+0.65(Fe_2O_3)}$		0.66 – 1.02	0.80 – 1.02
2	$(Al2O_3)\%$ / (FeO)%	(min)	0.66	0.66
3	Insoluble residue	(max)	2%	2%
4	MgO	(max)	5%	5%
5	Sulphur content (SO3) (max) For $C_3A \geq 5\%$ where, $C_3A = 2.65 (Al_2O_3) -1.69 (Fe_2O_3)$		3%	3%
6	Loss on Ignition (max)		4%	4%

Clinker Production:

The raw meal is fed into a rotary kiln where it is heated to temperatures upto 1400ºC – 1450ºC (Pandey & Banskota, 2008).This high-temperature process causes chemical reactions that result in the formation of clinker nodules, which are small, marble-sized balls of partially fused material.

Clinker Grinding:

The clinker is cooled and then ground into a fine powder along with a small amount of gypsum (calcium sulfate) (3–5%) (Pandey & Banskota, 2008), to regulate the setting time and enhance workability. For Production of PPC (Portland Pozzolana Cement), the clinker is blended with pozzolanic materials (e.g., fly ash or calcined clay) in specific proportions before mixing gypsum.

Packaging and Distribution:

The final product, Portland Cement, is then packaged in 50kg bags or bulk containers and distributed to construction sites, distributors, or retailers.

LC^3 CEMENT

LC^3 is a ternary cement that is similar to OPC except that it is composed of direct blending of crushed limestone and calcined clay creating a synergy between the three primary components (clinker, calcined clay and limestone) (Antoni et al., 2012), so that clinker volume reduces to as low as 40% to 50% (SDC, 2022). This new technology is proposed to support a sustainable growth by reducing emissions, energy consumption, capital and production costs, and wastage of raw materials (SDC, 2022).

Components of LC^3:

Limestone: Unlike traditional Portland cement, LC^3 includes raw limestone as one of its ingredients. In the process of manufacturing cement, limestone powder functions both as a calcium source and as a binding agent in concrete.

Clinker: Similar to traditional Portland cement, the grinded clinker nodules formed by fusing of limestone, clay and other additive at high temperature 1450ºC are essential component of LC^3 cement. However, the proportion of clinker by volume is reduced to 50% in LC^3 as compared to 95% in OPC

Calcined Clay: The unique aspect of LC^3 is the inclusion of calcined clay as a substitute for a portion of the traditional clinker (the main component of Portland cement). Calcined clay is clay that has been heated to high temperatures (typically around 600-800°C) to remove impurities and activate its pozzolanic properties. Pozzolanic materials react with calcium hydroxide in the presence of water to form additional cementitious compounds. This reduces the need for clinker, which is energy-intensive to produce. However, the clay should be Kaolinitic clay (40%) which are composed principally of Hydrated alumino silicate (SDC 2022).

Gypsum: Similar to traditional Portland Cement, the final step in LC^3 cement production is blending the materials with gypsum in specific proportions (5%) (SDC 2022). However, a caution is that the added gypsum should be balanced when using calcined clays as it considerably influences the early age strength (Antoni et al., 2012).

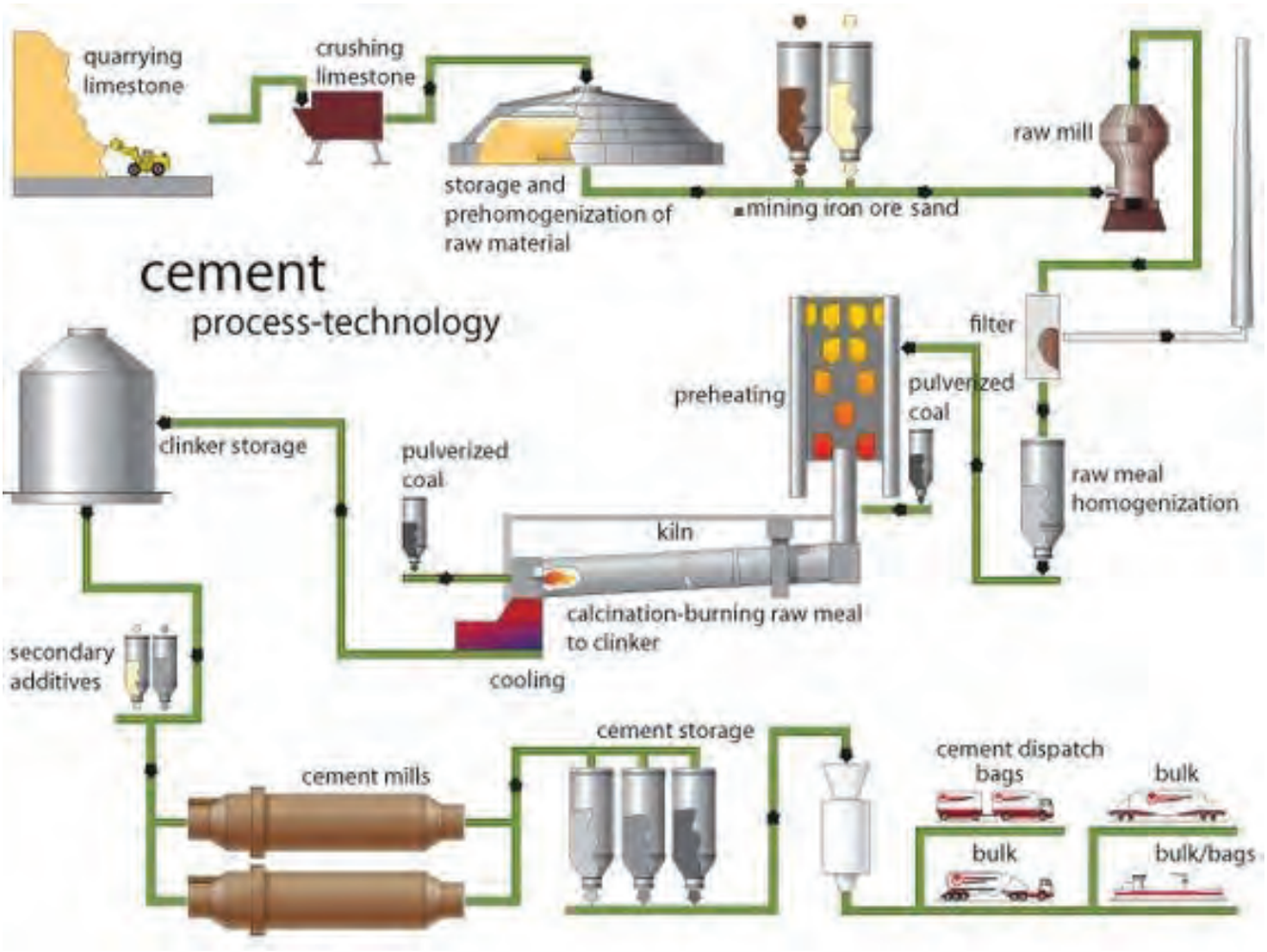


Figure 1: Process of Traditional Portland Cement Production (adopted from Abdelgader et al., 2022)

Production of LC^3

The production process of LC^3 involves using a blend of materials, including limestone, calcined clay, and low-grade clinker, which can vary slightly depending on the specific LC^3 formulation. It is noteworthy that the traditional Portland Cement plant involving the rotary kiln can be used without any modification, but with an addition of clay calcination plant so that the cost of upgrading to LC^3 plant is reduced significantly. The LC^3 production involves following processes (Figure 2).

Raw Material Mining: High grade limestone, suitable clay and also relatively lower grade limestones are quarried, crushed and impurities are removed for the production of clinker and raw lime dust. Limestone and clay are crushed into fine powder separately to ensure uniform particle size and consistency.

Calcination: The ground clay is subjected to high temperatures in a kiln or furnace, typically in the range of 650°C to 850°C (1200°F to 1560°F). This process is known as calcination. During calcination, several transformations occur such as dehydration and phase transformation of the crystalline structure of the clay minerals into metakaolin, which is a highly reactive pozzolanic material.

Mixing and Blending: A small percentage of clinker produced according to the traditional cement plant is blended with the calcined clay and fine limestone powder. This clinker is typically of lower quality compared to traditional Portland cement clinker. Precise proportions of limestone and calcined clay are thoroughly mixed to create a homogenous blend. The blend ratio may vary depending on the desired LC^3 formulation.

Grinding: The blended materials are ground into a fine powder in a cement mill. The grinding process ensures that the particles are of the right size and have the desired reactivity.

Packaging and Transport: The final LC^3 product is packaged into bags or bulk containers for distribution and used in construction projects. The finished LC^3 product is transported to construction sites or distributors for use in various applications, such as concrete production, mortar, and other construction materials.

Properties of LC^3

The LC^3 despite being a new technology, have been successfully tested as Micro Concrete Roofing Tiles

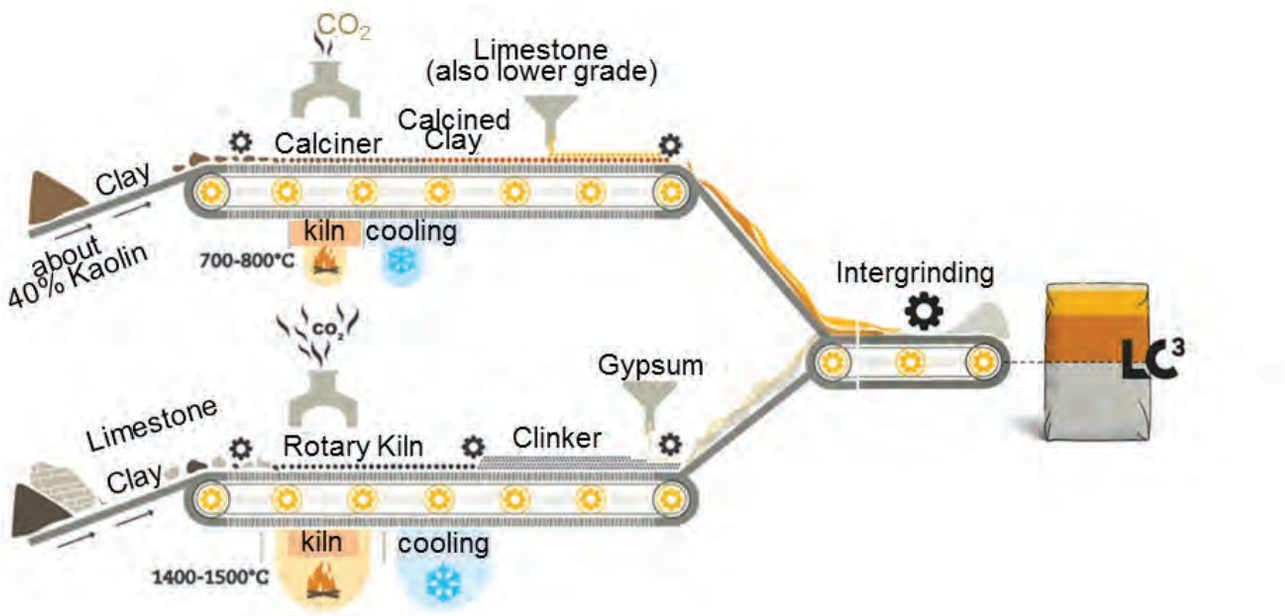


Figure 2: Process of LC³Cement Production (adapted from SDC 2022)

(MCR), solid concrete bricks, autoclaved aerated concrete (AAC) blocks, RCC door and window frames, and paving blocks (SDC 2022). These building materials have tested to meet the necessary standards without any modifications to the conventional mixture designs and production procedures (Antoni et al., 2012; SDC 2022). The LC^3 technology has been showing good results in the lab and recently commercial production has started. As a new product in the market, this cement is still a test in terms of its strength, ease of use, and commerce among builders and a matter of research for geoscientists, technicians and enterprises.

Strength and Durability

LC^3 concretes can achieve similar compressive strengths as Portland Cement when properly formulated, making it suitable for a wide range of construction applications (Antoni et al., 2012; SDC 2022). Additionally, LC^3 can offer improved durability due to its pozzolanic properties. Coupled substitutions of metakaolin and limestone for Portland Cement can give excellent performance at relatively early ages (Antoni et al., 2012). Furthermore, LC^3 is understood to have a finer pore-structure than OPC and a high chloride binding capacity. It is therefore durable against corrosion, sulphate attack and other deterioration mechanisms, making it suitable in aggressive conditions (Antoni et al., 2012).

Lower Carbon Emissions and Sustainability

LC^3 has the potential to significantly reduce carbon dioxide (CO_2) emissions compared to traditional Portland cement. The use of calcined clay instead of clinker reduces the amount of limestone required, and the manufacturing process generally consumes less energy resulting in a lower carbon footprint (Sharma et al., 2021). CO2 emissions from LC^3 production are expected to be 30% lower than OPC and 11% lower than PPC. Energy consumption in its production is also expected to be lower than OPC and PPC. (Sharma et al., 2021). Furthermore, the LC^3 is considered a more sustainable alternative to traditional cement as it makes use of clay, which is often readily available, as a raw material.

ADOPTING LC^3 IN NEPAL (SWOT)

LC^3 represents one of the many innovations in the field of sustainable construction materials as the industry seeks to reduce its environmental impact. While LC^3 shows promise as a greener alternative, there are challenges in terms of standardization, production consistency, and market adoption. The specific formulation of LC^3 can vary depending on local materials and conditions, which can make it more challenging to produce and use on a large scale. Before introducing this new technology in Nepal, caution on its long term strength, availability of required raw materials within country, and cost of technology upgrading should be thoroughly studied. The strength, weakness, opportunity and threats have been put forward (Figure 3).

Conclusions

The cement industry in Nepal has evolved through different ups and down to the present stage and still far from Maturation Stage. In the context of growing stage of Cement Industries, LC^3 may be a good alternative to the conventional Portland Cement (PC) and that can retain the limestone reserves without cutting cement production volume. However, before fully embracing LC3 technology, it is advisable to evaluate its resource capacity, suitability for industrial applications, as well as its economic advantages and disadvantages.

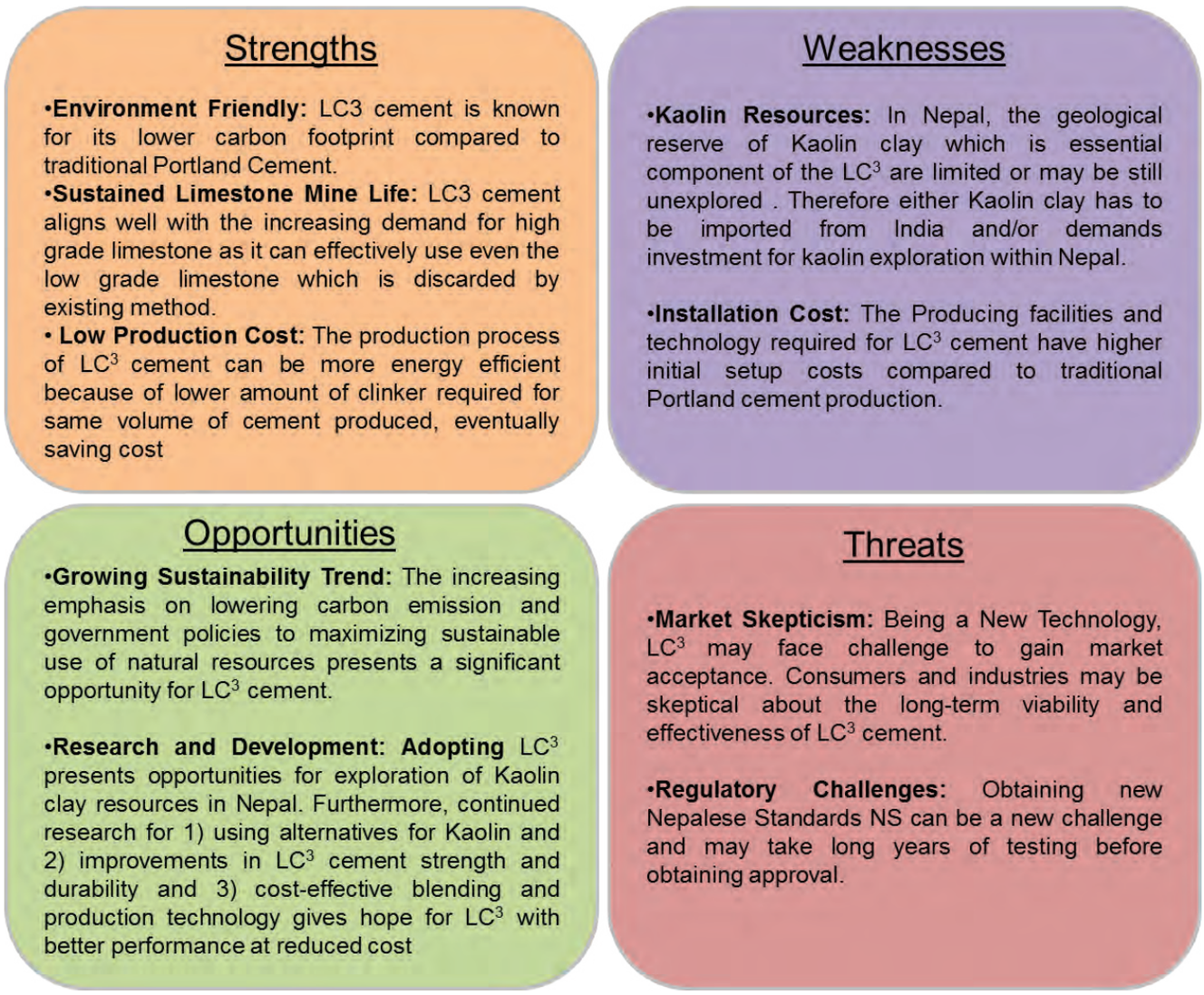


Figure 3: SWOT Matrix for Adaptation of LC³ pting LC³ Technology in Nepal

Acknowledgments

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आ.व. २०७९/८० मा रहेका खनिजकार्य अनुमति विवरण र संचालित तथा प्रस्तावित खानीहरुको अनुगमनको अवस्था

शिव कुमार बास्कोटा (सिनियर डिभिजनल जियोलोजिष्ट)

सारांश

खानी तथा भूगर्भ विभागबाट खानी तथा खनिज पदार्थ सम्बन्धि कानूनको अधिनमा रहि खनिज कार्य गर्न व्यक्ति वा कम्पनीहरुलाई अनुमति प्रदान गर्ने गर्दछ। आ.व. २०७९/८० को अन्त्य सम्ममा १५९ वटा उत्खनन् अनुमतिपत्रहरु बहाल रहे पनि ६१ वटा खानीहरुमात्र संचालनमा रहेका छन्। खनिज उत्खनन् कार्य गर्न जारी भएका उत्खनन् अनुमतिमा संचालित खानीहरुको विभागद्वारा नियमित अनुगमन हुने गर्दछ। यसका अलाबा प्रस्तावित उत्खनन् अनुमतिका लागि पेश भएका उत्खनन् कार्यको प्रस्तावित योजनाको प्राविधिक तथा वातावरणीय पक्षको स्थलगत भेरिफिकेशन हुने गर्दछ। खानी तथा खनिज पदार्थ ऐन तथा सो को नियमावली र अन्य प्रचलित कानूनको अधीनमा रही खानीहरुको अनुगमन निरीक्षण कार्य हुने र अनुगमनको क्रममा कुनै कैफियत पाईएमा आवश्यक कानूनी कारवाही, दण्ड जरीवाना एवं सुधारका लागि निर्देशन दिईने गरिन्छ। आ.व. २०७९/८० मा ७० वटा खानीहरुको अनुगमन गरिएको र ३२ वटा प्रस्तावित उत्खनन् अनुमतिको लागि स्थलगत भेरिफिकेशन गरिएको थियो। अनुगमनका क्रममा अधिकांश खानीहरु नियमित तथा पूर्ण क्षमतामा संचालन हुन नसकेको, स्वीकृत डिजाईन अनुसार काम हुन नसकेको, खानीजन्य वेष्टको उचित व्यवस्थापन हुन नसकेको एवं खानीद्वारमा परिमाण एकिन गर्ने उपकरण जडान नभएको जस्ता कैफियत पाईएकोले आवश्यक कानूनी कारवाही गरी सुधारका लागि निर्देशन समेत दिईएको थियो । त्यस्तै उत्खनन् कार्यको प्रस्तावित योजनाको स्थलगत भेरिफिकेशनका आधारमा प्रस्तावमा आवश्यक संशोधन गर्न वा स्वीकृतका लागि विभागमा पेश हुने गर्दछ। सिमित जनशक्ति र श्रोतका कारण खानी नियमन तथा प्रशासन कार्यमा डिजिटल प्रविधि भित्राउनु आजको आवश्यकता भई सकेको छ ।

Key Words: खनिज कार्य, खानी अनुमति, खानी अनुगमन, स्थलगत भेरिफिकेशन, निरीक्षक

१. परिचय

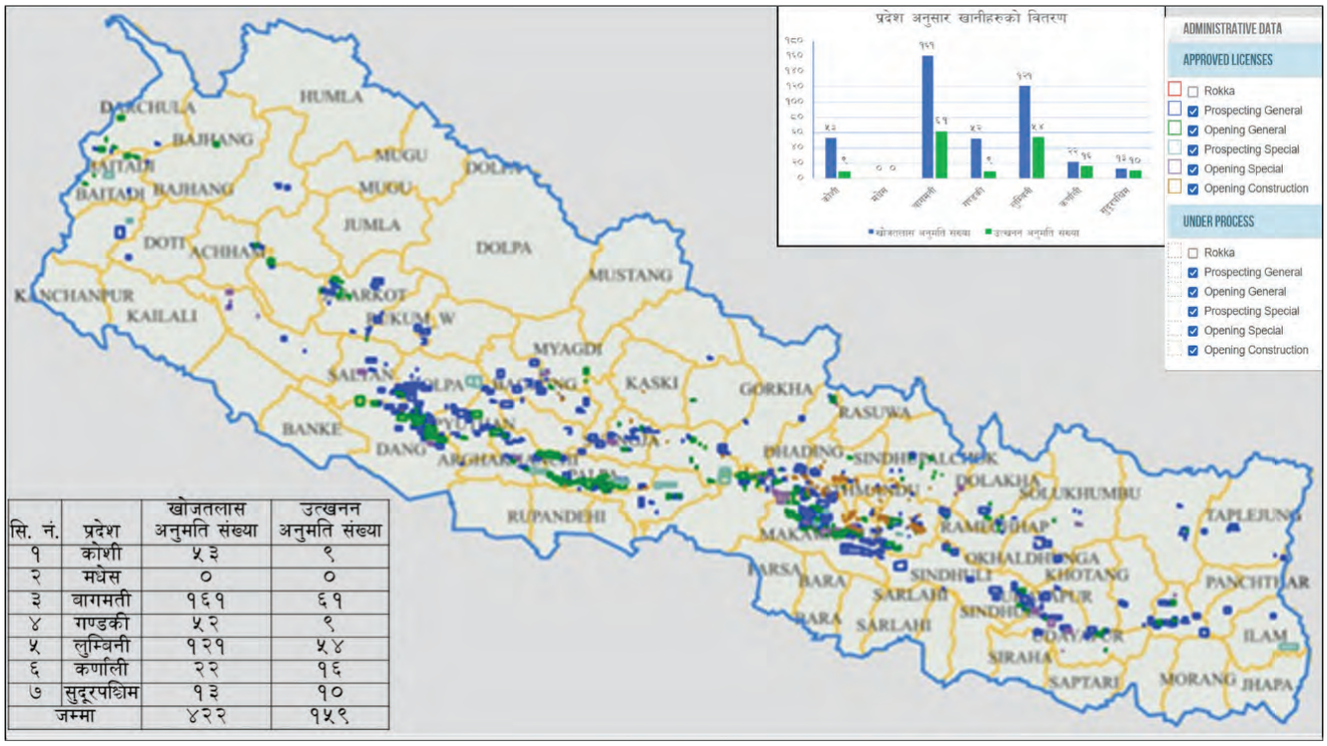
खानी तथा भूगर्भ विभाग देशभर रहेका खनिजहरुको अन्वेषण, सम्भाव्यता अध्ययन र खनिज खोजतलास तथा उत्खनन्को अनुमतिपत्र जारी गर्ने एक मात्र सरकारी निकाय हो। विभागलाई देशभरको खानी संचालन तथा अन्वेषण गतिविधिको निरीक्षण, अनुगमन र नियमन तथा प्रशासन गर्ने दायित्व र अधिकार रहेकोछ । विभागको खनिज सम्पदा महाशाखा अन्तर्गतको खानी अनुमति तथा प्रशासन शाखा र खानी अनुगमन शाखाबाट उत्खनन् अनुमति प्रदान गरिएका खानीहरुको नियमित अनुगमन तथा खोजतलास अनुमति प्रदान गरिएका स्थानमा प्रस्तावित खानीहरु एवं साधारण निर्माणमुखी खनिजको उत्खनन् सहमतिका लागि स्थानीय निकायबाट सिफारिस भई आएका प्रस्तावित खानीहरुको आवश्यकता अनुसार विभागले स्थलगत भेरिफिकेशन कार्य गर्ने गर्दछ ।

२. अनुमतिपत्रको विवरण

विभागबाट व्यक्ति विशेष तथा कम्पनीहरुलाई आ.व. २०७९/८० को अन्तसम्ममा खनिज कार्य गर्न जारी गरिएका खोजतलास अनुमतिपत्रको संख्या ४२२ वटा र उत्खनन् अनुमतिपत्रको संख्या १५९ वटा रहेका छन्। अनुमतिपत्रको संख्याको आधारमा सबैभन्दा धेरै खोजतलास अनुमतिपत्रहरु बाग्मती प्रदेशमा र त्यसपछि क्रमशः लुम्बिनी, कोशी, गण्डकी, कर्णाली र सुदूरपश्चिम प्रदेशमा जारी भएका छन् । त्यसै गरी संख्याको आधारमा सबैभन्दा धेरै उत्खनन् अनुमतिपत्रहरु बाग्मती प्रदेशमा र त्यसपछि क्रमशः लुम्बिनी, कर्णाली, सुदूर पश्चिम, कोशी र गण्डकी प्रदेशमा जारी भएका छन्। मधेश प्रदेशमा खनिज खोजतलास वा उत्खनन् अनुमतिपत्र जारी भएको छैनन्। (चित्र नं. १) ।

२.१. संचालनमा रहेका खानीहरुको विवरण

आ.व. २०७९/८० मा देशभर विभिन्न १८ किसिमका धातु तथा अधातु खनिज उत्खनन्को लागि जारी भएका १५९ अनुमतिपत्रहरु बहाल रहे पनि ९ किसिममा खनिज उत्खनन् गर्ने ६१ वटा खानीहरुमात्र संचालनमा रहेका थिए। जसमध्ये सबैभन्दाबढी चुनढुङ्गाका ४४ वटा खानी संचालनमा रहे भने त्यसपछि क्रमशः क्वार्जाईट (५), कोईला (३), खरी (३), काईनाईट (२), डोलोमाईट (१), क्वार्ज क्रिष्टल (१), मार्वल (१) र टुर्मालिन (१) खानीहरु संचालनमा रहेका थिए ।



सि. नं.	प्रदेश	खोजतलास अनुमति संख्या	उत्खनन अनुमति संख्या
१	कोशी	५३	९
२	मधेस	०	०
३	बागमती	१६१	६१
४	गण्डकी	५२	९
५	लुम्बिनी	१२१	५४
६	कर्णाली	२२	१६
७	सुदूरपश्चिम	१३	१०
जम्मा		४२२	१५९

चित्र नं. १: विभागबाट जारी गरिएका खनिज खोजतलास तथा उत्खनन् अनुमतिपत्रहरुको अवस्थिति नक्सा। ईन्सेटमा खोजतलास तथा उत्खनन् अनुमतिपत्रहरुको प्रदेशगत विवरण (श्रोत: www.dmgnepal.gov.np)

टेबुल नं. १: विभागबाट जारी गरिएका उत्खनन् अनुमतिपत्र र संचालनमा रहेको खानीहरुको प्रदेशगत विवरण

सि. नं.	खनिजको नाम	प्रदेश							जम्मा उत्खनन् अनुमति प्राप्त खानीको संख्या	संचालनमा रहेका खानीको संख्या
		कोशी	मधेस	बागमती	गण्डकी	लुम्बिनी	कर्णाली	सुदूरपश्चिम		
१	कोईला	०	०	०	०	१०	०	०	१०	२
२	डोलोमाईट	०	०	१	१	१	०	०	३	१
३	काईनाइट	०	०	०	०	०	५	०	५	२
४	चुनढुङ्गा	६	०	३७	४	४३	३	०	९३	४४
५	मार्बल	०	०	१	०	०	०	०	१	१
६	क्वार्ज	१	०	०	०	०	०	१	२	१
७	क्वार्जाईट	०	०	१०	२	०	०	०	१२	५
८	खरी	०	०	३	१	०	०	७	११	३
९	टुर्मालिन	०	०	०	०	०	५	०	५	१
१०	क्यालसाईट	०	०	०	०	०	१	०	१	०
११	तामा	१	०	०	१	०	०	०	२	०
१२	ग्रेनाईट	०	०	१	०	०	०	०	१	०
१३	फलाम	०	०	१	०	०	०	०	१	०
१४	शिसा	०	०	१	०	०	०	२	३	०
१५	म्यागनेसाईट	०	०	२	०	०	०	०	२	०
१६	औद्योगिक रातोमा	१	०	०	०	०	२	०	३	०
१७	बालुवा	०	०	३	०	०	०	०	३	०
१८	जस्ता	०	०	१	०	०	०	०	१	०
	जम्मा	९	०	६१	९	५४	१६	१०	१५९	६१

यसरी अधिकाशं खानीहरु संचालनमा नरहनुमा उत्खनन् अनुमति जारी भई सकेतापनि बन क्षेत्रको भोगाधिकारको प्रक्रिया नटुङ्गिनु, विगतमा संचालनमा रहि स्थानिय अवरोध, बजारको समस्या, विदेश निकासीमा बाधा आदि रहेका छन् ।

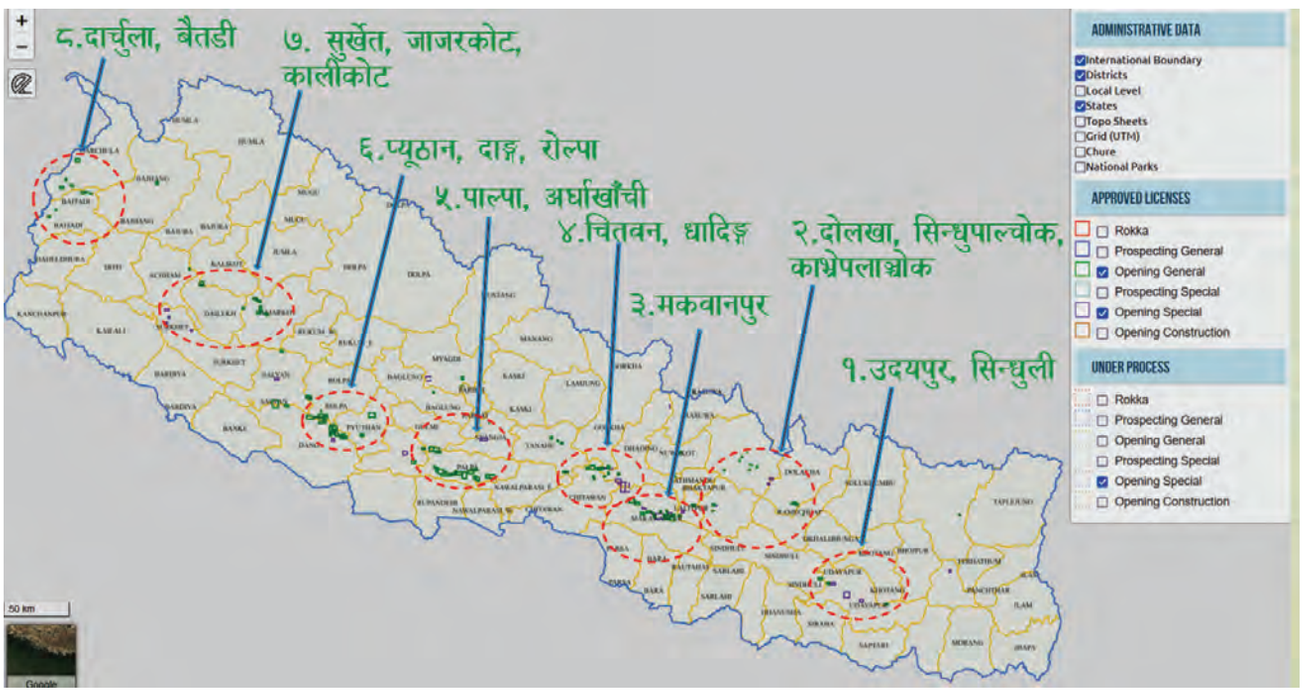
३. अनुगमन सम्बन्धी कानूनी व्यवस्था

विभागबाट उत्खनन् अनुमति प्राप्त गरी संचालनमा रहेका खानीहरुको देहायका कानूनी व्यवस्थाको आधारमा अनुगमन तथा निरीक्षण हुने गरेको छ ।

- खानी तथा खनिज पदार्थ ऐन, २०४२ को दफा २३मा "निरीक्षण तथा जाँचबुझ"को व्यवस्था रहेको ।
- खानी तथा खनिज नियमावली, २०५६को नियम ५०मा "निरीक्षण तथा जाँचबुझ सम्बन्धी कार्यविधि" उल्लेख भएको, जस्मा विभागले खानी निरीक्षण गर्न निरीक्षक तोक्न सक्ने तथा निरीक्षकले प्रयोग गर्न पाउने अधिकार को व्यवस्था भएको ।
- वातावरण संरक्षण ऐन, २०७६ को दफा २१मा "वातावरण निरीक्षक"को व्यवस्था रहेको। सोही ऐनको उपदफा २ मा वातावरणीय प्रतिवेदन स्वीकृत गर्ने मन्त्रालयले नेपाल सरकार वा प्रदेश सरकारको अधिकृत कर्मचारीलाई निरीक्षक तोक्न सक्ने व्यवस्था रहेको ।
- वातावरण संरक्षण ऐन, २०७६ को दफा २२मा वातावरण निरीक्षकको काम, कर्तव्य र अधिकार उल्लेख भएको ।

४. अनुगमन विधि

जनशक्ति र श्रोतको सीमितताको कारण एकै टोलीबाट सकेसम्म धेरै खानीहरुको अनुगमन र प्रस्तावित खानीहरुको फिल्ड भेरिफिकेशन हुनेगरी टोली खटाई विभागिय फिल्ड कार्यक्रमहरु तय हुने गरेको छ। धेरैजसो संचालित खानीहरु महाभारत हिमालयन क्षेत्रमा रहेका हुनाले खानीहरुको आकस्मिक निरीक्षण गर्नुपर्ने अवस्थामा बाहेक संचालित खानीहरुको क्षेत्रगत विभाजन गरी नियमित अनुगमन हुने गरेको छ। सामान्यतया अनुगमन गर्दा गरिने क्षेत्रगत विभाजन चित्र नं. २ मा देखाइएको छ। अनुगमन गर्दा अन्य भौगर्भिक सर्भेमा जस्तै वाकओभर सर्भे तथा आवश्यकता अनुसार टोपोग्राफिक सर्भे गरिन्छ। सर्वेक्षणका क्रममा ब्रन्टन कम्पास, जिपिएस, ड्रोन तथा अन्य सर्भेईङ्गका उपकरणहरु आवश्यकता अनुसार प्रयोग गरिन्छ। उजूरी वा विवादका विषय र विभागले आवश्यक ठानेमा आकस्मित निरीक्षण/अनुगमन गर्ने गरिन्छ। साधारण निर्माणमूखि खनिजको हकमा प्रायस: अनुरोधका आधारमा मात्र अनुगमन गरि सम्बन्धित निकायलाई निर्देशन दिईन्छ । त्यस्तै प्रस्तावित खानीहरुको फिल्ड भेरिफिकेशनमा प्रस्तावित उत्खनन् योजनामा उल्लेख भए बमोजिम फिल्डमा अन्वेषणका कार्य भए/नभएको, भौगर्भिक र भौगोलिक रुपमा प्रस्तावित खानी उत्खनन् योग्य रहे/नरहेको, सामाजिक र वातावरणीय हिसावले उत्खनन् कार्य गर्न सकिने/नसकिने



चित्र नं. २: विभागबाट खानी अनुगमन गर्दा गरिने क्षेत्रगत विभाजनको विवरण

आदि विषयबस्तुको अवलोकन गरिन्छ । फिल्ड भेरिफिकेशन प्रतिवेदनका आधारमा आवश्यकता अनुसार प्रस्तावमा सुधार वा संशोधन गर्न लगाई उत्खनन् प्रस्ताव अगाडी बढाउने वा नबढाउने निर्णय लिईन्छ। यसरी गरिने अनुगमनलाई अनुमतिपत्र नवीकरणमा आधार लिईन्छ ।

कुनै खानीको खास विषयबस्तुमा केन्द्रित भएर गरिने फिल्ड अनुगमन बाहेक विभागबाट गरिने नियमित खानी अनुगमन मुख्यतया तल उल्लेखित विषयबस्तुमा केन्द्रित भएर गर्ने गरिन्छ:

- खानीको पिलरसहितको उत्खनन् क्षेत्रको डिमार्केशन भए/नभएको,
- स्वीकृत क्षेत्र भित्र उत्खनन् भए/नभएको,
- वेष्ट उत्सर्जन व्यवस्थित भए/नभएको,
- स्वीकृत डिजाईन बमोजिम काम भए/नभएको,
- खानीका कारण वरपरको पर्यावरणमा उल्लेखनीय असर परे/नपरेको,
- कामदारहरुलाई सुरक्षा सामग्री प्रदान गरे/नगरेको,
- मापन यन्त्रको यथोचित व्यवस्था भए/नभएको,
- कामदार र मेशीनरीको विवरण,
- उत्पादित खनिजको विवरण (दैनिक/मासिक),
- सामाजिक उत्तरदायित्वका कार्यहरु आदि।

५. अनुगमनका क्रममा पाईएका तथ्यहरु

देशभरमा उत्खनन् अनुमतिपत्र जारी भएका खानीहरु मध्ये ७० वटा विभिन्न खानीक्षेत्रको स्थलगत अनुगमनमा देखिएका मुख्य विषयबस्तुहरु निम्न अनुसार रहेका छन :-

क. अधिकांश खानीहरु नियमित तथा पूर्ण क्षमतामा संचालन हुन नसकेको

विभागीय फिल्ड अनुगमन तथा खानी संचालकहरुले विभागलाई उपलब्ध गराएको तथ्याङ्क हेर्दा धेरैजसो खानीहरु नियमित संचालन हुन नसकेको देखिन्छ।बजारमाग कम भई खनिजमा आधारित उद्योगहरुमा कच्चा पदार्थको खपत कम भएको, खानीबाट उत्पादित कच्चा पदार्थ खपत हुने आफ्नै उद्योग नहुँदा माग अनुसार मात्र उत्पादन हुने गरेको, खानी संचालनमा स्थानीय समुदाय, स्थानीय तह र असम्बन्धित संघसंस्था वा समूहबाट समेत बेलाबेलामा अवरोध हुने गरेको आदि कारणबाट खानी नियमित तथा पूर्ण क्षमतामासंचालन हुन नसकेको पाईएको छ ।

ख. स्वीकृत डिजाईन अनुसार काम हुन नसकेको

धेरैजसो खानी प्राविधिक कर्मचारीको रेखदेखमा संचालन हुन नसक्दा स्वीकृत डिजाईनको पालना हुन सकेको छैन।खानी क्षेत्र र अन्य सहायक संरचनाहरु (वेष्ट यार्ड, स्टक यार्ड, टप स्वाईल यार्ड) को पिल्लर सहितको स्पष्ट डिमार्केशन नभएको, स्वीकृत कार्ययोजना बमोजिम जनशक्ति प्रयोग नभई प्राविधिक कर्मचारी विना नै खानी संचालन हुँदा बढी गुणस्तर को खनिजको मात्र छानीछानी उत्खनन् (Selective Mining) गर्ने जस्ता प्रवृत्ति देखिएको छ ।

ग. खानीजन्य वेष्टको उचित व्यबस्थापन हुन नसकेको

स्वीकृत डिजाईनमा तोकिएको स्थानमा वेष्ट व्यवस्थापनका लागि कतिपय खानी संचालकहरु उदासीन देखिएको, खानी संचालन गर्नुपूर्व पर्याप्त विस्तृत अन्वेषण नभई माईनिङ्ग स्कीम

टेबुल नं. २: आर्थिक वर्ष २०७९/८० मा भएका अनुगमन तथा फिल्ड भेरिफिकेशनको संख्या

सि.नं.	क्षेत्र	अनुगमन भएका खानीको संख्या	भेरिफिकेशन गरिएका प्रस्तावित खानीको संख्या
१.	उदयपुर, सिन्धुली	८	७
२.	दोलखा, सिन्धुपाल्चोक, काभ्रेपलाञ्चोक	२	४
३.	मकवानपुर	१२	१
४.	चितवन, धादिङ्ग	३	०
५.	पाल्पा, अर्घाखाँची	१५	१
६.	प्यूठान, दाङ्ग, रोल्पा	२१	४
७.	अन्य (क्षेत्रगत रुपमा नभएका र साधारण निर्माणमुखी समेत)	९	१५
	कुल	**७०**	**३२**

स्वीकृत गराउदा आसातित परिमाणभन्दा बढी खानीजन्य वेष्ट पैदा हुनु आदि कारणले वेष्ट व्यवस्थापनमा चुनौती देखिएको छ ।

घ. खानीद्वारमा परिमाण एकिन गर्ने उपकरण जडान नभएको

सबै खानीहरुको खानीद्वारमा उत्खनित खनिजको परिमाण एकिन गर्ने यथोचित उपकरण जडान भईनसकेको हुँदा उत्पादित वास्तविक खनिज परिमाणको प्रमाणीकरण खानीद्वारमै हुन सकेको छैन । यद्यपि पछिल्लो समयमा खानीद्वारमा तौलपुल जडानको संख्या उल्लेख्य रुपमा बढिरहेको छ ।

विभागबाट भएको अनुगमनका आधारमा नियमित संचालन नभएका खानीहरुलाई नियमित तथा पूर्ण क्षमतामा संचालन गर्न निर्देशन दिने गरिएकोछ भने स्वीकृत डिजाईन अनुरुप काम नभएका र खानीजन्य वेष्टको समोचित व्यवस्थापन नगर्ने खानीहरुलाई खानी तथा खनिज पदार्थ ऐन तथा नियमावलीको प्रावधान बमोजिम आवश्यक कारवाही गरी स्वीकृत डिजाईन बमोजिम काम गर्न निर्देशन दिईन्छ। यस्तै खानीद्वारमै उत्खनित खनिजको परिमाण एकिन गर्ने उपकरण जडान गर्न पटक पटक निर्देशन दिईएको र पछिल्लो पटक २०८१ बैशाख मसान्तसम्म सम्पुर्ण खानीहरुको खानीद्वारमा परिमाण एकिन गर्ने उपकरण जडान गरी सो को जानकारी विभागलाई गराउन निर्देशन दिईएको छ। खानी र अन्य सहायक संरचना रहने स्थानहरुको डिमार्केशन नभएका खानीहरुलाई अनिवार्य रुपमा डिमार्केशन गरी प्रतिवेदन पेश गर्न निर्देशन दिईएको छ ।

६. उपसंहार

खनिज कार्य अनुमतिकर्ताहरुलाई प्रचलित ऐन कानूनको अधीनमा रही विभागीय शर्त एवं निर्देशनहरु समेतको पूर्णरुपमा पालना गर्दै खनिज खोजतलास कार्य तथा खनिज उत्खनन् कार्य गर्न अभिप्रेरित गर्नुपर्ने देखिन्छ । यसका लागि खानी तथा खनिज व्यवस्थापन र वातावरण संरक्षण कार्यमा गरेको प्रगतिको आधारमा दण्डित र पुरस्कृत गरिने व्यवस्था हुनुपर्दछ । खानीद्वारमा तत्काल अनिवार्य तौलपुलको व्यवस्था गराई दीर्घकालीन रुपमा तौलपुलमा नै डाटा लगर जडान गरी रियल टाईम तथ्याङ्क विभागमा उपलब्ध हुने व्यवस्था मिलाउनुपर्दछ । खानी संचालनबाट खानीक्षेत्रको भू-धरातलमा परिवर्तन हुने भएकाले ठूला खानीहरुको हकमा कम्तीमा ३ वटा स्थायी वेञ्चमार्क खानीक्षेत्र बाहिर स्थापना गरी सो लाई सुरक्षित राखिनुपर्ने र भविष्यमा ती वेञ्चमार्कहरुको आधारमा सर्वेक्षण गरी उत्खनित खनिजको परिमाण एकिन कार्य प्रभावकारी बनाउन सकिन्छ। सिमित श्रोतसाधन र जनशक्तिका कारण डिजिटल अनुगमन प्रणाली मार्फत रियल टाईम मनिटरिङ्ग प्रविधी भित्राई खानी नियमन तथा प्रशासन कार्य गर्नु आजको आवश्यकता रहेकोछ ।

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आर्थिक वर्ष २०७८/०७९ र २०७९/०८० को बजेट, योजना प्रगति समीक्षाको प्रतिवेदन

नारायण बाँस्कोटा (सि.डि.जियोलोजिष्ट), सुलभ कायस्थ (जियोलोजिष्ट), शिला भट्टराई (जियोलोजिष्ट)

१. परिचय

भौगर्भिक अध्ययन, अनुसन्धान तथा खनिज सम्पदाको अन्वेषण, प्रवर्द्धन एवं विकासमा नेपालको संभवत सबैभन्दा पुरानो बिभागहरु मध्ये एउटा खानी तथा भूगर्भ विभाग हो। यस विभागको विकास क्रमको ऐतिहासिक पृष्ठभूमि केलाएर हेर्ने हो भने बि.सं. १९८६ मा नहर तथा जियोलजि अड्डा, बि. सं. १९९९मा खानीअड्डा, बि. सं. २०२४ मा भौगभिक सर्भेक्षण बिभाग हुदै बि.सं. २०३३ मा आएर यसको नामाकरण खानी तथा भूगर्भ विभाग हुन पुगेको हो ।

नेपाल सरकारको स्वीकृत संघिय विभागीय संगठन संरचना वमोजिम महानिर्देशकको मातहतमा (क) भू-विज्ञान, (ख) खनिज सम्पदा र (ग) योजना, प्रशासनिक तथा प्राविधिक सेवा महाशाखा गरी ३ महाशाखा तथा पेट्रोलियम अन्वेषण तथा प्रवर्द्धन केन्द्र, खनिज प्रवर्द्धन तथा प्रशोधन केन्द्र र राष्ट्रिय भूकम्प मापन तथा अनुसन्धान केन्द्र गरी ३ केन्द्र तथा २५ शाखाहरु, भूकम्प मापन केन्द्र सुर्खेत (शाखा कार्यालय) तथा पेट्रोलियम अन्वेषण परियोजनाको व्यवस्था गरिएकोछ ।

२. उद्देश्यहरु

२.१ भूविज्ञान महाशाखा;

- भौगर्भिक, भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्साहरु प्रकाशन गर्ने, सेवा उपलब्ध गराउने ।
- पूर्वाधार विकास, वातावरणीय सुधार तथा प्रकोप व्यवस्थापन कार्यका लागि आवश्यक पर्ने कार्य गर्ने, भौगर्भिक तथ्याङ्कहरु उपलव्ध गराउने ।

२.२ खनिज सम्पदा महाशाखा;

- खानी तथा खनिजजन्य पदार्थको अध्ययन, अनुसन्धान तथा अन्वेषण गर्ने गराउने ।
- खानीहरुको नियमन, प्रशासन तथा प्रवर्धन गर्ने गराउने ।
- खानी तथा खनिजजन्य पदार्थ सम्वन्धि नीति तथा कानून तर्जुमा गर्ने गराउने ।

२.३ योजना, प्रशासनिक तथा प्राविधिक सेवा महाशाखा;

- आवधिक तथा बार्षिक योजना तर्जुमा, बार्षिक कार्यक्रमहरु तयार गर्ने ।
- खनिज पदार्थको रसायनिक परिक्षण गर्ने ।
- विभागको जिन्सी, आर्थिक तथा कर्मचारी प्रशासन सञ्चालन गर्ने, गराउने ।

२.४ पेट्रोलियम अन्वेषण तथा प्रवर्द्धन केन्द्र;

- पेट्रोलियम तथा प्राकृतिक ग्याँस हुनसक्ने संभावित क्षेत्रमा अन्वेषण गरी राष्ट्रिय तथा अन्तराष्ट्रिय लगानीकर्तालाई पेट्रोलियम अन्वेषण एवं उत्पादन गर्न आकर्षण गर्ने ।

२.५ खनिज प्रवर्द्धन तथा प्रशोधन केन्द्र;

- खनिज भण्डारको मूल्याङ्कन गरी खनिज भण्डारमा आधारित खनिज उद्योगहरुको विकास तथा प्रवर्धन गर्ने ।
- किमति तथा अर्ध किमति पत्थर खनिजको प्रवर्द्धन तथा प्रशोधन सम्बन्धि कार्य गर्ने ।
- धातु खनिजको प्रशोधन सम्बन्धि कार्य गर्ने ।
- उपरोक्त बमोजिमको प्रयोगशाला सेवा सम्बन्धित कार्य गर्ने ।

२.६ राष्ट्रिय भूकम्प मापन तथा अनुसन्धान केन्द्र;

- भूकम्प मापन केन्द्रहरु निरन्तर संचालन गरी भूकम्पीय अध्ययन तथा अनुसन्धान गर्ने ।

उपरोक्त बमोजिमको उद्देश्य पुर्तिका लागि (१) खानी तथा भूगर्भ विभाग, (२) भू-विज्ञान तथा (३) खनिज सम्पदा तथा विकास गरि ३ वटा आयोजनाहरु मार्फत वजेट विनियोजित भई कार्य सम्पादन हुदै आएकोछ ।

३. आ.व. २०७८/७९ को मुख्य मुख्य कार्यक्रम र त्यसको प्रगती

➢ **भू-वैज्ञानिक सर्भेक्षण तथा अनुसन्धान आयोजना अन्तर्गत**

- भौगर्भिक म्यापिङ्ग: लम्जुङ्ग, कास्की, तनहुँ जिल्लाका विभिन्न क्षेत्रहरुको भौगर्भिक नक्साङ्कन तथा अपडेट फिल्ड कार्य सम्पन्न ।
- भू-ईञ्जिनियरिङ अध्ययन: गुलरिया, वर्दियामा १०० वर्ग कि.मि. क्षेत्रमा भू-ईञ्जिनियरिङ तथा भू-वातावरणिय अध्ययन फिल्ड कार्य सम्पन्न ।
- आकस्मिक पहिरो अध्ययन: पनौती, धादिङ्ग, गोरखा,

संखुवासभा, रामेछाप, उदयपुर जिल्लाका विभिन्न क्षेत्रमा गएको आकस्मिक पहिरोको अध्ययन कार्य सम्पन्न ।

- Landslide Susceptibility अध्ययन: म्याग्दि जिल्लाका पहिरो जोखिम क्षेत्रको Landslide Susceptibility अध्ययन कार्य सम्पन्न ।

➢ **खानी तथा भूगर्भ विभाग अन्तर्गत**

- नियो-टेक्टोनिक अध्ययन: बुडर, डडेलधुरा क्षेत्रमा नियोटेक्टोनिक अध्ययन कार्य सम्पन्न ।
- नियमित रुपमा भूकम्पीय डाटा संकलन तथा अध्ययन ।
- प्रयोगशाला सेवा ।

➢ **खनिज अन्वेषण तथा विकास आयोजना अन्तर्गत**

- अन्वेषणात्मक ड्रिलिङ्ग: ग्रेनाइट अन्वेषण, काभ्रेपलाञ्चोकमा ४०हे. टोपोग्राफिकल सर्भे फिल्ड कार्य सम्पन्न र अन्वेषणात्मक ड्रिलिङ्ग (१५०मि.) कार्यका लागि फिल्ड कार्य सम्पन्न ।
- तामा अन्वेषण: बौलिगाड, बझाङमा तामा अन्वेषण फिल्ड अध्ययन कार्य सम्पन्न ।
- फलाम अन्वेषण: बुङ्गल, बझाङमा प्रारम्भिक फलाम फिल्ड अन्वेषण, मल्लादेवी, बैतडीमा फलामको भू-भौतिक तथा भौगर्भिक अन्वेषण कार्यका लागि फिल्ड र लोहाकोट फलामको भौगर्भिक अन्वेषण कार्यका लागि फिल्ड कार्य सम्पन्न ।
- डोलोमाईट अन्वेषण: डोलोमाईटको औद्योगिक परीक्षण, प्राथमिकता र बजार अध्ययन, बोझे, खोटाङ्का लागि स्याम्पल कलेक्सन फिल्ड कार्य सम्पन्न ।
- नदिजन्य निर्माणमुखी खनिजको सम्भाव्यता अध्ययन: कैलाली जिल्लाको गोदावरी नगरपालिका आसपासबाट बग्ने नदिहरुबाट निर्माणमुखी खनिजको सम्भाव्यता अध्ययन फिल्ड कार्य सम्पन्न ।
- किमत्ति तथा अर्धकिमत्ति पत्थर अन्वेषण: ताप्लेजुङ र संखुवासभा जिल्लामा किमत्ति तथा अर्ध किमत्ति पत्थर अन्वेषण फिल्ड कार्य सम्पन्न ।
- खानीहरुको अनुगमन निरिक्षण तथा फिल्ड भेरिफिकेशन: संचालनमा र संचालनका क्रममा रहेका विभिन्न जिल्लाका ११० खानीहरुको फिल्ड अनुगमन, निरिक्षण कार्य सम्पन्न ।

४. आ.व. २०७९।८० को मुख्य मुख्य कार्यक्रम र त्यसको प्रगती

➢ **भू-वैज्ञानिक सर्भेक्षण तथा अनुसन्धान आयोजना अन्तर्गत**

- भौगर्भिक म्यापिङ्ग: रोल्पा, बाग्लुङ्ग जिल्लाका विभिन्न क्षेत्रहरुमा १:५०,००० स्केलको भौगर्भिक नक्साङ्कन अपडेट फिल्ड कार्य सम्पन्न ।
- भू-ईञ्जिनयरिङ अध्ययन: मधेस प्रदेश अन्तर्गत बर्दिबास र आसपासका क्षेत्रको भू-ईञ्जिनियरिङ तथा भू-वातावरणिय अध्ययन (१०० वर्ग कि.मि.) कार्य सम्पन्न ।

➢ **खानी तथा भूगर्भ विभाग अन्तर्गत**

- नियो-टेक्टोनिक अध्ययन: सुर्खेत देखि बुडर सम्मको नियोटेक्टोनिक अध्ययन फिल्ड कार्य सम्पन्न ।
- नियमित रुपमा भूकम्पीय डाटा संकलन तथा अध्ययन ।
- प्रयोगशाला सेवा ।

➢ **खनिज अन्वेषण तथा विकास आयोजना अन्तर्गत**

- क्ले खनिज अन्वेषण: मधेश, बाग्मती, लुम्बिनी, गण्डकी प्रदेशका केही स्थानहरुमा Ceramics तथा Tiles को लागी चाहिने कच्चा पदार्थहरुको अन्वेषण फिल्ड कार्य सम्पन्न ।
- डोलोमाईट अन्वेषण: टाईल्स, ऋययिगच, एगततथ लगायत अन्य प्रयोजनमा प्रयोग भइरहेको डोलोमाईट खनिजको लागि सुनौला बजार धादिङ्गमा अन्वेषण फिल्ड कार्य सम्पन्न ।
- ग्रेनाईट अन्वेषण: नेपालमा करिव वार्षिक ४ अर्वको आयात भइरहेको ग्रेनाईट खनिजलाई आयात कम गर्ने उद्देश्यले ग्रेनाईट खानीको सम्भावित क्षेत्र रहेको सिन्धुली जिल्लामा प्रारम्भिक अन्वेषण फिल्ड कार्य सम्पन्न ।
- तामा अन्वेषण: धातु खनिज अन्तर्गत तामा खनिज भण्डार पहिचानका लागि दिङ्गला, भोजपुर र पूर्वी रूकुमको झुन्लाबाङ्ग क्षेत्रमा फिल्ड अध्ययन कार्य सम्पन्न ।
- फलाम अन्वेषण: संखुवासभाको लोहाकोटमा फलामको भूभौतिक अध्ययन गरि र पूर्वी रुकुमको झुन्लाबाङ्ग क्षेत्रमा प्रारम्भिक फलाम अन्वेषण कार्य सम्पन्न ।
- किमत्ति तथा अर्धकिमत्ति पत्थर अन्वेषण: धादिङ्गको रूबी भ्याली क्षेत्र र मनाङ जिल्लामा किमत्ति तथा अर्धकिमत्ति पत्थरको अन्वेषण कार्य सम्पन्न ।
- खानीहरुको अनुगमन, निरिक्षण तथा फिल्ड भेरिफिकेशन: संचालनमा र संचालनका क्रममा रहेका विभिन्न जिल्लाका १०० वटा खानीहरुको फिल्ड अनुगमन, निरिक्षण कार्य सम्पन्न ।
- खनिजन्य उद्योग प्रवर्धन: विभागबाट हालसम्म ४० वटा विभिन्न खनिजहरुको प्रवर्द्धन भई विषेश गरी चुनढुङ्गामा आधारित सिमेण्ट उद्योगको स्थापना भइसकेको छ र यस आ.व. मा विभिन्न ९ खनिजहरुको प्रवर्द्धनका लागि खानीहरुको टेण्डर सूचना प्रकाशन गरिएको र मूल्याङ्कन कार्य पश्चात कुनै पनि प्रस्तावहरु प्रभावग्राही नरहेकोले सूचना रद्द गरिएको ।

५. राजश्व संकलनको विवरण

आर्थिकवर्ष	राजश्व संकलन
आ.व.०७८।७९	रु.१,२५,४५,८१,७०९।२७
आ.व.०७९।८०	रु.६२,१५,९१,४११.६९

६. विभाग र आयोजना अन्तर्गत भौतिक र वित्तिय प्रगतिको विवरण

आ.व.	क्र.सं.	निकायःआयोजना/कार्यक्रम	ब. उ. शी. नं.	भौतिक प्रगति (%)	वित्तीय प्रगति (%)
२०७८।७९	१	खानी तथा भूगर्भ विभाग	३०७०२०११	६८.७२	६८.३५
	२	खनिज अन्वेषण तथा विकाश आयोजना	३०७०२१०१	१८.६८	१८.०५
	३	भूवैज्ञानिक सर्वेक्षण तथा अनुसन्धान आयोजना	३०७०२१०३	९२.९६	८०.७९
२०७९।८०	१	खानी तथा भूगर्भ विभाग	३०७०२०११	४२.६३	६१.६७
	२	खनिज अन्वेषण तथा विकास आयोजना	३०७०२१०१	३४.०६	३०.०८
	३	भू-वैज्ञानिक सर्भेक्षण तथा अनुसन्धान आयोजना	३०७०२१०३	५०.९९	८१.०१

७. विभाग र आयोजना अन्तर्गत बिनियोजित वार्षिक रकम र यथार्थ खर्चको विवरण

आ.व.	क्र.सं.	निकायः आयोजना/कार्यक्रम	ब. उ. शी. नं.	वार्षिक विनियोजित बजेट (रु. लाखमा)			यथार्थ खर्च (रु. लाखमा)		
				चालु	पुँजीगत	जम्मा	चालु	पुँजीगत	जम्मा
२०७८।७९	१	खानी तथा भूगर्भ विभाग	३०७०२०११	९९८	१२८	११२६	६९३.६२	७५.७७	७६९.३९
	२	खनिज अन्वेषण तथा विकाश आयोजना	३०७०२१०१	९१	१८९३	१९८४	७२.०४	२८६.१५	३५८.१९
	३	भूवैज्ञानिक सर्वेक्षण तथा अनुसन्धान आयोजना	३०७०२१०३	९१	१०६	१९७	८१.१६	७८	१५९.१६
			जम्मा	११८०	२१२७	३३०७	८४६.८३	४३९.९२	१२८६.७५
२०७९।८०	१	खानी तथा भूगर्भ विभाग	३०७०२०११	९९६.८९	९३.८६	१,०९०.७५	८४१.८२	४१.८४	८८३.६६
	२	खनिज अन्वेषण तथा विकास आयोजना	३०७०२१०१	८१.६४	५७७.२९	६५८.९३	७०.१३	१२८.०७	१९८.२०
	३	भू-वैज्ञानिक सभेक्षण तथा अनुसन्धान आयोजना	३०७०२१०३	८३.३५	१५५.१२	२३८.४७	७९.८७	६७.२०	१४७.०७
			जम्मा	१,१६१.८८	८२६.२७	१,९८८.१५	९९१.८२	२३७.११	१,२२८.९३

८. विभागिय सूचकको प्रगति

क्र.स.	सूचक	इकाई	वेसलाइन (आधार वर्ष २०७६।७७)	आ.व.२०७७।७८को प्रगती	आ.व.२०७८।७९को प्रगति	आ.व.२०७९।८० को प्रगति
१	खानी अन्वेषणको क्षेत्रफल	वर्ग कि.मि.	४४०५१	८०४	११६२	१२०५
२	खनिज अन्वेषणात्मक सर्वेक्षण	हेक्टर	२८५०	१००	२४०	१००
३	खनिज अन्वेषणात्मक ड्रिलिङ्ग	मिटर	२५३५	२९५	१५०	-

९. विभागिय तथ्याङ्कको प्रगति

क्र. सं.	विवरण	ईकाई	विगत आर्थिक वर्षको तथ्याङ्क			
			२०७६।७७	२०७७।७८	२०७८।७९	२०७९।८०
१	गैरकर राजश्व संकलन	रू करोडमा	८४.२६	९५.५९	१२५.४६	६२.१६
२	खनिज अन्वेषणको क्षेत्रफल	वर्ग कि.मि.	८४६	८०४	११७२	१२०५
३	अन्वेषण भएका खानी तथा खनिज	वटा	६	११	१२	१०
४	खानी खोजतलासको प्रमाणपत्र	वटा	३८१	३६८	४१५	४२२
५	खानी उत्खनन् को प्रमाणपत्र	वटा	१४६	१५२	१५७	१५९
६	उत्खनन्/खोजतलास प्रमाणपत्र रद्द गरिएको	वटा	१३८	६७	१३५	१२१
७	निर्माणमुखी खनिज उत्खनन् सहमति प्रदान	वटा	४	७	६	१
८	खानी अनुगमन तथा निरिक्षण	वटा	४५	६०	१००	१००
९	खास खनिज प्रवर्द्धन	वटा	९	११	६	
१०	४ रेक्टर स्केल भन्दा माथिका भूकम्प	वटा	३४	३०	३३	३२
११	भौगर्भिक अध्ययनको लागि सहमति प्रदान	वटा	३	५	१८	२२

१०. विभागका क्रियाकलाप कार्यान्वयनमा देखा परेका प्रमुख समस्याहरु

- विभागका प्राविधिक जनशक्तीसंग उपकरण संचालनको लागी समय सापेक्ष प्राविधिक ज्ञानको कमी, आवश्यक तालिमको ब्यवस्था नहुनु ।
- सवारी साधनको अभाव- एउटै सवारी साधनबाट धेरै फिल्ड कार्य गर्ने बाध्यता र अधिकाँश सवारी साधन २० वर्ष भन्दा पुराना भएकाले वर्कशपमा मर्मतका लागि थन्किने अवस्थामा रहेको ।
- एउटै जनशक्तिबाट विभिन्न अन्वेषण, खानी प्रशासन, विपद् अध्ययनमा संलग्न रहने हुँदा तोकिएको जिम्मेवारी सम्पन्न हुन नसक्नु ।
- संघिय संरचनामा सहायक स्तरका Sampler, Lab assistant, Lab boy दरबन्दी कटौती हुनु ।

११. खानी अन्वेषण तथा बजेट कार्यान्वयनको चुनौतीहरु

- खानी तथा भूगर्भ विभागको हालको संघिय संगठानिक संरचनाको व्यवस्था अनुसार कार्याधिकार केन्द्रमा मात्र निहित रहेको र अधिकांश खानी क्षेत्र नेपालको विभिन्न जिल्लाका विकट क्षेत्रहरुमा समेत रहेकोले अनुगमन निरीक्षण गर्न कठिनाई भइरहेको।
- पछिल्ला O&M Survey हरुबाट विभागको दरबन्दी कटौती हुँदै जानु र जिम्मेवारी थपिदै जाँदा खनिज अन्वेषण तथा विकास पर्याप्त मात्रामा नहुनु र पुरानो विभागबाट अहिले सम्म देखिने रुपमा कार्य नहुनु ।
- नेपालमा रहेका विश्वविद्यालयबाट भूगर्भ अध्ययन बाहेक अन्य आवश्यक खानी सम्बन्धी जनशक्तिको उत्पादन नहुँदा धातुजन्य उद्योगमा आवश्यक जनशक्ति तथा प्रयोगशाला संचालन नहुनु ।

- नविनतम प्रविधिको प्रयोगमा अभ्यस्त हुन विभागमा कार्यरत जनशक्तिहरुलाई तालिमको कमिले प्रतिफल प्राप्त नहुनु ।
- जोखिम तथा रेडियोधर्मी पदार्थहरुको अन्वेषण, परिक्षण कार्यमा संलग्न कर्मचारीहरुलाई प्रोत्साहनका क्रियाकलापहरु नहुनु ।

१२. समस्याहरुको समाधानार्थ भएका प्रयासहरु

- प्रदेशलाई हेर्ने गरी संघिय कार्यान्वयन एकाईको संरचना तयार गरी मन्त्रालयमा पेश गरिएको ।
- अन्वेषणकार्य, उत्खनन् कार्य, खनिज प्रशोधन कार्यको लागी ज्ञान तथा सीप हस्तान्तरण गर्न वैदेशिक प्रविधिक वा संस्थासंग समझदारी गर्न आवश्यक पहल भईरहेको ।
- Mining and Metallurgical Engineering, Geophysics, Geochemist सम्बन्धि अध्यापन कार्यको लागी काठमाडौं विश्वविद्यालय, त्रिभूवन विश्वविद्यालयद्वारा पाठ्यक्रम विकाश गर्ने र अध्ययनकार्य संचालन सम्बन्धमा छलफल भई काठमाडौं विश्वविद्यालयबाट माईनिङ्ग विषयमा स्नातक डिग्रीको ४ बर्षे बी.ई. कोर्स संचालनमा ल्याएको ।

सूचनाको हक सम्बन्धि व्यवस्था र विभागको भूमिका

नारायण बाँस्कोटा (सि.डि.जियोलोजिष्ट), सुलभ कायस्थ (जियोलोजिष्ट)

सारांश

सूचना भन्नाले सार्वजनिक निकायबाट सम्पादन हुने वा भएको सार्वजनिक महत्वको काम, तत्सम्बन्धी कारबाही वा निर्णयसँग सम्बन्धित कुनै लिखत, सामग्री वा जानकारी सम्झनुपर्छ। सूचनाको हक भन्ने बित्तिकै कानुनी उपचार भन्ने बुझ्नुपर्दछ र यो प्रत्येक नागरिकको मौलिक हक हो। हाल विश्वका १०५ भन्दा बढी देशहरूले संविधान र कानुन निर्माण गरी सूचनाको हकको प्रत्याभूति गरेका छन्। संवैधानिक हकको रूपमा नभएका देशहरूले पनि कार्यविधि, मापदण्डहरू निर्माण गरी थप प्रभावकारी बनाउँदै लगेको पाइन्छ। संवैधानिक व्यवस्था हुनुपूर्व नेपालमा सूचनाको हक सम्बन्धि व्यवस्था कमजोर थियो। संवैधानिक व्यवस्था लागु भई सके पछि "राष्ट्रिय सूचना आयोग"को गठन भई प्रत्येक सार्वजनिक निकायमा सूचना अधिकारीको व्यवस्था समेत गरिएको छ। सूचनाको हक सम्बन्धमा विभिन्न अन्य गैरसरकारी संघ-संस्थाहरू समेत संलग्न रहेका छन्। सूचनाको हकले प्रत्येक नागरिकलाई सशक्तीकरण गराउँछ भने राज्य संयन्त्रलाई उत्तरदायी बनाउँछ। खानी तथा भूगर्भ विभागमा समेत सूचना अधिकारी मार्फत सूचना प्रभाव हुने गरेको छ। विभागबाट सूचना प्रभाव गर्न मिल्ने र नमिल्ने वर्गीकरण गरि सार्वजनिक गरिएको छ। सूचना प्रभावमा केही द्विविधा भएमा सूचना आयोगको निर्देशन माग गर्न सकिने र सोही बमोजिम सूचना प्रभाव गर्न सकिन्छ। सूचना उपलब्ध गराउने सन्दर्भमा नेपालमा केही समस्याहरु देखिएका छन्। तीनलाई नीतिगत सुधार, संस्थागत सुधार, कार्य विधिगत सुधार तथा अन्य सुधारका माध्यमद्वारा सम्बोधन गर्न सकिने अवस्था रहेकोछ।

Key Words: सार्वजनिक निकाय, आयोग, सूचना अधिकारी

१. अर्थ र परिभाषा

सूचना भन्नाले कुनै विषयमा भएको कामकारबाही वा कुनै विचारलाई बोलेर वा लेखेर वा कुनै दृश्य वा चित्रबाट सबैले वा धेरैले थाहा पाउने गरी प्रकाशित, प्रचार र प्रसार गर्ने कार्य हो। सूचना भनेको कुनै पनि कुराको जानकारी पाउनु हो। सूचना बिना कुनै पनि काम गर्न सकिँदैन र अर्को शब्दमा भन्दा सूचना ज्ञानको स्रोत हो। Business Dictionary ले Information लाई यसरी परिभाषित गरेको छ: Data that is (1) accurate and timely, (2) specific and organized for a purpose, (3) presented within a context that gives it meaning and relevance, and (4) can lead to an increase in understanding and decrease in uncertainty. सूचनाको हकका सम्वन्धमा "सूचना" भन्नाले सार्वजनिक निकायबाट सम्पादन हुने वा भएको सार्वजनिक महत्वको काम, तत्सम्बन्धी कारबाही वा निर्णयसँग सम्बन्धित कुनै लिखत, सामग्री वा जानकारी सम्झनुपर्छ।

सूचनाको हक भन्ने बित्तिकै कानुनी उपचार भन्ने बुझ्नुपर्दछ। आजको सङ्घीय लोकतान्त्रिक गणतन्त्र शासन प्रणाली भएको राष्ट्रहरूमा सूचनाको हकको अति नै महत्व हुन्छ। खुला समाजमा सरकारले गरेको कामकारबाही वा अन्य जुनसुकै सार्वजनिक सरोकारको विषयमा सबैलाई थाहा पाउने र छलफल गरी आ-आफ्नो धारणा र विचार व्यक्त गर्ने अधिकार प्राप्त हुन्छ। जनता र संविधान प्रति जबाफदेही सरकारले आफ्नो नैतिकता, जबाफदेहिता र जिम्मेवारीलाई ध्यानमा राखेर काम गर्नुपर्छ। त्यसैले सरकारले वा अरू सार्वजनिक निकायले के-कस्ता निर्णय वा नीति निर्माण वा अन्य काम गरे यस्ता कुराहरू थाहा पाउने प्रत्येक नागरिकको मौलिक हक हो।

२. सूचनाको हक

"सार्वजनिक निकायमा रहेको सार्वजनिक महत्वको सूचना माग्ने र पाउने अधिकार सम्झनुपर्छ र सो शब्दले सार्वजनिक निकायमा रहेको कुनै लिखत, सामग्री वा सो निकायको कामकार बाहीको अध्ययन वा अवलोकन गर्ने, त्यस्तो लिखतको प्रमाणित प्रतिलिपि प्राप्त गर्ने, सार्वजनिक महत्वको निर्माणकार्य भइरहेको स्थलको भ्रमण र अवलोकन गर्ने, कुनै सामग्रीको प्रमाणित नमुना लिने वा कुनै पनि किसिमको यन्त्रमा राखिएको सूचना त्यस्तो यन्त्र मार्फत प्राप्त गर्ने अधिकार" सूचनाको हक हो।

सूचनाको हकको अध्ययन गर्दा "सार्वजनिक महत्व" के हो भन्ने कुराको जानकारी हुनुपर्दछ। यस सम्बन्धि कानूनले "सार्वजनिक महत्व" भन्नाले सार्वजनिक सरोकारको विषय भनेकोछ। सर्वोच्च अदालतले सार्वजनिक निकायबाट गरिने कामकारबाहीबाट पूरै राष्ट्रलाई वा सर्वसाधारण जनताको कुनै वर्ग वा समुदायलाई प्रत्यक्ष वा अप्रत्यक्ष रूपमा असर पर्न सक्दछ भने ती कामकारबाही सार्वजनिक महत्वका हुन भनि व्याख्या भएको छ।

३. अवधारणा

आधुनिक रूपमा कानुन निर्माण गरी सूचनाको हकको

प्रत्याभूति गरिनु भन्दा पहिलेदेखि नै शासकहरूले आफूले गरेको महत्वपूर्ण कामहरू आफ्ना जनता अर्थात् त्यति बेलाका रैतीहरूलाई जानकारी गर्ने गराउने गरेको देखिन्छ। शताब्दियौं अगाडि सरकारको काम भनेको मालपोत उठाउने र शान्तिसुरक्षा गर्ने काममा मात्र सीमित थियो। त्यति बेला अहिलेको जस्तो कार्यकारिणी कामले व्यापकता पाएको थिएन। संविधान नै नभएकोले त्यति बेला मौलिक हक वा कानुनी हक भन्ने नै थिएन। आर्थिक विकासको नाममा बाटोघाटो, प्राथमिक विद्यालय, मठ-मन्दिर, पाटीपौवा, चौतारा, धारा सत्तल, गुठी स्थापना आदि निर्माणमा सीमित थियो। यस्तो कालमा पनि कसैले कुनै कार्य गर्दा कसको पालामा कसले किन कसरी कहिले के निर्माण कार्य वा स्थापना गरिएको हो सो कुराहरू पाटी, सत्तल, मठ-मन्दिरको घण्टीमा वा निर्माण गरिएको अन्य भौतिक संरचनामा, ढुङ्गामा, कुनै धातुमा वा काठमा कुदी (शिलालेख) गरी राख्ने प्रचलन थियो।

आधुनिक रूपमा भने स्वीडेनले पहिलो पटक १७६६ मा सूचनाको हक सम्बन्धी कानुन Freedom of Press Act बनायो। यसमा नागरिक र प्रेसले सहज तरिकाले सूचना प्राप्त गर्न सक्ने व्यवस्था गरियो। अमेरिकी संविधानलाई खुला सरकारको अवधारणामा आधारित मानिन्छ। यसले प्रत्यक्ष रूपमा सूचनाको हकको व्यवस्था गर्न सकेन तर पहिलो संशोधनले विचार र अभिव्यक्तिको स्वतन्त्रताको प्रत्याभूति गरिदियो। यसअघि नै अमेरिकी स्वतन्त्रता घोषणामा सूचनाको हकलाई अङ्गीकार गरेको थियो। सन् १७८९ मा फ्रान्स घोषणामा, बेलायतमा १७९१ को "विल अफ राइट्स" मार्फत सूचनाको हकलाई स्वीकार गरियो।

१९९० सम्म आउँदा केवल १३ राज्यले कानुनी व्यवस्था गरेकोमा हाल विश्वका १०५ भन्दा बढी देशहरूले संविधान र कानुन निर्माण गरी सूचनाको हकको प्रत्याभूति गरेका छन्। कतिपय देशको संविधानमा मौलिक हकअन्तर्गत समावेश गरी संवैधानिक सुनिश्चितता प्रदान समेत गरेका छन्। व्यवहारमा संवैधानिक हकको रूपमा स्वीकार गरेका देशहरूमा पनि नागरिकले सूचनाको हकको पूर्ण उपभोग गर्न नपाएका तथा संवैधानिक हकको रूपमा नभएका देशहरूले पनि कार्यविधि, मापदण्डहरू निर्माण गरी थप प्रभावकारी बनाउँदै लगेको पाइन्छ। पछिल्लो समय अलग्गै कानुन निर्माण गर्ने देशहरूमा बेलायत, ब्राजिल, चीन, बङ्गलादेश, स्विजरल्यान्ड, इन्डोनेसिया, नाइजेरिया, रसिया लगायतका देशहरू रहेका छन्।

४. नेपालमा सूचनाको हक, विगतदेखि वर्तमानसम्म

४.१ संवैधानिक व्यवस्था हुनुपूर्व

नेपालमा सूचनाको हक प्रचलनको लागि कानुन निर्माण तथा संवैधानिक हकको रूपमा स्वीकार गरिएको धेरै समय नभएको भए पनि नेपाल एकीकरण पूर्व लिच्छवि, किराँतकालमा पनि राज्यका महत्वपूर्ण कामकारबाहीको जानकारी गराउने प्रचलन चाहिँ रहेको पाइन्छ। शासकहरूले आफूले गरेको महत्वपूर्ण कामहरू आफ्ना जनता अर्थात् त्यति बेलाका रैतीहरूलाई जानकारी गर्ने गराउने गरेको पाईन्छ। संविधान नै नभएको ले त्यति बेला मौलिक हक वा कानुनी हक भन्ने नै थिएन। शासक वर्गले गरेका कामकारबाहीको जानकारी माग गरे मा राजद्रोह लाग्ने अवस्था थियो। "जम्मा नजोड्नु कच्चा नछोड्नु" भन्ने उक्ति थियो अर्थात् राज्यको ढुकुटी के कसरी सञ्चालन भएको छ भन्ने कुनै जानकारी जनतालाई थिएन।

४.२ लिखतहरूको गोप्यता सम्बन्धी ऐन, २०३९

नेपालको सुरक्षा, शान्ति तथा व्यवस्था कायम राख्नका लागि सरकारी तथा सार्वजनिक कार्यालयको महत्वपूर्ण कागजातहरू, अभिलेखहरू, सन्धिपत्रहरू जस्ता संरक्षणीय लिखतहरूको वर्गीकरण गर्न र गोप्यताको संरक्षण गर्न भनी लिखतहरूको गोप्यता सम्बन्धी ऐन, २०३९ जारी गरिएको थियो। राजपत्रमा सूचना प्रकाशित गरी तोकेको मितिदेखि लागू हुने भनिएकोमा ऐन लागू गर्ने गरी सूचना नै प्रकाशित नगरिएको कारण यो कानुन कार्यान्वयनमा आएन।

४.३ नेपाल अधिराज्यको संविधान २०४७

नेपाल अधिराज्यको संविधान २०४७ मा पहिलो पटक सूचनाको हकको प्रत्याभूति गरिएको थियो। तत् समयमा संविधानको धारा १६ मा "प्रत्येक नागरिकलाई सार्वजनिक महत्वको कुनैपनि विषयको सूचना माग्ने र पाउने हक हुनेछ भनिएता पनि यस धारामा लेखिएको कुनै कुराले कानून बमोजिम गोप्य राख्नुपर्ने सूचनाको जानकारी दिन कसैलाई कर लगाएको मानिने छैन" भन्ने व्यवस्था गरिएको भए पनि ऐन कानूनको अभावमा सूचनाको हक हात्तीको देखाउने दाँतमा सीमित भएको थियो भनि आलोचना गर्ने गरिन्छ। बरु सर्वोच्च अदालतबाट भएका केही फैसलाले सूचनाको हकको कानुनी संरक्षण चाहीँ गरेको देखिन्छ।

४.४ नेपालको अन्तरिम संविधान २०६३

नेपालको अन्तरिम संविधान २०६३ को धारा २७ मा सूचनाको हकको व्यवस्था गरी आफ्नो र सार्वजनिक महत्वको सूचना माग्ने र पाउने हकको सुनिश्चितता गरिएको थियो।

४.५ कानुनी व्यवस्था

२०६४ सालमा सूचनाको हकसम्बन्धी कानुन निर्माण भई कार्यान्वयनमा आएको छ भने उक्त ऐन कार्यान्वयनमा सहजीकरणका लागि २०६५ मा नियमावली समेत जारी भइसकेको छ।

४.६ सूचनाको हकसम्बन्धी राष्ट्रिय रणनीतिक कार्ययोजना

सूचनाको हकको माग, सशक्तीकरण र आपूर्ति पक्षको

सुदृढीकरण एवं "राष्ट्रिय सूचना आयोग"को क्षमता निर्माण गर्ने गरी तीनवटा मुख्य रणनीतिक प्राथमिकताका साथ सन् २०१५-२०२० सूचनाको हक सम्बन्धि राष्ट्रिय रणनीतिक कार्ययोजना तर्जूमा भई लागु भएको छ । यस पाँच वर्षे रणनीतिक कार्ययोजनाले मुलुकमा सरकारी क्षेत्रभित्रै मौलाएको सीमित सार्वजनिक जबाफदेहिता, उच्च भ्रष्टाचार, सरकारी कोषको हिनामिना, शक्तिको दुरुपयोग र कुशासनलाई मुख्य चुनौतीका रूपमा पहिचान गरेको छ । यसै गरी सूचना प्रवाहमा विभेद तथा विभिन्न सीमान्तकृत र सामाजिक रूपमा बहिष्कारमा परेका समूहको सुस्त गतिको सशक्तीकरण प्रक्रिया पनि अर्को चुनौतीका रूपमा देखिएको छ । यस अतिरिक्त नागरिक र सरकारबीच सूचनाको ठूलो खाडल देखिएको छ भने राजनीतिक दलभित्रै र दलबीच सूचना प्रवाहमा कमी देखिएको छ । साथै सार्वजनिक क्षेत्रमा प्रमाणमा आधारित निर्णय गर्ने अभ्यास अपर्याप्त वा न्यून भएका जस्ता चुनौतीहरू पहिचानसँगै यो रणनीतिक कार्ययोजना तर्जुमा गरिएको देखिन्छ ।

४.७ संस्थागत व्यवस्था

२०६५ साल वैशाख २२ गते एक स्वतन्त्र "राष्ट्रिय सूचना आयोग"को गठन भएको छ । प्रत्येक सार्वजनिक निकायमा सूचना अधिकारीको व्यवस्था समेत गरिएको छ । सूचनाको हक सम्बन्धमा विभिन्न अन्य गैरसरकारी संघ-संस्थाहरू समेत संलग्न रहेका छन् ।

४.८ नेपालको संविधान २०७२

वर्तमान संविधानको धारा २७ अन्तर्गत प्रत्येक नागरिकलाई आफ्नो वा सार्वजनिक सरोकारको कुनै पनि विषयको सूचना माग्ने र पाउने हक हुनेछ। तर कानून बमोजिम गोप्य राख्नुपर्ने सूचनाको जानकारी दिन कसैलाई बाध्य पारिने छैन भन्ने व्यवस्था गरिएको जुन अन्तरिम संविधानकै व्यवस्थालाई निरन्तरता दिएको छ ।

४.९ जिल्ला प्रशासन कार्यालयहरू

आयोगले २०७३ वैशाख ३१ गतेको निर्णयानुसार प्रमुख जिल्ला अधिकारीहरूलाई निम्न अनुसार ३ बुँदे अधिकार प्रत्यायोजन गरेको छ :

(१) प्रत्येक तीन/तीन महिनामा स्वत: प्रकाशन नियमित प्रकाशन गर्न जिल्लाका सबै सरकारी कार्यालय तथा सार्वजनिक संस्थानहरूलाई आदेश दिने ।

(२) जिल्लाका सबै सरकारी कार्यालय तथा सार्वजनिक संस्थानहरूमा सूचना अधिकारी तोक्न र पदाधिकारीको नाम, सम्पर्क र फोटो सहितको विवरण फ्लेक्स बोर्डमा सार्वजनिक गर्न आदेश दिने ।

(३) जिल्लाका सबै सरकारी कार्यालय तथा सार्वजनिक संस्थानहरूमा पर्ने निवेदन र सो बमोजिम सूचना उपलब्ध गराइएको वा इन्कार गरिएको विवरणको छुट्टै अभिलेख राख्न आदेश दिने ।

५. सूचनाको हकको आवश्यकता

आजको युग भनेको सूचनाको युग हो । सूचना भनेको कुनै पनि साध्य पूरा गर्न आवश्यक त्यस्तो अनिवार्य साधन हो जसको अनुपस्थितिमा कुनै पनि लक्ष्य हासिल गर्न कठिनाई हुने गर्दछ । कुनै पनि सूचना प्राप्त गर्नु प्रत्येक नागरिकको मौलिक हक मात्र होइन यो मानव अधिकारको विषय पनि हो । जसलाई संयुक्त राष्ट्रसंघका दस्ताबेजहरू समेतले पुष्टि गरिसकेको अवस्था छ । सूचनाको हकको सुनिश्चितता नभए राज्य निरंकुश बन्दै जान्छ । यसको अभावमा शासकहरू जनताप्रति उत्तरदायी हुँदैनन् । बुँदागत रूपमा भन्नु पर्दाभन्दा सूचनाको हक(ले):

- प्रत्येक नागरिकलाई सशक्तीकरण गराउँछ भने राज्य संयन्त्रलाई उत्तरदायी बनाउँछ ।
- मौलिक हकको पनि हक हो ।
- लोकतन्त्रको अभिन्न अङ्ग हो ।
- सरकारप्रति नागरिकको विश्वास बढाउने माध्यम हो ।
- शासन व्यवस्थामा पारदर्शिताको पूर्व शर्त हो ।
- सशक्त भ्रष्टाचार विरोधी अभियान हो ।
- अनियमितता र ढिलासुस्ती हटाउँछ ।
- राज्य संयन्त्रलाई थप उत्तरदायी बनाउँछ ।
- राज्य तथा नागरिकको हित प्रतिकूल सूचनाको संरक्षण गर्दछ ।
- सार्वजनिक निर्णय प्रक्रिया प्रभावकारी बनाउछ ।
- राज्य व्यवस्था सञ्चालन सूचनामा आधारित एवं वैज्ञानिक बनाउन मद्दत गर्दछ ।
- शासन व्यवस्थामा नागरिकको अर्थपूर्ण सहभागिता गराउछ ।
- सूचनाको माध्यमबाट जनता र सरकारबीचको सम्बन्ध मजबुत बनाउछ ।
- सूचना र ज्ञानमा आधारित समाज निर्माणको आधार बन्दछ ।

६. सूचनाको हक अन्तर्गत प्रवाह गर्न नमिल्ने सूचनाहरू

सूचनाको हक राज्यका कामकारबाही र सार्वजनिक सरोकारको विषयमा जनतालाई अधिकाधिक सुसूचित गराउनुपर्दछ भन्ने मान्यता भए पनि राज्यको गोप्यता (State Secret) र नीजि/व्यक्तिगत गोप्यता (Privacy) का सूचनाहरुको प्रभाव गरिँदैन र गर्न पनि हुदैन् ।

सूचनाको हक सम्बन्धि ऐन, २०६४ को दफा ३ को उपदफा (३) बमोजिम अन्यत्र जुनसुकै कुरा लेखिएको भए तापनि सार्वजनिक निकायमा रहेको देहायको विषय सम्बन्धी सूचना प्रवाह गरिने छैन भनी व्यवस्था गरिएको छ । सोहि बमोजिम, सार्वजनिक निकायमा रहेको देहायको विषय सम्बन्धी सूचना प्रवाह गरिने छैनः-

(क) नेपालको सार्वभौमसत्ता, अखण्डता, राष्ट्रिय सुरक्षा, सार्वजनिक शान्ति सुव्यवस्था वा अन्तर्राष्ट्रिय सम्बन्धमा गम्भीर खलल पार्ने,

(ख) अपराधको अनुसन्धान, तहकिकात तथा अभियोजनमा प्रत्यक्ष असर पार्ने,

(ग) आर्थिक, व्यापारिक तथा मौद्रिक हित वा बौद्धिक सम्पत्तिको संरक्षण वा बैकिङ्ग वा व्यापारिक गोपनीयतामा गम्भीर आघात पार्ने,

(घ) विभिन्न जातजाति वा सम्प्रदाय बीचको सुसम्बन्धमा प्रत्यक्ष रूपमा खलल पार्ने,

(ङ) व्यक्तिगत गोपनीयता र व्यक्तिको जीउ, ज्यान, सम्पत्ति, स्वास्थ्य वा सुरक्षामा खतरा पुर्याउने ।

तर त्यसरी सूचना प्रवाह नगर्नुपर्ने उचित र पर्याप्त कारण भएकोमा बाहेक त्यस्तो सूचना प्रवाह गर्ने दायित्वबाट सार्वजनिक निकाय पन्छिन पाउने छैन । सार्वजनिक निकायको अभिलेखमा यस ऐन बमोजिम प्रवाह गर्न मिल्ने र नमिल्ने सूचना भए सूचना अधिकारीले प्रवाह गर्न मिल्ने सूचना छुट्टयाएर निवेदकलाई उपलब्ध गराउनु पर्नेछ ।

७. सूचनाको हकमा सार्वजनिक निकायको दायित्वहरू

सूचनाको हकका दुई पक्ष- माग पक्ष र आपूर्ति पक्ष हुन्छन् । यसको अर्थपूर्ण कार्यान्वयन गर्ने कर्तव्य र दायित्व दोस्रो पक्षको रहन्छ । सूचनाको हक सम्बन्धी ऐन, २०६४ को दफा ४ मा सूचनाको हकका सम्बन्धमा सार्वजनिक निकायको दायित्व सम्बन्धी व्यवस्था रहेको छः

(१) प्रत्येक सार्वजनिक निकायले नागरिकको सूचनाको हकको सम्मान र संरक्षण गर्नु गराउनु पर्नेछ।

(२) उक्त प्रयोजनको लागि देहायका काम गर्नु सार्वजनिक निकायको दायित्व हुनेछः

- सूचना वर्गीकरण र अद्यावधिक गरी समय समयमा सार्वजनिक, प्रकाशन तथा प्रसारण गर्ने गराउने ।
- सूचनामा नागरिकको पहुँच सरल र सहज बनाउने ।
- आफ्नो काम कारबाही खुला र पारदर्शी रूपमा गर्ने ।
- आफ्ना कर्मचारीको लागि उपयुक्त तालीम र प्रशिक्षणको व्यवस्था गर्ने ।

सार्वजनिक निकायले खण्ड (२) को उपदफा (३)(क) बमोजिम सार्वजनिक सूचना प्रकाशन वा प्रसारण गर्दा विभिन्न राष्ट्रिय भाषा तथा आम सञ्चारका माध्यमबाट गर्न सक्नेछ ।

८. सूचनाको अद्यावधिक र प्रकाशन

सार्वजनिक निकायले देहायका विषयका सूचनाहरू सूचीकृत गरी प्रकाशन गर्नुपर्ने व्यवस्था गरेको छः

- निकायको स्वरूप र प्रकृति ।
- निकायको काम, कर्तव्य र अधिकार ।
- निकायमा रहने कर्मचारी संख्या र कार्यविवरण ।
- निकायबाट प्रदान गरिने सेवा ।
- सेवा प्रदान गर्ने निकायको शाखा र जिम्मेवार अधिकारी ।
- सेवा प्राप्त गर्न लाग्ने दस्तुर र अवधि ।
- निर्णय गर्ने प्रक्रिया र अधिकारी ।
- निर्णयउपर उजुरी सुन्ने अधिकारी ।
- सम्पादन गरेको कामको विवरण ।
- सूचना अधिकारी र प्रमुखको नाम र पद ।
- ऐन, नियम, विनियम वा निर्देशिकाको सूची ।
- आम्दानी, खर्च तथा आर्थिक कारोबार सम्बन्धी अद्यावधिक विवरण ।
- तोकिए बमोजिमका अन्य विवरण ।

९. विभागमा सूचनाको हक सम्बन्धी व्यवस्था

(क) विभागको स्वरुप र प्रकृतिः

स्वरुपः स्वदेशमा रहेको खनिज सम्पदाको अन्वेषण कार्य वाट खनिजजन्य उद्योगहरुको विकास गरी देशमा औद्योगिक उत्पादन तथा आर्थिक विकास गर्ने उद्देश्यले नेपाल सरकार बाट बि.स. २०३३ साल (सन् १९७६) मा खानी विभाग र भौगर्भिक सर्भेक्षण विभागलाई एकिकृत भई श्री उद्योग मन्त्रालय अन्तर्गत एक मात्र केन्द्रिय निकाय "खानी तथा भूगर्भ विभाग" नामाकरण गरी संचालनमा रहेको छ । नेपाल सरकारको निर्णय अनुसार स्वीकृत संघिय विभागीय संगठन संरचना वमोजिम महानिर्देशकको मातहतमा भू-विज्ञान महाशखा, खनिज सम्पदा महाशाखा र योजना, प्रशासनिक तथा प्राविधिक सेवा महाशाखा गरी ३ वटा महाशाखाहरु तथा पेट्रोलियम अन्वेषण तथा प्रवर्द्धन केन्द्र, खनिज प्रवर्द्धन तथा प्रशोधन केन्द्र र राष्ट्रिय भूकम्प मापन तथा अनुसन्धान केन्द्र गरी ३ वटा केन्द्रहरु र सो अन्तर्गतका २५ वटा शाखाहरु, भूकम्प मापन केन्द्र (शाखा कार्यालय), सुर्खेत तथा पेट्रोलियम अन्वेषण परियोजनाको व्यवस्था गरिएको छ ।

प्रकृति: भू-वैज्ञानिक तथा भूकम्पिय अध्ययन, भौगर्भिक सर्वेक्षण, खनिज अन्वेषण, पेट्रोलियम अन्वेषण, खनिज जन्य उद्योगको विकास, खनिज तथा खानी नियमन तथा प्रशासन, खानी अनुगमन तथा निरिक्षण ।

(ख) विभागको काम, कर्तव्य र अधिकार

नेपाल सरकार कार्य विभाजन नियमावली, २०६९ मा तोकिए बमोजिम उद्योग, वाणिज्य तथा आपुर्ती मन्त्रालयको काम, कर्तव्य र अधिकारको बुँदा नं. (२) र (३) मा खानी तथा भूगर्भ सम्बन्धि देहायको काम, कर्तव्य र अधिकारको प्रावधान निश्चित गरिएको छ :-

- ❖ खानी तथा खनिज पदार्थ अन्वेषण सम्बन्धि नीति, योजना, कार्यान्वयन तथा नियमन ।
- ❖ खानी तथा खनिज विकास विषयक अध्ययन, अन्वेषण तथा सर्वेक्षण ।

उपरोक्त काम, कर्तव्य र अधिकारको दायरालाई आत्मसात गर्दै खानी तथा भूगर्भ विभागले सम्पादन गर्ने कार्यको आधारमा यस विभागको देहायको काम, कर्तव्य र अधिकार रहेको छः-

- ❖ भू-वैज्ञानिक अध्ययन तथा अनुसन्धान गरी देशको भौगर्भिक ज्ञानमा अभिवृद्धि गर्ने ।
- ❖ खनिज सम्पदाहरूको अध्ययन, अन्वेषण, मूल्याङ्कन तथा प्रवर्धन गरी सो मा आधारित खनिज उद्योगहरूको विकास गरी आर्थिक विकासमा टेवा पुर्याउने ।
- ❖ खानी तथा खनिज पदार्थको अध्ययन, अनुसन्धानका लागि आवश्यक प्राविधिक सेवा उपलब्ध गराउने ।
- ❖ खनिज भण्डारमा आधारित खानी तथा खनिज उद्योगहरूको प्रवर्धन, विकास, तथा सञ्चालन गर्न खानी तथा खनिज पदार्थ ऐन तथा नियमहरू तर्जुमा गरी लागू गर्ने ।
- ❖ भूकम्पीय अध्ययन तथा अनुसन्धान, भूकम्प र भूकम्पीय प्रकोपको सहि निगरानी राख्ने ।
- ❖ पेट्रोलियम तथा प्राकृतिक ग्याँस हुन सक्ने संभावित क्षेत्रमा भौगर्भिक तथा भू-भौतिक अन्वेषण गरी पेट्रोलियमका भण्डारहरू पत्ता लगाई राष्ट्रिय र अन्तराष्ट्रिय लगानीकर्तालाई पेट्रोलियम अन्वेषण एवं उत्पादन गर्न आकर्षण गर्ने ।

(ग) विभागमा रहेका कर्मचारीको संख्या र कार्य विवरण

कर्मचारी संख्या: जम्मा कर्मचारी संख्या १४४ मध्ये प्राविधिक ९५, अप्राविधिकमा १९ र श्रेणी विहिन ३० कर्मचारीहरु कार्यरत छन्। महानिर्देशक, महाशाखा प्रमुख- ३, केन्द्र प्रमुख- ३ गरि रा.प.प्र श्रेणीको ७, जियोलोजिष्ट- ४९, केमिष्ट- ९, माइनिङ्ग इन्जिनियर-६, मेटालर्जिकल ईन्जिनियर, केमिकल इन्जिनियर, मेकानिकल इन्जिनियर, रिसर्च अधिकृत, डकुमेण्टेशन अफिसर, नापी अधिकृत, सिनियर ड्रिलर र कम्प्युटर अधिकृत ७ गरी जम्मा अधिकृत स्तरको प्राविधिक जनशक्तिहरु ७९ व्यवस्था गरिएको छ ।

मूख्य कार्य विवरण:

क) भू-विज्ञान महाशाखा

१. भौगर्भिक म्यापिङ्ग शाखा: भौगर्भिक तथ्याङ्क संकलन तथा भौगर्भिक नक्सा प्रकाशन ।

२. रिमोट सेन्सिङ्ग तथा जियोलोजिकल डाटा सेन्टर: दूर संवेदन प्रविधि तथा GIS प्रविधिको उपयोगबाट भौगर्भिक सर्वेक्षण तथा जियोहेजार्ड नक्सा प्रकाशन गर्ने ।

३. इञ्जिनियरिङ्ग जियोलोजी शाखा: व्यवस्थित शहरी विकासको लागि इन्जिनियरिङ्ग जियोलोजिकल अध्ययन गर्ने। व्यवस्थित शहरी विकास तथा फोहर मैला व्यवस्थापन को लागि अध्ययन, अनुसन्धान तथा प्रतिवेदन तयार गर्ने । फिल्डबाट संकलित चट्टानको नमुनाहरूको जियोटेक्निकल तथा इन्जिनियरिङ्ग गुणहरूको परीक्षण गर्ने ।

४. पहिरो अनुसन्धान शाखा: पहिरो सम्बन्धी भौगर्भिक अध्ययन अनुसन्धान तथा सूचना संकलन ।

५. भू-भौतिक तथा भू- रसायनिक शाखा: भू-भौतिक तथा भू-रसायनिक अध्ययनबाट खनिज श्रोतको अन्वेषण कार्य गर्ने ।

ख) खनिज सम्पदा महाशाखा

१. खनिज अन्वेषण शाखा: धातु तथा अधातु खनिजको अध्ययन अनुसन्धान गर्ने ।

२. ड्रिलीङ तथा एक्सप्लोटरी माइनिङ शाखा: खनिज भण्डार को परिमाण यकिन गर्न ड्रिलिङ्ग कार्य गर्ने ।

३. प्राकृतिक ग्याँस शाखा: कोइला तथा प्राकृतिक ग्याँसको अध्ययन तथा अनुसन्धान गर्ने ।

४. खानी अनुमति तथा प्रशासन शाखा: खनिज कार्यको लागि खोजतलास तथा उत्खनन् को अनुमतिपत्र प्रदान गर्ने ।

५. खानी अनुगमन शाखा: संचालनमा रहेका खानीहरूको प्राविधिक तथा वातावरणीय विवादको समाधानको तथा खानीहरूको अनुगमन र निरीक्षण गर्ने ।

ग) योजना, प्रशासनिक तथा प्राविधिक सेवा महाशाखा

१. योजना, कार्यक्रम तथा सूचना शाखा: पञ्चवर्षीय योजना, वार्षिक कार्यक्रम तथा बजेटको तयारी, कार्यक्रम संचालन तथा मूल्याङ्कन, प्रगति प्रतिवेदन तथा सूचना

प्रवाह र संकलन गर्ने ।

२. कन्भेसनल एनलाइसिस शाखा: प्रचलित तरिकाबाट धाउ, चट्टान र खनिज पदार्थमा रहेको तत्वहरुको गुणात्मक र परिमाणात्मक परीक्षण, विश्लेषण कार्य गर्ने ।

३. ट्रेस इलिमेन्ट एनलासिस शाखा: जियोकेमिकल नमुनाहरू जस्तै पानी, माटो आदिको गुणात्मक र परिमाणात्मक परीक्षण, विश्लेषण कार्य गर्ने ।

४. स्याम्पल प्रिप्रेसन तथा स्टोर शाखा: विभिन्न फिल्ड कार्यबाट सम्पन्न भएका नमुनाहरूको रसायनिक परीक्षणको लागि स्याम्पल प्रिपरेसन गर्ने तथा सो नमुनाहरूको व्यवस्थित रूपमा संकलन गर्ने ।

५. प्रशासन शाखा: विभागीय प्रशासन सम्बन्धी कार्य गर्ने ।

६. आर्थिक प्रशासन शाखा: विभागीय आर्थिक प्रशासन सम्बन्धी कार्य गर्ने ।

घ) पेट्रोलियम अन्वेषण तथा प्रवर्द्धन केन्द्र

१. पेट्रोलियम प्रवर्द्धन शाखा: पेट्रोलियम भण्डारको आर्थिक अध्ययन तथा प्रवर्द्धन कार्य गर्ने ।

२. डाटा इन्टरप्रिटेशन तथा डकुमेन्टेशन शाखा: भौगर्भिक, भू-भौतिक तथा भू-रसायनिक अनुसन्धान कार्यबाट प्राप्त डाटाहरुको इन्टरप्रिटेसन तथा डकुमेन्टेसन गर्ने ।

३. पेट्रोलियम अन्वेषण शाखा: पेट्रोलियम अन्वेषण कार्यको लागि भू-भौतिक एरोम्याग्नेटिक साइस्मिक तथा ग्राभीटी सर्वेक्षण सम्बन्धी कार्य गर्ने ।

ङ) खनिज प्रवर्द्धन तथा प्रशोधन केन्द्र

१. खनिज आर्थिक अध्ययन तथा प्रवर्द्धन शाखा: पत्ता लागेका खनिज भण्डारको प्राविधिक, आर्थिक, अध्ययनको आधार मा डाटा प्याकेज तयार गरी उद्योग प्रवर्द्धन सम्बन्धी कार्य गर्ने ।

२. खनिज भण्डार मूल्याङ्कन शाखा: अन्वेषण कार्यबाट पत्ता लागेको अधातु र धातु खनिज भण्डारको परिमाण तथा गुणको मूल्याङ्कन गर्ने ।

३. खनिज प्रशोधन प्रयोगशाला: धातु र अधातु खनिजको प्रशोधन तथा वेनिफिकेसन गर्ने ।

४. मिनरोलजी तथा जेमोलोजी शाखा: चट्टान तथा खनिजका नमुनाहरूको थिन सेक्सन तथा पोलिष्ड सेक्सन बनाई परीक्षण गर्ने ।

च) राष्ट्रिय भूकम्प मापन तथा अनुसन्धान केन्द्र

१. भूकम्प मापन तथा स्यास्मिक हजार्ड मूल्याङ्कन शाखा: साइस्मिक स्टेसन, डाटा संकलन तथा प्रशोधन कार्य तथा भूकम्पिय जोखिम मुल्याङ्कन गर्ने ।

२. जियोडेसी तथा प्यालियो सेस्मोलोजी शाखा: GPS स्टेसनको संचालन, सूचना संकलन तथा पुराना भूकम्पिय दरारहरुको अध्ययन अनुसन्धान ।

(घ) विभागबाट प्रदान गरिने सूचना सेवा

विभागबाट प्रदान गरिने सूचना सेवा सम्वन्धी शिर्षक अनुसुचिमा संलग्न रहेको ।

(ङ) विभागबाट सेवा प्रदान गर्ने शाखा र जिम्मेवार अधिकारी: विभाग वाट प्रदान गरिने सूचना सेवा, सूचनाको विवरण सूचना शाखा मार्फत उपलव्ध हुने । सूचना अधिकारीले विभागको सम्बन्धित शाखाहरुसंग सम्न्वय गरि सेवा उपलव्ध गराउने ।

(च) सेवा प्राप्त गर्न लाग्ने दस्तुर र अवधि: नागरिक वडापत्रको व्यवस्था गरिएको र विभागीय वेबसाइटमा पनि राखिएको ।

(छ) निर्णय गर्ने प्रक्रिया र अधिकारी: विभागवाट प्रदान गरिने सेवा सम्वन्धि सूचनाको विवरण शिर्षकमा समावेश भई अनुसुचिमा संलग्न ।

(ज) निर्णय उपर उजुरी सुन्ने अधिकारी: विभागिय प्रमूख महानिर्देशक तथा नोडल अधिकृत उपमहानिर्देशक श्री जय राज घिमिरे ।

(झ) सम्पादन गरेको कामको विवरण: नियमित रूपमा प्रकाशन गरी विभागीय वेबसाइटमा राखिने गरिएको ।

(ञ) सूचना अधिकारी र प्रमूखको नाम र पद: श्री नारायण बाँस्कोटा, सि.डि.जि., योजना, कार्यक्रम तथा सूचना शाखा प्रमूख ।

सहायक सूचना अधिकारी र प्रमुखको नाम र पद: श्री सुलभ कायस्थ, जि., श्री शिला भट्टराई, जि., योजना, कार्यक्रम तथा सूचना शाखा ।

(ट) ऐन, नियम, विनियम, निर्देशिकाको सूची:

१. खानी तथा खनिज पदार्थ ऐन, २०४२

२. खानी तथा खनिज पदार्थ नियमावली, २०५६

३. खनिज सर्वेक्षण (भत्ता तथा सुविधा) नियमहरू, २०२४

४. नेपाल पेट्रोलियम ऐन, २०४०

५. पेट्रोलियम नियमावली, २०४१

६. पेट्रोलियम अन्वेषण आयकर नियमावली, २०४१

७. राष्ट्रिय खनिज नीति, २०७४

८. खानी तथा भूगर्भ विभागको कार्यविधि, २०७५

९. आम्दानी, खर्च तथा आर्थिक कारोबार सम्बन्धी अद्यावधिक विवरण: नियमित रूपमा प्रकाशन गरी विभागीय वेबसाइटमा राखिने गरिएको ।

(ठ) तोकिए बमोजिमका अन्य विवरण:

सूचनाको हकसम्बन्धी नियमावली, २०६५ नियम ३ बमोजिमको सूचनाको विवरण:

- ❖ अघिल्लो आर्थिक वर्षमा सार्वजनिक निकायले कुनै कार्यक्रम वा आयोजना सञ्चालन गरेको भए सोको विवरण: (आ.व.२०७८।०७९ र आ. व. २०७९।८० को वार्षिक प्रगति विवरणमा खानी तथा भूगर्भ विभाग, खनिज अन्वेषण तथा विकास आयोजना, भू-वैज्ञानिक सर्वेक्षण तथा अनुसन्धान आयोजना अन्तर्गत संचालित कार्यक्रमहरूको प्रगति विवरण नियमित रूपमा प्रकाशन गरिँदै आएको ।
- ❖ सार्वजनिक निकायको वेबसाइट भए सोको विवरण:

  www.dmgnepal.gov.np

  www.seismonepal.gov.np

  http://gis.dmgnepal.gov.np/dmg

  http://lib.dmgnepal.gov.np
- ❖ सार्वजनिक निकायले प्राप्त गरेको वैदेशिक सहायता, ऋण, अनुदान एवं प्राविधिक सहयोग र सम्झौता सम्बन्धी विवरण नियमित रूपमा प्रकाशन गरिँदै सोको विवरण विभागीय वेबसाइटमा राखिएको ।
- ❖ सार्वजनिक निकायले संचालन गरेको कार्यक्रम सोको प्रगति विवरण: आ.व.२०७८।०७९ र आ.व. २०७९।८० को प्रगति नियमित रूपमा प्रकाशन गरिँदै सोको विवरण विभागीय वेबसाइटमा राखिएको ।
- ❖ सार्वजनिक निकायमा परेको सूचना माग सम्बन्धी निवेदन र सो उपर सूचना दिएको विषय: (अनुसूचि-१ मा संलग्न) ।
- ❖ सार्वजनिक निकायले वर्गीकरण तथा संरक्षण गरेको सूचनाको नियमावली र त्यस्तो सूचना संरक्षण गर्न तोकिएको समयावधि: (वर्गीकरण तथा संरक्षण गरेको सूचनाको विवरण (अनुसूची २ मा संलग्न) ।
- ❖ सार्वजनिक निकायका सूचनाहरू अन्यत्र प्रकाशन भएका वा हुने भएको भए सोको विवरण: विभागीय वार्षिक सम्पन्न क्रियाकलापहरू समावेश भई विभागको वार्षिक प्रकाशन "DMG Annual Report, ब्रोसरहरु" नियमित रूपमा प्रकाशन भई नि:शुल्क उपलब्ध गराउने व्यवस्था रहेको ।

(ड) सूचना उपलब्ध गराउने प्रक्रिया:

विभागबाट सूचना उपलब्ध गराउने प्रक्रिया निम्नानुसार रहेका छन्:

- ❖ सूचना मौखिक वा फोन वा पत्र वा आफै उपस्थित भई लिखित वा हेलो सरकार मार्फत माग गर्न सकिनेछ ।
- ❖ सूचना माग गर्नेले आफ्नो नागरिकताको प्रतिलिपी वा परिचय खुल्ने कागजात संलग्न गरि सूचना माग गर्नुको कारण खुलाई निवेदन दिनु पर्नेछ ।
- ❖ सूचना उपलब्ध गराउदा प्रत्येक पानाको प्रतिलिपी उतार फोटोकपी खर्च बराबरको रकम राजश्व दाखिला गर्न लगाई विभागीय निर्णय भई सूचना अधिकारी मार्फत उपलब्ध गराईनेछ । सूचना अधिकारीले आवश्यकता अनुसार अन्य शाखाहरुसंग समेत समन्वय गरी सूचना उपलब्ध गराउने छ । लिखित रुपमा सूचना उपलब्ध गराउदा विभागीय निर्णय पश्चात मात्र गराउनु पर्नेछ ।
- ❖ सूचना उपलब्ध गराउन नसकिने अवस्थामा सो को जानकारी गराईनेछ ।
- ❖ सूचना उपलब्ध गराउने सन्दर्भमा केही द्विविधा भएमा विभागबाट सूचना आयोगको राय लिई वा विभागले सूचना उपलब्ध नगराउने निर्णयमा चित्त नबुझेमा सम्बन्धित पक्षबाट सूचना आयोगमा उजुरी दिई तँहा आयोगबाट जे जस्तो निर्णय हुन्छ सोही बमोजिम हुने गरि सूचना / जानकारी उपलब्ध गराईनेछ ।

१०. सूचना उपलब्ध गराउने सन्दर्भमा नेपालमा देखिएका समस्याहरु

- उल्टो प्रवृत्ति (गोप्य रहनुपर्ने सूचना बाहिर आउने तर सूचित गर्नुपर्ने सूचना नदिने) ।
- सूचनाको हक भनेको सूचनाको प्रमाणित रूप प्राप्त गर्नु मात्र हो भन्ने आम बुझाइ (Right to Inspection, Right to participation in Decision making पक्ष कमजोर) ।
- राजनीति तथा प्रशासनको अर्थ पूर्ण प्रतिबद्धता (Meaningful Commitment) नरहनु ।
- मागेको रूपमा सूचना नदिई तोडमोड गरी आफ्नो अनुकूल मात्र दिने प्रवृत्ति ।
- थोकमा सूचना माग्ने प्रवृत्ति (हालसम्म भएका, अन्तर्गतका विभाग कार्यालयका, कुनै विषयमा भएका सबै) ।
- सूचनाको हक पत्रकारको हो भन्ने मानसिकता जब कि यो हक पत्रकारको नभई नागरिकको हो ।
- सूचनाको वर्गीकरण हुन नसक्नु ।
- सूचना अधिकारी नै सूचना विहीन हुनु ।
- सूचना अधिकारी सम्बन्धी सूचनाको अभाव (कोठा नं., नाम, पद.) ।
- सूचना मागको निवेदन, सूचना उपलब्ध गराउन प्रमुखको आदेश नै खोज्नुपर्ने ।
- गोप्य संस्कृति (भित्ताको पनि कान हुन्छ भन्ने आम संस्कृति) ।
- सूचनादाताको संरक्षण गर्ने कानुनी व्यवस्था नहुनु (विवादास्पद अभिव्यक्ति सञ्चार माध्यममा दिएको भनी

तत्कालीन वन मन्त्रालयका प्रवक्तालाई २०५९ असारमा जिम्मेवारीबाट हटाइयो)।

- दुरुपयोगमा सजाय हुने व्यवस्थाले अवरोध पुराएको।
- सूचनाको हक सम्बन्धी ऐनको सर्वोच्चता नहुनु (अन्य कानुनको गोप्यता सम्बन्धी व्यवस्था स्वीकार)।
- सरकारको सूचना प्रवाह गर्ने सार्वजनिक सञ्चार रणनीति नहुनु।
- एकीकृत सूचना अभिलेख प्रणालीको अभाव।
- हक अधिकारको प्रयोगभन्दा चिनजान, भनसुनको आधार मा सूचना लिने प्रवृत्ति।
- सूचनाको हकको महत्व सम्बन्धी जनचेतना कमजोर।
- राजनीतिक दलको उदासीनता, अपारदर्शिता।
- सार्वजनिक सेवा प्रदान गर्ने भए पनि निजी क्षेत्र बाहिरै।
- सूचनाको हक प्रचलनको लागि बजेटको अभाव।
- सूचना माग गर्नेको मनसाय स्पष्ट नहुनु।
- सूचनाका आधारमा अरुलाई दुःख दिने प्रवृति देखिनु।

११. आगामी कार्यदिशा

➢ नीतिगत सुधार

- अन्तर्राष्ट्रिय मान्यता अनुसार यो हक प्रत्येक व्यक्तिलाई हुने गरी संविधान संशोधन।
- सूचनाको हक सम्बन्धी ऐनको सर्वोच्चता कायम गर्ने (वाझिएका कानुन अमान्य हुने)।
- आयोगको स्वायत्तताको लागि संवैधानिक व्यवस्था।
- सूचना वर्गीकरणका आधार तोक्ने।
- सूचनादाताको संरक्षणको प्रत्याभूति।
- सार्वजनिक सेवा प्रदान गर्ने निजी क्षेत्रलाई ऐनको परिधिभित्र ल्याउने।
- RTI Audit/ RTI Budget को अवधारणालाई सघन रूपमा कार्यान्वयन गर्ने।

➢ संस्थागत सुधार

- आयोगको विकेन्द्रीकरण (प्रादेशिक सूचना आयोग)।
- आयोग र संसद् बीचको सम्बन्ध।
- आयोगका निर्णय/आदेशको कार्यान्वयनको अनुगमनको विशेष संयन्त्र निर्माण।
- अन्तर्रनिकाय समन्वय (आयोग, सार्वजनिक निकाय, नागरिक समाज)।
- प्रत्येक निकायमा सूचना एकाईको व्यवस्था गर्ने।
- सूचनाको Digitalization गर्ने, सूचनाको Archives खडा गर्ने।
- सचिव वा विभागीय प्रमुखको स्वविवेकबाट नभै सूचना अधिकारी नियुक्तिको मापदण्ड बनाउने।
- सूचना अधिकारीलाई स्रोत साधनको सुनिश्चितता।
- स्थानीय तहमा आरटीआई अम्बुड्स्म्यान गठन गर्ने।

➢ कार्य विधिगत सुधार

- सूचनाको वर्गीकरण गर्ने।
- प्रवर्द्धनात्मक कार्य गर्ने गराउने।
- सूचनामा नागरिक पहुँच सुनिश्चित गर्ने।
- Paperless Governance मा जोड दिने।
- सूचनाको गलत प्रयोगलाई हतोत्साही गर्ने संयन्त्र निर्माण।
- स्वतः सूचना प्रकाशन गर्नुपर्ने र सूचना अधिकारी तोक्नुपर्ने।
- सूचना माग गर्दा कारण र प्रयोजन खुलाई माग गर्नुपर्ने।

➢ अन्य सुधार

- सूचनाको हकसम्बन्धी विषयलाई पाठ्यक्रममा समावेश गर्ने।
- सूचना मागकर्ताको क्षमता अभिवृद्धि।
- सूचना व्यवस्थापन प्रणालीको विकास र विस्तार।
- सूचनाको माग नगरे पनि नियमित प्रकाशन र प्रसारण गर्ने संस्कृतिको विकास गर्ने।
- राजनीतिक तथा उच्च प्रशासनिक क्षेत्रमा इच्छाशक्ति बढाउने।
- खोज पत्रकारितालाई प्रोत्साहित गर्ने।
- विद्युतीय माध्यमबाट सूचना पाउने व्यवस्था लागू गर्ने।

१२. सन्दर्भ सामग्री

सूचनाको अधिकार वर्ष १ अङ्क १, राष्ट्रिय सूचना आयोग।

सार्वजनिक व्यवस्थापन, स्रोत सामग्री अग्र सारथि अध्ययन तथा अनुसन्धान केन्द्र।

पराग, अङ्क ४, राष्ट्रिय कर्मचारी संगठन, निजामती विभागीय समिति अर्थ मन्त्रालय। सूचना आयोगको वेबसाइटमा उपलब्ध विभिन्न सामग्रीहरू।

http://anticorruptionactivistsharada.com

Global Right to Information Rating, Centre for Law and Democracy

विभिन्न पत्रपत्रिकामा प्रकाशित विभिन्न लेखकका लेखहरू।

अनसूची- १

सूचनाको हक अन्तर्गत सूचना माग भएको विवरण

निकायको नाम : **खानी तथा भूगर्भ विभाग**

प्रतिवेदनको अवधी : २०७८ साउन देखि २०८० अषाढसम्म

क्र.स.	सूचना माग गर्नेको नाम, ठेगाना	सूचना माग गरेको मिति	माग गरेको सूचनाको संक्षिप्त विवरण	सूचना दिए नदिएको र सो निर्णयको मिति	कार्यालय प्रमुख वा सूचना अधिकारी मध्ये कुन तहबाट सूचना दिएको	सूचना नदिएको भए सोको कारण	कैफियत
१	श्री हिमाल खबर पत्रिका	२०७८।०४।११	चुनढुङ्गा उत्पादन गर्दै आएका विभिन्न कम्पनीहरुको विवरण तथा राजश्व	२०७८।०४।१८	विभागीय निर्णय भई सूचना अधिकृतबाट सूचना दिएको ।	सूचना दिएको ।	
२	श्री Environment Law Society	२०७८।०४।११	साधारण निर्माणमुखि खनिजको कम्पनी विवरण र उत्पादन विवरण	२०७८।०४।२५	"	"	
३	श्री नारायण प्रसाद शर्मा	२०७८।०४।२८	भुगर्भ सिमेन्टको, अर्घाखाँची जिल्ला, सन्धिखर्क- ७ स्थित चुनढुङ्गा खानीको विवरण तथा EIA प्रतिवेदन	२०७८।०४।२८	"	"	
४	श्री विष्णु प्रसाद थापा	२०७८।०८।२६	भुगर्भ सिमेन्टको, अर्घाखाँची जिल्ला, सन्धिखर्क- ७ स्थित चुनढुङ्गा खानीको विवरण तथा EIA प्रतिवेदन	२०७८।०९।०७	"	"	
५	श्री विष्णु प्रसाद थापा	२०७८।१२।०१	भुगर्भ सिमेन्टको, अर्घाखाँची जिल्ला, सन्धिखर्क- ७ स्थित चुनढुङ्गा खानीको उत्खनन् कार्यको क्षमता तथा EIA प्रतिवेदन	२०७८।१२।१०	"	"	
६	श्री राजकुमार तिमिल्सना	२०७८।०९।२५	ललितपुर जिल्ला स्थित विभिन्न निर्माणमुखि खनिजको विवरण	२०७८।१०।०६	"	"	
७	श्री प्रजु पन्त	२०७९।०३।०६	यस विभागबाट जारि बालुवा उत्खनन् खानीको विवरण	२०७९।०३।१७	"	"	
८	श्री केशवराज चन्द (मुरुल्ले बचाउ संघर्ष समिति)	२०७९।०४।१६	शुभम् खनिज उद्योग प्रा.लि. को IEEप्रतिवेदन र अन्य विवरण	२०७९।०४।२४	"	"	
९	श्री भैरब बाबा प्रशोधन उद्योग एण्ड सप्लायर्स प्रा.लि.	२०७९।०५।०१	नवलपरासी (व.स.पू.) र दाङ्ग जिल्लामा ढुङ्गा, गिटी, बालुवाको लागि उत्कनन् सहमति लिएका खानीहरुको विवरण	२०७९।०५।१५	"	"	
१०	श्री शिवलाल पौडेल (हिन्दुखबर डटकम)	२०७९।०९।२५	लुम्बिनि प्रदेश, पाल्पा जिल्लाको तिनाउ गा.पा. मा पर्ने खानीजन्य पदार्थहरुको विवरण र खानी दर्ता भए- नभाएको विवरण	२०७९।०९।२६			
११	श्री भेषराज लुईटेल	२०७९।१२।१२	मुक्तिश्री सिमेण्ट ई.प्रा.लि. सम्बन्धी विवरण	२०७९।१२।२३	"	"	
१२	श्री कमल प्रसाद पोखरेल	२०८०।०१।०८	पाल्पा सिमेन्ट ई. प्रा.लि. को चुनढुङ्गा उत्खनन् को विवरण	२०८०।०१।२७	"	"	
१३	श्री Diyopost	२०८०।०१।२५	श्री कुमारी माता रोडा ढुङ्गा उद्योग प्रा.लि. को उत्खनन् सम्बन्धी विवरण	२०८०।०२।०१	"	"	
१४	श्री Diyopost	२०८०।०२।१९	श्री कुमारी माता रोडा ढुङ्गा उद्योग प्रा.लि. को फिल्ड अनुगमन सम्बन्धी प्रतिवेदन	२०८०।०२।३०	"	"	
१५	हेलो सरकार						
१६	हेलो सरकार						
१७	हेलो सरकार						
१८	हेलो सरकार						

अनुसूचि- २

खानी तथा भुगर्भ विभाग

खानी तथा भु-गर्भ विभागको सुचनाको हक सम्बन्धी ऐन, २०६४ को दफा ३ बमोजिम दिन मिल्ने र नमिल्ने सूचनाको विवरण

१. गोप्य राख्नु नपर्ने सूचनाहरूमा

- आर्थिक विवरण (आम्दानी र खर्च)
- सामान खरिद गरेको संस्थाको विभागमा सूचीकृत भएको विवरण
- विभागीय संरचना, जनशक्ति र कार्य विवरण
- विभागबाट प्रकाशन भएका भू-वैज्ञानिक सर्वेक्षण तथा अनुसन्धान, खनिज अन्वेषण तथा विकाश तथा भूकम्प सम्बन्धी अध्ययन अनुसन्धानको प्रतिवेदन, प्रकाशन, ब्रोसर, नक्सा, भौगर्भिक सूचनाको विवरण
- विभागले तयार गरेको खनिज कार्यको कार्यविधि, नागरिक वडापत्र तथा अनुमतिपत्र प्रदान गर्ने विधि सम्बन्धी विवरण
- खनिजकार्यको लागि प्रदान गरिएको अनुमतिपत्रको विवरण
- खनिज उत्पादन तथा राजश्व संकलन सम्बन्धी विवरण
- खनिज अन्वेषण तथा प्रवर्धन कार्यको विवरण
- विभागीय कार्ययोजना तथा कार्य सम्पादनको विवरण
- स्वीकृत योजना, वार्षिक कार्यक्रम तथा प्रगति
- सेवाग्राहीलाई विभागबाट प्रदान गरिने सेवा तथा अन्य विभागीय गतिविधिहरूको विवरण
- पेट्रोलियम अन्वेषण सम्बन्धी प्रकाशित भएका प्रतिवेदन, ब्रोसर तथा अन्वेषण खण्डका भौगर्भिक नक्साहरू
- विभिन्न खानीहरूका स्वीकृत माईनिङ्ग स्किम, TOR, IEE/EIA प्रतिवेदनहरू
- विभागबाट भएका अनुगमन प्रतिवेदनहरूको आधारमा स्वीकृत भएकापत्र/ निर्देशन
- उपलब्ध भएका GPS र Strong Motion Dataहरु
- ४ रेक्टर Local Magnitude / Felt Earthquakeहरु सम्बन्धी Data

२. गोप्य राख्नु पर्ने सूचनाहरूमा:

- पेट्रोलियम अन्वेषण तथा उत्पादन कार्यको लागि अन्तराष्ट्रिय तेल कम्पनीहरूसँग भएको पेट्रोलियम सम्झौता पत्र
- विभाग तथा स्वदेशी/विदेशी लगानीकर्ता/ उद्धमीसँग भएको सम्झौता पत्र, विभागबाट भएका खनिज अन्वेषण तथा सर्वेक्षण र पेट्रोलियम अन्वेषण सम्बन्धी डाटा प्याकेजहरु
- कानुन परिवर्तन/संशोधनको प्रकृयामै रहेका ऐन तथा नियमहरू अन्तर्गतका विवरण
- विभागमा पेश भई स्वीकृत नभएका TOR, IEE/EIA
- कम्पनी तथा व्यक्तिगत विवरण
- अनुमतिपत्र जारी नभई सकेका माईनिङ्ग स्किमहरु
- अनुगमन प्रतिवेदनहरू
- ४ रेक्टर स्केल भन्दा तलका र अनुभव नगरिएका Unprocessed साईस्मिक डाटाहरु

३. गोप्य रहनु पर्ने अवधि:

- सम्झौता पत्रको हकमा सम्झौतामा उल्लेख भएको अवधिमा थप पाँच वर्ष सम्म ।
- डाटा प्याकेजहरूको हकमा सम्झौता नभए सम्म ।
- कानुन परिवर्तन/संशोधनको हकमा राजपत्रमा प्रकाशन नभए सम्म ।
- विभागमा पेश भएका TOR, IEE/EIA स्वीकृत नभए सम्म ।
- माईनिङ्ग स्किमको अनुमतिपत्र जारी नभए सम्म ।

४. गोप्य राख्नु पर्ने कारण:

- सूचनाको हक सम्बन्धी ऐन, २०६४ दफा ३ को उपदफा ३ (ग) बमोजिम आर्थिक, व्यापारिक हितमा गम्भीर आघात पार्ने भएकोले

नोट: क्र.सं. १ र २ मा उल्लेख नभएका अन्य विषयका सूचनाहरू विभागीय निर्णय बमोजिम निर्धारण हुनेछन् ।

MINERAL RESOURCES MAP OF NEPAL

0 25 50 100 150 200

Km

2024

N

81°0'0"E 84°0'0"E 87°0'0"E

30°0'0"N

27°0'0"N

DARCHULA
BAITADI
SIMIKOT
JUMLA
DUNAI
DHANGADHI
BIRENDRANAGAR
NEPALGUNJ
LIWANG
JOMSOM
CHAME
POKHARA
GORKHA
DHUNCHE
TANSEN
KATHMANDU
CHARIKOT
BHARATPUR
TAULIHAWA
OKHALDHUNGA
TAPLEJUNG
BIRGANJ
DHANKUTA
GAIGHAT
ILAM
BIRATNAGAR

SIMPLIFIED GEOLOGY AND MINERAL POTENTIAL MAP OF NEPAL

Iron, Gold, Slate, Magnesite, Talc, Phosphorite
Iron, Lead, Zinc, Gold, Slate, Magnesite, Talc
Quartz, Graphite, Pegmatite, Beryllium, Kyanite,Slate
Cobalt, Copper, Talc, Marble, Slate
Quartz, Garnet, Tourmaline, Beryllium, Pegmatite
Copper, Lead, Zinc, Tungsen, Granite, Pegmatite
Gold, Iron, Arsenic
Copper, Coal, Limestone, Dolomite
Lead, Tin, Tungsten, Iron, Copper, Graphite, Marble, Slate
Granite, Pegmatite, Limestone

Legend

- Lake deposit
- Gangetic Plain
- Siwalik Group
- Tethys Himalaya
- Higher Himalaya
- Lesser Himalaya
- Geological regions with potential minerals

Legend

Metallic Minerals

- Gold
- Silver
- Nickel
- Cobalt
- Bismuth
- Pyrite
- Iron
- Copper
- Lead
- Zinc
- Beryllium
- Chromium
- Mercury
- Tin
- Tungsten
- Titanium
- Arsenic
- Cadmium
- Lithium
- Uranium

Non-Metallic Minerals

- Calcite
- Barite
- Quartz
- Feldspar
- Corundum
- Garnet
- Kyanite
- Ruby
- Sillimanite
- Tourmaline
- Salt
- Gypsum
- Phosporite
- Magnesite
- Talc
- Coal
- Graphite
- Silica
- Clay
- Slate
- Granite
- Syenite
- Pegmatite
- Limestone
- Dolomite
- Marble

National Highway

Horizontal Datum
Spheroid: Everest 1830
Units: Degree

Administrative boundaries, geographical names are from Survey Department, Government of Nepal.
Road network are from Department of Road, Government of Nepal.

Data Source: Mineral Resources of Nepal, 2023 (DMG), Published and unpublished reports and maps of the Department and Mines and Geology, Mineral Exploration Development Board, United Nations Economic and Social Commission for Asia and Pacific.

First edition, 2024, compiled and modified after "Atlas of Mineral Resources of the ESCAP Region 1993"

GEOLOGICAL MAP OF NEPAL

SCALE 1:1,000,000

Government of Nepal
Ministry of Industry, Commerce and Supplies
Department of Mines and Geology

25 0 25 50 75 100 125 Kilometers

INDIA

CHINA

INDIA

SUDURPASCHIM PROVINCE

KARNALI PROVINCE

LUMBINI PROVINCE

GANDAKI PROVINCE

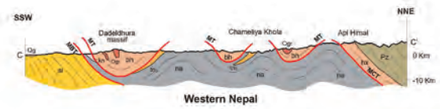
BAGMATI PROVINCE

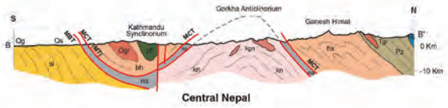
KOSHI PROVINCE

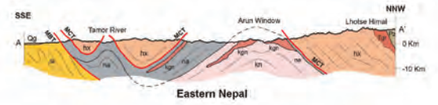
MADHESH PROVINCE

Api Himal 7132
Saipal Chuli 7031
Kanjirowa Himal 6883
Annapurna 8093
Dhaulagiri 8167
Manaslu Himal 8163
Ganesh 7429
Langtang Ri 7205
Gaurishankar 7134
Cho Oyu 8201
Sagarmatha(Mt. Everest) 8848.86
Makalu 8463
Kanchanjangha 8586

GEOLOGICAL SECTION







GANGETIC PLAIN

Qg Quaternary alluvial river deposits.

SUB-HIMALAYA

Qs Quaternary alluvial deposits of Dun Basins.

SIWALIK GROUP

Si Middle-Miocene to Pho-Pleistocene molassic fluvial deposits, conglomerates, sandstone and shale with vertebrate fossils.

LESSER HIMALAYA

Ql Plio-Pleistocene to Quaternary. Fluvial/fluvioglacial gravels, conglomerates and lacustrine clay deposit with vertebrate fossils.

LESSER HIMALAYAN METASEDIMENTS

Precambrian to Tertiary. Predominantly low grade clastic metasediments of Precambrian to Lower Paleozoic age with a few marker limestone/dolomite horizons. Intensively folded. Permo-Carboniferous to Mid-Miocene sediments, locally rich in flora and fauna.

Tansen Group

Permo-Carboniferous to Mid-Miocene clastic sediments (diamictites, sandstones, siltstones and shales) with local limestone beds.

Tertiary Series (Eocene to Mid-Miocene). Lower Part: marine shales and limestones with Foraminifera. Upper part: sandstones and shales of fluvial flood plain origin with plant remains.

Mesozoic Series (Upper Jurassic to Cretaceous). Lower part: continental fluvial sediments (conglomerates, sandstones, siltstones and shales/slates) with lava flows and plant fossils. Upper units are partly marine (limestones and shales), dominantly fluvial sediments (sandstones, quartzites and shales) with plant remains.

Permo-Carboniferous Series (Permo-Carboniferous). Partially glaciomarine and predominantly glaciofluvial and fluvial sediments (diamictites, shales/slates. sandstones and siltstones) with flora and fauna.

Nawakot Group

Precambrian to Lower Paleozoic. Mainly shallow marine sediments; lower part dominantly clastic (phyllites, sandstones, quartzites and calcareous sandstones). Stromatolitic limestones and black slates occur in the upper part. Basic sills and dykes present.

Kuncha Group

Precambrian. Mainly flyschoid sequence (bedded schists, phyllites and metasandstones), locally shallow water quartzite beds and basic sills and dykes present.

LESSER HIMALAYAN CRYSTALLINES

Precambrian to Middle Paleozoic. Lower sequences consist of greenschist facies metamorphic rocks, partially migmatised and granitised. Upper part: weakly metamorphosed sediments with fossils.

Phulchauki Group

Early to Middle Paleozoic, fossiliferous (crinoids and trilobites) calcareous rocks with subordinate siliceous and argillaceous sediments in the upper part. Lower part: clastic and feebly metamorphosed rocks (phyllites, quartzites and siltstones). Equivalent to Paleozoic rocks of the Tibetan sedimentary zone.

Bhimphedi Group

Precambrian. Green schists metamorphosed rocks, Schists, quartzites and few marble horizons. Locally migmatised and granitised. Granite intrusions present. Equivalent to Precambrian rocks of the Higher Himalayan Crystallines.

IGNEOUS ROCKS

Ordovician. Two mica granites with tourmaline.

Precambrain and probably Paleozoic. Augen gneisses and two mica granites mainly in Kuncha Group, some also in Nawakot Group.

Precambrian. Nepheline syenite in Kuncha Group.

HIGHER HIMALAYA

Plio-Pleistocene to Quaternary. Mainly fluvial and fluvio torrential sediments with local lacustrine clays and marlstones.

TIBETAN SEDIMENTARY ZONE

Mesozoic (Triassic to Lower Cretaceous). Mainly shallow continental plateform sediments with local pro-delta facies in the Early Cretaceous. Sandstones, slates, shales with glauconite. Mainly ammonites and belemnites in Jurassic limestone.

Paleozoic (Cambrian to Permian). Lower part mainly calcareous, middle part pelagic and upper part is rich in detrital sediments, limestone, sandstone and shale. Early Permian tillioid beds with plant fossils and local spilitic lava flows.

HIGHER HIMALAYAN CRYSTALLINES

Precambrian high grade metamorphic rocks comprising gneisses, quartzites and marbles. Migmatites and granite gneisses present predominantly in the upper part.

Tertiary (Miocene). Two mica leucocrstic granites with tourmaline.

GEOLOGICAL FEATURES

- Geological boundary
- Anticlinal axis
- Synclinal axis
- Fault
- Major lineaments
- MBAF — Main Boundary Active Fault (interpreted from LANDSAT images)
- Thrust (MCT : Main Central Thrust, MT: Mahabharat Thrust, MBT : Main Boundary Thrust)

TOPOGRAPHIC FEATURES

- Peaks with height in metres (5845.86)
- Major Road Network
- Town / City
- River
- Lake
- International boundary
- Province boundary
- Contour (1000)

HORIZONTAL DATUM

Spheroid: ..... Everest 1830
Origin: ..... Longitude 84° East, Latitude: 0° North
Scale factor at Central Meridian: 0.9999

DATA SOURCE

Geological Map of Nepal, 1993, Scale 1:1,000,000 ESCAP Geological Maps of five Development Regions of Nepal 1984-1987, Scale 1:250,000, S. B. Shrestha, J. N. Shrestha, and S. R. Sharma, Department of Mines and Geology (DMG). Geological Map of Kathmandu Area and Central Mahabharat Range, 1980, Scale 1: 250,000, J. Stocklin and K. D. Bhattarai, UNDP. Various unpublished geological maps of scale 1:63,360 prepared by several geologists of the Department of Mines and Geology and the Mineral Exploration Development Board, 1975 - 1992. LANDSAT - MSS (Pub. 1984) and LANDSAT - TM (1988 - 1992) Data.

Administrative Boundaries, Rivers and Topographic Contour in Scale 1:1,000,000 from Survey Department, Government of Nepal, Kathmandu.

Road Network from Department of Road, Government of Nepal, Kathmandu.

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