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Government of Nepal
Ministry of Industry, Commerce and Supplies
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu, Nepal
Te. +977-1-4414740, 4412065, Fax: +977-1-4414806
Email: info@dmgnepal.gov.np, website: www.dmgnepal.gov.np

FOREWORD

Department of Mines and Geology's main endeavor is to have an in depth study and research in the field of Geosciences, Petrology, Mineralogy, Seismology and associate subjects and to disseminate the gain knowledge for the Development of Infrastructures, Natural Disaster Risk Reduction, and promotion of mineral and petroleum based industries. This has been the objectives of the Department since its existence.

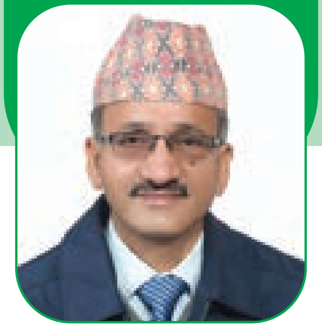
To meet the above objectives DMG is persistently working in these fields and have been updating and publishing geological maps not only of whole Nepal but also of all the seven provinces and according to the local needs. It has also undertaken geophysical and geo-environmental study to plan and develop accordingly of major urbanizing centers. The study and publications of landslide and seismic hazard map are some other activities that are of outmost important for natural disaster risk reduction and management. Similarly mineral resources exploration and promotion for the development of mineral based industries has played a key role in the national economy by substituting the import of some of the commodities like cement, talc powder etc. More opportunities in other minerals/metals like dolomite, phosphorite, magnesite, copper and iron ore are in offing.

These information and database are being disseminated to the stakeholders through various means and the Annual Bulletin is one of these. I am delighted to bring forward the rituals of disseminating the DMG activities into form of research articles and database by publishing the "Annual Report of Department of Mines and Geology, Volume 13". We at DMG believe and have strong determination that the policy-makers, planners, mines developers, stakeholders etc. will recognize the contribution of the geo-scientific studies and development of mineral/petroleum resources for meeting the goal of 'समृद्ध नेपाल सुखी नेपाली' and prioritize this sector in the overall planning process.

I would like to thank all the contributing author, co-author for timely submitting their research article and special gratitude goes to the reviewer and editorial board for their tireless effort on going through the manuscript and compiling all the articles into this volume within short interval of time that being affected by the lockdown and COVID-19 pandemic. I hope this volume will be informative for the geoscientist, investors in the mineral sector, students and general public who are keen to know about DMG research activities in coming days.

Ram Prasad Ghimire
Director General

EDITORIAL



Annual Report Publication is one of the routine work of Department of Mines and Geology (DMG) to share its activities and accomplishments among concerned stakeholders and public at large. This report (Annual Report Volume 13) for fiscal year 2078/79 has been published as the continuation of preceding volumes.It consists of different articles related to the various activities undertaken as per the annual programme completed in the earlier and current fiscal year. This volume aims to provide some new insights and information which could be helpful for the different group of stakeholders involved in the geo-scientific research and mineral based industries. Since the beginning of publication it was intended to incorporate study and research outcomes obtained utilizing sophisticated field equipment and laboratory based investigation rather using minimum invasive method of traditional techniques for mineral exploration and geo-scientific research. Given the fact that the increased volume of work carried out since few years back, we have started to work on geo-electrical imaging, induced polarization imaging, entertained digital based laboratory geotechnical measurement facilities, various seismic equipment to understand ground seismicity (MASW and SPAC), topographical mapping by drone, magnetic mapping, mineral identification in the field by hand held XRF, upgraded chemical laboratory by using ICPMS measurements, AS measurements etc. These upgraded facilities would definitely make the articles better and eventually encourage the governmental and non-governmental stakeholders to collaborate with the DMG in the new domain of geo-scientific research.

Editorial Board appreciates all the reviewers for their meticulous effort in reviewing the articles contained in this volume. We are delighted in bringing out this volume in the present form and would like to extend our sincere appreciation and express gratitude to all the authors, co-authors and staff members of the Department for their contribution and cooperation. Any comments and suggestions for improvement will be highly appreciated.

Dr. Sudhir Rajaure
Chief Editor

TABLE OF CONTENT

An account of limestone as a cement raw material in Nepal

Dharma Raj Khadka (Sr. Div. Mining Geologist)

ABSTRACT

This study focuses on the limestone demand analysis as a cement raw material in Nepal using revenue result base year of 2076/77. The results show that the market behaviour will define the investment in the sector which has tremendous potential to grow. The future focus should be paid in robust mineral economic database generation.

Keywords: Limestone demand; cement raw material; growth; future outlook.

1. INTRODUCTION

Nepal, being a South Asian country located between India and China has sizable population, is upgrading into a Lower middle income country in 2022. It has open borders with India. It is connected with friendly countries for free trade. It is constantly increasing it's doing business environment. The accelerated infrastructure development pace at the moment fascinates the future of Nepalese business potential. Right posture from the calamities in a meaningful ways during devastating earthquakes, trade embargo and floods trigger our attention to rise from the rubbles. The message, we care, is resource potential should be sustainably harnessed to scale up living standards of the people of Nepal.

As per the Cement Manufacturing Association, 20 integrated circuits for clinker production and 32 grinding units have been installed in Nepal. Two of them are government owned and others are private sector undertakings with 100% ownership. Only a few of them have FDI inflow. The internal environment to the sectoral performance drivers, no matter what others may be, is considered to be strengths and weaknesses. Strengths of the sector could be high demand and annual increment throughout the country, cheap labor, large potential of infrastructural development in Nepal and weaknesses could be related to quality, sustainability and poor transportation networks.

The external environment to the sectoral performance drivers, are opportunities and threats. Increasing infrastructural projects, technology transfer, development of SMEs, building code and insurance policies for housing are strengths in the sector while big competitors, social conflicts and favouritism could be considered as threats. Coming back to the strengths and opportunities, the sensing is seemingly positive to the sector to grow and minimize or neglect weaknesses and threats with policy harmonization. The main focus of the study is limestone market projection which possibly is useful to realize sustainable revenue, employment and investment for anticipated future.

2. MATERIALS AND METHODS

The demand is a factor of so many unstable variables both macro and micro environmental variables that a very few estimates are correct and most future forecasts are based on three approaches, opinions, past sales trend and market tests (Koirala, 2000). This study uses the trend analysis of limestone using revenue results base year of 2020.

3. RESULTS AND DISCUSSION

3.1 Results

Limestone is a sedimentary rock consisting of dominantly calcite ($CaCO_3$) minerals. Dolomitic limestone is a rock in which limestone is partially alters to dolomite. The operating limestone mines in the year 2076/77 was 43, Figure 1. The limestone deposit consisting of gray laminated limestone is shown in Figure 2 from Lakharpata, Surkhet, Nepal.

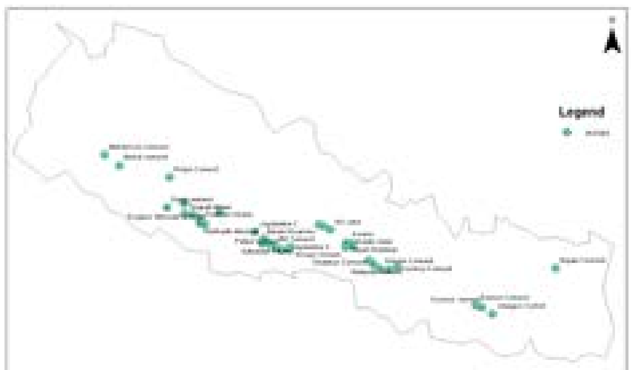


Figure 1: Operating limestone mines

Figure 2: Gray laminated limestone deposit, Lakharpata, Surkhet.

Table 1: Compositional variation of the some of the limestone deposits.

Districts	Salyan	Uday-apur	Kavre	Ar-gha-khan-chi	Nawal-parasi	Maka-wan-pur	Syangja	Palpa	Baitadi
No. of samples	136	148	18	30	44	49	332	77	329
CaO%									
Stdev	5.23	6.9	2.4	6.24	8.8	4.41	4.01	4.5	5.04
Average	52.17	48.52	29.46	29.17	45.39	45.05	47.88	44.55	45.73
MgO%									
Stdev	2.75	6.28	4.59	5.17	6.6	1.95	1.42	2.14	2.27
Average	1.85	4.72	10.11	16.81	12.22	2.76	2.77	2.13	2.72

Source: Shrestha et al, 2012

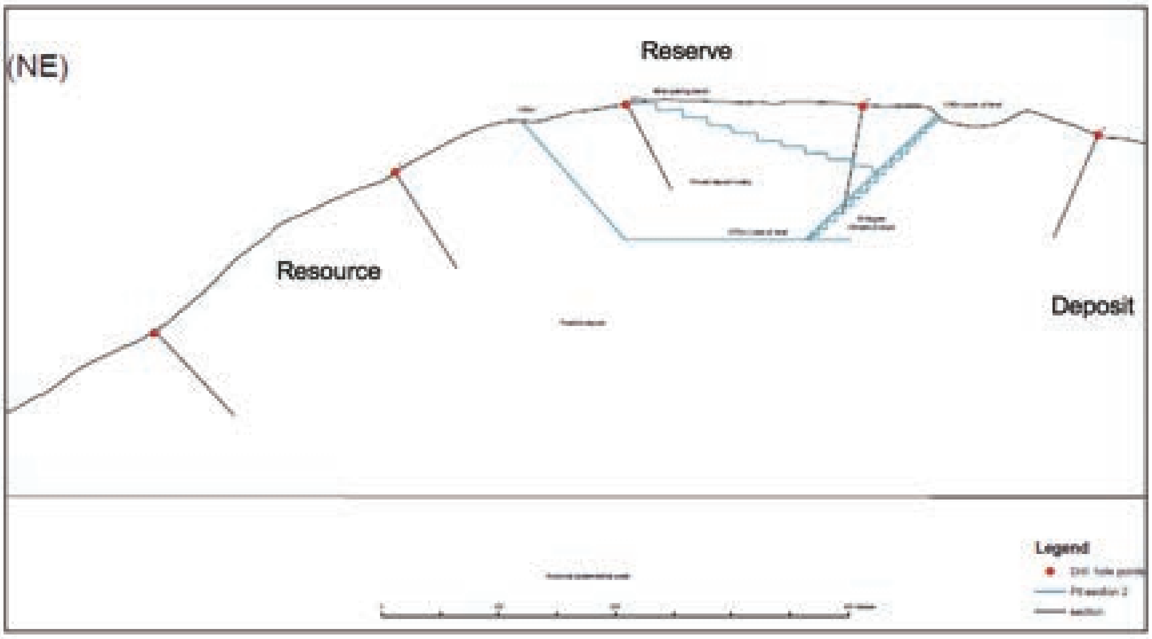


Figure 3: Limestone deposit, reserve and resource, an example from Lakharpata limestone.

The limestone deposit is characterized based on the exploration results in which reserves are economically viable and resources are potentially economic deposits. (Figure 3)

Theoretically, dolomitization is a process in which it modifies calcite into dolomite. Marble is a metamorphic rock in which a variant is crystalline limestone. Speleothems i.e. stalactites & stalagmites are limestones that formed through evaporation. Fossiliferous limestone contains brachiopods, crinoids, mollusks, gastropods, and coral. Oolitic limestone consists of Oolites which are small, sand-size clasts of calcium carbonate. Tufa is a porous limestone produced by precipitation of calcium carbonate from the waters of a hot spring. Marl is lime rich mudstone.

Geologically, Nepal Himalaya consists of marl beds in Lower Siwaliks. The Lesser Himalayan Sequences consists of limestone, dolomite, marble, speleothems, fossilifeous limestone and tufa. The Higher Himalayan Sequence consists of marble, crystalline limestone and dolomite. The Tethys Himalayn Sequence consists of limestone, dolomite, marble, fossiliferous limestone, speleothems. The age ranges from Proterozoic to Tertiary. The status of prospecting and opening licenses of limestone, dolomite and calcite as well as production data of limestone, dolomite and marble, to date so far, are presented in Table 2.

Table 2: Limestone License status (www.dmg.gov.np).

Attributes	Status
Prospecting Licenses As of 2021.5.10	Dolomite:17 Limestone:196 Calcite: 1
Opening Licenses As of 2021.5.10	Limestone: 70 Dolomite:2 Marble:1 Calcite:1
Production As of 2021.5.10	Limestone: 8097242.35 ton Dolomite: 22440.11 ton Marble: 43228.73 m^3 blocks, 22055.52 ton chips

Source: Mineral Resources Division, DMG

Uses of Limestone and Dolomite

Limestone is widely used as a cement raw material in Nepal. The product diversification and its use in other applications should be facilitated. The other uses of limestone and dolomite are as follow- (www.geology.com).

Dimension Stone: Facing stone, floor tiles, stair treads, window sills etc.

Roofing Granules: heat-resistant coating on roofing, top coat on built-up roofs.

Road base, railroad ballast, aggregate. Flux Stone: Smelting.

Ag Lime: Cost-effective acid-neutralizing agent

Lime: The calcium oxide is a powerful acid-neutralization agent is used as a soil treatment agent in agriculture and as an acid-neutralization agent by the chemical industry.

Animal Feed Filler: Chicken grits, dairy cattle Mine Safety Dust: Coal surfaces in an underground mine improves the air for breathing, reduces explosion hazard by particles of flammable coal dust suspended in the air

Filler in paper, paint, rubber, and plastics

Sorbent (a substance that absorbs pollutants) at many coal-burning facilities

Limestone demand analysis

A linear regression analysis based on the production data of limestone in 2017, 2018 and 2019 is presented and shows the future trend of limestone demand, Figure 4. The limestone demand analysis based on the following assumptions has been presented for the period of 2020-2030 in Table 3. The revenue from limestone, employment at mine and future value of investment in limestone mine has been given in Table 4. This shows that there will be no resource scarcity till 2030 as per projected production of limestone for cement production. About Nrs 16.67 Arab revenue will be generated as per present regulatory regime. The future value of investment will be approximately Nrs. 1337 Arab in limestone quarry based cement production in 2030. The demand of limestone will increase if cement is exported to neighbouring countries. Public private partnership could be one of the options for sustainable limestone quarry operations in Nepal.

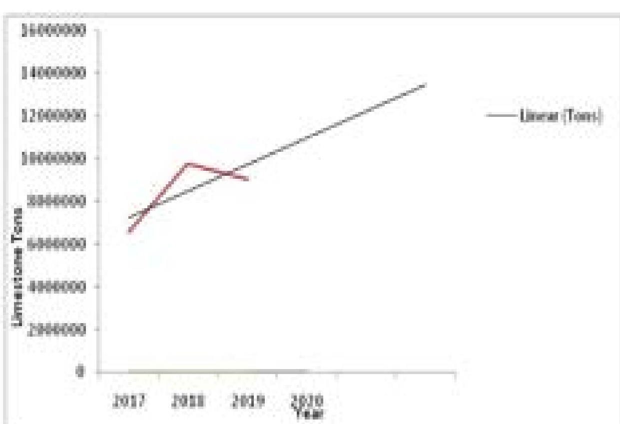


Figure. 4: Linear trend analysis of limestone production.

Assumptions

1. Base year 2076/77
2. 90% of the revenue generated from limestone
3. Rs 68 per ton revenue for limestone including local tax and renewal charges
4. Annual market increment 10%
5. 1.5 ton limestone requirement for 1 ton clinker production
6. Demand projected employment participation base year 2020, Nepal market study report, 2018
7. Peak demand 2050, infrastructure rapid development 2021-2050
8. Mining and quarrying sector employment participation 0.5% of total employment number= 89056(2020)
9. Limestone mines employability 60%, direct and indirect together,
10. As a rule of thumb 10% of the total employment will be direct employment in limestone quarry
11. Nepal will be leaning to high income country within next 30 yrs.

The projected annual limestone requirement in tons is shown in Figure 5, and revenue generation and employment generation has been estimated and shown in Table 5.

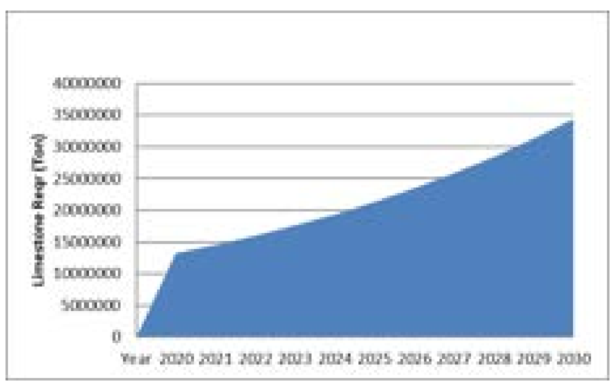


Figure 5: Projected cumulative limestone requirement (ton)

3.2 Discussion

Limestone resources are the limited and non-

Table 3: Limestone requirement calculation.

Estimated deposit	5000000000	tons
Cement demand	10000000	tons/year
Limestone requirement	15000000	tons/year
Revenue realized	1000000000	year
Limestone Tonnage@90% Revenue at DMG	13235294.12	year
Capacity utilization	0.882352941	
Clinker import	0.117647059	
Limestone prod, tpd	44117.64706	300 working days
Annual Limestone production	13235294.12	
Annual market increment	10%	

Table 4: Demand analysis.

Year	Annual limestone requirement(ton)	Cumulative Reqr, (Ton)	Cement prod (Tpd) Reqr
2020	13235294.12		24,509.80
2021	14,558,823.53	27,794,117.65	26,960.78
2022	16,014,705.89	43,808,823.54	29,656.86
2023	17,616,176.47	61,425,000.01	32,622.55
2024	19,377,794.12	80,802,794.13	35,884.80
2025	21,315,573.53	102,118,367.67	39,473.28
2026	23,447,130.89	125,565,498.55	43,420.61
2027	25,791,843.98	151,357,342.53	47,762.67
2028	28,371,028.37	179,728,370.90	52,538.94
2029	31,208,131.21	210,936,502.11	57,792.84
2030	34,328,944.33	245,265,446.44	63,572.12

Table 5: Revenue and employment generation.

Projected	2020	2030	
Revenue (Nrs)	900,000,000	16,678,050,357.96	
Employment No.	53433	54833	Direct and indirect
	5343	5483	Direct employment
Future value Investment in cement (NRs), (7% Inflation rate)		1337	Arab

renewable resources. Economically, limestone mines are structured under primary sector of industries. Limestone production insists on resources, labor and capital whereas consumption pattern of the limestone ore is based on consumer, producer and government relations. It demands to make a choice to gear up opportunities in this sector. Nepal is under the mixed economic environment, the competitive limestone demand is based on attractive business environment, that core of the supply side is linked with desired policies. The intervention and facilitation is always a part of regulation in this sector. The impact of the limestone quarries in the economy depends on efficiency that how well scarce resources are utilized in a given market structure. The perfect competitive market is the best option. Economic growth measures quality and quantity of the resources. Economic development should be in focus to foster better quality life of the people from this sector. The regulatory mechanism demands institutional development to harness sustainable results in national development from this sector.

4. CONCLUSION

The limestone demand projection shows that the limestone resources are sufficient for cement production till 2030 at the growth rate of 10% per year. The consumption of the cement will be based on the economic growth of the country and export if it is competitive. The revenue generation will be sustainable provided that the business environment is stable. The limestone quarry itself will generate low direct employment but its indirect employment is significant. The market behaviour will define the investment in the sector. The sector has tremendous potential to grow; moreover, product diversification will enhance value addition. Lastly, mineral economics could be the essential component of limestone mining sector with robust mineral economic database.

5. RECOMMENDATION

The robust mineral economic database should focus on the following components-

- National Mineral inventory consisting of classification, production, trade, future outlook database
- Market survey reports including specification, use, price, demand supply
- Mineral Information Bulletin consisting of license, renewable, amendments
- Annual reports, national and international periodicals and bulletins of different organizations related to mineral economics
- National Mineral information repository of mines, geology, mining industry, exploration and mining consultants, royalty and taxes

These databases will also be equally used in inter ministry, intra ministry, NPC, parliamentary questions, mineral policy, status report and future availability of mines and minerals.

REFERENCES

Koirala K.D. (2000) Marketing Management, MK Publishers and Distributers, Kathmandu, P 229.

MoFA the Nederlands, (2018) Nepal: market study, identifying foreign direct investment opportunities in Nepal, p147.

Shrestha R, Khadka DR and Rahman H (2012) A Short review of compositional variation of some limestone deposits of Nepal, DMG Annual Report Vol.8, pp21-24.

www.dmg.gov.np

www.geology.com

Performance monitoring of mineral exploration and mining projects in Nepal

Dharma Raj Khadka (Sr. Div. Mining Geologist), Jay Raj Ghimire (Deputy Director General), Rupak Kumar Khadka (Senior Divisional Mining Engineer), Rishi Poudel (Senior Legal Officer), Pramod Simkhada (Geologist), Naresh Maharjan (Geologist), Rajendra Acharya (Geologist), Ramananda Chaudhary (Mining Engineer)

ABSTRACT

Based on the reviewed IEE reports, inspection and monitoring reports, field verification reports and other progress reports it is realized that the performance monitoring could be the major component of mineral sector development and environmental sustainability which could lead to data informed decision for current outputs and future outcomes and also impacts of mineral exploration and mining projects. The issues could be addressed by harmonizing good practices for resource characterization, operation and environmental management along with new set of skills to thrive the roles.

Keywords: Performance monitoring; mineral exploration and mining projects; issues and good practices

1. INTRODUCTION

Mineral resources are vital to the production of goods, services and infrastructures and so the systematic mining is important and unavoidable act. The performance monitoring of exploration and mining projects is crucial for improving outputs. Performance monitoring technique is used to analyse the progress being made towards actions and activities periodically. It also provides sense of real time information of the exploration and mining projects, hence, management could make data informed decision. It incorporates reckoning of input, activities and output variables and indicators during project implementation. The results emphasize on improvements and deviation correction. The main function of the monitoring is project tracking and oversight. The purpose of the monitoring is to improve efficiency of the project.

The overall goal is to improve 1) current management of outputs and 2) future management of outcomes and impacts of mining projects. A total of 18 IEE reports were reviewed, 10 mining scheme were verified and 28 operating mines were inspected for the FY 2077/78. Others are the case studies, environmental audits, conflict resolution, outreach programs and clients satisfaction surveys which are the basis for this analysis. The minimum annual target of DMG was 100 operating mines inspection and monitoring in 7 corridors for the FY 2077/78.

2. MATERIALS AND METHODS

The materials are field reports, program review reports, rapid assessment reports, compliance monitoring reports, environmental audit reports and GIS based Mining Information Management System database and other secondary literature reviews. The methods are routine reviews of reports, registers, and administration database and field observations. The field data collection methods consist of site visits, key informant interviews, focus group interviews, community engagements, direct observations and instrumental surveys and analysis.

Moreover, Drone technology has been used for inspection of some mines. It is also used in automatic surveying and mapping for stockpile management. The focus areas are prospecting and exploration of mineral commodities, mining scheme verifications considering physical, managerial, environmental and legal standards and variables, enhancing Initial Environmental Examination (IEE), periodic and rapid inspection and monitoring of operating mines and conflict management in exploration and mining projects.

The standards are Mines and Mineral Act 2042 and Regulation 2056, Environmental Protection Act 2076 and Regulation 2077, technical manuals of DMG, procedures, instructions provided during inspection and monitoring, conditions provided during mining licensing etc. Others are Constitution of Nepal 2072, different cross cutting acts and regulations such as Forest act 2076, regulation 2076, Local Government Operation Act 2074, Water Resources Act 2049 etc. The following lists provides the IEE and EIA requirements for the mining projects-

IEE requirements (Env. Protection Regulation, 2077)

- Less than 25 Ha. forest land
- Resettlement of upto 100 people from the mine area
- Underground mining for metallic minerals except radioactive mineral: 1000 tpd, surface mining 2000tpd
- Non-metallic mineral underground mining 2000 tpd, surface mining 4800 tpd
- Mine based Construction material mining, 50-500m3/day
- Coal underground mining 1000tpd, surface mining 2000 tpd

- Natural gas 200000m3/day
- Riverbed construction material 100-300m3/day

EIA requirement (Env. Protection Regulation, 2077)

- More than 25 Ha. forest land
- Resettlement of more than 100 people from the mine area
- Radioactive mineral mining
- Underground mining for metallic minerals except radioactive mineral: > 1000 tpd, surface mining >2000tpd
- Non-metallic mineral underground mining >2000 tpd, surface mining >4800 tpd
- Mine based Construction material mining, >500m3/day
- Coal underground mining > 1000tpd, surface mining > 2000 tpd
- Natural gas >200000m3/day
- Riverbed construction material >300m3/day
- Petroleum exploitation and refining

Participatory monitoring

The participatory approach of mines monitoring focuses on Target group and project team working together. It provides space for self-assessment, analysis of strength and weakness in a program, local realities integration, and stakeholders in decision making, adjusting project strategy, and better performed activities. This method has been used infrequently in case of mines inspection and monitoring.

Key assumptions for monitoring

1. Covid -19 will be in control
2. Human resources will be available at DMG
3. Logistic support to the task will be in firm
4. Technical support in place

3. RESULTS AND DISCUSSIONS

3.1 Results

The license status shows that a total of 334 prospecting licenses covering an area of 1717 km^2 and 144 mining licenses covering over an area of 590 km^2 consisting of metallic and non-metallic mineral commodities throughout Nepal are granted to the investors both private and public undertakings. (Table 1)

The mineral exploration projects that have been under the DMG licensing system has to fulfill anticipated activities in which their progress are monitored via progress reports. Majority of the projects have shown satisfactory compliance status, Table 2. Inspections of the performance of projects are based on the activities and time stipulated in the prospecting plan during licensing. Inspection is mainly based on progress reports submitted by the proponents. Costing, negotiations, leadership, partnerships, problem solving, conflict dealings, program implementation, priority setting, problem identification, capacity developments are the process input indicators that could be considered in the monitoring plans.

Table 1: Prospecting and opening license status, DMG, as of 2078/1/22

Province	Prospecting License issued	Area, km^2	Commodities	Opening License issued	Area, km^2	Commodities
1	46	327.3	Polymetal, Tourmaline, Talc, Quartz, Limestone, Dolomite, Red clay, Copper	10	44.28	Limestone, Quartz, Copper, Red clay
Madesh	-	-	-	-	-	-
Bagmati	145	545.06	Polymetal, Limestone, Granite, Copper, Talc, Slica sand, Ruby, Quartzite, Iron, Emerald, Dolomite, Calcite	54	186.3	Zinc, Magnesite, Limestone, Lead, Iron, Granite, Talc, Slab stone, Quartzite, Marble, Dolomite
Gandaki	18	88.15	Copper, Dolomite, Limestone, Quartzite, Iron	11	33.39	Limestone, Talc, Slabstone, Red clay, Quartzite, Dolomite
Lumbini	101	629.05	Limestone, Gold, Coal, Quartzite, Lead, Dolomite, Copper	38	231.96	Calcite, Iron, Limestone
Karnali	13	66.37	Tourmaline, Quartzite, Limestone Kyanite, Iron	20	60.36	Red clay, Limestone, Tormaline, Kyanite Calcite
Sudur Paschim	11	61.02	Limestone, Copper, Talc, Kyanite, Iron, Gold, Dolomite	11	34.3	Talc, Quartzite, Lead, Kyanite
Total	334	1716.95		144	590.59	

Table 2: Attributes of input, activities and output for exploration projects

Attributes	Input variables	Anticipated activities	Anticipated Outputs	Compliance Status
Reconnaissance prospecting	Project cost Human Resource Machine Time Standards Logistics	Lease area geology, geochemical survey, geophysiscal survey Target seleciton	Prospect generation reports	Satisfactory
Preliminary exploration		Topogeological survey, chip, channel sampling, analysis, geophysical survey, target drilling, evaluation	Surface exploration reports	Satisfactory
Detailed exploration		Detail trenching pitting, sampling, evaluation drilling	Surface and subsurface exploration, grade and tonnage, resource definition, environmental considerations, prefeasibility studies reports	Satisfactory
Mining Scheme and IEE		Mining reserve, grade, cutoff grade, mine plan, economic, social, technological and environmental analysis	Feasibility studies reports, verification reports	Satisfactory

Time factor: based on commodity classification,2-4yrs, as per Mines and Mineral Regulation 2056.

The mining projects which are under the DMG license system has to fulfill their anticipated activities and monitored through production reports, revenue reports, environmental audit reports, case study reports, field verification reports, inspection reports. Majority of the mining projects have shown satisfactory compliance status, Table 3.

Table 3: Attributes of input, activities and output for mining projects.

Attributes	Input variables	Anticipated activities	Anticipated Outputs	Compliance Status
Mine development Production Environmental management Mine closure Reclamation	Project cost Human Resource Machine Time Standards Logistics	Excavation, Drilling, Blasting, Mucking, Hauling, Dumping, Transportation, Environmental obligations, Safety and security, Trainings, CSR, Closer and reclaim	Production reports Revenue reports Environmental audit reports Case study reports Inspection and monitoring reports Reclamation reports	Satisfactory
Sustainability			Skill and scale up R &D raw material Machine optimization Policy harmony Working culture	Satisfactory

Time factor: based on commodity classification 10-30 yrs, as per Mines and Mineral Regulation 2056

The project impacts and its effectiveness in the society and economy and its sustainability has to be considered for the impetus of this sector to the economic development of the country. This is also a part of evaluation of the projects. The impact variables are listed in the Table 4. It has room for improvement and needs quantitative survey to generate esteemed data. (Table 4)

Table 4: Impact monitoring of mining projects.

Impacts	Status	Sustainability	Status
Increased employment, Consumer benefits, Increased income, Service availability, Ecological effects, Attitude, skill up, Role model opportunities, New opportunities, Benefit distribution, Team work culture, CSR effectiveness	Positive feedbacks but room for improvement Quantitative survey potential	Replicability Local ownership Cost effectiveness Environmental sustainability	Room for improvement Quantitative survey potential

Status of IEE reports, mining scheme verification and inspection and monitoring of operating mines

The IEE reports submitted and approved at DMG during FY 2077/78 have been listed in Table 5. The proponent, commodity, quarry area and location have been listed. Altogether 18 IEE reports were examined during the period.

Table 5: IEE reports submitted and approved.

SN	Proponent	Commodity	Quarry area	Easting(m) MP	Northing(m) MP	Location	Reference
1	Lumbini Minerals and Mines	Dolomite	4.54ha	454462.5	3072987.5	Tinau RM, Palpa	IEE report
2	Geo Mineral Reserves	Talc	4.22ha	472675.0	3263030.0	Dilasaini RM, Baitadi	IEE report
3	Srisha quarry	Sand	2.24ha	595575	3077887.5	Galchhi RM, Dhading	IEE report
4	Arinak Roda Dhunga	Construction Stone	1.49ha	375430	3041670.5	Temal RM 5, Kavre	IEE report
5	Lumbini Minerals and Mines	Dolomite	4.54 ha	454462.5	3072987.5	Tinau RM 5, Palpa	IEE report
6	Jhamkeshwori Mai Roda Dhunga	Construction stone	1.1ha	625500	3053750	Dakshinkali M 8, Kathmandu	IEE Report
7	Rolpa cement	Limestone	7.65ha	636575	3131612.5	TribeniRM 3, Rolpa	IEE Report
8	Huwaxin Cement Narayani	Limestone	4.98 ha	581965	3064030	Benighat Rorang RM-2, Dhading	IEE report
9	Pabitra Nirman Housing	Sand	3.85ha	606287.5	3082632.5	Bidur RM-3, Nuwakot	IEE Report
10	Rolpa Chundhunga Khani	Limestone	8.57ha	640325	3131700	Tribeni RM-4, Rolpa	IEE Report
11	Shivam Cement	Limestone	4.25ha	613075	3042650	Makwanpur RM 8, Makwanpur	IEE Report
12	Himalaya Mines and Minerals	Limestone	4.17ha	554625	3076600	Ichhakamana RM 6, Chitwan	IEE report
13	Shubham Khanij Udhyog	Limestone	4.5ha	646570	3116370	Runtigadi RM 6, Rolpa	IEE Report
14	Jay Siddhi Ganesh Roda Dhunga	Construction stone	1.9ha	622217.5	3072150	Dhunibeshi RM 1, Dhading	IEE Report
15	Surya Bahadur Tamang	Construction stone	1.05ha	371375	3044612.5	Roshi RM-7, Kavre	IEE Report
16	Manakamana Mines and Minerals	Limestone	6ha	558775	3076750	Ichhakamana RM-2, Chitwan	IEE Report
18	Jagriti Industries	Quartzite slab	1.51ha	362512.5	3076075	Indrawati RM-5, Chitwan	IEE Report

Out of total mining scheme verification during FY 2077/78 a total of 10 mining schemes were verified and are listed in Table 6.

Table 6: Mining Scheme Field Verification.

SN	Proponent	Commodity	Quarry area	Easting(m) MP	Northing(m) MP	Location	Reference
1	B S Cement	Limestone	4.88ha	459716	3074380	Mathagadi RM 1, Palpa	verification report
2	CG Cement Industries	Limestone	5.95ha	440680	3091262.5	Rainadevi Chhahara RM-1, Palpa	,,
3	,,	Limestone	9ha	439193.75	3088693	,,	,,
4	Daunne Devi Minerals	Limestone	4.05ha	480250	3075475	Pubakhola RM-1, Palpa	,,
5	Jagdamba Cement Industries	Limestone	4.55ha	434500	3091050	Rainadevi Chhahara RM-1, Palpa	,,
6	Kanchan Quarries	Limestone	1.27ha	449150	3071740.36	Tinau RM 4, Palpa	,,
7	KK Lime and Cement Industries	Limestone	2ha	488000	2976275	Chaudandi M-8, Udaypur	,,
8	Cosmos Cement Industries	Limestone	1.07ha	454180	2981375	Udaypurgadhi RM-4, Udaypur	,,
9	Shubhashree Agni Cement	Limestone		393450.00	3116062.50	Naubahini RM, Pyuthan	,,
10	Satyam Cement Industries	Limestone		638987.50	3135012.50	Tribeni RM, Rolpa	,,

A total of 28 operating mines have been inspected during FY 2077/78 and listed in Table 7.

Table 7: Operating mines inspection/monitoring.

SN	Proponent	Commodity	License No	Location	Reference
1	Sarbottam Cement Industry Pvt. Ltd	Limestone	11/069/70	Tinau RM/Palpa	Inspection reports
2	Alpha Construction and developers Pvt. Ltd.	Limestone	07/073/74	,,	,,
3	Dolomite Chundhunga Udhyog	Limestone	82/063/64	,,	,,
4	Satyawati Khanij Utakhanan Pvt. Ltd.	Limestone	29/072/73	,,	,,
5	B S Cement Industries Pvt. Ltd.	Limestone	125/074/75	Matthagadi RM/Palpa	,,
6	Palpa Cement Industry Pvt.Ltd.	Limestone	06/073/74	Matthagadi RM/Palpa	,,
7	Jagadamba Cement Industries Pvt. Ltd.	Limestone	04/073/74	Rainadevi Chhahara RM/ Palpa	,,
8	Hongshi Shivam Cement Pvt.Ltd.	Limestone	42/073/74	Nisdi RM/Palpa	,,
9	Kanchan Quarries Pvt Ltd	Limestone	119/064/65	Tinau RM 4, Palpa	,,
10	Satya Sai Coal Udhyog Pvt Ltd	Coal	8/62/63	Ghorahi SM-19	,,
11	KK Lime Industries	Limestone	131/074/75	Chaudandigadhi M-8, Udaypur	,,
12	Cosmos Cement Pvt Ltd	Limestone	30/068/69	Udaypurgadhi M-8, Udaypur	,,
13	Krishna Bahadur Lama	Quartzite	92/071/72	Bethanchok RM 5, Kavre	,,
14	Ladkeshwor Dhunga Udhyog	Quartzite Slabstone	155/071/72	,,	,,
15	Maruti Cements Pvt Ltd	Limestone	221/397/045/46	Dudhauli RM-14, Sindhuli	,,
16	Saurya Cement Pvt Ltd	Limestone	38/055/56	Katari M-8, Udaypur	,,
17	Udaypur Cement Ltd	Limestone	303/479/045/46	,,	,,
18	Udaypur Cement Ltd	Red clay	39/059/60	Triuga M-5, Udaypur	,,
19	Udaypur Cement Ltd	Red Clay	40/059/60	,,	,,
20	Udaypur Mineral Tech	Limestone	26/069/70	Katari M, Udaypur	,,
21	Sonapur Minerals and Oil Pvt Ltd	Limestone	80/066/67	Ghorahi M, dang	,,
22	Sonapur Minerals and Oil Pvt.Ltd	Limestone	213/071/72	Runtigadi RM, Rolpa	,,
23	Dang Cement Industries Pvt. Ltd	Limestone	36/061/62	Babai RM, Dang	,,
24	Tirupati Mines Pvt.Ltd	Limestone	49/073/74	Runtigadi RM, Rolpa	,,
25	Samrat cement Company Pvt. Ltd.	Limestone	116/075/76	Banglachuli RM, Dang	,,
26	Bishwokarma Mines and Minerals Pvt. Ltd	Limestone	72/067/68	Banglachuli RM, Dang	,,
27	Shubhashree Cement Pvt.Ltd	Limestone	40/075/76	Banglachuli RM, Dang	,,
28	Satya Sai Coal Udgyog Pvt.Ltd	Limestone	135/074/75	Runtigadi RM, Rolpa	,,

Photograph of different mines sites

Photo 1: Cosmos Cement Galtar

Photo 2: Udaypur Cement Sukaura

Photo 3: Saurya Cement Galtar

Photo 4: Maruti cement Kakurthakur

Photo 5: Udaypur Mineral Tech Gerudada

Photo 6: Krishna Bahadur Lama, Quartzite quarry, Bethanchok.

Photo 7: Satyabati Khani Utkhanan, Koldada, Tinau RM, Palpa

Photo 8: Sarbottam Cement, Basenidada, Tinau RM Palpa

Photo 9: Kanchan Quarry, Bhutuke, Tinau RM, Palpa

Photo 10: Hongsi Shivam Cement, Jyamire, Nisdi RM, Palpa

Photo 11: Alpha Construction, Suketal, Tinau RM, Palpa

Photo 12: BS Cement Mathagadi RM, Palpa

Photo 13: Satya Sai Coal Udhyog, Ghorahi Sub M, Dang

Photo 14: Bishwakarma Cement, Tapa, Banglachuli RM, Dang

Field observation shows that some of the operating mines have mine wastage management problems (Photo-1, 3, 4, 9, 10). Some of them have haulage and mine road management, cut slope, bench height and width management problems (Photo-2, 7, 8, 9, 11). These problems were identified in the field and DMG have given suggestions and directions to mitigate and minimize these problems.

Exploration and mining project issues in outputs

Based on these observations, some of the issues related to output maximization have been listed here which could be basis for improvement in the future activities in the areas of resource characterization, mining scheme field verification, environmental protection and project inspection and monitoring.

Resource characterization

- Spot check sampling for accuracy
- Minimum or none evaluation Drilling
- No cutoff grade calculation including operating costs, taxes, recovery factors, capital costs
- Dilution factors
- Conventional way of resource characterization

Mining Scheme Field verifications

- Pit slope justification, sufficiency of slopes and benches
- Final pit limits determination
- Equipment delivery, setup and spares costs
- Appropriate labor rates
- Operating cost-grade control
- Capital cost- fencing
- Contract mining mechanism
- Safety trainings
- For metals, Metallurgical recovery, concentrate grade, crushability, grindability, ore variability, ore dewatering tests, reagents recommendations, piloting, water requirements, material balance, quality control
- Sensitivity analysis

Initial Environmental Examination reviews

- Baseline indicators
- Site specific Environmental impact analysis
- Appropriate Impact mitigation plans
- Appropriate mine waste management plan
- Emergency response plan
- Conceptual environmental cost estimation

Mines inspection and monitoring

- Erosion, effects of heavy metal pollution in farm lands
- Deforestation & desertification
- Health and safety
- Dust pollution, noise pollution
- Ore mining out of quarry limit
- Grade, tonnage
- Bench height, width and haulage road management
- Top soil , overburden and under burden management
- Waste yard management and stability
- Pit Slope stability

Output maximization efforts

The output maximization efforts related to the exploration and mining activities by three tire of government have focused mainly in conflict resolution, outreach programs and case studies. The feedback from the clients is also considered for the continual improvement of the service delivery.

Conflict resolution

The concerns raised by the affected households nearby mining areas, RM and M authorities at local levels to the investors, proponents are basically related to safety and security, resettlements, land ownership and consent, environmental degradation, CSR commitments and fulfilments. Similarly, provincial level authorities have raised concern over exploration license permitting and infrastructure damage. The central level authorities have concerns of mining license permitting, mine infrastructure support, 50:25:25 revenue sharing , service delivery, value addition in semiprecious stones, mine based construction material, control of artisanal illegal mining mainly in construction material.

Outreach programs/ seminars

Interaction program on challenges and opportunities of Cement production in Lumbini province with Provincial governmental authorities was undertaken this year. The outcome of the program was to understand-

- Export potential of the cement
- Internal demand situation
- Cement brands PPC, PSC, OPC
- Sustainability of the sector

Case studies

Additionally, issue based case studies in the mine sites as well as Client satisfaction survey at DMG are also a part of the monitoring activity.

3.2 Discussion

The efficiency optimization potential in exploration and mining is always there for public and private sector for sustainability of extractive industry in Nepal. The good practices in other parts of the world have been highlighted and discussed for sustainability of the sector and benefit of the society.

Raymond L. 2002 noted the following technical standards for mineral resource characterization-

- CIM Canadian National Instrument 43-101
- JORC code
- SME Guide for reporting exploration information, mineral resources and mineral reserves

United Nations Framework Classification (UNFC) system for fossil energy and mineral reserves & resources was adopted in 2009 and upgraded in 2019. Committee for Mineral Reserves International Reporting Standards (CRIRSCO) template was harmonized with UNFC 2009 classification. Other codes which are in practice are SAMREC, SEC Industry Guide-7, etc. Geometric and geostatistical methods for qualitative reserve estimation of limestone deposit by Afeni et al 2021 is key to effective production scheduling and accurate projection of raw materials for cement production.

Montsion et al 2021 applied geostatistical approach to mapping structural complexity using geophysics for making exploration a more rigorous process with increased confidence. MAPTEK-Vulcan, Micromine, GEOVIA Surpac, GOCAD etc are the exploration and mining softwares which are extensively used in other parts of the world. Simulation, machine learning algorithms and optimization are methods used in dealing with uncertainties in resource estimation. More et al 2020 use application of digital technologies at mine sites with The Internet of Things (IoT), Wireless Sensor Networks (WSN), artificial intelligence, swarming drones and automation which are the most widely used smart technologies in the mining industry. They also applied automation in mines like self-driving trucks, drones. The WSN are used for automated measurement systems like physico-chemical parameters. These technologies will positively affect the mining industry in the long run, making it possible for the mines to reach their expected full-scale production. Mines monitoring technology and instrumentation for Smart mining in all spheres of production include sensor technology, 3D modelling, and advanced robotics. Garbarino et al 2020 applied Best Available Techniques (BAT) for the waste management. Trivedi et al 2014 studied prediction of blast-induced flyrock in limestone mines using neural networks. There is Environmental Management Software GENSUIT in practice in some places. Mines inspection and monitoring are done with the help of digital monitoring, 3D image analysis, daily satellite image processing and interpretation for production volume, area and time series analysis for dynamic modeling. Conflict resolution focused study were done by Liu et al 2020 for effects of heavy metal pollution on farmland soils and crops, Hg, Pb, Cd, Cu, and Zn pollution by mining activities. Dahlsrud, 2008 integrates CSR of social and environmental concerns with stakeholders. Adebayo et al 2021 highlighted the benefit sharing to the communities in 3 modes such as discounted benefits from the agreed amount, 1.08% of the estimated life-of-mine revenue, 2.10% with the primary contributions coming from jobs and financial transfers. Lindman et al, 2020 listed the sustainability initiatives, guidelines and tools in which some of them are as follow-

- The Extractive Industries Transparency Initiative. The EITI Principles
- International Council on Mining & Metals. Sustainable Development Framework
- Accountability 1000
- Social Accountability 8000
- ISO 14001 Environmental management systems
- ISO 26000 Guidance on social responsibility
- OHSAS 18001 Occupational health and safety management systems - requirements
- UNE 22470 Sustainable mining management indicators
- ISO 50001 Energy management systems
- ISO 9001:2015 Quality management systems - requirements
- ISO 31000 Risk management standard

These initiatives have to be considered for short, medium and long term policy planning for sustainable mineral sector development in Nepal.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Performance monitoring is the major component of mineral sector development and environmental sustainability which leads to data informed decision for current outputs and future outcomes and impacts.

Sustainability is integral to operate exploration and mining projects which are finite resources and ensuring contribution to the economic development.

4.2 Recommendation

Harmonizing good practices for resource characterization, operation and environmental management could be beneficial in a long run.

Human resource trainings and management in monitoring and evaluation with new set of skills to thrive in their roles

REFERENCES

Adebayo E, Werker E (2021) How much are benefit-sharing agreements worth to communities affected by mining? Resources Policy 71 (2021) 101970, doi.org/10.1016/j.resourpol.2020.101970

Afeni TB, Akeju VO, Aladejare AE (2021) A comparative study of geometric and geostatistical methods for qualitative reserve estimation of limestone deposit, Geoscience Frontiers 12, pp243–253, https://doi.org/10.1016/j.gsf.2020.02.019

Chaudhary R, Simkhada P (2020) Mining scheme verification, inspection and monitoring of mines, Internal reports, DMG

CRIRSCO (2015) Bridging Document between the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) Template and the United Nations Framework Classification for Resources (UNFC), 2015

Dahlsrud A (2008) how corporate social responsibility is defined: an analysis of 37 definitions. Cor. Soc. Respons. Environ. Manag. 15, pp1–13.

Environmental Protection Act 2076 and Regulation 2077

Garbarino E, Orveillon G, Saveyn GM (2020) Management of waste from extractive industries: The new European reference document on the Best Available Techniques, Resources Policy 69, 101782, https://doi.org/10.1016/j.resourpol.2020.101782

Khadka DR, Paudel R, Acharya R (2020) Mining scheme verification, inspection and monitoring of mines, Internal reports, DMG

Lindman A, Ranangenb H, Kauppilac O (2020) Guiding corporate social responsibility practice for social license to operate: A Nordic mining perspective, The Extractive Industries and Society 7, 892–907, https://doi.org/10.1016/j.exis.2020.07.013

Liu RP, XU YN, Zhang JH, Wang WK, Elwardany RM (2020) Effects of heavy metal pollution on farmland soils and crops: A case study of the Xiaoqinling Gold Belt, China. China Geology 3, 402−410, doi: 10.31035/cg2020024

Mines and Mineral Act 2042 and Regulation 2056

Montsion RM., Perrouty S., Lindsay M.D., Jessell M.W., Frieman BM (2021) Mapping structural complexity using geophysics: A new geostatistical approach applied to greenstone belts of the southern Superior Province, Canada, Tectonophysics 812, 28889, doi.org/10.1016/j.tecto.2021.228889

More KS, Wolkersdorfer C, Kang N, Elmaghraby AS (2020) Automated measurement systems in mine water management and mine workings – A review of potential methods Water Resources and Industry 24 (2020) 100136, https://doi.org/10.1016/j.wri.2020.100136

Trivedi R., Singh TN, Raina AK (2014) Prediction of blast-induced flyrock in Indian limestone mines using neural networks Journal of Rock Mechanics and Geotechnical Engineering 6 (2014) 447-454, http://dx.doi.org/10.1016/j.jrmge.2014.07.003

Raymond L. Lowrie, PE (2002) SME Mining Reference Handbook, Colorado, USA

United Nations Framework Classification for Fossil Flues, Mineral Resources & Reserves, Update 2019, Website: http://www.unece.org,

Zhu Min, Liu Dingjuan, Li Mingjian Li Haicheng, (1992) A computer MIS of an iron ore pit mine in China. IFAC Automation in Mining, Mineral and Metal Processing, Beijing, PRC,pp 41-46

Detail Exploration of Bojhe Limestone Prospect, Bojhe Area, Khotang District Province No.1, Nepal.

Dinesh Kumar Napit (Sr. Div. Geologist), Narayan Banskota (Sr. Div. Geologist), Naresh Maharjan (Geologist), Basant Adhikari (Research Officer)

ABSTRACT

The Bojhe Limestone deposit was preliminarily investigated by the geological mapping team in the fiscal year 2073/74 and recommended for further detailed exploration. Detail Exploration of Bojhe Limestone/Dolomite Prospect, Bojhe Area was further investigated with channel and chip sampling, topogeological survey, and core drilling to characterise the limestone and dolomite deposit and estimate their reserves. A detail surface sampling in 13 Sections with 143 samples covering 158.5 m thickness for identification grade of limestone deposit along with topographical survey was done with detailed geological mapping at 1:1000 scale covering 140 ha. 223 samples from 7 exploratory holes obtained from 288 m drilling length for subsurface quality of limestone and dolomite. The drilling data shows the proportion of limestone and dolomite is about 34:66. Proved limestone reserve is 2.8 million tons and probable reserve is 10.1 million tons as well as proved dolomite reserve is 7.5 million tons and probable reserve 22.7 million tons. This study concludes that the study area has both limestone and dolomite deposits, which would be varying of economic importance, if exploited.

Keywords: Limestone; Dolomite; Prospecting; Exploration; Exploitation

1. INTRODUCTION

Carbonate rocks are raw materials indispensable to industrial development. In recent years, limestone, dolomite, and marble constituted more than 90% of all rocks quarried in Nepal. The uses to which carbonate rocks and minerals can be put is a function of their physical and/or chemical properties. More than one hundred uses for carbonate rocks and minerals are given together with the users' general chemical and physical requirements. Because of space limitations, only three of the many areas of active research on carbonate properties are discussed: solid, solution and subsolidus relations, thermoluminescence, and infrared absorption.

For the identification of carbonate rock, DMG has conducted a mapping program in Khotang District including present limestone prospect area around Bojhe Halesi in the fiscal year 2073/74. The report has shown limestone and dolomite prospect around Bojhe area. As a continuation of the project, detail topogeological survey and core drilling in 7 locations covering 288 m was carried out in accordance with the annual field program 2075/76 by DMG.

1.1 Location and Accessibility

Location

Bojhe Carbonate Prospect lies in Bojhe Area, Halesi-Tuwachung Municipality -4 Khotang District, Province 1 Nepal. The topographic map 2786 15A (scale-1:25,000; entitled CHYASMITAR) of scale-1: 25,000 published by the Department of Survey, Government of Nepal encompass the area. The limestone exploration was carried out within the following boundary.

Table 1: Boundary of the study area.

Easting from	455000 m	Northing from	3005000 m
Easting To	459000 m	Northing to	3009000 m
Total area covered = 16 sq. km			

Exploration Area

Geological mapping in whole topo-sheet and around of 16 sq.km was proposed for detail exploration as shown in Regional Geological Map of the area. (Figure 3) Based on the potential limestone prospects, Bungdel area was selected for detail exploration where topogeological survey, channel sampling and core drilling was done.

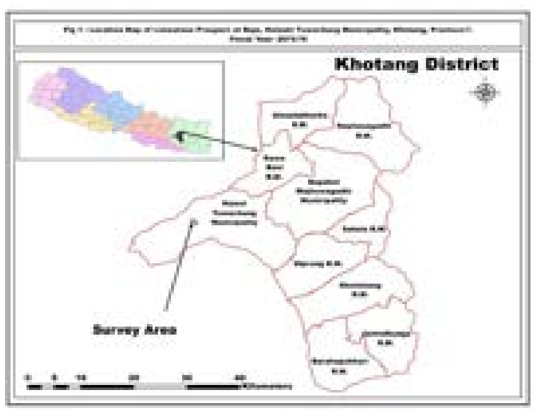


Figure 1: Location Map of Carbonate Prospect at Bojhe, Haleshi-Tuwachung Municipality, Province No-1, Nepal.

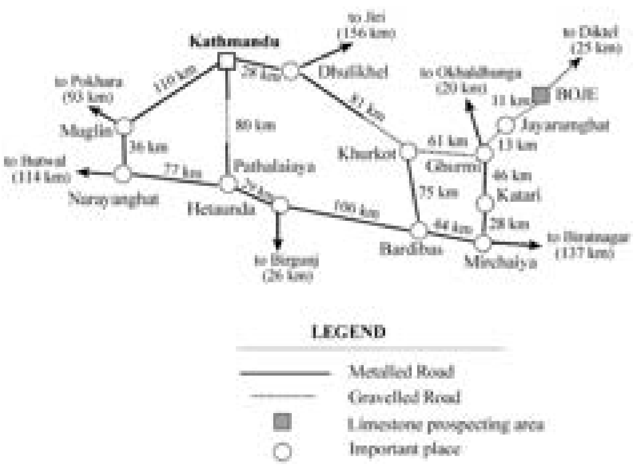


Figure 2: Route diagram to reach the Carbonate Prospect at Bojhe, Haleshi-Tuwachung Municipality, Province No-1, Nepal.

Accessibility

The area is accessible by road and lies east of Kathmandu. The shortest distance to Bojhe from Kathmandu is 194 km via Dhulikhel (Kabhre)-Khurkot (Sindhuli)-Ghurmi (Udayapur)-Jayaramghat (Okhaldhunga), whereas it is 494 km via Muglin (Chitwan)-Bardibas (Mahottari)-Katari (Udayapur).

Topography and Drainage

The Bojhe area is a mountainous terrain with high hills and river valleys. Chyasmitar (1392)-Mayankhu (1405m)-Sarchun (1499m) is a NE-SW extending ridge which acts as the main drainage divide and divides the prospecting area roughly into northern and southern halves. The peak of Sarchun (1499m) and the bank of Dudh Koshi River (380m) are respectively the highest and the lowest altitudes within the area (Figure 3). The northern slope drains into the NE-SW flowing Dudh Koshi River mainly through Bhalu Khola, Mayankhu Khola and Gelun Khola. Similarly, the southern slope drains into the W-E flowing Sun Koshi River mainly through Durchhim and Laurse Khola. In general, the drainage pattern of the area is dendritic. The area is mostly barren land forest area and with partial cultivated in village.

2. GEOLOGY

2.1 Regional Geological Setting

The metasedimentary rocks of the Nawakot Group and the metamorphic rocks of the Higher Himalaya constitute the Bojhe area. The two complexes are separated by the east-west extending and south dipping Main Central Thrust (MCT) (Figure 3).

Geological Structures

The limestone deposit is bounded by thrust. There are many local scale normal fault and folds are present (both Syncline and Anticline) with limestone band. The geological cross section shows that deposit is mostly south dipping and some local folds and faults are present.

2.2 Local Geology

The study area consists of a continuous carbonate band consisting of dolomite and limestone inter-banding which can be traced over 3 Km strike length along Mayankhu- Chhapdanda- Halesi area. The same formation is detached and exposed east and west of it at various places. The carbonate band is thrusted over the schist which is separated by Main Central Thrust (Figure 3). The general trend of rocks is due south. The carbonate bands are high folded within the strike. The road section have maximum thickness of 50 m and in central part of the slope thickness of carbonate is about 5 m. Portion of limestone is more towards Bojhe then Khachupatla area. The limestone, dolomite, calcite schist and quartzite are major rock unit of the study area.

Limestone: Bluish grey, thinly to medium bedded, crystalline limestone with calcite vein and calcite lamina. Coarse grained crystalline limestone in being interbanding with fine grained dolomite. Limestone has cavity structure where calcite leaching was found. There are 2-3 bands of limestone within the carbonate formation. Thickness of limestone band is same throughout the strike length. A limestone band gets terminated in some places by fault.

Dolomite: Both gray and white dolomites are found within the study area. Dolomites are fresh to deeply weathered in the sub surface. The calcite leaching is associated with the dolomite.

Calcite: Milky white, crystalline calcites are found in the study area. Calcite band are associated with both limestone and dolomite. Maximum thickness of calcite band within the study area is about 50 cm.

Schist and quartzite: The basal part of the limestone consists of schist and quartzite. The mylonite layer of thickness 1 -2 m the encountered between carbonate layer and the schist, which indicate the thrusting of the carbonate band.

Attitude of beds

The dip amount of limestone rocks varies within the deposit area. Rocks are steeper along the river sections and gentle in the top part. 330-3500 /15-500 (Strike / Dip amount) SW dip direction.

Limestone Prospects

About 140 hectares of area was considered for detailed exploration. The present deposit area lies

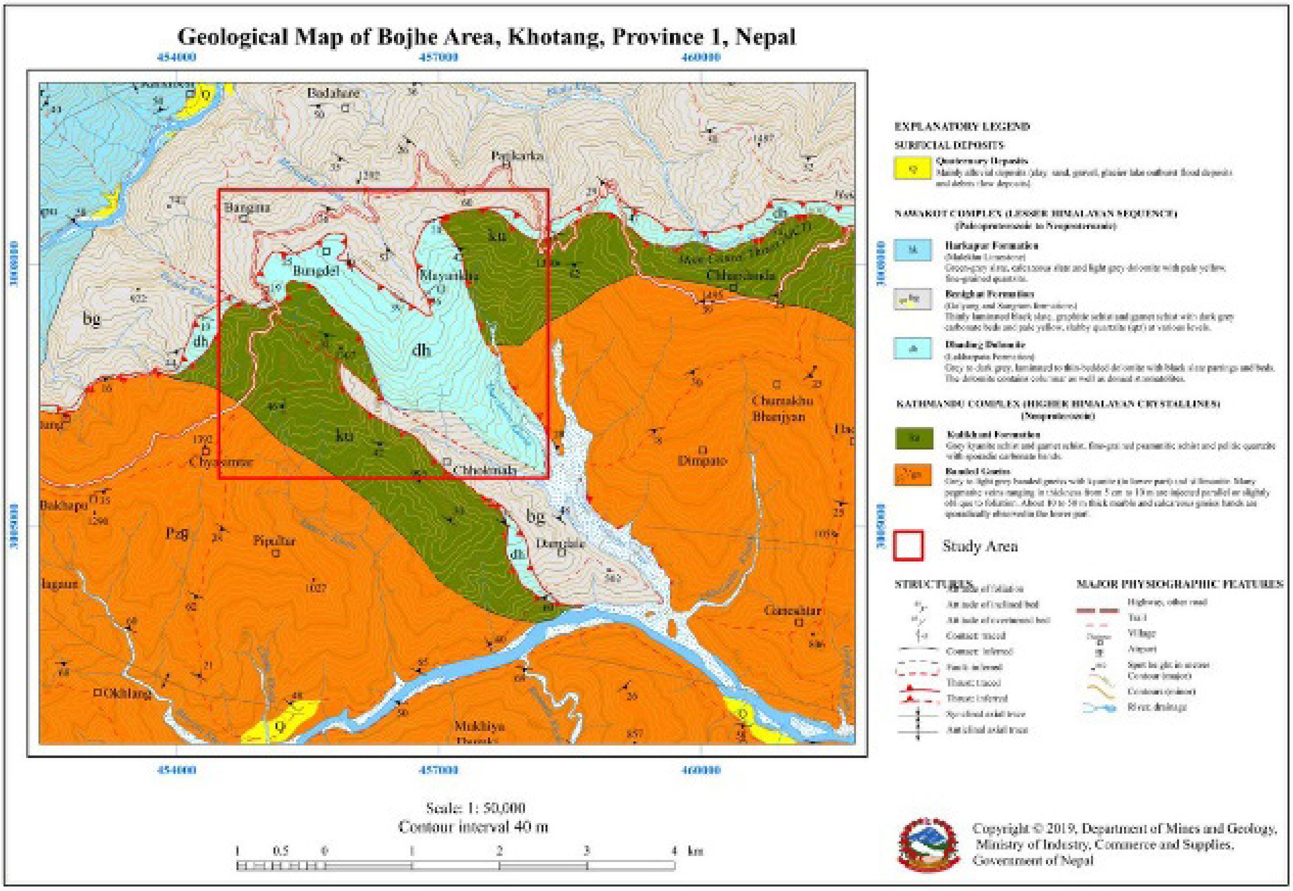


Figure 3: Geological map of the Limestone at Bojhe Limestone deposit (The geological boundaries and rock types are based on the map prepared by previous team in the fiscal year 2073/74).

around Bungdel Village. The deposit is northwest to southeast elongated. The study area consists of a continuous carbonate band consisting of dolomite and limestone interbanding which can be traced over 3 Km strike length along Mayankhu- Chhapdanda-Halesi area. The thickness of limestone is decrease in central part in survey area.

The Limestone within the area is bluish gray, thinly to medium bedded, crystalline limestone with calcite vein and calcite lamina. Coarse grained crystalline limestone in being interbanding with fine grained dolomite. The Limestone has a cavity structure where calcite leaching was found. The dip amount of limestone rocks varies within the deposit area. Rocks are steeper along the river sections and gentle in the top part. 330-350o /15-50o (Strike / Dip amount) SW dip direction.

3. EXPLORATION WORK ON LIMESTONE PROSPECT

For the assessment of the quality and quantity of carbonate deposit prospecting survey, geological mapping, surface sampling, exploration drilling and detail topogeological mapping were conducted in the study area.

3.1 Prospecting Survey

DMG has carried geological mapping in the fiscal year 2073/74 as prospecting survey works has been completed and the chemical analysis result and geological cross section has shown the area has promising limestone deposit both qualitatively and quantitatively.

3.2 Geological Mapping

Regional geological map of the study area was done in 1:25,000 scale topographical base maps. Bojhe area identified. Detail geological mapping of about 140 hectors in the scale of 1: 1000 was done covering the prospect areas based on the consideration of infrastructure, environment and the nature of outcrop.

3.3 Channel Sampling

143 channel samples were collected from different 13 channel section from Bungdel area with channel length of 158.5 m. These channel samples were collected continuously at necessary interval after removal of weathered part. The sampling point were marked and denoted as KBLA, KBLB, KBLC, KBLD, KBLE, KBLF, KBLG, KBLH, KBLI, KBLJ, KBLK, KBLL and KBLM for channel Samples. Detail is shown in the table and locations are shown in topogeological map (Figure 4).

3.4 Exploratory Drilling

Diamond core drilling is a pipe encrusted in industrial diamonds being used to drill through rock layers, with a "core" of rock being left in the centre of the pipe. This core is recovered and gives information not only about the rock types, but also chemical analysis of limestone bed beneath the surface where only surface sampling is carried out. Within 140-hectare area around the Bojhe Area, Halesi Tuwachung, Khotang District continuous carbonate band consisting of dolomite and limestone inter-bedding which can be traced. So drilling was carried out for sub surface sampling and geological condition of carbonate band as well as to estimate the reserve of the deposit within the study area.

Drilling was carried out in 7 different locations within the given timeframe. The locations of drilling site are shown in the Figure 4. The detail of drilling site is shown in Table 3.

Table 2: Summary of channel sampling site within the survey area

S. N.	Sampling Section	Sample code	No. of Samples	Thickness (m)
1	KBLA	CH-1 to CH-24	24	24.55
2	KBLB	CH-1 to CH-12	12	11.95
3	KBLC	CH-1 to CH-6	6	4.75
4	KBLD	CH-1 to CH-12	12	11.65
5	KBLE	CH-1 to CH-12	16	16.65
6	KBLF	CH-1 to CH-7	7	8.6
7	KBLG	CH-1 to CH-12	12	15.3
8	KBLH	CH-1 to CH-13	13	18.2
9	KBLI	CH-1 to CH-7	7	9.1
10	KBLJ	CH-1 to CH-17	17	19.2
11	KBLK	CH-1 to CH-5	5	5.75
12	KBLL	CH-1 to CH-4	4	4.3
13	KBLM	CH-1 to CH-8	8	8.5
Total			143	158.5

Run Sheet: Run sheet is prepared by drillers and this sheet provides the information about depth and type of rod used during the machine running hour.

Geological Logging: Geological log is prepared by the geologist and this sheet provides the information about the sub surface geology like type dolomite, limestone, calcite, mylonite, schist and quartzite.

The geological logging showed the presence of,

- Limestone: Blueish gray crystalline limestone with calcite veins
- White Dolomite: white, crystalline
- Calcite: white calcite veins
- Dolomite: weathered to fresh grey dolomite
- Calcite: white calcite veins
- Compact Mylonite encountered with limestone
- Schist and quartzite interbanding below mylonitic layer.

Sampling Log Sheet: Sampling log sheet is prepared by the chemist and geologist. This sheet was prepared after splitting the core sample from the drill hole. This sheet provides the information about the core type send for chemical analysis like dolomite, limestone, and calcite. 7 different log sheet of individual drill hole is prepared. Altogether 223 samples are obtained after core splitting from 287.55 m drilling length from all 7 holes

4. QUALITY AND QUANTITY OF CARBONATE DEPOSIT

Surface sampling and sub-surface drill core sampling and their chemical analysis were done for assessment of quality if the carbonate deposit in Bojhe area. The outcomes of such analysis on the surface and exploration drill hole are presented.

4.1 Surface Exploration Data

The surface channel samples over the prospect shows the overall weightage average of CaO 51.65% and MgO 2.57%, as tabulated below.

4.2 Exploration Drilling Data

The seven exploration drilling over the detailed survey area shows presence of high grade of dolomite and the cement grade limestone with few dolomites in each hole as shown in chemical analysis of drilling core. The drilling data shown the presence of the dolomite and limestone within the carbonate unit in Bojhe. The drilling data shows weighted average of limestone CaO 50.68% and MgO 2.71% and dolomite of CaO 33.26% and MgO 19.35%.

4.3 Resource Estimation

Mineral resource estimation is used to determine and define the ore tonnage and grade of a geological deposit. There are different estimation methods used for different scenarios dependent upon the ore boundaries, geological deposit geometry, grade variability and the amount of time and money available.

Prospect Reserve: Total prospect reserve is calculated simply by vertical section method regarding the available technology. Sections A-A', B-B', C-C', D-D', E-E', F-F', G-G', H-H', I-I' and J-J' are drawn on the topogeological map prepared after survey of the study area in scale of 1:1000. Prospective site will be developed using those Sections.

Based on these assumptions, the geological reserve

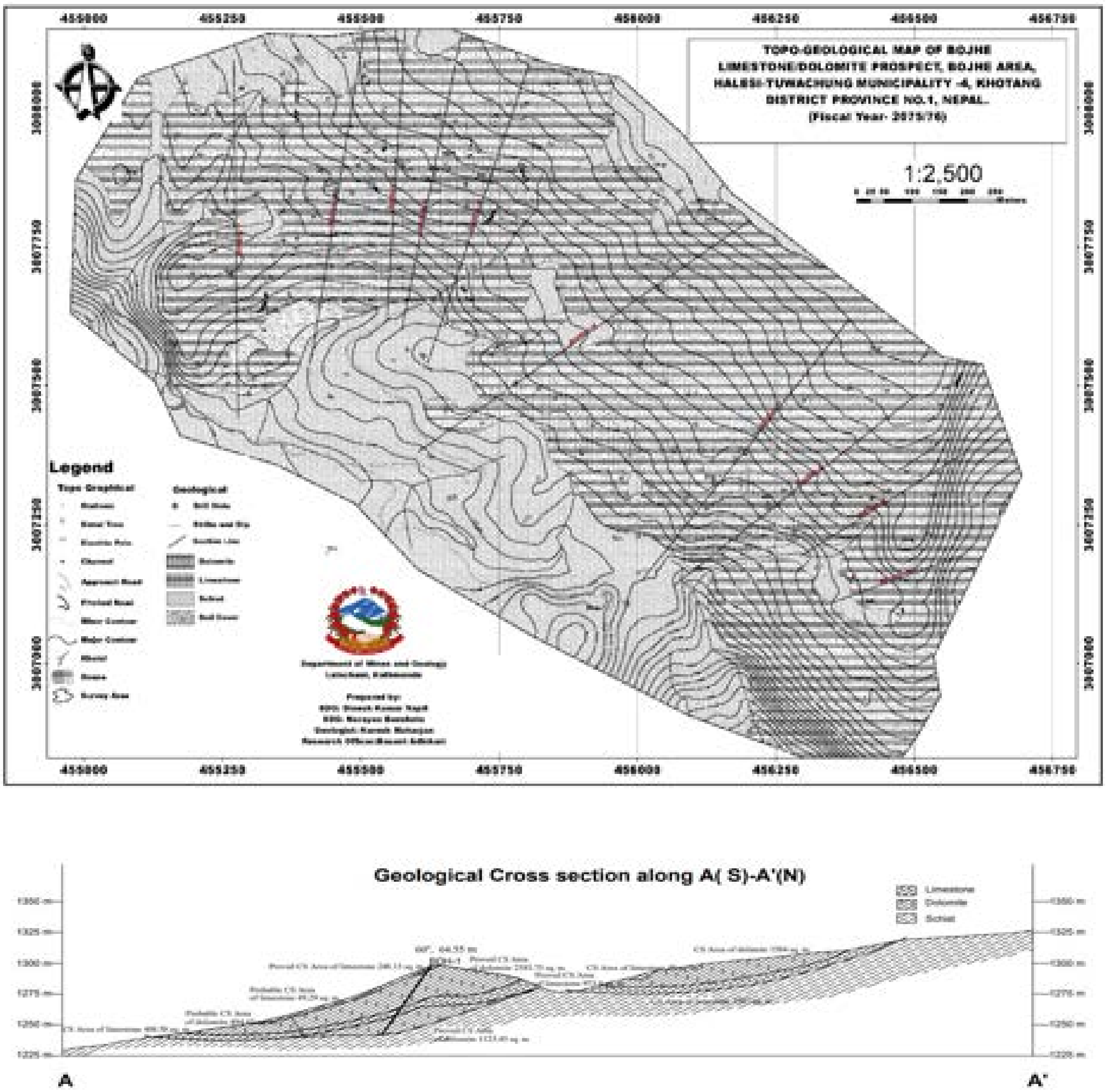


Figure 4: (a) Topogeological map of the Bojhe Limestone/Dolomite Prospect. (b) Geological cross-section through AA'.

of limestone is calculated by vertical section and limestone band wise. The proved and probable reserve over the prospects are tabulated as below. The detail carbonate reserve of Bojhe area is 43.10 million tons within 140 ha of area as shown in Table 3.

Table 3: Detail of drilling site with their location and depth.

Hole Name:	BDH -1	BDH -2	BDH -3	BDH -4	BDH -5	BDH -6	BDH -7
Collar Easting:	00455268 E	00455454 E	00455575 E	00455632 E	00455724 E	00456235 E	00456137 E
Collar Northing:	03007698 N	03007845 N	03007896 N	03007870 N	03007870 N	03007281 N	03007327 N
Collar Elevation:	1295 m	1309 m	1345 m	1339 m	1347 m	1313 m	1326 m
Total Depth:	64.55 m	31.70 m	25.80 m	29.95 m	44.50 m	31.55	59.50 m
Av. core recovery	50.12%	42.87%	54.73%	73.62%	73.03%	63.80%	78.39%
Starting Date	2075.10.13	2075.09.09	2075.09.30	2075.10.06	2075.09.20	2075.10.25	2075.11.04
Finished Date	2075.10.20	2075.09.14	2075.10.03	2075.10.09	2075.09.27	2075.10.29	2075.11.11
Azimuth	225°	55°	180°	180°	210°	210°	170°
Hole Dip	60° (down)	65° (down)	75° (down)	60° (down)	75° (down)	60° (down)	55° (down)

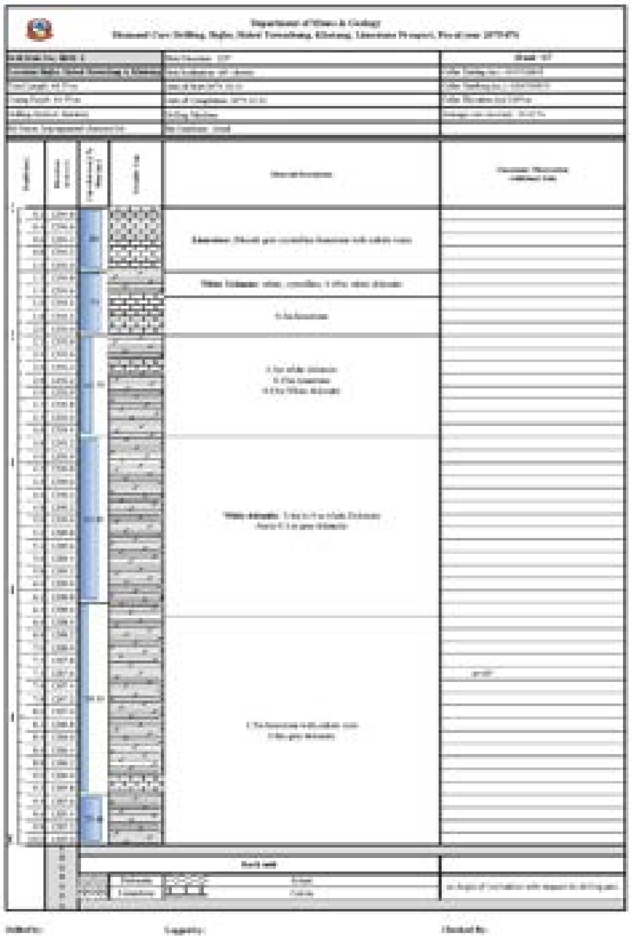


Figure 5: Litho-log of the drilling core.

Table 4: Summary Sheet of Limestone and Dolomite

S. N.	Hole No.	Core Depth	Volume of Materials	
			Limestone	Dolomite
1	BDH-1	31.98	25.45%	74.55%
2	BDH-2	13.02	54.69%	45.31%
3	BDH-3	14.12	32.22%	62.11%
4	BDH-4	19.74	25.08%	74.92%
5	BDH-5	27.40	47.81%	52.19%
6	BDH-6	19.23	23.40%	76.60%
7	BDH-7	46.44	27.99%	71.04%
Total		171.93	33.81%	65.25%

Table 5: Sample log sheet

S.N.	Hole No.	Depth (m)	Core Recovery	No. of Samples
1	BDH-1	64.55	50.12	49
2	BDH-2	31.7	42.87	17
3	BDH-3	25.8	54.73	17
4	BDH-4	29.95	66.24	25
5	BDH-5	44.5	73.03	35
6	BDH-6	31.55	63.80	22
7	BDH-7	59.5	78.39	58
Total		287.55		223

5. USE OF CARBONATE QUALITY OF BOJHE AREA

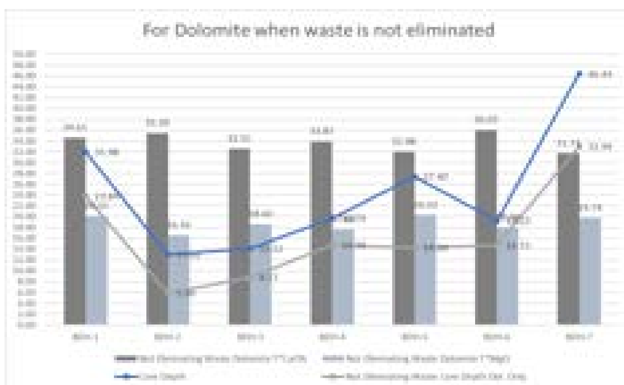
5.1 Chemical analysis

The surface sampling within detail survey shows limestone bands has the weightage average (geological) grade of CaO 51.65% and MgO 2.57%, with consideration of CaO greater than 40% and MgO less than 5% in calculation as shown in Table 6. The drilling data shown the presence of the dolomite and limestone within the carbonate unit in Bojhe as shown in Table 6. The core sample analysis of drilling data shows weighted average of limestone CaO 50.68% and MgO 2.71% and dolomite of CaO 33.26% and MgO 19.35% as shown in Table 7.

Reserve estimation

The carbonate reserve of Bojhe area is 43.10 million tons within 140 ha of area. Where proved limestone reserve is 2.8 million ton and probable reserve is 10.1 million tons as well as proved dolomite reserve is 7.5 million ton and probable reserve 22.7 million ton. The proportion of limestone and dolomite is about 34:66 within the carbonate deposit.

Proved Limestone Reserve, million ton	2.792993
Probable Limestone Reserve, million ton	10.09675
Proved Dolomite Reserve, million ton	7.477351
Probable Dolomite Reserve, million ton	22.74106
Both Limestone and dolomite reserve, million ton	43.10816



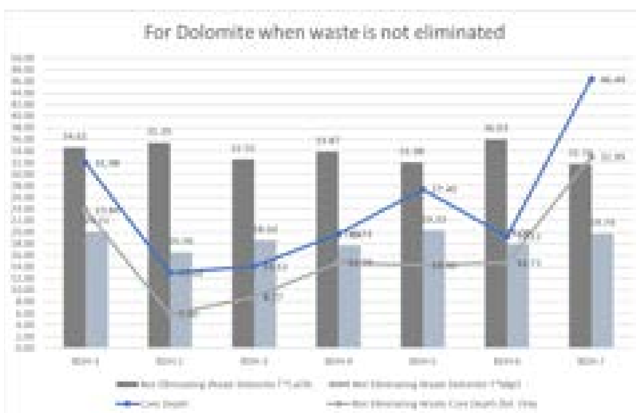


Table 6: Sampling Sections with Weighted Averages of Chemical Compositions.

S.N.	Sampling Section	Sample code	Thickness (m), t	CaO %	MgO %	t* CaO %	t* MgO %
1	KBLA	CH-1 to CH-24	24.55	47.27	2.69	1,160.58	65.92
2	KBLB	CH-1 to CH-12	11.95	53.21	2.97	635.82	35.50
3	KBLC	CH-1 to CH-6	4.75	52.64	3.70	250.03	17.60
4	KBLD	CH-1 to CH-12	11.65	53.35	2.81	621.57	32.69
5	KBLE	CH-1 to CH-12	16.65	52.63	2.65	876.22	44.11
6	KBLF	CH-1 to CH-7	8.6	53.40	0.60	459.22	5.13
7	KBLG	CH-1 to CH-12	15.3	53.54	2.70	819.19	41.30
8	KBLH	CH-1 to CH-13	18.2	51.55	2.87	938.23	52.20
9	KBLI	CH-1 to CH-7	9.1	53.17	2.70	483.88	24.54
10	KBLJ	CH-1 to CH-17	19.2	54.07	2.73	1,038.23	52.33
11	KBLK	CH-1 to CH-5	5.75	53.83	2.62	309.53	15.09
12	KBLL	CH-1 to CH-4	4.3	54.06	2.04	232.46	8.75
13	KBLM	CH-1 to CH-8	8.5	42.48	1.41	361.04	11.94
Total			158.5			8,186.01	407.09
Wt. Average of surface sample						51.65	2.57

Table 7: Summary of carbonate band within drilling hole

S. N.	Hole No.	Core Depth	Volume of Materials		Core Value	
			Limestone	Dolomite	T*CaO%	T*MgO
1	BDH-1	31.98	25.45%	74.55%	39.03	15.61
2	BDH-2	13.02	54.69%	45.31%	43.68	8.86
3	BDH-3	14.12	32.22%	62.11%	37.80	14.05
4	BDH-4	19.74	25.08%	74.92%	38.28	13.77
5	BDH-5	27.40	47.81%	52.19%	40.66	11.83
6	BDH-6	19.23	23.40%	76.60%	39.13	14.75
7	BDH-7	46.44	27.99%	71.04%	37.40	14.71
Total		171.93	33.81%	65.25%	275.98	93.58
Wt. Average					39.026	13.82

Table 8: Summary of chemical analysis limestone and dolomite bands within drilling hole

S. No.	Hole No.	Core Depth	Without Eliminating Waste					
			Lst only	T*CaO%	T*MgO	Dol. Only	T*CaO%	T*MgO
1	BDH-1	31.98	8.14	51.99	2.46	23.84	34.61	20.11
2	BDH-2	13.02	7.12	50.54	2.48	5.90	35.39	16.56
3	BDH-3	14.12	4.55	48.86	4.25	8.77	32.55	18.60
4	BDH-4	19.74	4.95	51.43	2.23	14.79	33.87	17.63
5	BDH-5	27.40	13.10	50.14	2.56	14.30	31.98	20.33
6	BDH-6	19.23	4.50	49.29	3.97	14.73	36.03	18.04
7	BDH-7	46.44	13.00	51.33	2.36	32.99	31.74	19.74
Total		171.93	55.36	353.58	20.30	115.32	236.18	131.01
Wt. Average				50.68	2.71		33.43	19.15

5.3 Limestone Grade

Table 9: Broad Chemical Specification of Cement Grade (Run-of- Mine) Limestone

Oxide component/ Other Constituents	Acceptable range for manufacture of Ordinary Portland Cement (33, 43 & 53 Grade) (percent)	Limiting values taking into consideration other types of cements, scope of beneficiation and blending (percent)
CaO	44-52	40(min)
MgO	3.5(max.)	5.0(max)
SiO_2	To satisfy LSF, silica	–
Al_2O_3	Modules and alumina	–

5.4 Dolomite Grade

Dolomite is a complex mineral. It is relatively a soft mineral which can be easily crushed to a soft powder. The mineral is an anhydrous carbonate mineral consisting of a double carbonate of calcium (Ca) and magnesium (Mg). It is chemically represented by CaMg(CO3)2 or CaCO3.MgCO3.

Table 10: Theoretical composition of Dolomite

Theoretically, dolomite contains:	*In other words, it contains:*
$CaCO_3$ - 54.35%	*CaO - 30.4%*
$MgCO_3$ - 45.65%	*MgO - 21.7%*
Molecular ratio of 1:1.	*CO_2 47.9%*

5.5 Depositional Environment

Dolomite originates in the same sedimentary environments as limestone i.e. in warm, shallow, marine environments where calcium carbonate (CaCO3) mud accumulates in the form of shell debris, fecal material, coral fragments, and carbonate precipitates. Dolomite is thought to form when the calcite in carbonate mud or limestone is modified by magnesium-rich groundwater. The available magnesium facilitates the conversion of calcite into dolomite. This chemical change is known as dolomitization. Dolomitization can completely alter a limestone into a dolomite, or it can partially alter the rock to form a dolomitic limestone.

5.6 Uses of Dolomite

Table 11: Dolomite State-Use-Specification (Source: O'Driscoll, 1988)

Physical State	Uses	Specification
Block/Slab	Dimension Stone	Joint-free, Suitable color/ texture
Coarse crushed	Aggregate, terrazzo, metallurgical flux	Flux-CaO~30% MgO 17%, FeO 1.5%, max SiO2 3% max S<0.1%
Fine- ground	Filling, chemicals, glass, water treatment, agriculture	FeO<0.2%, low other impurities, high whiteness
Half Burnt (800-1000ºC)	Fertiliser, Mg-Based Cements	CaO 30%, MgO 20%, low Iron, alumina, silica, TiO2<0.05%
Burnt (1100-1300 ºC)	Water treatment, chemicals, cement	As above
Dead Burnt (1500-1600 ºC)	Refractories, chemical	As above

6. CONCLUSIONS

a. The area is accessible by road and lies east of Kathmandu. The distance to Bojhe from Kathmandu is 194 km via Dhulikhel (Kabhre)-Khurkot (Sindhuli)-Ghurmi (Udayapur)-Jayaramghat (Okhaldhunga), whereas it is 494 km via Muglin (Chitwan)-Bardibas (Mahottari)-Katari (Udayapur).

b. The detail exploration includes detail geological mapping in the scale of 1:1000 scale about 140 ha along with 158.5 m of channel in 13 different sections with thickness varying from 4 to 24 m and 7 exploratory drilling of 288 m along the ridge and ridge slope to cover the limestone deposit.

c. The metasedimentary rocks of the Nawakot Group and the metamorphic rocks of the Higher Himalaya constitute the Bojhe area. The two complexes are separated by the east-west extending and south dipping Main Central Thrust (MCT). The formation is composed of laminated to thinly bedded massive, gray to dark gray fine crystalline to dense limestone. Some dolomites beds and light gray slate are found in between the limestone deposits. Limestone and dolomite are in alternating portion in the deposit area. Bluish gray, thinly to medium bedded, crystalline limestone with calcite vein and calcite lamina. Coarse grained crystalline limestone in being interbanding with fine grained dolomite.

d. The channel sampling was done only is limestone bands so the weightage average (geological) grade of the limestone within detail survey area is CaO 51.65% and MgO 2.57%, with surface sampling data with consideration of CaO greater than 40% and MgO less than 5% in calculation.

e. The drilling data shown the presence of the dolomite and limestone within the carbonate unit in Bojhe. The drilling data shows weighted average of limestone CaO 50.68% and MgO 2.71% and dolomite of CaO 33.26% and MgO 19.35%.

f. The carbonate reserve of Bojhe area is 43.10

million tons within 140 ha of area. Where proved limestone reserve is 2.8 million ton and probable reserve is 10.1 million tons as well as proved dolomite reserve is 7.5 million ton and probable reserve 22.7 million ton. The drilling data shows the proposition of limestone and dolomite is about 34:66 within the carbonate deposit.

g. The limestone present in the carbonate band can be used as raw material for cement production.

h. The dolomite presents in the area shown industrial grade so it can be used industrial use other than constructional

RECOMMENDATIONS

a. In the context sustainable development and the 3R Principle in rational management of resource (Reduce – Reuse – Recycle), detailed mineralogical, chemical and textural characteristics of dolomite has to be studied for potential industrial applications.

b. The carbonate band of Bojhe must be used as cement manufacturing and dolomite as and Industrial use.

PHOTOGRAPHS

Photograph 1: Accessibility status of site area

Photograph 2: Set up for drilling work at site

Photograph 3: Inter-bedding of limestone and dolomite unit

Photograph 4: Core box and bore hole samples

REFERENCES

Baskota, SK, Adhaikari S (2019) Geological map of the part of Khotang, Okhaldhunga, Udayapur and Solukhumbu District. Scale 1:50000. Department of Mines and Geology, Kathmandu

Dhital MR (2015) Geology of the Nepal Himalaya Regional Perspective of the Classic Collided Orogen, springer

ESCAP (Economic and Social Commission for Asia and the Pacific) (1993) Geology and mineral resources of Nepal, atlas of mineral resources of the ESCAP region, vol 9. United Nations, New York.

Limestone & Other Calcareous Materials 56th Edition Published Government of India Ministry of Mines Indian Bureau of Mines. Indian Minerals Yearbook 2017 (Part- III : Mineral Reviews)

O'Driscoll M. 1988. Dolomite, more than crushed stone. Industrial Minerals

Shrestha SB, Shrestha JN, Sharma SR (1986) Geological map of central Nepal. Scale: 1:250,000. Department of Mines and Geology, Kathmandu

Stocklin J, Bhattarai KD (1977) Geology of Kathmandu area and central Mahabharat Range, Nepal Himalaya. HMG/UNDP mineral exploration project, Technical report, 86 pp (unpublished).

Geological Mapping in Different parts of Gorkha and Lamjung Districts. (Toposheet No. 2884 15 A & 15 B), Central Nepal for Annual report of Department of Mines and Geology

Sujan Devkota (Geologist), Sulav Kayastha (Geologist)

ABSTRACT

This report deals with the results of geological fieldwork carried out in different parts of Gorkha and Lamjung districts. The present geological study covers the both Lesser Himalaya and some part of Higher Himalaya. It consists of the rocks of Lower Nawakot Group and Upper Nawakot Group of Nawakot Complex and rocks of Higher Himalaya. The Nawakot Complex has been further divided into two groups i.e. Lower Nawakot Group and the Upper Nawakot Group. They are separated by an erosional unconformity. The study area consists of Kuncha Formation of Lower Nawakot Group and Benighat Slate of Upper Nawakot Group. A small intrusion of Ulleri Gneiss and rocks of Higher Himalaya also represents the study area. All the above formations are well-exposed along the road and river sections.

Keywords: Lesser Himalaya; Higher Himalaya; Ulleri Gneiss; Kuncha Formation; Benighat Slates.

1. INTRODUCTION

The field investigation was carried out in accordance with the approved yearly program of the Department of Mines and Geology for the fiscal year 2076/77. The study area lies in Gorkha and Lamjung districts of Gandaki Province. Central Nepal *(Figure 1)*.

Figure 1: Location of the Study area.

This area falls under the topographic sheet no. 2884 15 A & B in the scale of 1: 25,000, published by the Department of Survey, Government of Nepal and bounded by coordinates 84°30’00”E to 84°45’00”E and 28°07’30”N to 28°15’00”Nand total area is about 325 Km². The study area is about 180 to 200 Km west from Kathmandu. It can be easily reached via Prithivi Highway up to Khaireni and then Amarsingh Thapa Rajmarg connects Gorkha and graveled and pitched road to different parts of study area.

There are numerous seasonal roads, foot trails, canals and ephemeral rivers scattered in the area which can be used to take the geological traverses in the area. The altitude ranges from 650m at Jhallaphat (Left bank of the Daraudi River) to 3500m at Naagepokhari. The Daraudi and Chepe are the major rivers in the study area having the low gradient with wide valleys that generally flows north-south. These rivers are the principal feeders of Marshyangdi River. *(Figure 2)*.

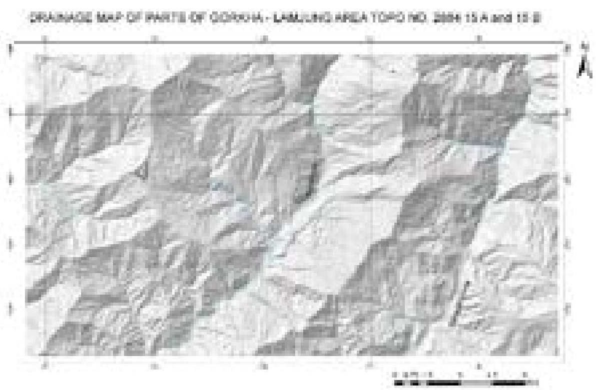


Figure 2: Drainage map of the Study area.

2. OBJECTIVE

The major objectives of the present study are to prepare geological map in the scale of 1:50,000 for publication and identify mineral prospect for further exploration.

3. METHODOLOGY

Present geological investigation was started with the desk study. In this stage, previously published geological maps, journals, articles and other related materials were collected and reviewed thoroughly. Further, some inferences were made regarding the geological characterization and potential mineralization in the proposed area. The possible tracks, routes and camping stations were identified prior to the fieldwork.

The bulk exercise of the present investigation was centered on the field study. The geological mapping of the area in the scale of 1: 25,000 was done by detailed field survey. It was prepared by traversing along different river sections, highways, foot trails, newly constructed roads, canals, etc. Targeted rock sampling was done to represent each rock types from each lithological succession observed in the field. Site sketching, taking photographs, structural analysis were other activities performed in the fieldwork. Finally, the geological map in the scale of 1:50,000 was prepared in GIS environment.

4. GEOLOGY OF THE AREA

The present geological study covers the small part of the Lesser Himalaya in the southern part and some part of Higher Himalaya in the northern part. It consists of the rocks of Lower Nawalot Group and Upper Nawakot Group of Nawakot Complex (Stöcklin, 1980). The Kuncha Formation, Benighat Slates and small intrusion of Ulleri Gneiss represents the present study area of Lesser Himalaya along with the rocks of Higher Himalaya separated by Main Central Thrust (MCT). All the above formations are well-exposed along the road and river sections. The Nawakot Complex consists almost exclusively of low grade metasediments.

The Ulleri Gneiss intruded in Lesser Himalaya which consists of quartz, feldspar, biotite, and muscovite as primary minerals. This Gneiss is believed as an element within Kuncha Formation of Lesser Himalaya, Nawakot Complex. In most cases, they are found in upper part of Kuncha Formation. They have thin lenticular smaller bodies of augen gneiss. The gneisses and host rock have gone metamorphism under same condition.

The Kuncha Formation is the oldest unit of the Lower Nawakot Group and of the Lesser Himalaya. It forms monotonous, flysch-like alteration of phyllite, phyllitic quartzite and phyllitic gritstone resembling greywacke. The phyllite is argillaceous, more or less silty or quartzitic and include extremely fine-grained to dense, laminated siliceous varieties. The quartzite is mostly impure, of olive green colour and often shows an oily luster on fresh fracture planes. The characteristic feature of the Kuncha formation is a pronounced NNE mineral lineation.

The Benighat Slate of the Upper Nawakot Group consists of dark, soft, weathered slate and phyllites mainly argillaceous, subordinately siliceous or finely quartzite. In some places, the slate and phyllites show a distinct carbonate content, and more prominent zones of such calcareous rocks have been distinguished as 'Jhiku calcareous beds'. The Carbonate member consists of a thin to thick bedded, dense to very fine grained siliceous dolomite and dolomitic Marble of white to light grey associated with black carbonaceous types of Benighat Slates. The main middle part is more thickly bedded dolomite or dolomitic limestone of dark grey colour bands. Parallel laminations are well preserved. The Graphitic Schist lies just below MCT. It is highly sheared and folded. It is lead black in colour showing schistosity. Quartz veins are quite common.

Table 1: Stratigraphic sub-division of the Study Area

Complex	Group	Formation	Members	Main Lithology
		Ulleri Gneiss		Gneiss
Nawakot Complex	Upper Nawakot Group	Benighat Slates	Jhiku Carbonate Beds	Slate, Marble, Dolomite
	Lower Nawakot Group	Kuncha Formation		Phyllite, Quartzite
Main Central Thrust				
Higher Himalayan Zone				Garnet- Kyanite bearing Gneiss and Schists

The rocks of Higher Himalayan zone consists of strongly metamorphosed garnet-kyanite bearing gneisses and schists along with some marble band in some area. The north-south width of the unit varies from place to place. The general trend is NW and NE. The metamorphic grade (Garnet-Kyanite) increases moving towards North. *(Figure 8)*

4.1 Ulleri Gneiss

This unit is well distributed in southern west of the study area along Dharapani, Nepane, and north of Sisneri and south of Bhanjyan, nearby Pyarjun. It consists of quartz, feldspar, biotite, muscovite rich gneiss. This Gneiss is in upper part Kuncha Formation. The unit has augen as well.

Plate-1. Contact between Ulleri Gneiss and Benighat Slate

Plate-2. Augen as seen in Ulleri Gneiss

Plate- 3. An outcrop of Ulleri gneiss in road cut section

Plate- 4. Sample of Ulleri Gneiss

Figure 3: Photographs of Ulleri Gneiss taken in the Study area.

4.2 Kuncha Formation

The Formation is well distributed in the south western part of the study area along Kerabari, Kuyale, Sisneri, Pyarjun, Lakhjun, Dadathok and some part of Phinam, Jaubari, Birauta and Antu area. It consists of grey, greenish, fine-grained phyllite with grey to dirty grey, fine-grained small quartzite bands. Outcrop in weathered condition looks yellow-brown. The rock beds are gentle to steep dipping towards North, North-East.

An especially noteworthy feature of the Kuncha Formation is a strong lineation, predominantly in N or NNE direction. The present study on the outcrops of sandy phyllite of Kuncha Formation along the Pyarjun to Kokegau, Simlegau to Deurali shows the prominent lineation towards NNE direction.

Plate- 5. Phyllite of Kuncha Formation

Plate- 6. Quartzite of Kuncha Formation

Figure 4: Photographs of Phyllite and Quartzite related to Kuncha Formation.

4.3 Benighat Slate

This Formation is distributed around south of Dharapani, Ghyachok, Dhansira, Tumsika, Chhailun, Pachok, Batase area and north of Phinam, Ghaiyaban, Gauda, Kolki Bhanjyan, Chainpur area. It has a marker horizon. Calcareous bed a marble unit (Jhiku Carbonate beds) can be observed all along east to west of the study area. It consists of white to light grey, medium grained crystalline marble near Simjung (Odare) and dolomite in many places. Along the Daraudi River Section, moving upstream the left side of the river consists of dolomitic marble whereas the right side of the river consists of variegated yellowish, purple, white coloured dolomite. It has gentle to steep slope in the territory. Northern part of the formation the slate is metamorphosed to Graphitic Schist. Schistosity plane can be observed in northern part of the area and south form the MCT. Black schist amd small marble bands are observed around the MCT.

Plate- 7. An outcrop of Benighat Slate in Agridada area

Plate- 8. Contact between Slate and carbonate mem Benighat Slate

Plate- 9. Graphitic Schist near Barpak

Plate- 10. Carbonate Member of Benighat Slate

Figure 5: Some photographs of rocks related to Benighat Slate.

4.4 Higher Himalaya

The rock of Higher Himalayan zone is distributed in northern portion of the study area along Wakswara, Chhailun, Pachok, Batase, Dharapani, Ghyachok, Dhansira, Tumsika. It consists of strongly metamorphosed garnet bearing gneisses and schists north of MCT and metamorphic grade increases to Kyanite bearing gneisses and schists towards North. Some marble band is observed in some area on the way Syamer.

4.5 Correlation and comparison with previous studies

The present study area has been previously regionally mapped by Department of Mines and Geology (1980). No such other detailed works in and around the area has been carried out as shown in Table 2

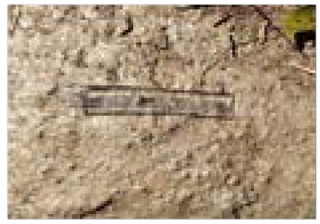


Plate- 13. Garnet bearing Gneiss

Plate- 14. Kyanite bearing Gneiss

Plate- 15. Kyanite in Quartz vein in Gneiss

Plate- 16. Close view of Gneiss of Higher Himalaya

Figure 6: Some photographs of rocks related to Higher Himalaya.

Table 2: Stratigraphic Correlation with Previous Studies around the Study Area

Regional Geological Map of Central Nepal by DMG			Present Study		
Midland Group	Bandipur Subgroup	Ulleri Gneiss (Ug)	Nawakot Complex		Ulleri Gneiss (Ug)
		Ghanapokhara Formation (Gp)		Upper Nawakot Group	Benighat Slate (Bg)
		Carbonate Member (Cr)			Jhiku Carbonate Member (Jk)
		Ranimatta Formation (Rm)		Lower Nawakot Group	Kuncha Formation (Kn)
		Higher Himalaya (Hm)			Higher Himalaya (Hm)

5. GEOLOGICAL STRUCTURES

Geological structures are the special features, which developed during and after the deposition of sediments. Structurally, the study area is very complicated, and comprises megascopic to microscopic structures of various origin. The different types of structures can be categorized as follows.

5.1 Sedimentary Structures

The sedimentary structures formed during and immediately after the deposition of the sediments are included within this heading. In the study area many such structures are preserved. Some of the important primary structures so far identified are as follows.

Beddings and Lamination

The rocks of the study area were derived from the sedimentary origin exhibiting stratification. The layering is identified by the change in color, change in composition, change in grain size etc. The strata are very thickly bedded to thin-laminated. Very thick-bedded layers are found in the Ulleri Gneiss, Kuncha formation, Benighat Slate and rocks of Higher Himalaya.

Figure 7: Photographs of dolomite bedding in Kolki area.

5.2 Tectonic Structures

The geological features developing after the diagenesis of the rocks are the secondary structures. Tectonic structures can be described within following headings. They are megastructures, mesostructures and microstructures.

Megastructure

The structures that can only be expressed by the geological mapping of large area, like large scale faults folds, etc. are included in this subheading.

In most cases, the precise location of the thrust plane was difficult to map, it was realized that a thrust in this position is the most significant and fundamental of the thrusts that have contributed to the geodynamic evolution of the Himalaya. The thrusts separates two fundamentally different domains of the Himalaya: MCT separates the Lesser Himalayan zone (un-metamorphosed and low grade metamorphic rocks) with the high grade metamorphic rocks of the Higher Himalaya. This thrust extends regionally from East to West throughout the study area along Barpak in east, Dhansira, Ghyachok, Dharapani, Batase, Jorni, Pachok, Chhailun in west. *(Figure 9)*

Main Central Thrust

In most cases, the precise location of the thrust plane was difficult to map, it was realized that a thrust in this position is the most significant and fundamental of the thrusts that have contributed to the geodynamic evolution of the Himalaya. The thrusts separates two fundamentally different domains of the Himalaya: MCT separates the Lesser Himalayan zone (un-metamorphosed and low grade metamorphic rocks) with the high grade metamorphic rocks of the Higher Himalaya. This thrust extends regionally from East to West throughout the study area along Barpak in east, Dhansira, Ghyachok, Dharapani, Batase, Jorni, Pachok, Chhailun in west.

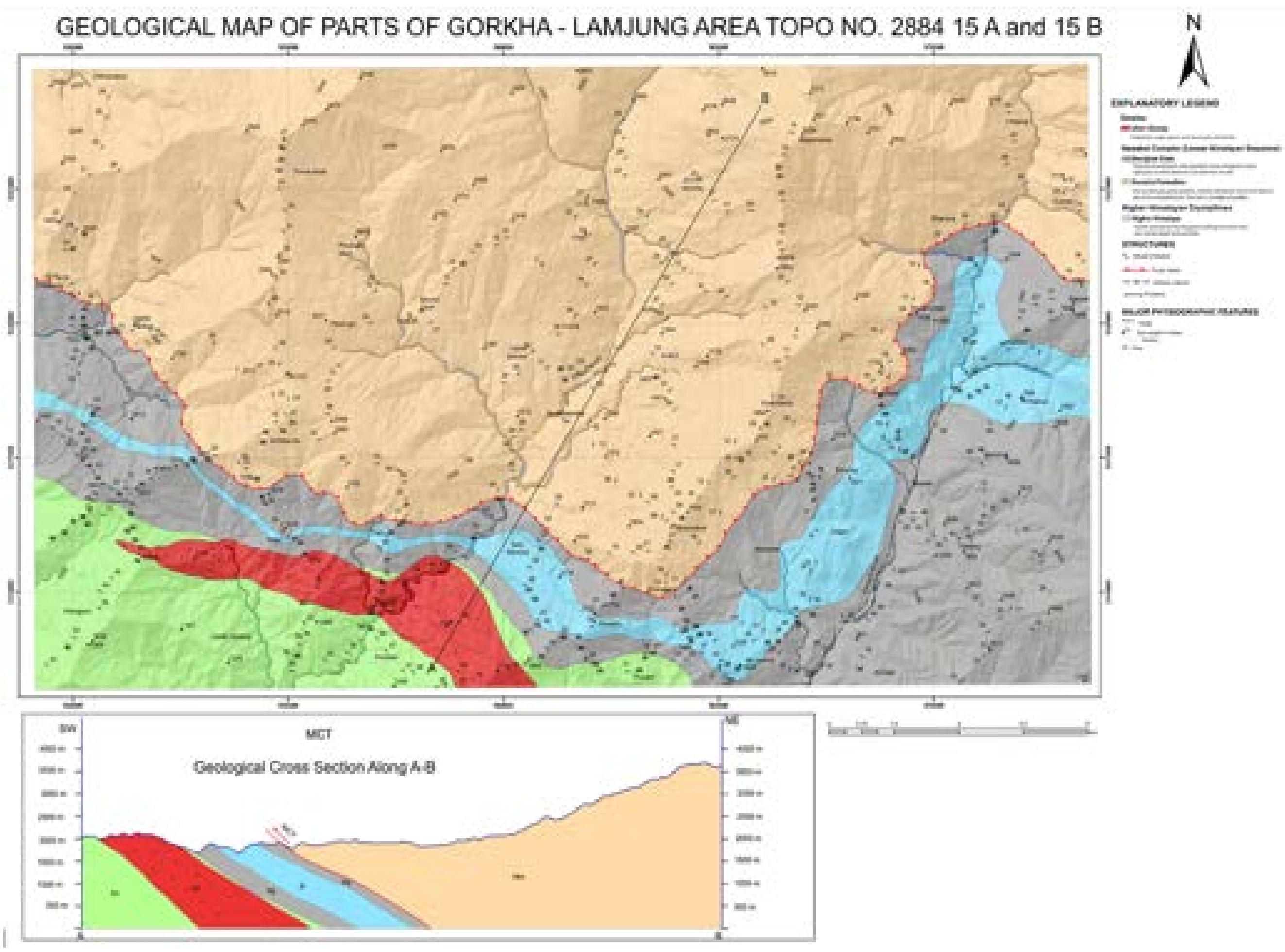


Figure 8: Geological Map of the Study Area.

Figure 9: Red marker line on the photographs shows the MCT.

Folds

The rocks of the study area are highly disturbed and display small scale folds, anticlines and sometimes repeated folding. These structures are found in almost all parts of our study area.

Daraudi Anticline

The name of anticline is derived from the Daraudi River flowing along the axis of the anticline. It is an open, asymmetrical, plunging fold, whose axis passes NE-SW. While moving upstream the general trend of the left side of the river is NNW and general trend of right side of the river is NNE.

Figure 10: Photograph of the right limb of Daraudi Anticline at left bank of Daraudi River.

Mesostructures

Foliation

Foliation is a planar or layered structure found in mostly metamorphic rocks. Foliation is usually formed by the preferred orientation of minerals within a rock. Foliation is known by more specific terms like bedding, cleavage, schistose or gneissic layering. It is the property of rocks from where they tend to break in parallel surfaces. The Kunchha Formation exhibit the slaty cleavage. The foliation of augen gneiss seems to be always parallel to the bedding of the enclosing or interfering metasediments. Foliation are defined by parallel orientation of platy minerals like muscovite, chlorite, biotite etc.

Plate- 20. Foliation in Gneiss

Plate- 21. Stretched garnet, quartz in Gneiss

Plate- 22. Lineation observed in Marble

Plate- 23. Foliated Slate with quartz veins

Figure 11: Photographs of rocks show the foliation.

Lineation

Lineation is the expressed by the parallelism of some directional property in the rock. Primary lineation is found in both sedimentary and igneous rocks. Secondary lineation is superimposed in the rocks sometime after they were originally deposited, erupted or intruded. Secondary lineation may be imposed on rocks more than once, so that several differently oriented lineation may be present in the rocks. In our study area secondary lineation is well developed in Ulleri Gneiss. The orientation of the lineation relative to the major structures and origin depend on the kind of lineation.

Augen

Augen are large, lenticular eye-shaped mineral grains or mineral aggregates visible in some foliated metamorphic rocks. In cross section they have the shape of an eye. Feldspar, quartz, and garnet are common minerals which form augen. Augen form in rocks which have undergone metamorphism and shearing. The core of the augen is a porphyroblast or porphyroclast of a hard, resilient mineral such as garnet. In our study area, the porphyroblast or porphyroclast is of quartz.

Small scale Drag Fold

A minor fold, usually one of a series, formed in an incompetent bed lying between more competent beds, produced by movement of the competent beds in opposite directions relative to one another. Drag folds may also develop beneath a thrust sheet. They are usually a centimeter to few meter in size. These folds are found in rocks of Higher Himalaya in our study area.

5.3 Tectonics and Deformation

The Lesser Himalaya of Central Nepal between Nuwakot-Gorkha-Kunchha areas shows the central part of Kunchha-Gorkha anticlinorium, a dominant structural feature in the large NW-SE trending, megafold with steep flanks, a well-developed western closure and a narrow elongated eastern wing.

These types of deformations are commonly seen in the meta-sediments of the study area. Schistosity is well developed

Plate- 24. Drag Fold

Plate- 25. Drag Fold

Plate- 26. Augen in Ulleri Gneiss

Plate- 27. Lineation in Phyllite in Kuncha formation

Figure 12: Photographs of rocks containing drag fold and lineation.

in phyllite and schist of the Kuncha Formation, Two schistosities of different orientation can often be seen in the same rocks. If the rock shows clear bedding by rhythmic changes in lithology one schistosity is usually parallel to the bedding and another discordant to it.

Lineations are frequently observed in phyllite, schist, gneiss. They often appear as fine crenulations as schistosity planes. They are particularly characteristics attribute of gritty phyllite of the Kuncha Formation. Similarly mineral lineations are frequently observed in the Kuncha formation, Ulleri gneiss, Benighat Slate also in some outcrops of Higher Himalaya.

The major tectonic structure of the study area is the MCT. Originally MCT was defined as the thrust that produced a marked break in metamorphic grade between higher-grade hanging wall and lower-grade foot wall rocks (in review of Searle et al. (2008)). And this definition is not free of debates as the MCT have been positioned at different structural levels whose structural distance often exceeds 5km. In the field we located MCT at the base of inverted metamorphic sequence, using metamorphic and structural criteria. In the MCT area numerous folding of all scales (microscopic, mesoscopic and megascopic) are observed most of which shows shear towards North. There are sporadic occurrences of dike of quartz and Pegmatite veins cross cutting kyanite gneiss which indicate the multi stage deformation in the study area. In the footwall of MCT many small scale, tight, isoclinal, drag folds are also seen, while larger folds of mapable size make gentle anticlines trending in general NWW to SEE direction. By the interpretation of statistical data of these folds, we can conclude that these folds are formed by N-S stress during MCT activity following the general Himalayan trend. Above the MCT (Higher Himalaya) rocks are pervasively deformed and present undifferentiated sequence of gneiss, schist, marble and quartzite, often forming numerous small-large scale brittle faults and shear zones following main Himalayan foliations.

6. MINERAL RESOURCES

Mineral resource is backbone of each and every country for their development. Good identification and mobilization of mineral resources plays the key role of national economic as well as the development of infrastructures of mineralized area. Due to the poorly distributed metallic minerals in the Higher Himalayan Zone in Nepal, the study area is also poorly mineralized.

Similarly, within the stratigraphic zones of mineral distribution, concentrations of minerals are largely controlled by faults and fractures. Among the faults, the least important in this respect seems to be large thrust faults like Main Central Thrust (MCT). No significant ore concentrations are directly associated with them.

6.1 Non-metallic minerals

Construction materials like aggregates, dolomitic marble, slabstones are the only non-metallic minerals in the study area which are frequently found in different lithological units of study area.

Aggregates

The study area consist two major rivers. i.e. Daraudi River in east, and Chepe River in west part of study area. The aggregates deposited at the bank of these rivers can be the source of construction materials in vicinity area.

Dolomitic Marble

The study area consist carbonate member of Benighat Slate all along east to west of study area. These deposits are the main source of construction materials in this area. Locals are extracting these rocks for the construction of Chepetar - Bhachhek Road. These deposits are also in abundance in both the sides of Daraudi River. A band of crystalline marble was observed near Simjung (Odare) whose chemical analysis report is as follows:

Table 3: Chemical analysis of Marble from Simjung (Odare) performed by chemical lab (Department of Mines and Geology).

Sample Code	CaO%	LOI%	Al%	R_2O_3%	Fe_2O_3%	Al_2O_3%	MgO%
S-6-1	39.56	39.89	2.57	2.13	2.02	0.12	13.52
S-6-2	36	36.49	7.94	4.52	1.14	3.38	14.38
S-6-3	42.45	39.29	10.44	4.44	1.93	2.51	1.82

Plate- 28. Dolomitic Marble near Balekhu used for Mining activity of road construction

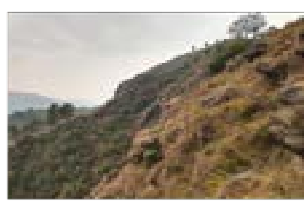


Plate- 29. Dolomitic Marble in Muchchok area

Figure 13: Photographs of dolomitic marble Muchchok and Balekhu area.

Slab stone

The study area consist rocks of Higher Himalaya mainly gneiss. These gneiss slabs near Namki are the main sources of slabstone materials in this area. These stones were previously extracted by the locals and were supplied to nearby villages for roofing, boundary of the houses.

Plate- 30. Old mining site of slabstone near Namki

Plate- 31. Slabs used by locals for roofing

Plate- 32. Slabs present in old mining site

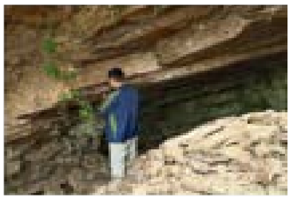


Plate- 33. Slabstone (Gneiss) near Namki

Figure 14: Photographs of slab stone near Namki.

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusions

The present study covers the small part of Lesser Himalaya and major part of Higher Himalaya. The rocks of Ulleri Gneiss and metasedimentary rocks of Lower Nawakot Group and Upper Nawakot Group of Nawakot Complex and Higher Himalaya constitute the area.

The Kuncha Formation from Lower Nawakot Group and the Benighat Slates from Upper Nawakot Group comprises the study area. The Kuncha Formation consists of thinly foliated, light green to grey, lineated phyllite which is followed by the intercalation of grey to dark grey metasandstone and then by thickly bedded, medium grained, white quartzite in some places. The Ulleri Gneiss forms an intrusive sill complex at the upper part of Kuncha formation. The Benighat Slate consists of dark, soft, weathered slate and phyllites mainly argillaceous, subordinately siliceous or finely quartzite. The Jhiku Carbonate member within the Benighat Slate, consists of a thin to thick bedded, dense to very fine grained siliceous dolomitic marble of white to light grey colour. The MCT is marked by graphitic schist beds at the footwall. The graphitic schist is highly sheared and folded and quartz veins are quite common. The rocks of Higher Himalayan zone consists of strongly metamorphosed garnet-kyanite bearing gneisses and schists along with some marble band in area. The metamorphic grade (Garnet-Kyanite) increases moving towards North.

7.2 Recommendations

The present mapping work has identified major tectono-stratigraphic unit in the study area. However, the present effort is limited in identifying any promising metallic mineral depositing the study area. The aggregates deposited at the bank of Daraudi River and Chepe River are the main sources of construction materials in this area. The Dolomitic Marble on both the sides of Daraudi River, and other different places can also be used as a construction material and locals are using them for road construction near Balekhu. The Higher Himalayan Gneiss near Namki can be used as slab stone and locals used to extract slab stone for roofing.

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REFERENCES

Auden JB (1935) Traverses in the Himalaya. Records of the Geological Survey of India 69, pp.123-167.

Bordet P, Colchen M, Le Fort P (1971) Esquisse geologique du Nyi-shang (Népal Central) au 1/75000. Paris Edition du Central National Dela Recherche Scientifique, Paris.

Colchen M, Le Fort P, Pêcher A (1980) Carte geologiquevvAnnapurna-Manaslu Ganesh, Himalaya du Nepal Echelle 1:200,000, Centre National de la Recherche Scientique, Paris.

Dhital MR (2015) Geology of the Nepal Himalaya, Regional Perspective of the Classic Collided Orogen [M]Springer. Regional Geology Reviews (8643):1-498

Fuchs G (1980) Geologic-tectonical map of the Himalaya at 1:2000000 scale. Geologische Bundesanstalt, Wien.

Gansser A (1964) Geology of the Himalayas. Interscience Publishers, John Wiley and Sons, London, 289p.

Hagen T (1969) Report on the geological Survey of Nepal. Preliminary reconnaissance: Denkschriften der Schweizerischen Naturforchenden Gesellschaft, Memoires de la Societte Helvetique des Sciences naturees, Zurich, 86, 185p.

Paudel LP, Arita K (1998) Geology structure and metamorphism of the Lesser Himalayan metasedimentry sequence in Pokhara Region, Western Nepal. Journal of Nepal Geological Society-18, pp. 97-112.

Searle MP, Law RD, Godin L, Larson KP, Streule MJ, Cottle JM, Jessup MJ (2008) Defining the Himalayan Main Central Thrust in Nepal. Journal of the Geological Society,London: 165(2):523-534.

Shrestha SB, Maskey ND, Sharma T, Bashyal RP (1993) Atlas of mineral resources of the ESCAP region: Geology and mineral resources of Nepal, explanatory brochure, vol. 9 (ST/ESCAP/1250): New York United Nations/ESCAP.

Stöcklin J (1980) Geology of Nepal and its regional Frame. Journal of the Geological Society of London, 137, pp. 1-34.

Stöcklin J, Bhattarai KD (1977) Geology of the Kathmandu area and central Mahabharat range, Nepal Himalaya. Report of Department of Mines and Geology/ UNDP (unpublished), 86p.

Upreti BN (1999) An overview of the stratigraphy and tectonics of the Nepal Himalaya. Journal of Asian Earth sciences, 17, pp. 577-606.

Trend of Mineral Licensing, Production and Revenue Generation During 2010-2020

Kumar Khadka (Sr. Div. Geologist)

ABSTRACT

Mineral resources are one of the most important natural resources available in Nepal. Mining creates job opportunities and physical development in the virgin and remote areas. At present, prospecting licenses for 30 different mineral commodities and mining licenses for 17 mineral commodities have been granted to the government owned industry and private sector. In the fiscal year 2066/67, the mining license issued by DMG was less than 70 for 12 minerals and in the Fiscal year 2077/078, there are altogether 152 mining licenses for 17 different minerals. This study is the compilation of the data related to issue licenses, production and royalty and revenue and showing the trend in mining. The number of mining licenses has increased by more than double in a decade. The royalty collected for limestone is increasing rapidly in each fiscal year than that of other minerals which alone contribute more than 95% in total. Mining not only generates royalty to the government but also creates jobs which finally help to increase the socio-economic condition of the mining areas and the whole nation.

Keywords: mining, licenses, production, royalty, limestone

1. INTRODUCTION

Nepal is rich in various natural resources like minerals, water, forest, agricultural, herbs etc. Among these natural resources, minerals are the non-renewable natural resources which are the hidden and most valuable treasure of a country. For the economic development of the country exploitation and proper use of these mineral resources is very important. The geological mapping and exploration of mineral prospect/ deposits is a crucial and time and capital investment task. After the exploitation, feasibility study and mining of known resources is important for the economic growth and sustainable development of the country. Mining creates job opportunities, increase economic activities and value of land through physical development in the virgin remote area.

Nepal's mining history is more than 200 years old. The mining sector is yet neglected and has remained as the smallest sector of the country's economy, contributing to about 0.66% of the gross domestic product (GDP), (National Planning Commission/ Nepal Bureau of Statistic, 2019/020). Nepal Rastra Bank (NRB) identified mining and quarrying sector as a primary sector in GDP. The overall mines and mineral industries sector contribute about 2.4% in the national GDP. The Department of Mines and Geology (DMG) is the sole organization for geological mapping, mineral exploration, evaluation and promotion of mineral based industries and administration of Mineral and Mining Rules and Regulation in the country. According to the Mines and Minerals Act (MMA), 2042, all the mineral resources in the country are owned by the state. The geological and mineral exploration studies of DMG have stated that there are 63 different mineral commodities available in Nepal. They are mainly categorized as metallic minerals, non metallic minerals. They are further divided into industrial minerals, decorative stones, precious and semi-precious gemstones and construction materials.

2. OBJECTIVES

The main objectives of this study are:

- To collect the data related to licenses issued for prospecting and mining within a decade.
- To accumulate data related to the production of minerals from mining license and the royalty generation.
- To study the trend of tax free revenue collected by the department.
- To study the trend of promoting prospecting licenses to mining licenses..
- To study continuity and extinct of investors from the mining sector.

To fulfil the objective of the study, the data related to licenses issued, production and royalty status were collected from the Mining section of department. For compilation of data, the base year taken is the fiscal year 2066/67 and the present year mentioned is the year 2077/78. The total numbers of licenses mentioned here are the cumulative numbers of licences that are in renew state in the particular year. In this study, the license numbers, production and royalty collection from mines related to construction materials are not included. This data will be helpful and beneficial to the government agencies, professionals, researchers, new investors and general public for further study or to invest in the mineral sector.

3. MINING ACTIVITIES

After the implementation of Mines and Mineral Regulation (MMR) 2056, and after the end of Civic war in 2063, the private entrepreneur interest in mining sector increases rapidly. This has direct impact in the issuing of prospecting licenses of various minerals and the exploration works lead to issuing mining licenses which enhance mining activities. This study focuses mainly on the licenses issued during the last decade FY 2066/67 to 2077/78 (2010-2021). Till the base fiscal year 2066/67, the total number mining licenses issued by DMG are less than 70 for 12 different minerals. Now in this fiscal year, there are altogether 152 mining licenses issued for 17 different mineral Commodities. DMG issued the prospecting and mining licenses for the General, Important and Very important minerals as categorized by MMR 2056. But in case of construction materials, DMG provides the consent letter of mining to the Local Level Government (LLG) after the detailed study and field verification on the technical report (Mining Scheme MS) and Environmental report (IEE/EIA) forwarded by those particular LLG that were prepared and submitted by the concerned proponents/miners. The licensing, administrative management and mines supervision and inspections of construction materials (stones, gravel, sand and slate) are the responsibilities of LLG. The data production and royalty collection is also the administrative work of LLG. So, DMG do not have exact present status of the consent licenses as well as the production quantity and royalty collection from the concerned mines.

4. STATUS OF LICENSING AND PRODUCTION

According to the MMR 2056, DMG issued prospecting licenses of particular mineral in the area to the proponent interest after fulfilling the requirement of technical and financial capabilities. The demand area must not be in a restricted area and preserved area of further exploration by DMG or previously licensed area or some conservation area. DMG also issued prospecting license as special prospecting license in the prospect area where preliminary assessment was done and prospect was identified for further detailed exploration by DMG. Similarly, after detailed exploration studied with proven quality and reserve, DMG issued special mining license under special license provision.

According to licensing status at present, prospecting licenses for 34 different mineral commodities and mining licenses for 17 mineral commodities are granted to the government owned industries, private companies and individuals. The data related to construction materials (105 mining licenses for stones, sand and gravel) are not included in this study.

4.1 Prospecting License

Among 63 different identified minerals available in Nepal, prospecting licenses for 34 different minerals from DMG are issued. These licenses are for two years for General minerals and four years for Important and Very Important minerals. Some prospecting license holder prospects for 1-2 years and surrender the licenses as they do not found the target mineral or mineral deposit suitable for mining. Some minerals may not show the quality or mineable reserves for further prospect or exploration. In case the prospecting licenses need more than four years for exploration, DMG provide additional period of two (1+1) years according the exploration report submitted by the license holder and the demand. Before Nepal's Constitution of Nepal 2072, promulagated in 20th September 2015, there were more than 500 prospecting licenses. But according to the provision of constitution, the right of issuing mining license is of Federal Government and prospecting licenses is of Province Government, DMG stopped issuing prospecting license for about one year in 2072-2073. This caused a rapid decrease in number of prospecting licenses as shown in Figure 1. As there is no act and regulation from the Federal and Provincial government till now, then DMG again start to issue prospecting licenses which finally increased in prospecting licenses after that. According to the trend of issuing and renewing of prospecting licenses, prospecting licenses for limestone is nearly half of the total licenses issued among 34 mineral comodities. The cumulative number of prospecting licenses in the last seven fiscal years is given in Table 1.

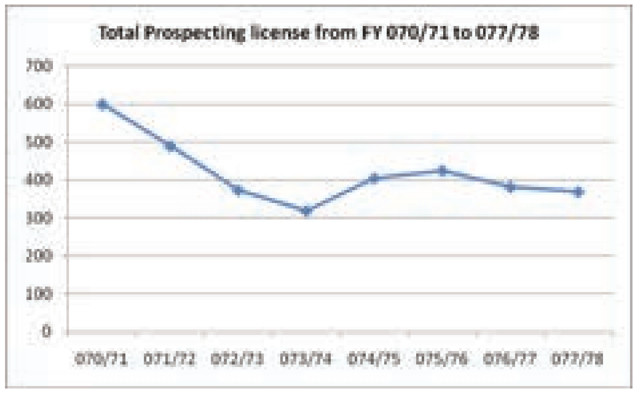

Figure. 1: Total number of prospecting licenses.

In the present fiscal year the cumulative number of prospecting licenses for 19 different mineral commodities is 368, among them 138 licenses are issued during this year shown in Figure 2.

Figure. 2: Cumulative prospecting licenses in fiscal year 077/78.

The data shows that the license for limestone seems to be consistent and always more than 170. Similarly, the prospecting licenses for decorative stones (quartzite, granite) and dolomite increased whereas for placer gold, coal and gemstones (Kyanite, Tourmaline) decreased rapidly.

4.2 Mining Licenses

The number of mining licenses gradually increased from 69 for 12 different minerals in base year to 152 in this year for 17s different minerals in present year as shown in fig. 3. Among 17 different minerals, the mining licenses issued for metallic minerals are for iron, copper, lead and zinc and remaining for gemstones (tourmaline, kyanite, and quartz), industrial minerals (calcite, limestone, dolomite, magnesite, talc, redclay), fuel mineral (coal) and decorative stones (quartzite slab, marble, granite). The mining licenses for metallic minerals are only seven out of 152, but unfortunately, at present none of these metallic mines are in operation. Mining Licenses are issued for 10, 15, 20 and 30 years according to the per production capacity as Very Small, Small, Medium and Large Scale respectively. The licenses are issued according to the mining scheme submitted and the provision of MMR 2056. The total mining licenses issued in these last twelve fiscal years are given in Table 2.

As per number of the mining licenses, the licenses for limestone are for more than other minerals and continuously increasing each year. The licenses for calcite, copper and granite is only one for each and are issued in recent year only shown in Figure.4. From this data, limestone is the most important mineral resource in Nepal, followed by quartzite, talc, coal, and Tourmaline which cross in ten in numbers of issued licenses. The cumulative numbers of mining license in the present year is shown in Figure. 5.

Figure. 3: The increasing trend of mining licenses.

Table 1: No. of Prospecting Licenses from F.Y. 070/71 to F.Y. 077/78

S. N.	Fiscal Year Minerals	070/71	071/72	072/73	073/74	074/75	075/76	076/77	077/78
1	**Aquamarine**	10	8	6	4	4	2	1	2
2	**Bauxite**	3	0	0	0	0	0	0	0
3	**Beryl**	0	1	1	1	0	0	0	0
4	**Calcite**	3	2	1	1	5	2	1	0
5	**Coal**	21	16	7	3	5	3	4	5
6	**Copper**	31	24	14	6	6	5	8	15
7	**Corundum**	2	2	1	1	0	0	0	0
8	**Dolomite**	19	16	12	7	16	17	18	18
9	**Emerald**	0	0	0	0	0	0	1	1
10	**Feldspar**	0	0	0	1	2	1	0	0
11	**Garnet**	3	1	0		0	0	0	0
12	**Gold**	69	64	46	16	13	5	4	9
13	**Granite**	6	7	4	3	12	8	15	15
14	**Graphite**	1	0	0		0	0	0	0
15	**Industrial Clay**	0	0	1	1	0	0	1	0
16	**Iron-ore**	26	20	12	7	9	11	5	10
17	**Koline Clay**	1	6	4	1	0	3	0	2
18	**Kyanite**	36	27	11	10	6	5	3	2
19	**Lead**	10	9	4	3	1	0	1	0
20	**Limestone**	179	169	172	170	200	208	207	193
21	**Magnesite**	0	0	0	1		0	1	0
22	**Marble**	4	5	3	1	2	2	1	0
23	**Marl**	1	0	0		0	0	0	0
24	**Mica**	3	2	0		1	0	0	0
25	**Polymetal**				1	2	3	2	2
26	**Quartz**	19	15	10	3	5	3	2	3
27	**Quartzite**	29	41	31	20	55	66	47	44
28	**Red Clay**	7	5	2	1	1	0	0	3
29	**Ruby**	1	3	1		2	4	5	3
30	**Silica Sand**	0	9	10	23	33	58	40	31
31	**Talc**	44	37	19	20	16	12	10	8
32	**Tin**	1	0	0			0	0	
33	**Tourmaline**	66	52	15	10	5	4	4	2
34	**Zinc**	4	2	3	3	3	2	0	0
	Total	**599**	**489**	**372**	**318**	**404**	**424**	**381**	**368**

Table 2: Number of opening license issued from Fiscal year 2066/67 to 2077/78

S. N.	Fiscal Year Minerals	066/67	067/68	068/69	069/70	070/71	071/72	72/73	73/74	74/75	75/76	76/77	77/78
1	Coal	20	19	19	21	20	17	14	14	11	11	10	10
2	Iron-ore	0	1	1	1	2	3	3	3	2	2	2	2
3	Kyanite	4	4	8	8	9	9	8	9	8	8	8	8
4	Lead	1	1	1	1	1	1	3	3	3	3	3	3
5	Limestone	24	30	36	37	37	41	44	49	55	62	71	77
6	Magnesite	1	1	1	1	1	1	1	1	1	1	2	2
7	Marble	4	4	4	4	5	4	4	3	3	3	3	2
8	Quartz	1	1	1	2	3	3	3	4	4	3	2	2
9	Quartzite	2	2	2	2	3	6	7	8	12	13	15	15
10	Red Clay	4	6	8	7	7	7	7	5	3	3	5	5
11	Talc	5	6	8	9	10	12	11	12	14	14	12	12
12	Tourmaline	2	2	3	8	13	13	13	12	12	9	8	8
13	Zinc	1	1	1	1	1	1	1	1	1	1	1	1
14	Dolomite	0	0	0	0	0	0	1	1	1	1	2	2
15	Calcite	0	0	0	0	0	0	1	1	1	1	1	1
16	Copper	0	0	0	0	0	0	0	0	0	1	1	1
17	Granite	0	0	0	0	0	0	0	0	0	0	0	1
	Total	69	78	93	102	112	118	121	126	131	136	146	152

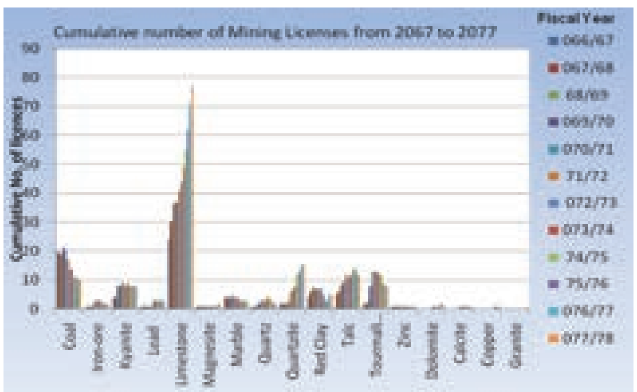

Figure. 4: No. of Mining Licenses from F.Y. 066/67 to F.Y. 077/78

Limestone: In the base year, the number of mining license for limestone was 24 out of 69. This shows that mining license for limestone is nearly one third of the total licenses issued till that year. The limestone mining licenses increased continuously in each fiscal year, and reached to 77 in 2077/78 which is half of the total issued (Figure. 5). Mining license for limestone are issued as Small, Medium and Large category according to the production capacity. Almost all the limestone mines are located in the Mahabharat Range within the Lesser Himalaya except a few which are in Pre Siwalik Zone and one Nigale mine, Dhankuta is in Higher Himalaya. These mines have production capacity of almost 60,000 tons of limestone perday. Among 77 mines, less than 50 mines are in operations, remaining are in infrastructure and mines development and getting permission from authority for mining in forest land. The government policy of self sufficient in cement causes the increase in limestone mine. At present, 55 cement industries are in operation in Nepal which has the installed production capacity of nearly 15 million tons of cement per annum.

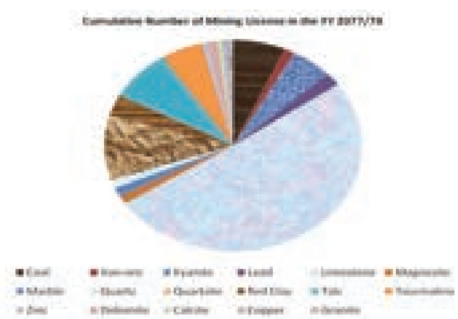

Figure. 5: Number of Mining License in the FY 2077/78

Coal: Coal is the only fuel mineral for which the mining licenses are issued. In the base year, there were 20 licenses but at present it decreased by half. All of the coal mining licenses are in Eocene Coal deposits Tosh, Dang and Gondawana coal of Palpa district in Lumbini Province.

Red clay: Red clay is the ingredients in the cement industry. There were four in the base year which reached up to eight in fiscal year 068/69 and decrease to five at present.

Talc: In the base year there were five mining licenses and are continuously increases till the present year. Few licenses were expired but new mining licenses are issued regularly. In the present year, there are 12 mining licenses and half of them are in Baitadi district, Far Western Province.

Gem-stones: Among the different gemstones explored in Nepal, mining licenses are issued for three gemstones quartz, kyanite and tourmaline. In the base year, there was only one, four and two license for quartz, kyanite and tourmaline respectively. These reached up to four, nine and 13 and now there are three, eight, eight mining licenses for quartz, kyanite and tourmaline respectively (Figure. 6). All tourmaline and Kyanite license are issued in Karnali

Province except one Kyanite license in Accham district of Far Western Province. These gemstones are associated with high grade metamorphic schist and gneiss of Higher Himalaya. Due to the decision of one step processing of gemstone before exporting in fiscal year 2072/73, the number of licenses, gems production and collection of royalty from gemstones decreased gradually from the same fiscal year.

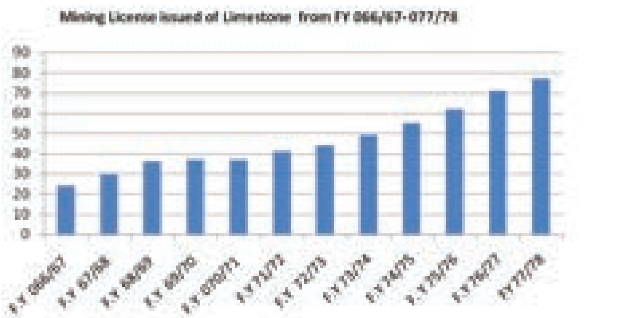

Figure. 6: Number of limestone mining licenses from F.Y. 066/67 to F.Y. 077/78

Figure. 7: Commodity wise Semi-precious stone mining licenses from F.Y. 066/67 to F.Y. 077/78 .

Decorative stones: The major decorative stones available in Nepal are marble, quartzite, gneiss and granite. In the base year only four licenses for marble and two for quartzite were issued. At present year, licenses for marble declined by half but quartzite increased to 16. For the first time, one mining license for granite was issued in this fiscal year.

Metallic Minerals: Lead and Zinc mining licenses in Ganesh Himal were issued in the fiscal year 2036/37. In the fiscal year 2072/73, two lead mining licenses were issued in Darchula district. No mining licenses for iron were issued in base year but one license in Rammechap was issued in F.Y 067/68. Similarly, others for Falamkhani Parbat, Phulchoki - Lalitpur and Masyam Palpa were issued but at present only 2 are remaining. One copper mining license was issued in Wapsa, Solukhumbu in F.Y 076/77.

Others: One magnesite license was issued for mining Kharidhunga Magnesite in Dolakha in 2036 B.S which is not in operation now. One calcite and one dolomite mining licenses were issued in 2072/73. At present, there are two magnesite and two dolomite mining licenses.

5. REVENUE AND ROYALTY

DMG collects the revenue and royalty as per the MMR, 2056. After the decision of DMG to grant the license, the individual or the company need to pay license fee, land rent and security deposit has to deposit for the licensing period at the time of issuing license. Similarly, the license holder need to pay renew fee and land rent in each fiscal year within the first three month of the FY till the license period. The production royalty of the individual minerals has to be deposited regularly in each month according to the mineral production. The royalty and revenue rate is adjusted and amendment in 2072 B.S. The royalty and revenue collected from mining sector is non taxable royalty. Under this category, DMG collects royalty from production, renewal and land rent charge under mines royalty. Similarly, royalty from administrative works, maps charge and other services collected are under other revenue heading. The total royalty collected in last 10 fiscal years is given in Table 2.

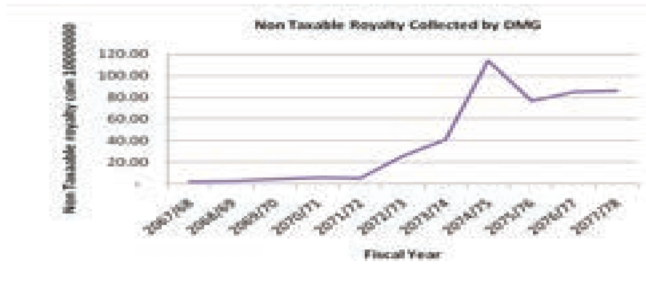

Figure. 8: Total Non taxable royalty collected by DMG from F.Y. 067/68 to F.Y. 077/78

After getting mining licenses, the mining license holders get two years time for the physical infrastructure and mines development. In case the quarry area lies in forest, the license holders need to take consent and permission from the Ministry of Forest and Environment to work in the forest area. Among 152 mining licenses, about 90 mining licenses are in operation and producing the concerned minerals. All the mines are not in operation may due to no facility of road to the mines area, process of getting permission of using forest, due to social or policy level problems. Quantity of minerals production in the last decade is given in Table 4.

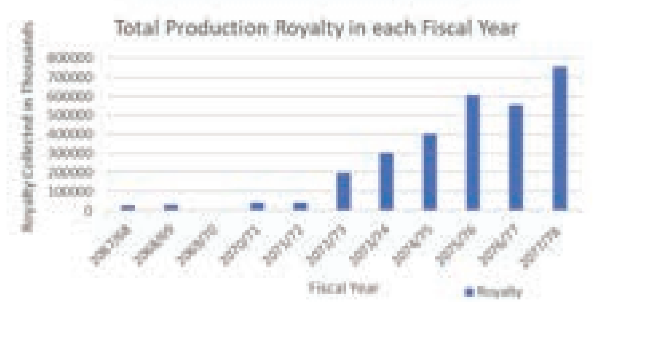

Figure. 9: Production royalty collected from F.Y. 067/68 to F.Y. 077/78

The table shows that the royalty collected for limestone is increasing gradually in each fiscal year. The royalty of limestone collected in 2068/69 was Rs. 15317422.32 and in the present fiscal year it is more than Rs. 73 Corer. The government has taken policy to be self sustained in cement which increased the production of limestone, leading to an increase in annual royalty. As shown in fig 10, the royalty collected from limestone alone covers more than 95% of the total royalty collected from nine different mineral commodities.

Table 3. Total Production Royalty of individual Minerals collected in a decade

Mineral	068/69	2069/70	2070/71	2071/72	2072/73	2073/74	2074/75	2075/76	2076/77	2077/78
Limestone	15317422.32	2605286.72	40440317.2	41478028.2	197203050	298389107	397904455.6	599351481	546041355	736824207.16
Talc	6935	5140.28	124871	107160	186550	309253	936886.6	756330	238100	451000.0
Coal	10903.9	14084.05	287304.95	24326	366996.5	1273521.88	2027793.86	1138044.93	944632.5	1567356.0
Tourmaline	124161	456126	2187828.81	76649.66	24681.68	0	0	0	0	0
Quartz	17697	32847	86463.66	453.09	108459.5	67577.5	12507	10033	620290	0
Kyanite	11405	7473	4378.65	372.75	186745.12	21406.45	44240	16500	29293.88	
Marble	1969.2	2994.5	124178	225440	230550	317750	221500	2720472	1518493.2	9374604.2
Redclay	9066.25	13400	232592	141960	360503.4	554241.5	619866.45	502973.99	466361.7	35552
Iron	0	0	0	0	0	41765	15850	10660	88634	0
Zinc	0	0	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	11000	0	0	7800	0
Quartzite	0	0	8000	12560	86360	27900	286500	975973.99	1074602	756240
Calcite	0	0	0	0	0	726	2520	2100	1950	4290
Magnesite	0	0	4297.5	900	0	0	0	0	0	0
Dolomite	0	0	0	0	0	71000	157000	574050	760165.92	1646366.95
Roda	0	0	0	0	0		18000	0	0	
Stone	0	0	**0**	**0**	**0**		253750	**0**	750730	3073108.75
Gravel	0	0	0	0	0		345405	0	151337.25	287400
Total	31,402,966.13	56,253,218.78	43500231.7	42067849.7	198753897	301085248	402846274.6	606058619	552693745	753984573.06

Table 4: Total Not Taxable Royalty income of Department of Mines and Geology

			Total Revenue collected in fiscal year								
Non Taxable Royalty	**067/68**	**068/69**	**2069/70**	**2070/71**	**2071/72**	**2072/73**	**2073/74**	**2074/75**	**2075/76**	**2076/77**	**2077/78 Jestha**
Production Royalty	23,757,645.43	31,402,966.13	47,505,229.80	63,827,414.15	56,782,111.49	261,452,315.78	407,362,180.86	469,965,391.86	606,058,618.90	521170651.8	619,974,330.60
Other revenue	273,227.63	695,675.50	494,948.50	951,607.50	1,259,448.32	1,579,245.93	2,633,605.70	669,430,848.00	164,265,105.28	328,973,699.10	240,162,087.70
Total	24,030,873.06	32,098,641.63	48,000,178.30	64,779,021.65	58,041,559.81	263,031,561.71	409,995,786.56	1,139,396,239.86	770,323,724.18	850,144,350.90	860,136,418.30
Increament in %		25.13429902	33.12807834	25.90166218	-11.60799583	77.93361396	35.84530126	64.0163999	-47.9113526	9.389067473	1.161684029

Table 5: Commodity wise Mineral Production from Fiscal Year 2066/67 to 2077/78

S. N	Minerals	Fiscal Year / Unit	066/670	067/68	068/69	069/70	070/71	071/72	072/73	073/74	074/5	075/76	076/77	077/78
1	**Limestone**	M.Ton	514023.08	768150.48	1276451.86	2605286.72	3371071.21	3453781.8	4703056.3	4893587	6588301.79	9796436.7	7543759.8	12279432.75
2	**Talc**	M.Ton	5674.2	3556.08	6935	5140.28	5702.5	5254.8	1860.4	3003.03	8658.19	4604.88	2181	4450
3	**Coal**	M.Ton	11798.53	13164.85	10903.9	14084.05	8151.23	6754.12	2900.3	7269.77	3941.1	5921.2	3927.3	8722.5
4	**Dolomite**	M.Ton	0		0			0	0	1420	3140	11481	10144.62	32664.75
5	**Calcite**	M.Ton	0	0	0	0	0	0	0	11	0	0	0	55
6	**Magnesite**	M.Ton	0	0	0	0	225	60	0	0	0	0	0	0
7	**Redclay**	m3	9583	13321.51	9066.25	13400	18070	19980	10300.1	13889.76	17291.36	30952.44	9643.08	0
8	**Tourmaline (Ind Grade)**	M.Ton	39.5	75.76	59.77	26.718	68.83	2.34	0.004	0	0	0.19	0	0
	Tourmaline (Gem Grade)	K.G	0	o	30	147	696	23.55	49.55	0	0	2	0	0
9	**Quartz(Ind Grade)**	M.Ton	6	3.4	26.1	5	37.33	1.2	0.46	36.38	0.47	0.36	0.07	0
	Quartz (Gem Grade)	K.G	1196	1003	2980	1614	4256	249	1044	521	124.6	125	25	0
10	**Kyanite (Ind Grade)**	M.Ton	23.37	27.86	26.1	17.46	10.69	6.39	1.36	0.2025	0.21	0.35		0
	Kyanite(Gem Grade)	K.G	9568	3085.57	2900	1875	1187	659.3	105	22.5	24.75	39.3	0	0
11	**Iron**	M.Ton	0	0	0	0	0	0	0	771.55	396.25	182.5	0	0
12	**Zinc**	M.Ton	0	0	0	0	0	0	0	0	0	0	0	0
13	**Lead**	M.Ton	0	0	0	0	0	0	0	10000	0	0	0	0
14	**Copper**	M.Ton									0	0	0	0
15	**Marble block**	m2	2688.8	1124.2	13595.2	2994.5	2463.46	4457	908	491	886	4598	5500.19	43228.73
1	**Marble chips**	ton										4598	400	27123.52
16	**Quartzite**	m2	0	0	0	0	2000	3140	8908	9450	16605	23400	51714.5	37372
17	**Granite**	m2									0	0	0	0
18	**Construction Stones**	Cu.m									12558	23057	30022	118660.81
19	**Boulders**	Cu.m									300	20594.3	0	0
20	**Gravel**	Cu.m									18177	0	10089.15	15160.0
21	**General Clay**	Cu.m									2227.5	0	0	0

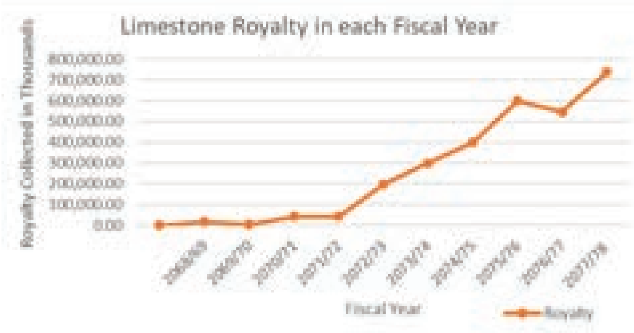

Figure. 10: Trend of production royalty collection from limestone F.Y. 068/69 to F.Y. 077/78

The royalty of gems stones (Tourmaline, Kyanite and Quartz) increased till FY 2071/72 but after that it decreased to nil in these fiscal years. In Table 3, the royalty data related to roda, stones and gravel are of the by-products of the limestone mines. Because of the DMG policy of optimum use of mines product and zero waste, the associated rocks and wastes are used as roda, gravel, and stones and royalty are collected for them too.

6. DISCUSSION

During the decade, the numbers of mining licenses and mineral commodities for mining are increasing gradually. In the same time, the cumulative numbers of prospecting licenses are up and down. As the prospecting and detailed exploration completed, these prospecting licenses turned into mining. At present also more than 50 prospecting licenses has completed exploration work and submitted the mining scheme and environmental examination report and are in the process of approval. This shows that in coming years, the numbers of mining licenses will increase continuously. According to the data, mining and prospecting license for limestone is half of the total licenses issued.

The royalty collected from limestone is alone more than 95% of the total production royalty which play major role in revenue generation. According to the report of Nepal Rastra Bank (NRB) related to Foreign direct Investment in cement industry, at present, there are 2 governments, 3 direct foreign investments and 50 private cement industry are in operation with a total installed cement production capacity of 15 million tons per year. The present local market demand for cement is nearly 10 million tons but these industries are producing 7.5 million tons cement per year. If these industries will run in full installed capacity, Nepal will be self sufficient in cement and can even export in neighbouring countries. According to an economic survey conducted by the Ministry of Finance, there is a direct relationship between the amount of cement production and the GDP of Nepal; for example, if the GDP increases by one percent, the consumption of the cement will increase by 4.8%(Economic Activities Study Report, Government of Nepal, 2019-2020).This signals the heightening use of cement with the country's economic growth. This indicates that the number of cement industries and their production capacity will surely increase in future. Similarly, the present amendment in Environmental Protection Regulation, 2077, in the use of forest area for limestone mining is increased to 25 ha from 5ha under IEE provision; this will help mines to increase their production capacity in coming days.

The increase in cement production through an increase in limestone mining will also impact in construction materials mining. The use of construction materials in infrastructure development and private housing seeks the new mines of these materials. This will eventually helps in royalty collection, job creation and income generation of public. At present, there are about 12000 workers directly involved in mining sector. Mining creates job opportunity in a chain. For example, the present production capacity of limestone mines is 60000 tons per day. If a tripper carries 15 tons at a time and carry twice aday, then there will be 2000 tripper drivers and 2000 tripper helpers. In Indirect workers like in small tea and food restaurant in each mine, workers for mine road maintenance, garage and machineries mechanics and so on will increase. Agricultural, animals and chicken farming in nearby mines area will increase the local market.

Similarly, the mining licenses for talc, dolomite and quartzite slab also increased rapidly. But the number of licenses, production and royalty for other non-metallic minerals decreased. The mining licenses for the coal decreased as the quality of coal cannot compete with the imported coal. In case of prospecting licenses, except limestone, dolomite and decorative stones all other licenses increased gradually till 2072 and decreased continuously.

In general, analytical studies show positive impacts of mining on the socio-economic aspects in the communities nearby the mining areas. Many remote areas immensely benefitted from the mining, with electricity, access road for transportation to the mine site can also boost the land prices. Mining generates employment opportunities, directly by hiring local people and indirectly by stimulating business activities in the mining area.

There are some problems in mining sector for its development. Mineral resources exploitation is the huge capital-intensive work which may or may not be viable in future. As mining is a continuous investment industry, the lack of huge capital for various stages of exploration is a major problem in mining. The other problems are availability human resources and laboratory. The infrastructure, mainly road and electricity to mines for its development and use of forest land for mining are crucial things to be solved by the government. Use of modern methodology, technology and machineries in mining will help to run mines in full production capacity which ultimately increases the royalty and revenue of nation.

7. CONCLUSION

Mineral resources are the major natural resources of Nepal. For the development of nation, exploration and exploitation of mineral resources is very crucial. This report is the compilation of data to provide information related to the licenses issued, production and the royalty collection and the overall trend of mining in Nepal. From the data it is concluded that government is increasing its yearly budget in mineral exploration, forming investment friendly policy, acts and regulations and modern tools and techniques for the development of mining sector. These tools help in increasing interest of private entrepreneurs in mining and causes increase in licenses, productions of minerals, job opportunities and ultimately royalties and revenue to the government.

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REFERENCES

Central Bureau of Statistics, Nepal (2020). (https://cbs.gov.np/ Nepal-in-Figures-2020).

Department of Mines and Geology (DMG), Nepal (2020). Annual Report of Department of Mines and Geology, Annual Report No. 2-12

Department of Mines and Geology (DMG), Nepal (2017). Mineral Resources of Nepal

Economic Survey 2019/2020, Government of Nepal (2020). Economic Survey: Ministry of Finance, Government of Nepal (2020), 144p.

Foreign Direct Investment in Cement Industry in Nepal A Study on Socio-economic Impact, Study Report: Nepal Rastra Bank Economic Research Department May 2021

Government of Nepal; Mines and Mineral Act 1985, and Mines and Mineral Resources Regulation 1999.

Government of Nepal; Environment Protection Act 2019, and Environmental Protection Regulation 2020.

National Planning Commission report 2019/2020

Sah, R. B., &Paudyal, K. R. (2019). Geological control of mineral deposits in Nepal. Journal of Nepal Geological Society, 58 (Special Issue), 189-197.

Stöcklin, J. (1980). Geology of Nepal and its regional frame. Jour. Geol. Soc., London, 137, 1-34

Unpublished report of DMG

Geological study of Landslides in Balaucha Area, Aalital Rural Municipality- 7, Dadeldhura District, Sudurpashchim Province

Kumar Khadka (Sr. Div. Geologist), Sujan Devkota (Geologist)

ABSTRACT

Water induced landslide event that occurred in northeast facing slope of Balaucha, Owa and Khinnebhadi of Aalital Rural Municipality-7, Dadeldhura district causeds a remarkable loss of property. The area lies in Siwalik hilly region. The rock exposed areexposed rock is slightly to highly weathered and , the mudstones and shaleswhich are converted into residual soil in the cultivated land. The affected area has steep slope (>36) which is mostly unstable during heavy rainfall conditions. The area is drained by numerous northing flowing streams flowing towards north and the water is collected and drained towards west. Many small, shallow seated landslides, debris flow, rill and gully erosion were triggered by the heavy and continuous rainfall that occured for more than 10 days which resulting in the oversaturatione of the soil. Because of that the soil on the slope could not resist the stress/pressureload exerted by the over saturated soil that resulted in , thea series of landslidesoccurred in this area.

Keywords: landslide; steep slope; rainfall; mudstone; Siwalik;

1. INTRODUCTION

1.1 Background

Every year during monsoon, landslides cause loss of many people lose and huge loss of their their life with huge properties loss because ofby the landslides, which are induced by heavy rainfall in different parts of the country. Due to the water induced landslide event of 31st Shrawan, 2077 (Rainfall of 18th – 30th Shrawan, 2077) in Balaucha, Owa and Khinnebhadi of Aalital Rural Municipality-7, Dadeldhura district, considerableremarkable loss of property had occurred, however there was no but noloss of liveswere taken. As per the request letter from the Ministry of Home Affairs (MOHA) dated 2077/06/05, a team of geologists from Department of Mines and Geology has carried out a 2-days long field study from 14th to 15th Aswin, 2077 in the affected area.

1.2 Location and Accessibility

Balaucha area of Aalital Rural Municipality lies about 8 Km southwest of Budar Bazar of Doti District. The affected area lies in ward no. 7 of Aalital Rural Municipality Sudurpashchim Province, Nepal (Figure 1).

The study area is easily accessible from Kathmandu and is at about 760 km. Similarly, it is about 70 km in the sSouth from District Headquater of Dadeldhura. One can reach upto Budar (Doti) from Dadeldhura or from Atariya, Kailali along Bhimdatta Highway. And from Budar Bazar to Balaucha, it is accessible by Budar Jogbuda Road.

1.3 Objectives

- To study the general geological condition of the study area.
- To study the cause of massive landslide in the affected area.
- To study the stability of the hill slope of the affected area based on the visual observation.

1.4 Limitations

The field programme was conducted infor a very short time. Hence, detailed geological and geotechnical setting of the study area is beyond the scope of this study. Therefore-Hence, the recommendations presented from the study in this report are based on the walk through survey and therefore thus do not replace any instrument added investigation.

1.5 Methodology

Site Investigation

The site investigation comprisesd of performing geological investigationfor 1 day and study of a. Available data on soil and hard rock of of the affected area including the slope conditions of the affected areawere studied.

1.6 Topography and Drainage

The study area lies in Churiya hilly region and comprises. The area comprises the rugged and north facing moderate to steep topography of the Siwalik. The maximum and minimum elevation inaround the area is 1181 m in north of Balaucha at Bar Pipal Danda and nearly 841 m along the bank of Koirale Khola downhill of Balaucha respectively (Figure 2). From Bar Pipal Danda at the top, the drainage flows towards north to Koirale Khola and towards south and joins themix in Bhalu Khola.

The area is drained by numerous northing flowing streams and the water is collected and drained towards west by Koirale khola which ultimatelyin end confluences joins the to Puture Gad after it confluencejoining with Bhalu Khola at Dhayanikharka. The topography rises abruptly on either side of the river with small tributaries in dendritic drainage fashion. An E-W trending ridge along Pipal Danda above Balaucha divides the area into two watersheds of Koirale Khola and Bhalu Khola in theon north and the South respectively.

The landslides affected area in Aalital Rural Municipality-7 is northeast facing slope. The upper part of the hill slope

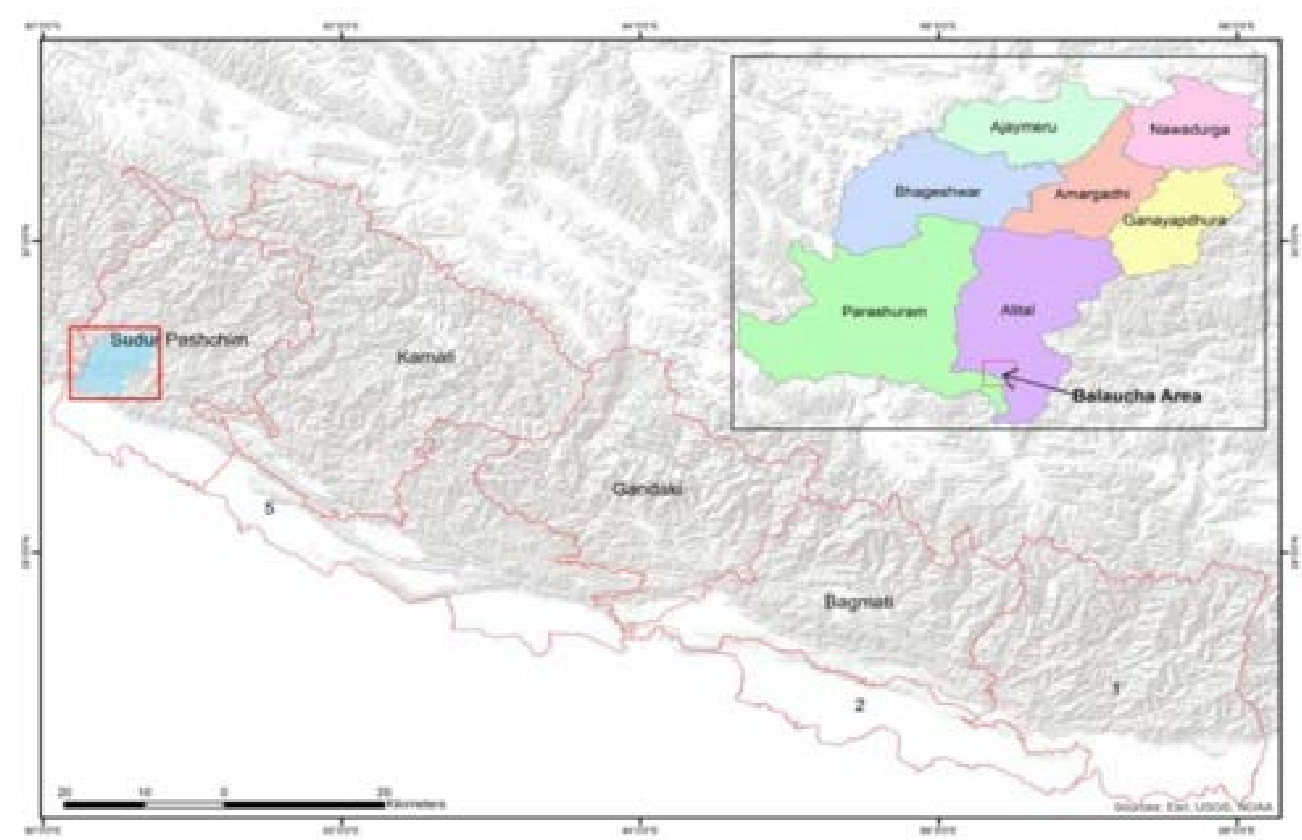


Figure 1: Location map of the study area

is moderate to steep and is composed of cliffs of bedrock of Siwalik Group whereas lower part comprises of gentle to moderately dipping colluvial, and cultivated Land.

1.7 Landuse

Balaucha and the surrounding area has diverse landuse pattern. However, the part of Aalital- 7 that suffered from landslide has dominantly cultivated land in the lower part and forest to barren land in upper part and central part of Owa and Balaucha village. The lower part of the colluvial slope is being utilized for the purpose of settlement and the cultivation purpose. There were many old stream and gully (small to medium size) prior to the landslide event but large gullies were carved out allowing surface runoff to flow through it.

Figure 2: Topographic Map showing the study area and landslide (Red Line)

1.8 Regional Geological setting

The study area lies in the Lower Siwalik underlined by Upper Siwalik of the Sub Himalaya. The area is composed of black to yellowish grey to black shale and brownish Mudstone, dark grey to light grey conglomerate along with green to grey calcareous shale. A synclinal structure and couple of thrusts passes through the nearby the landslide affected area according to the published geological map of that area by Department of Mines and Geology (Figure 3). The rock exposed in the landslide and surrounding area of Aalital Rural Municipality- 7 has strike of NW-SE in general with varying dip amount of 15° to 40° dipping towards NE.

1.9 Slope and Slope Aspect

Slope

The gravity is the force that causes the material to move downward. The steeper the slope, higher is the shear induced by gravity and the more risk of landslide. Hence, slope is the principle factor affecting the landslide occurrence. The slope map (Figure 4) shows most of the landslides affected area with steep slope (>36) which is mostly unstable during heavy rainfall conditions.

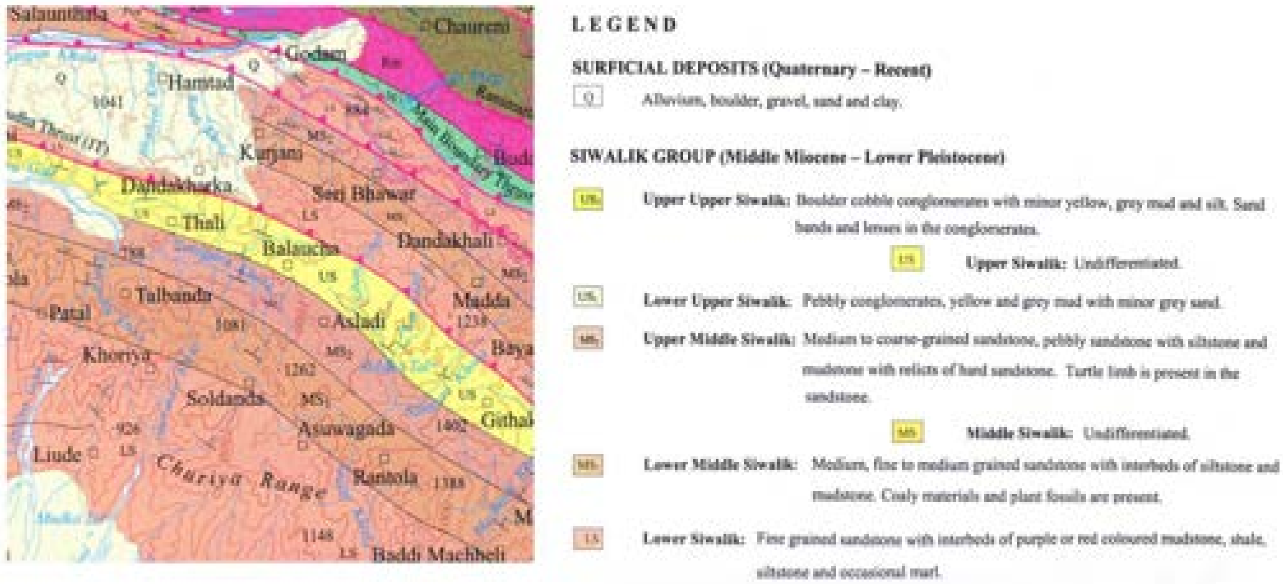


Figure 3: Geological Map of Aalital and Surrounding Area (PEPP/DMG: 2000)

Aspect

The effect of the slope aspect on the landslide occurrence may be direct or the indirect. The slope aspect determines the amount of the soil moisture content in different direction or aspect of the hill slope of same region. Slope aspect strongly affects hydrologic processes by the process of the evapotranspiration and thereby affecting the weathering processes and vegetation root development.

The direction of slope faces with respect to the sun has a profound influence on vegetation. The aspect map shows (Figure 5) landslide-affected area has mostly north and northeast aspect. North facing slope has relatively higher moisture content and vegetation. Soil in this aspect may saturate quickly during rainfall.

Figure 4: Slope Map of Aalital area

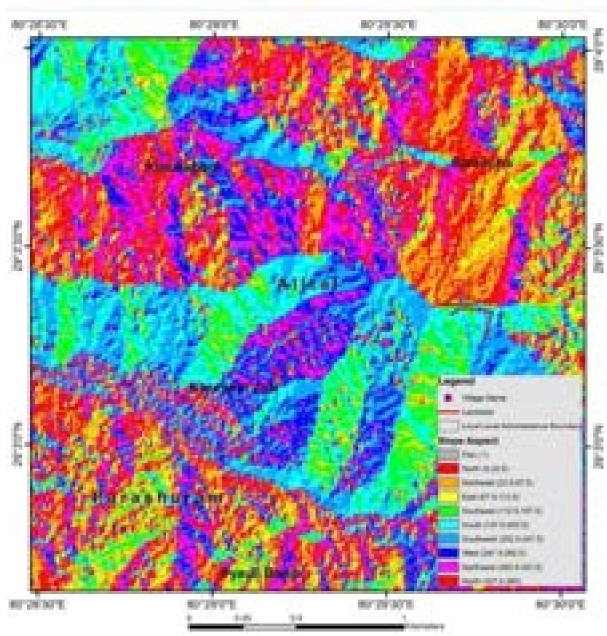


Figure 5: Slope Aspect map of Alital Area

2. GEOLOGICAL HAZARD ASSESSMENT

2.1 General Overview

Due to the continuous rainfall from the 18th -30th Shrawan 2077, many parts of the Aalital Rural Municipality – 7 werewas badly affected by the slope failure. Many small, shallow seated landslides, debris flow, rill and gully erosion were triggered by the continuous rainfall that occured for more than 10 days (according to the local peopleof that area). Due to that event, landslide and creeping and subsidence of land beganins from 23rd to 25th Shrawan. On 31st Shrawan, on the sunny day time and around 11 A.M, the Siwalik hill near Barpipal Danda was brustburst resulting in and there occur heavy mass movement whichthat caused cause people to loss of loss their large cultivated lands. The mass movement destroyed, a couple of few houses are completelytotally damaged and somefew were partially damaged leaving lots of other houses and lands at risk mainly in Balaucha, Owa and Khinnebhadi area of Aalital.

2.2 Geomorphology

In theAround the Aalital Rural Municipality, ward no. 7area, where the incident of landslides occurred has very moderate to steep sloppy terrain with gradient of more than 35 degree generally facing toward North with less than 1 m to 2m residual soil cover and colluvial soil. Similarly, the small stream that drain the area have moderate gradient with the high potential energy during the heavy rain fall which can easily erode the weathered rocks and its peripheral area creating the debris flow in the downstream parts. The upper part of Balaucha and Oba village is of barren land to forest land and the village has cultivated land with scatter houses. In between this villages the major portion is the sal and salla mix forest.

2.3 Geology and Soil Type

The study area consists rocks of Sub Himalaya, Siwalik Group. The major rock types of the area are grey to brownish grey to yellow sandstone and mudstone with intercalation of thin bands of shales of Lower Siwalik. Conglomerate of Upper siwalik is well exposed which is underlained by fine grained sandstone of Lower Siwalik. The rock exposed are slightly to highly weathered, the mudstones and shales are converted into residual soil in the cultivated land. The rock exposed in the landslide and surrounding area of Aalital Rural Municipality- 7 has strike of NW-SE in general with varying dip amount of 20° to 45° dipping towards NE.

In many parts of the studied area, mainly in the upper steep slope, the residual soil and cColluvium thickness seems to be very thin (less than 0.5m to 2.0m) and covered by forest land. The middle and lower parts, near the Koirale Khola, have thick soil deposit that is used for cultivation and that landform seems to be formed by the soil slides from the adjacent slope.

2.4 Field Observations

At about 25m uphill from the Koirale khola along the left bank, the cracks on the colluvium deposits were observed. The area is within 451024m E and 3216079m N and the height is about 863 m above the msl. The crack developed crack is more than 10 m in length and it was about 0.2 m wide.

At the location 451128m E and 3215571m N, anthe old landslide was reactivated. The cultivated land iswas creepinged and slidinge. The area was the paddy cultivation land and there was seepage of water from in this area. ADutte Bohara house was completely damaged by the mass movement and the family iswas living in a tent.

At the location 450968m E and 3215366m N, Public water tank was destroyed. Several No. of cracks were observed on the surface. The land was found moved my more than 1 mdown towards NE. The land shows subsidencewas subsided in many parts. The area was left barren since last yearfromprevious year after the development of due to the crackss development. The major cracks arewere more than 300 m long and the parallel crackswere developed running in the S-N directionSouth to North.

At the location 451021m E and 3215063m N, 3-4 houses were shifted to other location from this area 15 years back due to the landslide. Gully was formed here. There iswas landslide from eastern part, western part and southern part and moves towards North. Rocks are north dipping along the hill slope of the village. Springs were developed during monsoon season.

At the location 450981m E and 3214967m N, Barpipal Dada, Sandstone and mudstone of Siwalik arewas observed. The attitude of the bedding plane is 80/240.

At the location 450856m E and 3215571m N, there waswas the Siwalik rock brustburst and mass movement occurred the mass were moved towards north facing slope. But there was no effect on the south facing slope. The fine grained sandstone and mudstone overlying conglomerate beds dipping towards NE at an angle of 20-300 were broken and fell down the slope.

At Oba area in the west of Balaucha, 9 houses movedwere slide down due to athis landslide. The land was cracked and continuous S-N fractures were observed in the sloppy terrain. At Saurani khola below the Owa village, there iswas a slide of about 150 m length and subsided the exixistingexisting land subsided by about 2-3 m depth.

At Aureni, 2 houses are completely damaged, numerous fractures are observed in land and houses (Figure 6). Dhupkheda; At the location 449024m E and 3215461m N, about 1m land subsided and moved towards North slope by 4m and 2 houses are moved by this slide. The landslide was about 150m wide and of 200m in length. It covers both cultivated land and barren land.

On the right bank of Bhalu Khola at Khursane jala, three houses were damaged by the landslide.

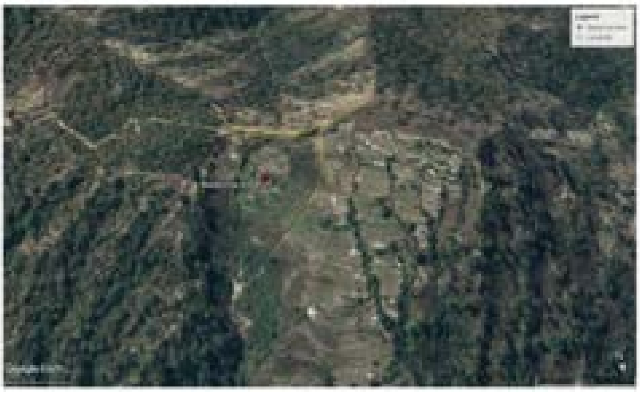


Figure 6: Google image of Balaucha, Owa and Aureni Tole showing the houses at risk

2.5 Causes of landslides and probable risk

Topographically the study areas have moderate to steep slope and most of the settlement areas are within slope or in the peripheral areas. Although the slope seems to be stable during dry season but during the monsoon period due to precipitation the soil becomes saturated which increases the shear stress. If the shear stress overcomes the resisting force then the materials resting on the slope starts to move downwards creating slope failure so the rainwater play very crucial role in the slope stability. Heavy and continuous rainfall for more than 7 days fromat the date 2077/4/18 to 4/30 over saturated the soil and that is the major cause for series of landslide in the Balaucha-Owa area of Aalital Gaupalika-7. Other causes those are also responsible for the landslides can beare listed as below:

Road construction in the steep slope without anythe proper drainage management for surface runoff is the cause for the landslides in some places. The landslides were triggered by the surface run off from the road to the steep slope just above the Balaucha Tole upper part of landslide areas.

Houses constructing on the steep slope or nearby areas are always vulnerable sites for the landslides during heavy rainfall. The slope angle of the affected area is more than 35 degree so series of landslide small to very small occurred in the Balaucha - Owa area.

The study area consists of weak and weathered rocks like shale and sandstone with intercalation of conglomerate. Loose soil in the area is easily erodible and it creates debris flow in the downstream. The debris flow in the Koirale khola is caused by the damming of stream due to landslide in the upstream area for some time and outburst creating big debris flow. This debris flow damaged Public water tank, cultivated lands and few houses near the Balaucha, Owa and Aureni.

2.6 Probable risk

Rainfall induced landslides in the Balaucha, Owa and Aureni area of Aalital-7 are small-scale shallow seated landslides mostly in steep slope. The soil/ colluviums on the steep slope are wet so whenever there is heavy rainfall there is probability of landslide as before. Rill and gully erosion might occur on the bare slope created by the slope failure and the debris could affect the downhill houses. The houses in the Balaucha, Owa and Aureni Tole below the landslides are at risk as the debris accumulated by the landslide might again flow during heavy rain. Similarly, there is probability of slope failure above the Balaucha, Owa and Aureni and surrounding areas of Aalital during heavy rain so people living on the steep slope or in the peripheral area of previous slides should stay alert and aware.

3. CONCLUSION AND RECOMMENDATION

A short field visit was made in the landslide-affected area in different parts of Aalital Rural Muncipality-7, Dadeldhura district to study the geology and cause of slope instability of the area. The study area Balaucha of Aalital-7 consists of grey to dark brownish yellow moderately to highly weathered sandstones and mudstones with intercalation of thin shales, thickly bedded conglomerate of Siwalik Group rocks are major rocks types. Most of the landslides affected areas have steep slope i.e. >35 degree with forest and cultivated land. The residual soil or colluviums developed in the slope are thin from 0.5m to less than 2m.

In most cases, cause of landslide is the continuous rainfall of monsoon from 2077-04-18 to 2077-04-30. The colluviums and the residual soil, in the steep slope are already moist due to monsoonal rainfall become over saturated by the heavy precipitation and surface run off through the foot track and streams. Because of that the soil on the slope could not resist the stress/pressure exerted by the over saturated soil and series of landslides occurred.

Some houses in theat upper part of Balaucha area are still at high risk due to colluvial slide from the steep slope. So, it is recommended not to stay in those areas until the preventive and mitigation measures are applied. Similarly, houses at Oba Tole, Aaureni are already damaged and at high risk due to the debris deposited by the landslide in the steep slope, which might again flow down affecting the downhill houses and the houses at the steep slope could be pulled by landslides. Therefore, the people living in those areas should be permanently relocated.

Dip direction of foliation plane of rocks and natural hill slope are almost same or similar in landslide affected area so there is high probability of Plain failure of rocks from the uppermost portion. It is recommended to take technical support for the construction of road in that area.

Lastly, the settlements in the steep slope or nearby the steep slope more than 35 degree are always vulnerable sites for rainfall-induced landslides so it is recommended to build the integrated settlement area in safe place for relocation of the vulnerable communities. The landslide affected area can only be used for dry crops and for Fruits and cash crops. No settlement should be placed again in that risky, vulnerable Chure hill slope.

ACKNOWLEDGMENTS

We would like to acknowledge the Director General and Geosciences Division head (DDG) for giving us this opportunity to study the landslide effect in the area. I also acknowledge CDO sir of Dadeldhura District and Ward Head of ward no. 7 of Alital Rular Muncipality for their help to conduct this fieldwork. Similarly, I would like to thanks all the villagers for showing the area in details and the cooperation during the study. I would like to give special thanks Mr. Bishow Silwal, Geologist for his support in preparing maps in the report.

Photographs related to the present field study

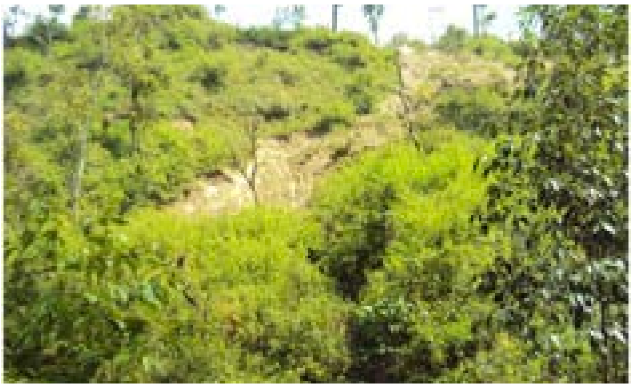


Photo 1: Mass movement alongwith development ofand cracks and creeps in the sloppy terrain

Photo 5: Cracks in the public water tank

Photo 2: Shifting displacement of existing motor-able road by 4m and slide 2m down

Photo 6: Land subsidence by more than 1m.

Photo 3: Cracks on the Hillslope

Photo 7: The land is crepinged in different steps

Photo 4: Cracks developed in the house in Balaucha

Photo 8: Rocks burstlast and landslide occur in the upper part of Balaucha area along the plane surface ofparallel to the bedrock

Photo 9: House damaged due to shifting of land by 4m in Aaureniby due to land displacement

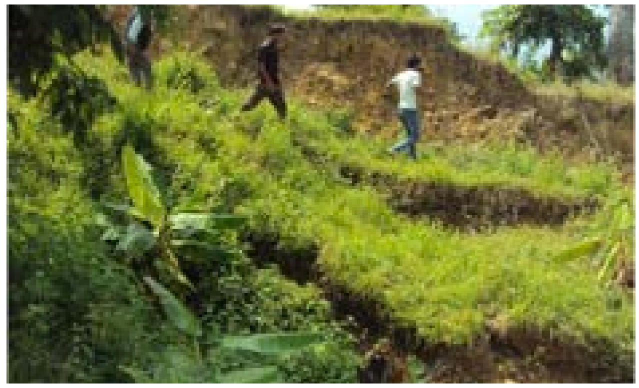


Photo 11: Landslide scrap observed in the upper part of the Balaucha area.

Photo 13: Landslide in tallo Oba tole

Photo 12: Shallow slide

Photo 10: Overall view of upper portion of debris flow and landslide in Balaucha

Photo 13: DMG Team with Villagers of Balaucha

Geological Study of Landslide in Duwar Village of Dordi Rural Municipality-8, Lamjung District, Gandaki Province

Suchita Shrestha, Ph.D. (Senior Divisional Geologist), Sulav Kayastha (Geologist)

ABSTRACT

This report deals with geological and engineering geological condition of the landslide affected area at Duwar Village of Dordi Rural Municipality, Gandaki Province. This short field study was initiated carried out in landslide withshort field inspection of the affected communities. This report study comprises of geological, geomorphological, engineering geological, geological and pertinent social parameters of the villages/settlements. The affected village is located in the concave slope of colluvial material. There is an old deep-seated landslide at Duwar village. The movement of this slide causes formation of cracks and small scale, local landslide, at the downslope part of the area. The complexity of the slope indicates that it is difficult to mitigate. Sealing of cracks sealing in and outside by clayey soil, whereas the, rills and gully protection can be done as treatment to an extended life span of protect the hill slope. Some houses at Magar Tole, Mijar Tole and Palchhe Tole, Simal Bot Tole area and cultivated land are at high risk due to slide of rock and soil from the steep slope and development of cracks developed along with subsidence of land. Some sinkholes are observed around Simal Bot Tole. Landslide may occur again be formed if the soil gets oversaturated on account of excess water enters through percolation through the sinkholes. People living in those areas should be temporarily relocated until the recommended preventive and mitigation measures are applied.The results of landslide studies have practical applications to society via the avoidance, prevention, and mitigation of landslide hazards and risks. Landslide avoidance and prevention are the primary interests for landuse policies based on landslide mapping, followed by the prediction of landslide processes and their consequences. Landslide mitigation includes the development of engineering technologies for landslide investigation, monitoring, and remediation and application of the technology.

Keywords: Slope Failure; Landslide Prone; Stability; Stress

1. INTRODUCTION

As per the request letter from Ministry of Home Affairs (MOHA) and Ministry of Internal Affairs and Law this field work aimsed to study the general geological condition of the area. It includes the assessment of the hill slope of the affected area and settlement. The field program was conducted for a very short time and rapid field investigation only. Hence the detailed geological and geotechnical setting of the study area is beyond the scope during this study. The recommendations presented from this study are based on the walk through survey and thus do not replace any instrument added investigation.

The study area is easily accessible from Kathmandu, which is at about 200 km west from Kathmandu. The Udipur area of Lamjung district is connected through the Prithvi Highway from Kathmandu. Duwar, the study area can be reached from Udipur by moving towards NE on a graveled road through Chitti. (Figure 1)

Duwar is located within 84°25'79'' E to 84°27'30'' E longitude and 28°14'11'' N to 28°15'0'' N latitude and falls within the Topo-sheet No. 2884 14B. at the scale 1:25,000 (SD 1998).

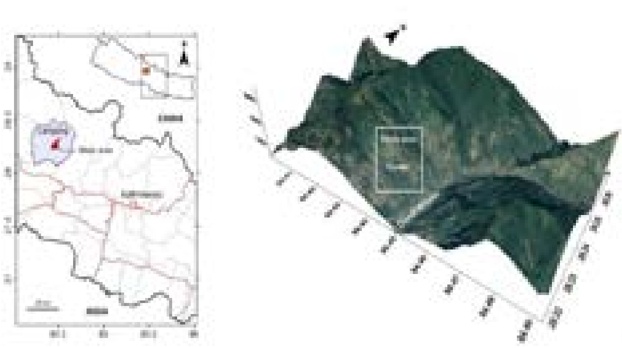
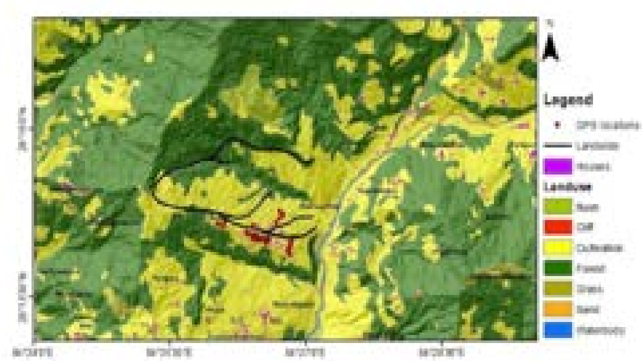


Figure 1: Location of the Study area.

The area comprises the rugged and steep topography of the Lesser Himalaya. The maximum and minimum elevation around the area is 1750 meter above mean sea level (masl) NW at Duwar and nearly 750 masl along the bank of Dordi River which flows downhill from Duwar. Landuse serves as the source of hazardous events in mountain regions. Duwar and the surrounding area has diverse landuse pattern. The upper part of the study area covered by forest and the lower part occupied by cultivated land which consists of landslide and cracks (Figure 2).

Figure 2: Landuse Map of the study area



The lower part of the slope is being utilized for settlement and the cultivation such as maize, wheat and vegetables that mostly depend on monsoonal rain. There were many old stream and gully (small to medium size) before the landslide but large gullies were carved out allowing surface runoff to flow through it.The top of the hill from where settlements were evacuated due to high risk of landslide was

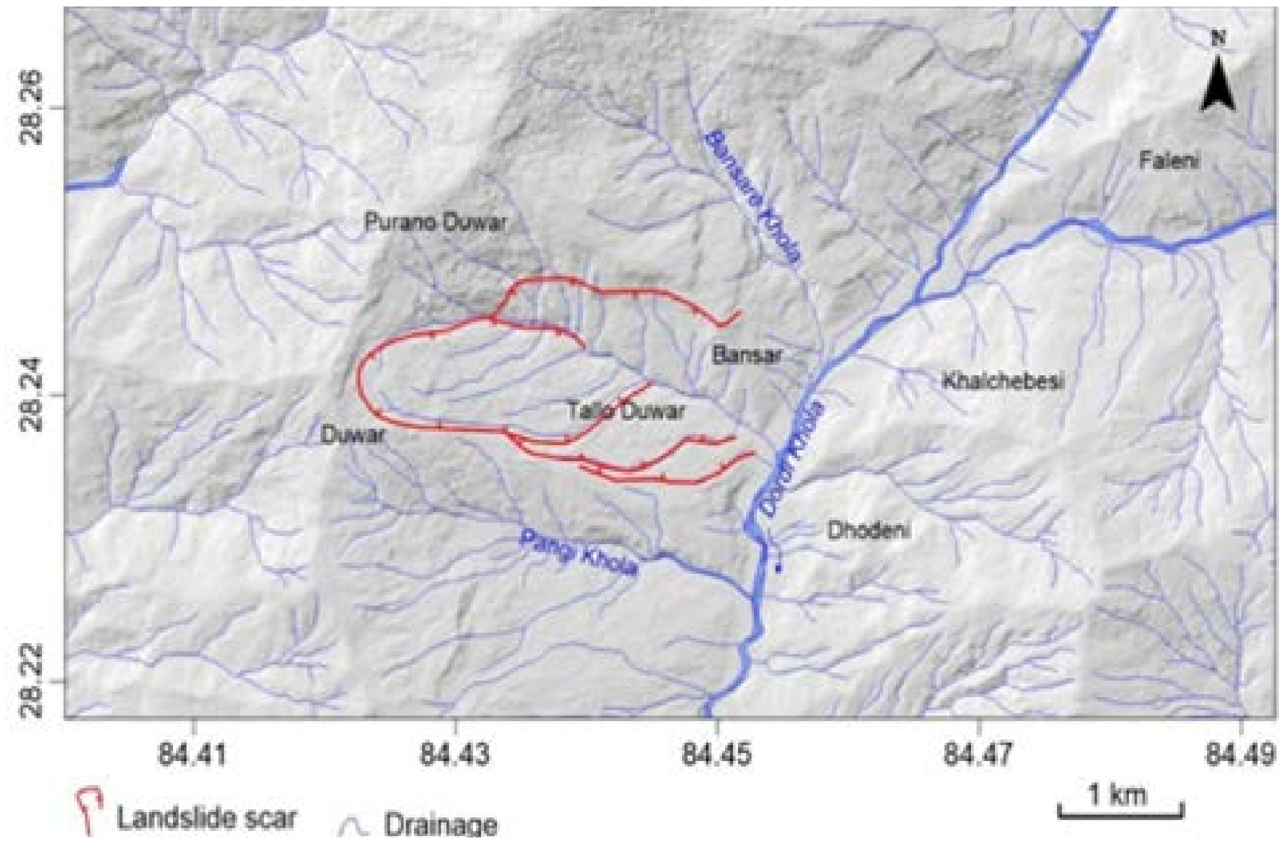


Figure 3: Drainage map of the study area

made flat and used as a football ground and for organizing cultural events. The facility of drinking water and water for irrigation is made available to all in Duwar village.

The study area has many steeply flowing perennial and ephemeral tributaries that drain to Dordi River. Duwar village of Dordi Rural Municipality- 8, is drained by numerous streams which all confluences join their Dordi River that finally joins the which combined with Marshyangdi River. The topography rises abruptly on either side of the river with small tributaries in dendritic drainage fashion as shown in Figure 3. The main River flowing in the study area are Dordi River, Bansare Khola, Syaud Khola and, Pangi Khola.

2. GEOLOGICAL HAZARD ASSESSMENT OF THE STUDY AREA

2.1 General Overview

The study team made walkthrough surveys and measured rock attitude, and identification of rock type. over the study area. The study was started from the toe of the hill slope following the slide scar on the top. Location of cracks, seepage movement of the surface was marked during the field study. Local people helped to identify the most vulnerable areas. They were consulted and interviewed during the field study to get their knowledge, the extent of damage and the possibility of mitigation measures. Due to the heavy rainfall, many parts of Duwar village werewas badly affected resulting in the such as formation of cracks and slope failure. Some small, shallow seated landslides, debris flow, rill and gully erosion were triggered by the continuous heavy cloudburst that occureds for more than 12 hours as explained by local people. Due to that event, largely cultivated lands and some houses were damaged and few were partially damaged. Rainfall on that day also causeds the settlement risk mainly in Magar Tole, Palchhe Tole. Some of the cracks were filled out by the local people whereas most cracks are still visible (Figure 4a). Some sinkholes are observed around Simal Bot Tole (Figure 4b).

The landslides affected area in Duwar village is NNE facing as shown in Figure 5. The upper part of the hill slope is steep whereas the lower part comprises of steep to moderately dipping bedrock. The attitude of rock exposure at Mijar Tole is 50°/40°.

2.2 Geomorphology

Duwar village lies on the old landslide as presented in Figure 5. Around Duwar Village area, where crack formation and landslides occurred has medium slope terrain with a gradient of around 40° generally facing toward NNE with thin to very thin (i.e. less than 0.5 m to 1.5m) residual soil cover. Similarly, the small stream that drains the area has a high gradient with the high potential energy during the heavy rainfall which can easily erode the weathered rocks and its peripheral area creating the debris flow in the downstreamparts.

Gravity is the force that causes the material to move downward. The steeper the slope, higher is the shear-induced by gravity and the more risk of landslide. Hence, the slope is the principle factor affecting the landslide occurrence. The slope map (Figure 6) shows most of the

Figure 4: Observed cracks and sinkhole: a) filled cracks in the ground floor and b) sinkhole in cultivated land

Figure 5: Google earth image with location of landslides.

landslides affected area with a steep slope (15°-45°) which is mostly unstable during heavy rainfalls conditions.

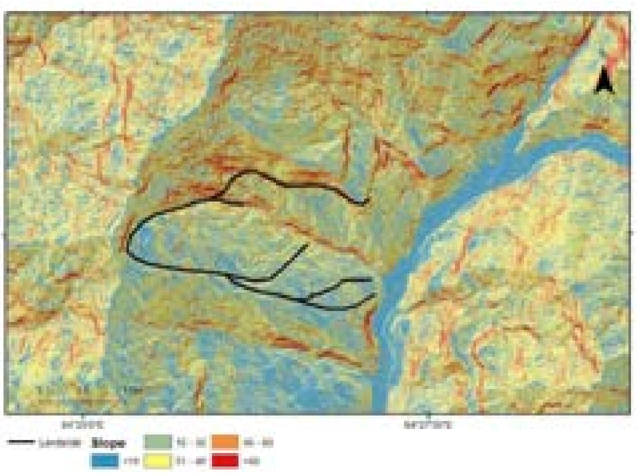


Figure 6: Slope Map of Duwar Village and Surrounding Area.

2.2 Geology

Geological formation plays an important role in the production of loose materials on the slope by weathering and slope movements such as landslide, debris flow etc. The study area lies in the Ghanpokhara Formation, Pokhara Sub-group of the Lesser Himalaya (DMG 2000). The area is composed of loose clayey soils, black to yellowish-grey to black colored slate along with green to grey calcareous phyllite. Some quartzite bands and quartz veins are also common in the area. A fault passes nearby the landslide affected area according to the published geological map of that area by the Department of Mines and Geology (Figure 7).

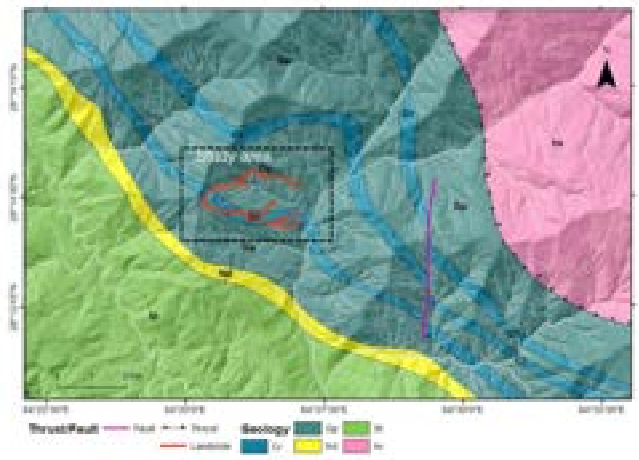


Figure 7: Regional geological map of Duwar and surrounding area (DMG 2000).

The Geology of the study area consists of Ghan Pokhara Formation (Gp) with Chour Carbonates (Cr) member, Naudanda Formation (Nd), (St) and Precambrian rock (hx). Gp Formation consists of black to grey carbonaceous slates and green shales, Cr consists of white to grey compact dolomites and dolomitic limestone interbedded with shale beds. Nd consists of fine to medium- grained white quartzites with ripple marks and thin intercalations of green chlorite phyllites. Hx consists of high-grade metamorphic rocks comprising gneisses, quartzites and marbles. Migmatites and granite geneisses present predominantly in the upper part. The rock exposed in the landslide and surrounding area of Duwar Village has a strike of NW-SE in general with varying dip amount of 20° to 50° dipping towards NE. (Figure 7).

3. ASSESSMENT OF LANDSLIDE AND PROBABLE RISK

3.1 Cause of Landslide

In the hilly region, rainstorms are widely caused as significant landslide-triggering events. A large number of human settlements on the mountains and hills are situated either on old landslide masses or landslide-prone areas. Among major geo-hazards, landslides account for 9% of global natural disasters (Gökceoglu and Aksoy 1996). A preliminary landslide location was delineated in a remote Google earth TM-aided recognition survey that was verified during the field survey. Figure 8 shows the GPS tracking of the surveyed route.

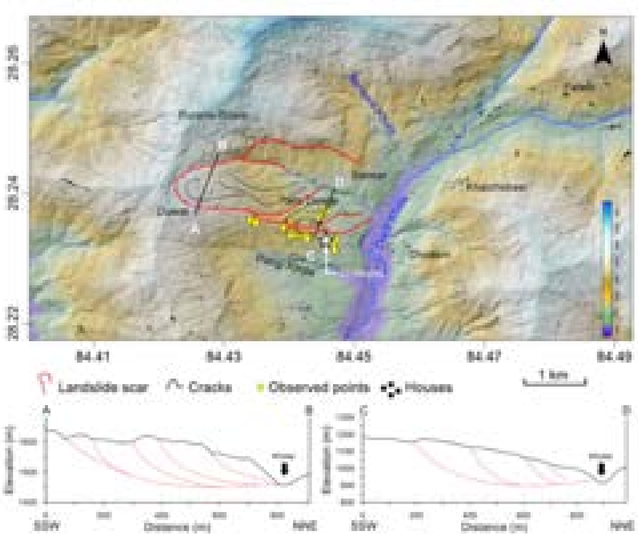


Figure 8: Landslide of Duwar village and profile along AB and CD.

Landslide are distributed on the whole area of Duwar village. According to local people creeping started since 2056 B.S. at Paradevi football ground area. Because of this, they shifted whole settlement (41 houses) to Tallo Duwar. The cultivated area and settlements of Duwar wereas destroyed at that time. Nowadays, the local people use this area as a football ground and for a cultural program like Maghesankrati mela. Numerous small scale creeping is visible in the whole area of Duwar. The cross-section view along AB and CD shows probable multiple slip surfacesurfaces and its direction of the slope towards NNE (Figure. 8). Rock attitude collected at some place which shows the rock dip direction is toward NE. Here the slope of the study area and dip direction of the rock exposure are nearly toward same direction which cause landslides.

Extensive cracks were observed on the ground over the area of Duwar village. The study area has a steep slope and most of the settlements areas are within steep slope or in the peripheral areas as shown in Figure 8. Although the slope seems to be stable during the dry season but the monsoon period due to precipitation the soil becomes saturated, which increases the shear stress. Local people reported that the heavy cloudburst for more than 12 hours (2077/03/25 B.S.) which over saturated the soil. This is the major cause for the development of cracks and landslide in Duwar area. The area is visibly creep displacing cultivated terraces and tilting of houses and trees as shown in Figure 9a and b.

Figure 9: Tilting of a) house and b) tree.

This area being a creep zone is always a vulnerable for settlementszone. The following cCauses are responsible for the landslidesare listed as:

- The heavy rainfall is the main cause for the formation of creeps. According to local people, old settlement was shifted from Paradevi Temple area to Tallo Duwar (Simal Bot Tole) in 2056 B.S. as cracks developed during that year. In B.S. 2077, rainfall triggered the creep which causes the development of huge cracks and subsidence of land all over Duwar Village (Tea Garden at top of Duwar to Simal Bot Tole at down).
- Lack of proper drainage management for surface runoff causes landslide and seepage of water in cracks which can result in further subsidence of land.
- Haphazard road construction in the steep slope without anythe proper drainage management for surface runoff is the cause for the cracks and landslides along the road section.
- High-intensity earthquake mayis also be one of the main cause for unbalance of the earth mass that may haveand triggered landslides.
- The study area consists of weak and weathered rocks like phyllites, slates and schist. Loose soil in the area is easily erodible and it creates debris flow in the downstream.

3.2 Probable risk

The main risk of Duwar village area iswas creeping that started insince 2056 B.S . and development of cracks triggered after heavy rainfall and water seeping in the cracks. Rainfall-induced landslides in the Duwar village area is deep seated. The soil on the steep slope is wet so whenever there is heavy rainfall there is a probability of landslide. Rill and gully erosion might occur on the bare slope created by the slope failure and the debris could affect the downhill houses. The houses in the Magar Tole, Mijar Tole, Palchhe Tole near gullies are at risk as the debris might get dammed and explode during heavy rain. Landslide may be formed if excess water enters through sinkholes.

Mitigation

Soil type, thick soil cover, high-intensity rainfall, and terrain are the primary cause of the landslides. Mitigation measures are intended towards achieving the following goals:

Reducing the pore water pressure on the soil and protection against surface erosion by surface overland flow.

The basic strategies to mitigate for a landslide hazard are stabilization and avoidance. Landslide stabilization measures include grading the unstable portion of the slope to a lower gradient, construction of retaining walls, and drainage improvements. Except for drainage improvements, stabilization measures are typically moderate to high cost, but provide a long-term solution with low, long-term maintenance costs. Avoidance measures constitute a permanent solution to a landslide hazard. Measures include realignment of road away from the slope, relocation of the facility.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusions

A short field study visit was made carried out in the landslide-affected area in different parts of Duwar Village to study the geology and cause of slope instabilityof the area. The colluviums and the residual soil, in the steep slope, are already moist due to monsoon rainfall become oversaturated by the heavy precipitation and surface runoff through the roads. Similarly, the poor drainage of rain water through gullies also plays a vital role initiating the slope failure.

The major portion of land owns wet irrigation which has helped the land to creep on. The village is located in the concave slope of colluvial material. The terraces of cultivated land are visibly displaced indicating land creep. Also, most of the houses are out of plumb, cracks are developed on the wall as well as terraces.

Field investigation and data interpretation revealed that the region is complex in terms of a mass movement. There is old deep-seated landslide at Duwar village. The movement of this slide causees formation of cracks and several, small scale, local landslide at the downslope of this area. The complexity of the slope indicates that it is difficult to mitigate. Sealing of cracks Crack sealing in and outside by clayey soil, rills and gully protection are mitigative measures that can be done as treatment to stabilize extended life span of the hill slope.

Some houses at Magar Tole, Mijar Tole,and Palchhe Tole, and Simal Bot Tole area and cultivated land are at high risk due to slide from the steep slope and cracks developed along with subsidence of land. Therefore, the people living in those areas should be temporarily relocated until the recommended preventive and mitigation measures are applied. Some sinkholes are observed around Simal Bot Tole. Landslide may be formed if excess water enters through these sinkholes.

Recommendations

The precipitation in the coming days of this monsoon and future may increase the displacement threatening the residents of houses in that area. So, it is recommended to evacuate the area and relocate the people in safer site. Avoidance of wet farming and diversion of water routes away from the area is also recommended. As the land is continuously creepingon, it is advised not to make new residential houses in the area and avoid wet cultivation. Also, it is recommended to divert the rainwater as well as surface water from the creep area. However, further study such as geophysical methods may help is needed to find out the exact slip surface, rate of creep and related factors. A detailed study is requiredneeded to find out the exact cause of creep and appropriate consequent preventive measures.

Immediate protection measures including retaining wall and drainage management are recommended to prevent further expansion of the cracks and landslide. There is a steep slope and cracks are developed at the top due to intense rainfall. If the rainwater is allowed to pass through these cracks, it may take the form of a landslide causing damage to the village downhill. So, it is recommended to cover immediately these cracks by tarpaulin or plastic sheets, if possible to seal those cracks with mud/clay to avoid water percolation in the cracks. Controlled removal of the unstable portion of landslide and installation of protection measures like construction of retaining wall is recommended.The drainage of the road has not been managed and the surface runoff is concentrated to the concave slope of the terrain. Proper Drainage management work is recommended in the area. Landslide may be formed if excess water enters through sinkhole hence it is recommended to fill this hole.

Acknowledgments

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REFERENCES

CBS, 2014. Central Bureau of Statistics of Nepal, National Population and housing census 2011 (village development committee/municipality).

DMG, 2020. Regional Geological Map of Gandaki Province (Unpublished)

Gökceoglu, C. and Aksoy, H.Ü.S.E.Y.İ.N., 1996. Landslide susceptibility mapping of the slopes in the residual soils of the Mengen region (Turkey) by deterministic stability analyses and image processing techniques. Engineering Geology, 44(1-4), pp.147-161

Survey Department, 1998. Topographical Sheets field verified during 1992 & 2001 (1:25,000 and 1:50,000 scales). Kathmandu: Survey Department, Government of Nepal.

Landslide study in some parts of Jaljala, Modi, Phalebas and Kushma Municipality, Parbat District, Gandaki Province, Nepal.

Thakur Prasad Kandel (Sr. Div. Geologist), Sulav Kayastha (Geologist)

ABSTRACT

A Landslide study has been carried out in different places of Parbat District, which were affected during monsoon season. We focused our study in Jaljala, Modi, Phalebas and Kushma Municipality of Parbat district. Geological and engineering geological investigation, mainly, brief rock and soil types, drone topography survey, and landslide inventory mapping were done during this field observation. Among the various factors affecting the stability of settlement, nature of hillslope (slope angle and slope aspect), rock or soil (depth of colluviums, alluvium or rock), dip or anti-dip slope, distance from river/stream were analyzed to evaluate the potential hazard condition. Recommendations are made based on the field study (walkthrough survey). The study area is found to have different types of hazards, e.g. soil slides, debris flow, creeping and subsidence. Most of the landslides in the study area are aggravated by new road cut and further associated in and around old existing road section. Recommendations were made to the concerned authority and stakeholder to build proper drainage in the local road alignment in order to evacuate the excess surface water. Likewise retaining wall, gabion wall, bioengineering works were recommended to minimize the further landslides in future. Based on visual inspection in field, we recommend immediate evacuation of some vulnerable houses in Banskharka, Gaurete and Farce area.

Keywords: Slope Failure; Landslide hazard; Debris flow; Drainage management

1. INTRODUCTION

1.1 Background

Every year landslides take several lives and property that worths millions in different parts of the country. Monsoon induced landslide in Jaljala Rural Municipality, Modi Rural Municipality, Phalebas Municipality, and Kushma Municipality, loss of lives and property were evident. Large to small cracks were observed all around the village. Numerous landslides were occurred within study area. We mainly focused on settlement affected landslides. As per the request letter from Phalebas Municipality, Office of the Municipal Executive dated 2077/06/11, a team from the Department of Mines and Geology has carried out 6 days long field study from 23rd Ashoj to 28th Ashoj, 2077 in the affected area on the request of National Assembly, Secretariat, different areas of Jaljala R.M., Modi R.M. and Kushma Municipality were also studied. This field work aimed to study the geological and engineering geological condition of the landslide and affected settlement. The study area lies on western Nepal, Gandaki Province, shown in Figure 1.

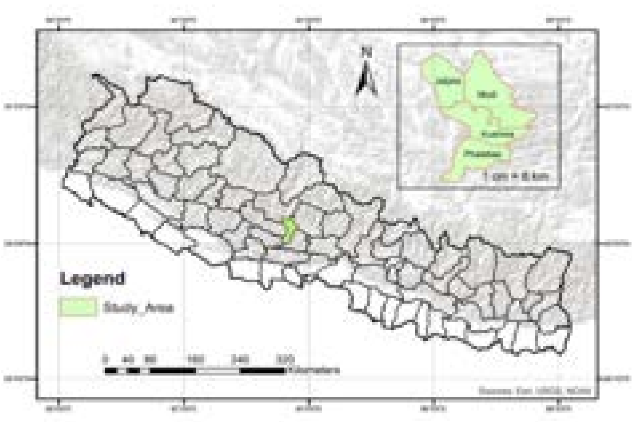

Figure 1: Location map of the study area.

1.2 Objectives

The main objectives of this study are as below.

- To study the cause of landslides and their effect on settlements.
- To explain the landslide hazard condition, and giving the recommendation to reduce the possible landslide hazard in the future.

1.3 Limitations

The field program was conducted for a concise time, as compared to numbers of landslides. The study's recommendations are based on the walkthrough survey and thus do not replace any instrument added investigation.

1.4 Methodology

It includes a desk study, field observation, and field data analysis. Desk study includes studying the topo-sheet, geological maps, landslide hazard maps, scientific papers related to landslide, and other similar literature. The DMG database (DEM and Topo-sheet map) was used to generate slope, aspect, and relief maps of the study area to analyze the landslide hazard. Among the various factors affecting the stability of settlement, factors such as nature of hillslope (slope angle and slope aspect), rock or soil (depth of colluvium, alluvium or rock), dip or anti-dip slope, distance from river/stream were analyzed to judge the potential hazard condition. Visual inspection (including drone images) is the main tools to evaluate the landslide hazard conditions, in this study.

2. OBSERVATIONS

2.1 Hazard condition

Geological setting: - Regionally, the study area lies in theLesser Himalayas of Western Nepal. The study area

Jaljala (Banskharka, Mallaj, Dhairing, Lungdi, Lasti, Farce), Kushma (Khurkot) lies in the Kuncha Formation (DMG, 2000, 2002) of the Lesser Himalaya. Similarly, the study area Phalebas (Rungdi, Churi, Mudkuwa) lies in Kuncha Formation and Kushma Quartzite whereas Kurgha of Phalebas Municipality lies in Benighat Slate of Lesser Himalaya and The study area of Modi Rural Municipality lies in the Kushma Quartzite of the Lesser Himalaya.

Kuncha Formation is composed of light greenish grey to dark grey, sericitic to chloritic, phyllite intercalated with gray to white, thick to very thick-bedded, jointed, slightly to moderately weathered, meta-sandstones. Some quartzite layers are also common in the area. Kushma Quartzite is composed of white, platy fine-grained quartzites with dykes of some basic rocks. Benighat Slate consists of a black and yellowish-grey banded slate, dark grey to black carbonaceous slate with some quartzite bands. The regional geological map is shown in Figure 2.

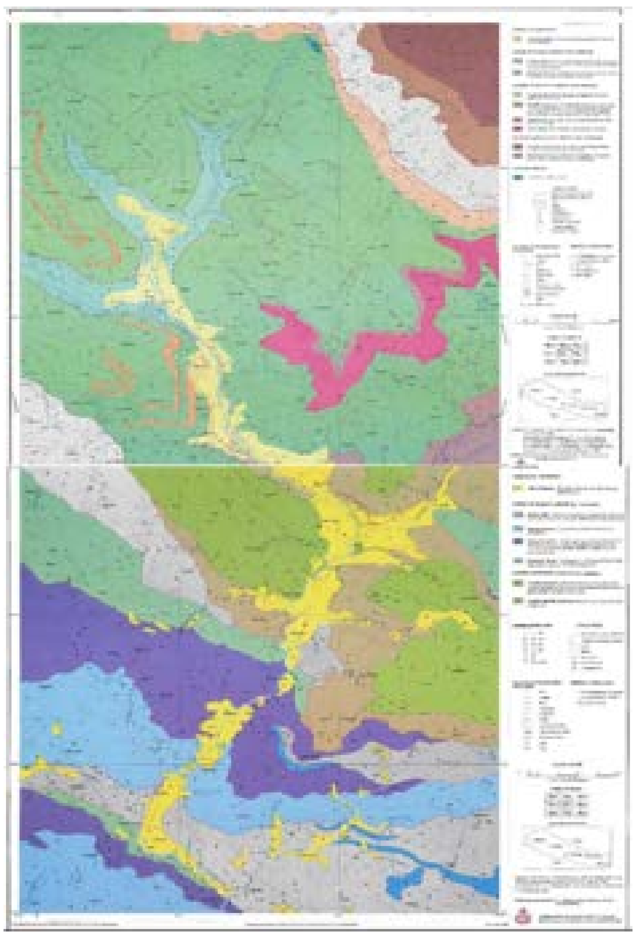

Figure 2: Geological Map of the study area and its surrounding (DMG: 2000, 2002).

Land use of the area: - The study area has diverse land use patterns. However, the part of the areas that suffered the landslide has dominantly cultivated land in the lower part and jungle to barren land in the upper part, shown in Figure 3. In general, the area's cultivation is wet during summer due to the availability of an ample amount of water from ephemeral springs.

Nature of Hill slope (Slope angle and Slope Aspect): - The slope and aspect is the principal factor affecting the landslide occurrence. The effect of the slope aspect on the landslide occurrence may be direct or indirect. Slope aspect determines the amount of the soil moisture content in different directions or aspects of the same region hill slope. Slope aspect strongly affects hydrologic processes by the process of the evapo-transpiration and attitude of rock bedding or foliation. The slope and aspect map of the study area are shown in Figure 4 and Figure 5

Topography and Drainage:- The landslide study area lies in the hilly region. The area comprises the rugged and steep topography of the Lesser Himalaya.

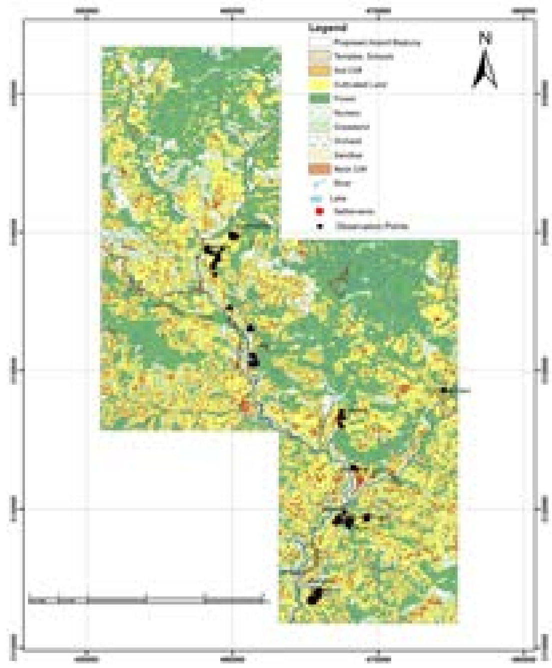

Figure 3: *Land use map of the study area and its surrounding.*

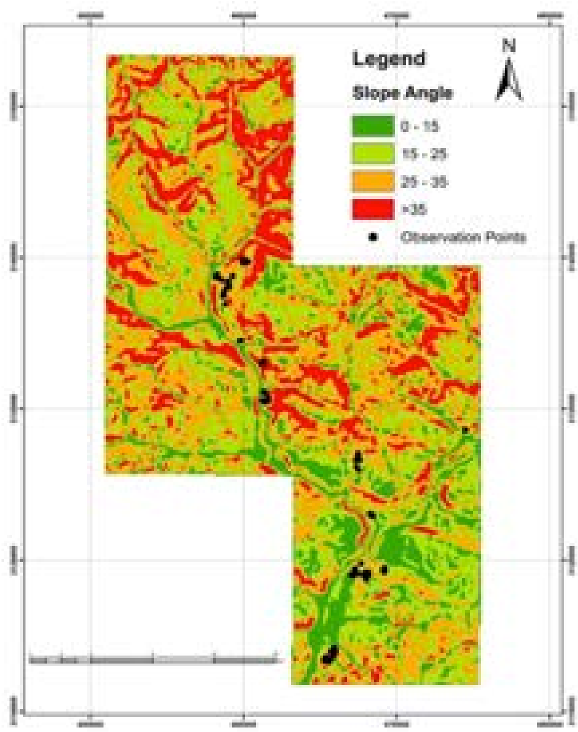

Figure 4: Slope map of the study area and its surrounding.

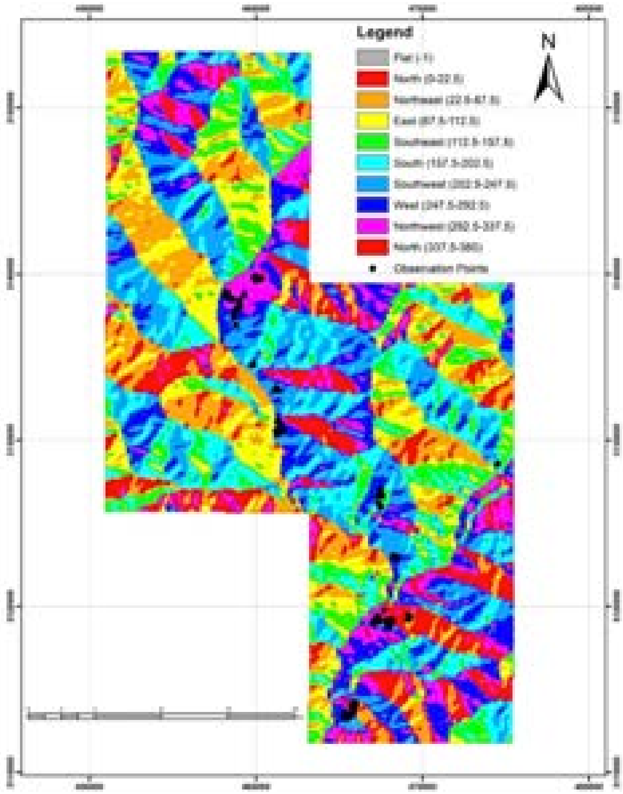

Figure 5: Aspect map of the study area and its surrounding.

The maximum and minimum elevation around the study area in Jaljala Rural municipality is 1800 m in Banskharka and nearly 750 m along the Kaligandaki Riverbank. Jaljala Rural Municipality is drained by numerous streams which all confluences in Kaligandaki River.

Modi Rural Municipality is drained by numerous streams, mainly Pati Khola, which all confluences in Modi River. Modi River joins with Kaligandaki River near Kushma. Phalebas Municipality is drained by numerous streams which all confluences in Kaligandaki River. Kushma Municipality is drained by small unnamed tributaries fed to Pati Khola and ultimately drained by Modi Khola.

2.2 Settlements

Most of the landslides occurred in the cultivated land. Only the landslides that impose an immediate risk to settlements have been focused on in this study. Therefore, the urgencies for risk zonation depend on proximity to the settlement rather than its size.

Jaljala Rural Municipality (Dhairing, Maajphat, Banskharka, Gaurete, Lungdi, Lasti, Farce): - The landslide area of Dhairing has > 35° slope angle and west to southwest aspect. This area has 0.5 to 5m thick residual soil cover. The rock exposed in the area has strike NW-SE in general with varying dip amount of 10° to 40° dipping towards NE. Instabilities in the Dhairing area are associated along the road cut section. Some houses around the road cut section and some houses below the landslide, near Kusma-Beni road are at risk due to further sliding the landslide, shown in Figure 6.

One house in Rakhelul Bishura (Mallaj) is at risk due to surface mass sliding on the road cut section, having having

Figure 6: Google image of Dhairing showing landslide and settlements in risk and high risk.

> 30° slope angle and west to southwest aspect. Banskharka area has stand on residual soil having up to around 5 meters thick, 25- 35° slope angle and west to northwest aspect. Gaurete also stand on residual soil having > 30° slope angle and west to southwest aspect. The rock exposed in the area has strike NW-SE in general with varying dip amount of 20° to 50° dipping towards NE. Cracks developed on the surface and land subsidence occurred in mainly three places in Banskharka area, shown in Figure 7, Figure 8 (Gaurete) and Figure 9. The settlements under these area are at high risk. We recommend the house inside the creeping area (inside the Red dotted line) in Figure 7, Figure 8, and Figure 9 to shift immediately to a safer place.

Figure 7: Google earth image of Banskharka, showing instability in different observation points.

Figure 8: Google earth image of Gaurete (Banskharka) showing instability with obervation points where the red dotted line shows cracks observed in the area.

Figure 9: Google earth image of Banskharka showing cracks in red dotted line.

The landslide area of Lasti and Force area has > 35° slope angle and west aspect. This area has 0.5 to 2m thick residual soil cover. Numerous cracks and soil slide occurred in Lasti and settlements lies just below it, near the Kushma-Beni road, shown in Figure 10. The settlements below these landslides are at high risk. We recommend around 10 houses in Farce (inside the Red line) in Figure 10. to shift immediately to a safer place.

Figure 10: Google earth image of Farce showing slope failure and settlements at risk.

Modi Rural Municipality (Deopur): - The landslide area of Deopur-Purungdihi stand on thin layer of residuals soils, having, > 40° slope angle and west to southwest aspect. The land around the road cut section was badly affected by cracks, and slope failure, due to the heavy rainfall, shown in Figure 11.

Some houses near road section and below the landslide, near Pati Khola are at risk. There are chances of debris flow to Pati Khola damming, and outbursts can create big debris flow destroying the Patichaur city area. We recommended some civil works like proper drainage management, supporting wall, and bioengineering to minimize future risk.

Khurkot and Kushma (Kushma Municipality):- The landslide area of Deopur-Purungdihi stand on thin layer of residuals soils, having, > 40° slope angle and west to southwest aspect. The area has less than 4m thick residual soil cover.the rock exposed in the area has strike NW_SE in general with varying dip amount of of 10° to 40° dipping towards NE. Due to the heavy rainfall, different areas of Kushma Municipality were badly affected by the landslide, development of cracks and slope failure, shallow landslides in road cut section triggered by the continuous heavy cloudburst. Due to that event, largely cultivated lands and some houses are damaged, and a few were partially damaged leaving many other houses and lands at risk. One house was collapsed due to the subsidence of land in Kusma Bazar (Gaidatole), shown in Figure 12. The main risk of Gaidatole, Kushma Bazar, is sinkhole and subsidence of land. We recommended conducting detailed geophysical study for subsidence site.

Figure 11: Orthomosaic image of Deopur showing slope failure and settlements in risk during heavy rainfall.

Figure 12: Damaged of house due to subsidence of land in Kushma Bazar.

Phalebas Municipality (Rungdi, Churi, Kurgha, Mudkuwa):- Relatively Churi and Kurgha are badly damaged than Rungdi and Mudkuwa in Phalebas Municipality. We recommended maintaining the already existing drainage system in Rungdi. The numerous surface slides were observed due to excessive rainfall in the red soil with some cracks in Churi village, shown in Figure 13. Landslide on road cut section also damage the irrigation canal in Churi. Churi village stand on red residual soil, having 25-35° slope angle and north to northwest aspect.

Debris flow from long-distance gradually increases and dams the stream, which later due to excessive rainfall, bursts out, causing a landslide in Sirsuwa (Figure 14). Some houses around the road cut section and around the debris flow are in Risk.

Figure 13: Three limbs of Churi surface slide that killed a child in Sirsuwa (Mudkuwa)

The crown of the major landslide in Kurgha started from the road cut section, around 500 m uphill of the Kurgha village, that gradually increases and dam the stream, which later due to excessive rainfall, bursts out, causing a landslide and destroyed Kurgha Village, shown in Figure. 14. Kurgha Area stand on thin layer residual soil, having 25° to 40° slope and west to Northeast aspect. Some houses are partially damage and some are in risk now. Road cut material is the cause for debris in this area. We recommended to maintaining the drainage to manage surface water with possible civil works.

Figure 14: Landslide in Kurgha due to slope failure and settlements in risk.

3. CONCLUSIONS

A brief field assessment of risky settlements of Dhairing, Mallaj, Banskharka, Gaurete, Lungdi, Lasti, Farce, Deopur, Khurkot, Gaidatole (Kusma), Rungdi, Churi, Mudkuwa and Kurgha, has been done in this study. The study area has different degrees of hazards of soil slide, debris flow, and creeping and land subsidence. This report is an outcome of the technical study only of the landslide. Due to this event and the following effect of rainfall, the studied villages are under high risks of slope stability problem. Based on this preliminary study, it is concluded that many parts of these hillslope are still unstable. Other causing factors are the slope factor, the natural hill slope. The natural stability of hill slope was disturbed by haphazard construction of road which led to plane failure in most cases, except for Banskharka, Gaurete, Lasti, Farce. One of the major causing factors is the surface runoff and subsurface infilteration, in road cut section. During the intense rainfall maximum infiltration due to lack of proper drainage management in road section for the surface and subsurface flow ultimately caused the slope failure.

4. RECOMMENDATIONS

Based on the visual inspection during this fieldwork, we recommend immediate evacuation of some vulnerable houses at Banskharka, Gaurete and Farce area. Other settlements, especially close to the newly cut road section, and around the landslide area are at high-risk zone (described in the respective headings), should be made aware of possible hazards in the future. We recommended some civil works like placement of retaining wall, construction of drainage management facility, bioengineering, slope maintainenance etc. to minimize future risk in these area.

Most of the landslides in the study are aggravated by newly cut road section, associated at and around local road, except Banskharka, Gaurete, Lasti, and Farce. We suggest to the related body and stakeholder to build proper drainage management structures for the surface water at the time of new road construction. We request the locals to observe and monitor the advancement of existing landslides and associated cracks and evacuate if displacement is noticed.

Detail geophysical and geotechnical investigation of the area around Gaidatole (Kusma) could be useful to understand the sub-surface sinkhole on alluvium trace, and find out the linkage to Gupteshor Gufa. We also recommend the feasibility study before constructing new roads.

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REFERENCES

Department of Mines and Geology (2000) Geological map of parts of Parbat-Baglung and Gulmi district, western Nepal.

Department of Mines and Geology (2002) Geological map of parts of Myagdi-Parbat and Baglung district, western Nepal.

Landslide risk evaluation of vulnerable settlements in parts of Ramaroshan Rural Municipality, Achham district, Nepal.

Thakur Prasad Kandel (Sr. Div. Geologist), Gautam Prashad Khanal (Geologist), Basanta Adhikari (Research Officer)

ABSTRACT

A brief field assessment has been done in landslide and flood affected parts of Ramaroshan rural municipality, Achham district, Sudurpaschim province, Nepal. The assessment aimed to evaluate the risky settlements; Shaini, Patal, Bandatal, Sodna, Aulaghat, Baksad, Tadigaira, Sallesain, Allerigaun, Jethari, Santada, Mujabagar, and Malata in terms of different hazards (shallow slides, bank erosion, flood, and rockfalls). The field assessment (geological investigation, rock and soil mapping, drone topographic survey, and landslide inventory mapping of the area) and desk analysis (GIS based landslide susceptibility mapping) pointed urgency of evacuating some vulnerable houses at Alleri, Sodna-Aulaghat-Dhanesalla and Bandatal area. Other areas, which fall into high landslide-susceptibility zone, should be avoided during resettlement within.

Keywords: Slope Failure; Landslide hazard; Soil slide; Landslide susceptibility map.

1. INTRODUCTION

1.1 Background

During every monsoon, Nepal suffers from huge property-loss due to the intense rainfall induced landslides. Due to the rainfall-induced landslide of July 28, 2020 (13th Shrawan, 2077) and flood on August 18, 2020 (2nd Bhadra, 2077), settlements in ward no. 1 to ward no. 7 in Ramaroshan Rural Municipality are at risk. The landslide and flood in the Kailash Khola claimed lives of 17 people and displacd many people from their houses, forcing them to take shelter in nearby schools. To conduct the safety assessment of the settlements, a survey team was deployed by the Department of Mines and Geology (DMG) on request from the Ministry of Home Affairs (MOHA), which carried out a 8-day long emergency field assessment of the affected settlements in the Ramaroshan Rural Municipality. This municipality lies 30 km northeast of Mangalshen (the district head quarter of Achham), Sudurpaschim Province, Nepal (Figure 1). It is accessible from Kathmandu by traveling along the Prithvi Highway, Mahendra, and Mahakali highway or Mid-Hill Highway via Surkhet-Dailekh-Achham.

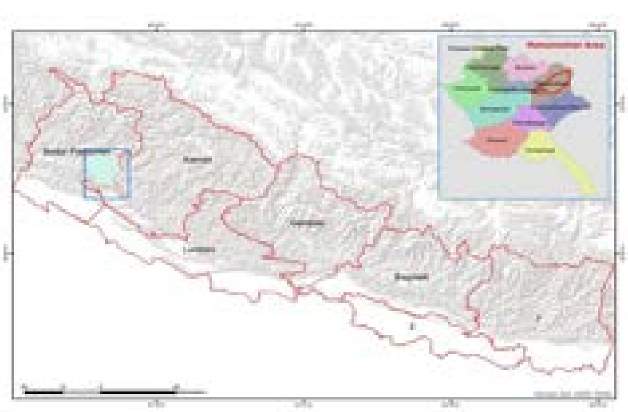

Figure 1: Location map of the study area.

1.2 Objectives

The main objectives of this study are as below.

- To study the cause of landslides and its effect on settlements
- To explain the cause and landslide hazard condition to the local people
- To prepare a relative landslide susceptibility map of the area based on the field observation and GIS analysis.

1.3 Methodology

Brief geological investigation, rock and soil mapping, drone topography survey, and landslide inventory mapping were carried out in the field. A digital elevation model of 5m*5m resolution was used from the DMG database to generate slope map, aspect map, and relief map of the affected area, which was later combined with other field data to produce a landslide hazard map. Among the various possible factors affecting the stability of settlement, only major geological, geomorphological and hydrological factors viz. nature of hillslope (slope angle and slope aspect), rock or soil (depth of colluvium, alluvium or rock), dip or counter-dip slope and distance from river/stream were taken into account during landslide susceptibility analysis. The risks to the existing settlements have been judged in the field, based on landslide size and nature of cracks (extension, depth, and width). Recommendations from the assessment are intended for adopting immediate safety measures and cannot fulfil the need for geotechnical survey required for each landslide.

2. OBSERVATIONS

2.1 Hazard condition

Topography and relief:- The elevation in the study area varies between 3500 m (north of Ramaroshan Lake) and ~900 m (along the lower reaches of the Kailash Khola) (Figure 2). The topography rises gently on the colluvial slope while abruptly along the river incised rocky cliffs. The major rivers Kailash Khola, the Balle Khola and its tributaries carve the landscape into dendritic fashion. fashion.

Slope and Slope Aspect: - The slope map of the area (Figure 3) shows most of the landslides affected areaes have steep slope (>30°), (usually considered unstable during heavy rainfall).

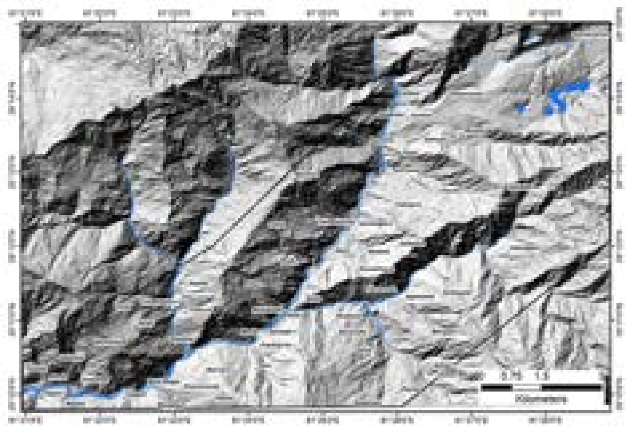

Figure 2: Shaded relief map of the study area.

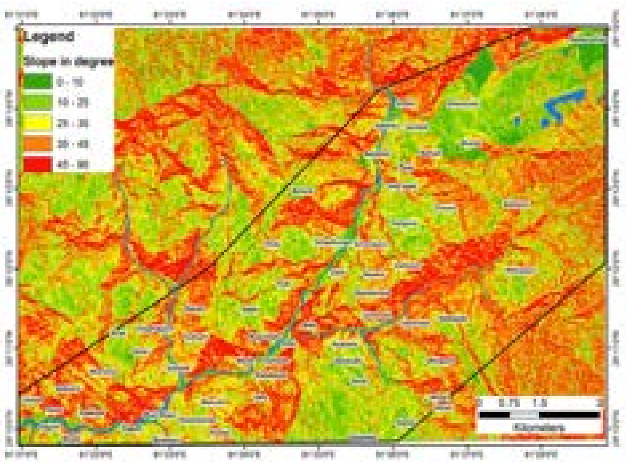

Figure 3: Slope Map of the study area.

The slope aspect map (Figure 4) shows that the landslide-affected areas mostly face towards north and northeast direction. One reason may be, the top soils in North or Northeast facing slopes saturate quickly raising pore water pressure and facilitating sliding. Second reason may be, the slopes facing North are oriented dip-slope with respect to the foliations.

Dip/Anti dip: - The majority of the outcrops in the landslide area and surroundings have foliations with dip direction towards ~N60°E and slope ~45° (Figure 5). Therefore, the chances of plane failure is high on the NE facing slope with an angle greater than 45°. This situation has also been observed on the field, and the majority of the NE facing landslides classifies as soil slide (Varnes, 1978).

Geological setting: - Regionally the study area forms the eastern end of the Dadeldhura Klippe and is covered by the Precambrian Dadeldhura Group (DMG, 2020). More specifically, the area belongs to the Kalikot Formation (Kk), (with its members Budi Ganga Gneiss (Bu) and Ghatte Gad Carbonates (Gh)) overlain by the Sallyani Gad Formation (Si) of the Dadeldhura Group in Lesser Himalaya (Figure. 6). The area is composed of Augen gneisses, garnet-

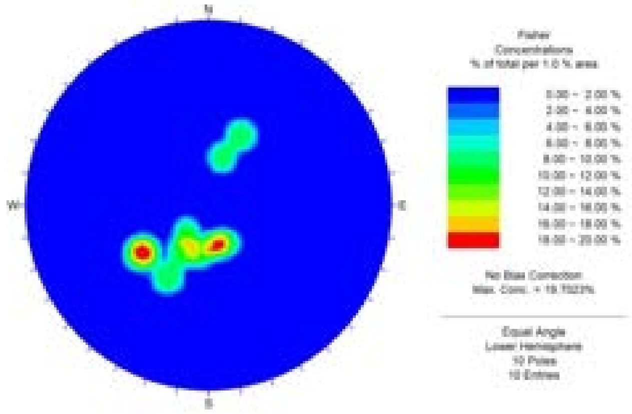

Figure 5: Pole plot of the major foliations measured in the study area.

biotite schist, and micaceous quartzites with gneisses with frequent granitic gneiss and calcareous schists, quartz-biotite-schists. A synclinal structure and a local thrust pass nearby the landslide affected area (Figure 6).

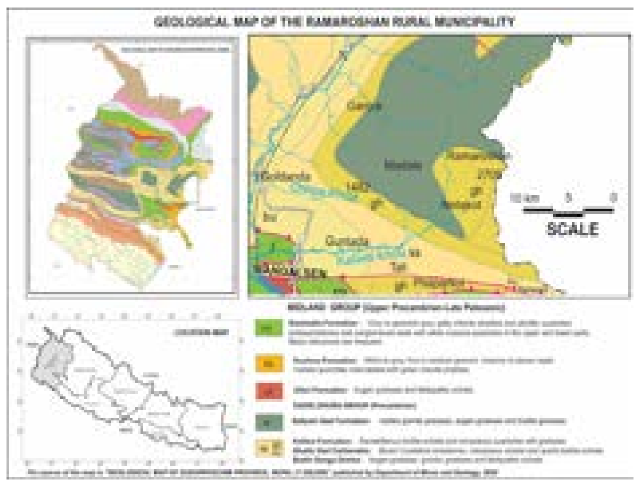

Figure 6: Regional geological map of the study area (DMG, 2020).

Rock and soil cover :- The settlements Allerigaun, Dhanesalla, Netakot, are resting on the colluvial soil while rocks are seen in Salimkot, Borena, and Mugretado, shown in Figure 7. Most of the landslides that affect the settlements are on the colluvial soil. Although the depth of colluvium is highly variable a rough estimate of 10-15 m thick soil covers most hill slopes. During analysis it is considered that the area covered by alluvial soils (having loose, unconsolidated, lesser cohesion than the colluvial soil) are more prone to bank cutting and erosion. On the other hand, area covered showing rocks (or area with shallow soil cover) are considered more stable ground for settlement (have higher shear strength) than colluvium or alluvium. However, rock stability depends on its rock mass properties (weathering, water, joint characteristics) and the relation of rock attitude with the hill slope.

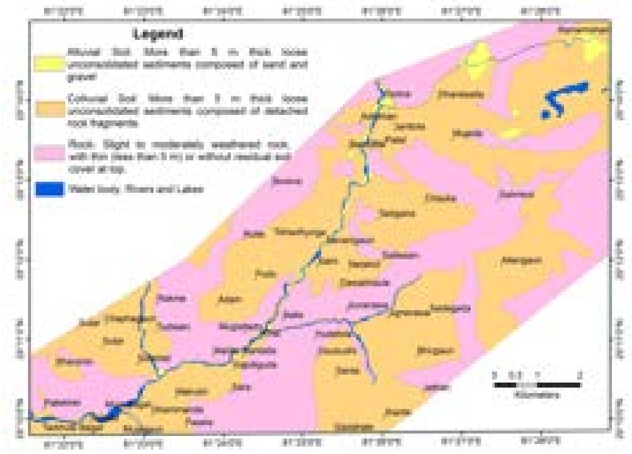

Figure 7: Rock and Soil distribution map of the study area.

Drainage and Rainfall:- Ramaroshan Rural Municipality is drained by numerous streams, all of which confluence with Kailash Khola (a tributary of Seti River). The Kailash Khola is a perennial river that drains to the Budi Ganga River towards the west. However, during the monsoon season, the flood level rises significantly due to extreme rainfall, and the discharge becomes unpredictably high enough to erode its bank.

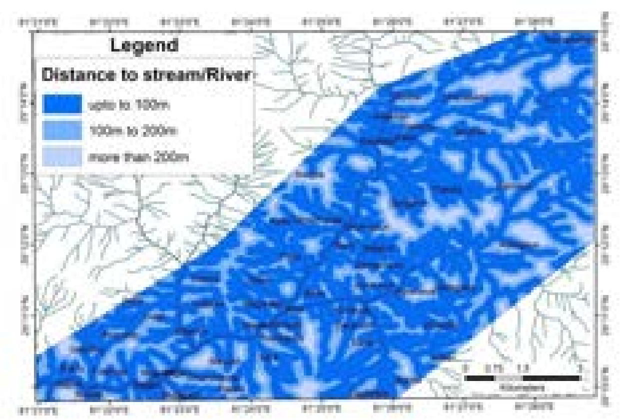

Figure 8: Drainage Distance Map of the study area.

The erodeability of the Kailash Khola is higher in the upper reaches because of a higher gradient (~30° around the Sodna area). Towards the lower reaches, the floodplains are much wider, and thus the gradient become lower (~10 degrees). As observed in the study area, most instabilities are either triggered or aggravated by the unfavourable drainage condition (both anthropogenic and natural causes). The settlements which close (within ~100m) to the stream/river (Shaini, Bandatal, Santada areas) have a high risk of landslide or bank cutting (Figure 8); whereas settlements away (>200m) from river/stream (some parts of Tadigaira, Allerigaun, and Borena) have lower chances of landslide that are triggered by toe cutting.

In the Himalayan region, where water is the most potent erosional agent, landslide occurrences are intrinsically related to rainfall in that area. The average annual rainfall for the Achham district is ~1900mm, out of which ~1700mm precipitate during the monsoon (June-July-August) alone, making these months a season for landsliding. In the study area, the landslide of July 28 can be related to the extreme rainfall that recorded 103.6mm in the nearest Sugali Station (Figure 9). This cloud burst event triggered most landslides present in the Allerigaun.

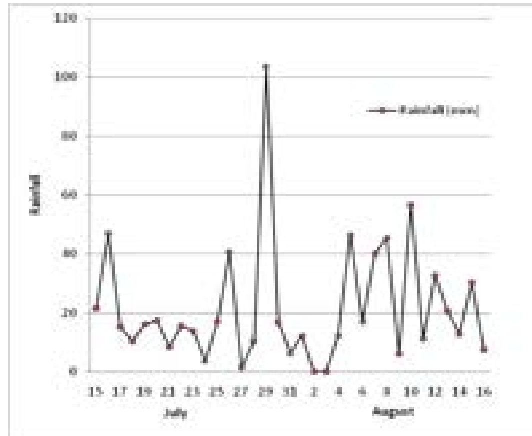

Figure 9: Rainfall record of the nearest station (Sugali) in the study area, Achham (Source: DHM)

2.2 Settlements

Because of presence of numerous landslides in the area, accessing all of them in a short visit is physically impossible. Therefore, only the landslides that impose an immediate risk to settlements have been focused in our study. Figure 10 shows the distribution of instabilities and their proximity to the settlement.

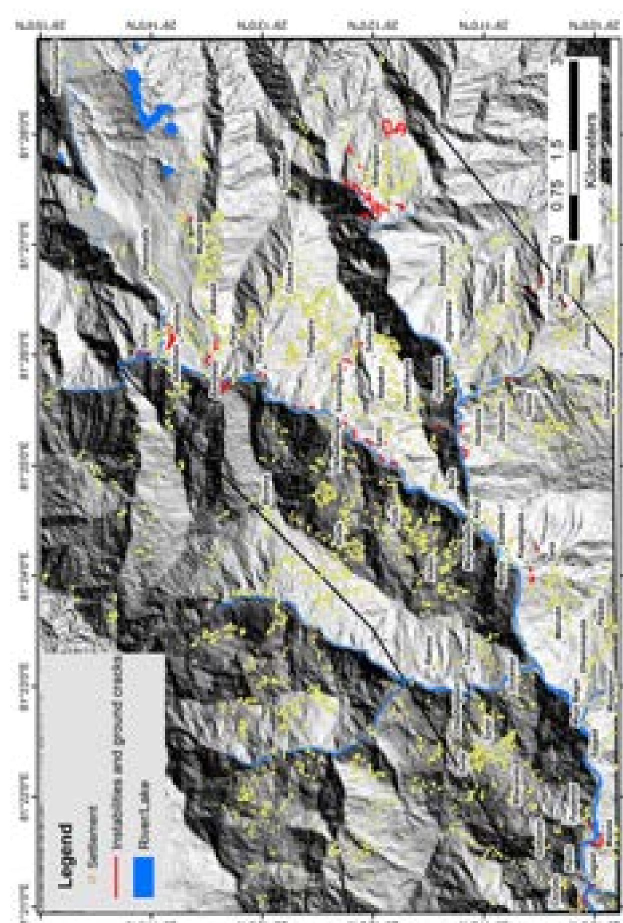

Figure 10: Settlements (Yellow dots) and the observed instabilities (red lines)

Shaini Area: - Sanani Gaun is resting on a moderate hill slope (10-25 degrees) towards Northwest covered by colluvial soil, while Shaini Bazar rests on a flat (<10degree) alluvial flood plain of the Kailash Khola (~300m wide) (Figure 11). An outcrop of quartzite (N30E/32°) is exposed at the cut bank at Shaini Bazar. Instabilities in the Shaini Bazaar area are associated with the flood event on Bhadra 2nd at 11:45 pm. About 25 houses on the flood plain were completely damaged, leaving behind the rubble of boulders (Figure 12a, b, c). According to a local, it took 17 lives from 8 families, among which 8 bodies are still missing. The flood also washed H.E.P at Shaini Bazar and eroded paddy cultivation.

Figure 11: Satellite image of the Shaini showing instabilities and the observation points.

Figure 12: a) Boulders deposited by flood on the Kailash Khola (view of upstream from destroyed Shaini Bazar); b) Bank cutting on unconsolidated alluvial soil, and houses(abandoned) at risk; c) Channel shifting leading to bank cutting and damage of a Hydro power at Shaini Bazar; d) Scar of reactivated colluvial soil slide above Shainigaun.

Crown cracks (2cm wide and*20m long) associated with colluvial soil slides (25m long* 20 m wide* 5m deep) are seen towards the uphill slope of Shainigaun settlement (Figure 12d).

Patal-Bandatal area: - The Patal-Bandatal area has settlements named Tallopatal, which rests on the rock, Patalgaun, and on colluvial soil and Bandatal area on colluvial and alluvial soil. The settlements PatalGaun and Jantolla rest on a gentle hillslope with colluvial cover. Tallopatal settlement has Northwest facing gentle hill slope (10 degrees) and rests on rock.

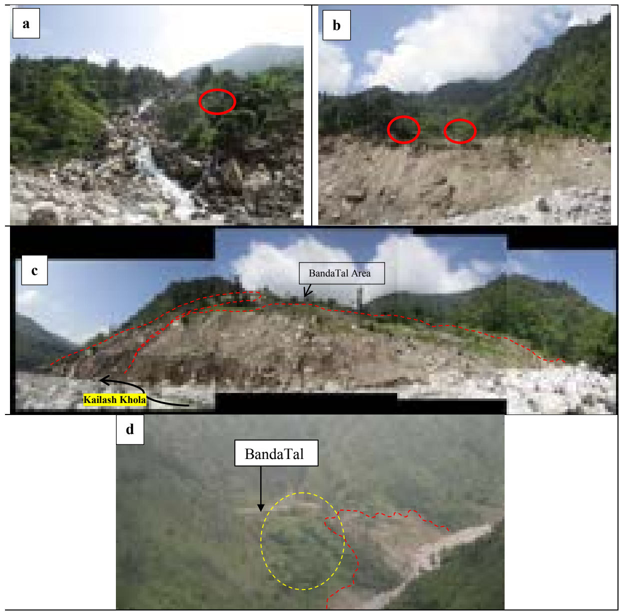

Figure 13: a) incision by high gradient Todobuiya Khola; b) Threat to houses on the edge due to bank cutting; c),d) Flood induced colluvial soil slide at Bandatal area and settlement above the scar (red dash).

The Bandatal has a paleo-lake deposits that form nearly table-plain geomorphology at the top, while the east-facing slope is formed on the right bank of Kailash Khola. Bandatal-Patal area is drained by Todobuiya Khola flowing from east to west, shown in Figure 13. During the flood on the Kailash Khola, bank cutting has occurred on the downhill slope of the Bandatal settlement, resulting soil slide (< 100m wide * 50m high * 20m deep). Because of this soilslide, ~30 houses above the crown are under high risk. The Todobuiya Khola also has soil slides along its banks, but the settlements are more or less at a safe distance (>200m) from the active cutting.

Sodna-Aulaghat-Baksad area: - The Sodna-Aulaghat-Baksad area has settlements resting on colluvium. Natural lakes (Ramaroshan, Kinimini, and Jigale lakes), which have potentially leaked from permeable colluvium beneath, could generate a subsurface drainage condition around Janttola. The Aulaghat Khola and Todobuiya Khola originate from the mentioned lakes and erode downstream with high discharge and incision.

A major colluvial soil slide (500m long *50m high* 30m deep) has generated on the left bank of Kailash Khola near Aulaghat. Active toe cutting, shifting in the river channel towards its left bank and presence of numerous radial cracks often exceeding ~200m have indicated existing threat to overlying settlement. Some houses have already been abandoned. Minor alluvial and colluvial soil slides (which have affected cultivation) are also present along both banks of Todobuiya Khola, (Figures 15 and 16).

Discontinuous cracks (>100m), nearly parallel to the hill slope, are seen in the cultivated area parts of Baksad.

Figure 14: Satellite image of the Patal-Bandatal area showing instabilities and the observation points.

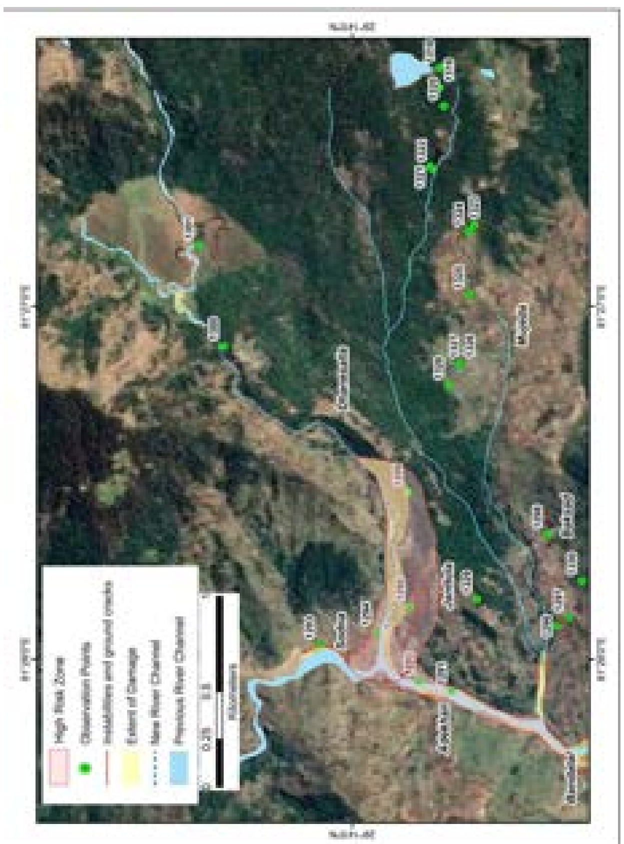

Figure 15: Satellite image of the Sodna-Aulaghat-Baksad area showing instabilities and the observation points.

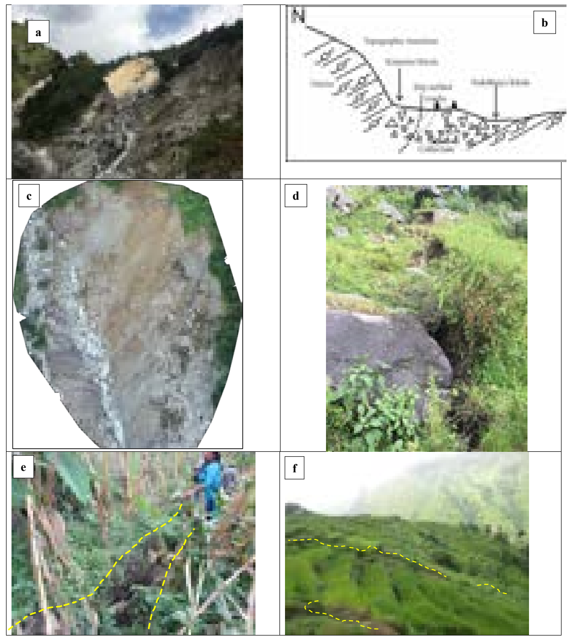

Figure 16: Landslide as viewed from; a) Sodna towards upstream and b) sketch showing cross-section through the landslide, c) Air Drone shot d) Tension cracks above the landslide, e) and f) cracks and shear surface at Baksad area.

Tadigaira-Sallesain area:- Most of the settlements in Tadigaira and Sallesain area are on gentle (<15 °) Northwest facing colluvial slope, except for rocky cliffs covered by forest and barren land (Figure 17). Settlements in this area are away from the Kailash Khola and its major tributaries. However, a seasonal stream that originates from the NE of the Sallesain area is a major cutter of its bank.

Instabilities in the area can be classified into colluvial slides and rockslide. Two majors reactivated colluvial slides ~50m long * 30m wide * 5m deep with exposed slip ~1m and ~50m long * 10m wide are present in the Melsain area in Tadigaira. The cracks associated with the landslide pass across 4 houses, three of which are slightly tilted (Figure 18).

The rock slide at Sallesain is on a road cut and has been aggravated by poor drainage management. Mitigation measures facilitated by the geotechnical study can resolve the problematic road condition.

Allerigaun area: - The Allerigaun lies on a wide cup-shaped valley, filled by colluvium, which probably has been brought by large paleo-landslide as paleo-scars are seen along the ridges (Figure 19). However, at the present condition, the majority of the settlement lie on a moderate (15-25°) slope facing towards the North, making it a relatively stable ground. All minor streams join Khopdi Khola (a tributary of the Balle Khola) forming a parallel drainage pattern. The streams have low discharge and erodeability, as the catchment areas are also small (~2 sq Km). However, towards downstream of the Allerigaun, the Khopdi Khola has a relatively higher discharge. Here active toe cutting along left bank, soil slides (together covering >500m wide*50m high and~20m deep) (Figure 20a, b, c) and cracks associated with them (Figure 20d, e) is seen.

The rock slide at Sallesain is on a road cut and has been aggravated by poor drainage management. Mitigation measures facilitated by the geotechnical study can resolve the problematic road condition.

Allerigaun area: - The Allerigaun lies on a wide cup-shaped valley, filled by colluvium, which probably has been brought by large paleo-landslide as paleo-scars are seen along the ridges (Figure 19). However, at the present condition, the majority of the settlement lies on a moderate (15-25 degree) slope facing towards the North, and it is relatively stable ground with dense settlement (~100 houses), except at the top and bottom of the Allegri village.

Figure 17: Satellite image of the Tadigaira-Sallesain area showing instabilities and the observation points.

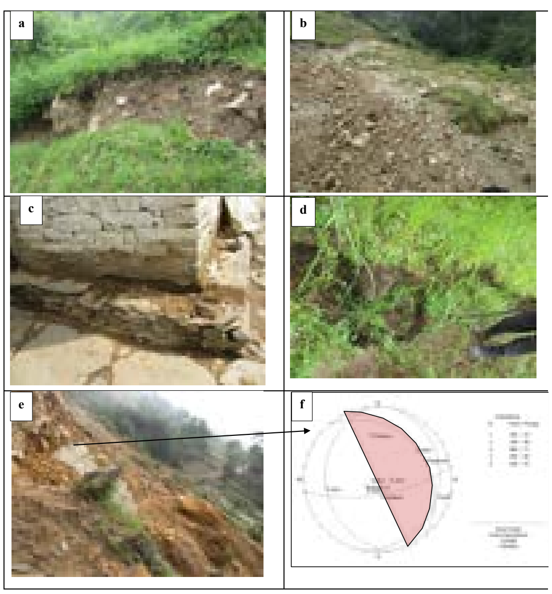

Figure 18: a), b) Exposed slip surface on colluvial soil slide at Melshain; c) cracks on a house and d) cultivation; e) damage to road near Sallesain ; f) stereographic projection of the rock slide.

The drainage is a parallel pattern in the village, and all streams join Khopdi Khola (a tributary of the Balle Khola). The streams have low discharge and erode ability within the settled area, and the catchment area is also small (~2 sq Km). However, at the Allerigaun village base, the Khopdi Khola has a relatively higher discharge and is cutting toe of an old landslide.

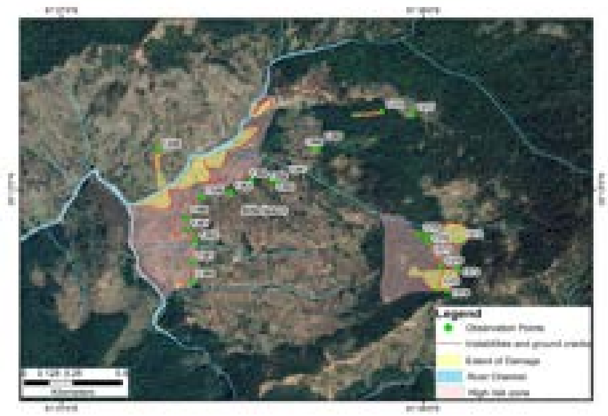

Figure 19: Satellite image of the Alleri area showing instabilities, high risk zone and the observation points.

These instabilities are caused by sliding in a dip slope direction (the exposed micaceous schist (N10E/29°), as well as the hillslope both face towards North). In addition to the rock slides, there are numerous soil slides. The majority of the soil slides in this area must have been further triggered by extreme rainfall (103.6mm) on July 28 (Figure 9).

Figure 20: a), b) c) landslides at the downhill slope of the Alleri Gaun; d) crack on house since landslide event and e) cultivated land above landslide; f) complex failure on colluvium above Alleri village.

At the top of the village, two major landslides are present on deeply weathered gneiss. The radial cracks along the main body of these landslides frequently merge together, suggesting their linkage (Figure 20f). A considerable distance (>300m) from the landslide's deposition zone suggests a relatively low risk to settlement at the foothill.

However, cattle sheds near the ridge should be on alert during extreme rainfall events, and the advancement of the existing landslides should be monitored.

Jethari-Santa area:- Major settlements visited were the Jethari, Santa, and settlements along the way to Balle Khola. Ghatte Khola (which confluences with the Balle Khola) is the main drainage line in the area (Figure 21)

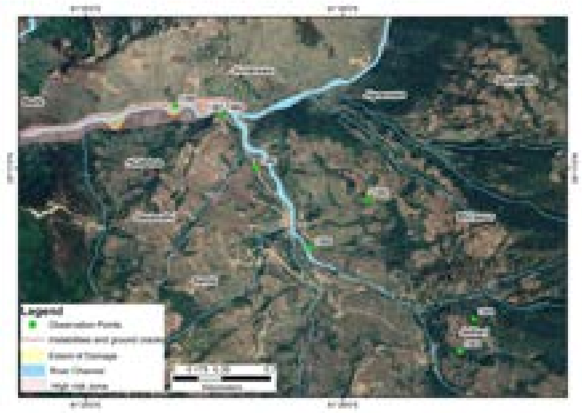

Figure 21: Satellite image of the Jethari-Santa area showing instabilities and the observation points.

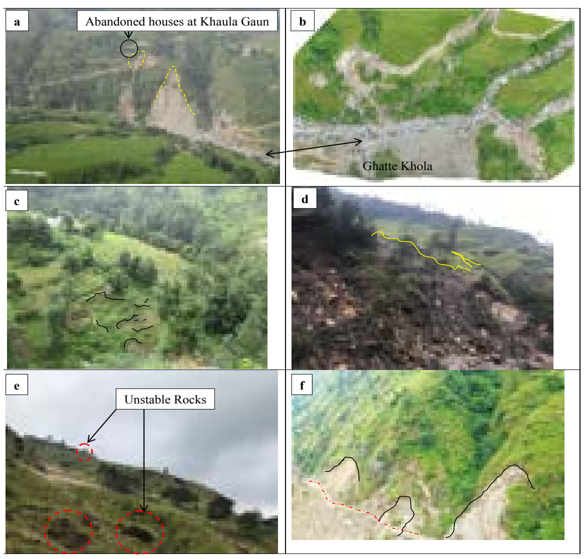

Figure 22: a) landslide triggered after a road construction on colluvium; b) Drone shot mosaic of Landslide along Ghatte Khola; c) shallow soil slide at Jethari village; d) Complex rock and soil slide on the left bank of the Balle Khola affecting Hudetola area; e) detached rocks on steep uphill slope of the road; f) dangerous road with rock falls and soil slide.

TThere are two soil slides at the Santa area; at downhill (80m High*50m wide * 5m deep), and at uphill (30*30*5m) of newly constructed road (Figure 22a, b). These landslides might have been aggravated by poor engineering practice, especially poor drainage management. The Jethari village is relatively stable in terms of soil slide, as only shallow (<5m deep) soil slides are present (Figure 22c). Furthermore, stereographic projection of the measured joints above the Jethari village (Figure 21) shows favourable condition (village has a hillslope aspect towards the South which is counter dip slope with respect to quartzite and schists). Although the Jethari-Santa area seems relatively stable, there are hazards on the way to these settlements. For example, a complex failure (100m wide*30m high) is present at the downhill slope of the Hudetola (Figure 22d). This is a reactivated slide due to toe cutting action of the Balle Khola. The road is also full of a rockfall hazard as the detached blocks (up to 5m longest dimension) are present on the slope of ~30 degrees (Figure 22 e, f).

Santada-Mujabagar-Malata area: - The landslides around Santada, Sara Gaun, Mujabagar, Patekhet, and Malatikot are related to the Kailash Khola Flood event. The Kailash Khola Flood has cut down the alluvial and colluvial terraces on its way, damaging houses, cultivation, and irrigation canals on its flood plains.

The Patekhet settlement (~16 houses) has cracks on the paddy field and is affected by the bank cutting (Figure 24a). Cultivated lands have turned into sandy beach due to flooding on Kailash Khola at the lower part of Patekhet (Figure 24b). A road section (~30m) has been entirely swept by the Kailash Khola during Flooding (Figure 24c). The toe cutting has also reactivated one of the old landslides towards thedownhill slope of the Malatikot Village. However, this landslide has more effect on the road to Malatikot, and the settlement is far from the crown. As numerous bank cutting have been triggered along the banks of Kailash Khola, (Figure 23) 1) construction of river training works along the banks and 2) building new houses at a safe distance from the river channel are needed.

Figure 23: Satellite image of the Santada-MujaBagar-Malata area showing instabilities and the observation points.

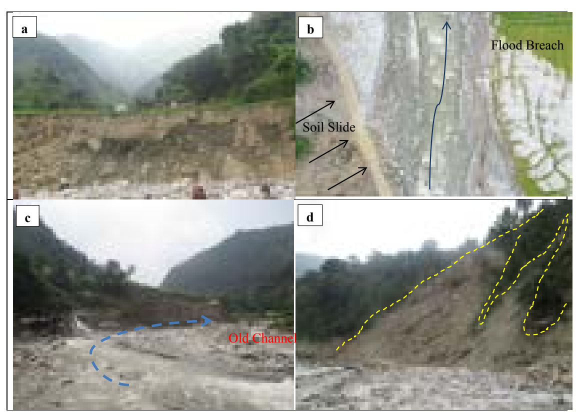

Figure 24: a) Vulnerable settlements at Patekhet due to bank cutting by Kailash Khola; b) Damage due to Kailash Khola on cultivation and road; c) Diverted Kailash Khola swiping out the road on its new path; d) Landslide of Malatikot affecting road at top and below.

3. HAZARD ANALYSIS

3.1 GIS-based landslide susceptibility Analysis

Different factors, 1) Slope, 2) Aspect, 3) Distance to drainage, and 4) Rock or soil were overlaid in Arc GIS to obtain a susceptibility map. Each class's weights were assigned according to their relative contribution to generating landslide (higher role of class to landslide, higher the weight) (Table 1). Different factors were overlaid using the product of each weight for a particular grid, and a final outcome was reclassified into low medium and high susceptibility values (Figure 25). The susceptibility map has its intrinsic limitations and cannot replace site-specific investigation required for resettlement purposes but can estimate regional risk while taking any emergency decision.

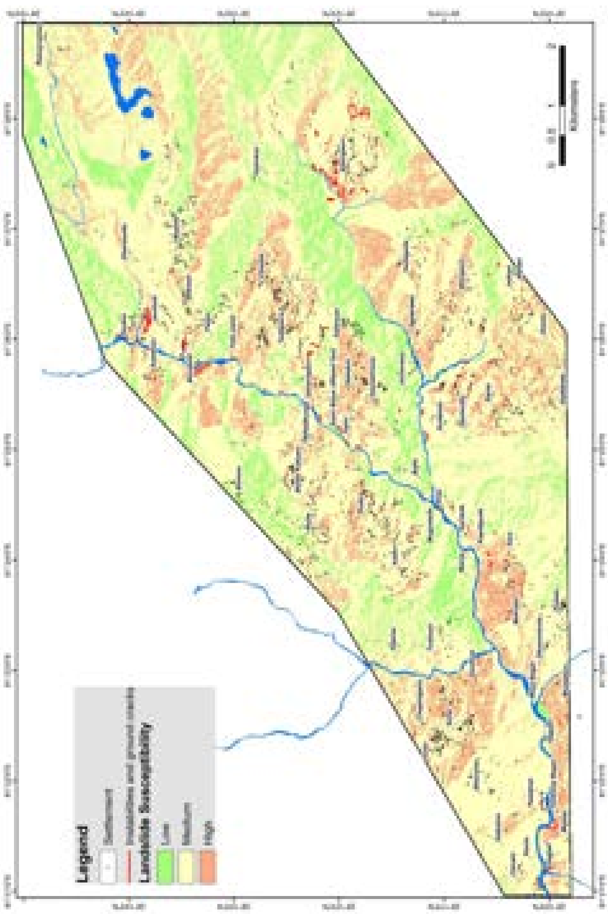

Figure 25: Landslide Susceptibility map of the study area showing instabilities (red line) and the settlements (black dot).

Low susceptibility areas shown by green color (Figure 25) are the places usually gentle in slope, covered by rock, far from drainage or active river erosion, and are relatively stable ground for settlement and relocation purpose. Medium susceptibility areas shown in yellow are places with a moderate slope angle, covered by rock or colluvium, and unstable to moderately stable ground. High susceptibility areas shown in red color are the places near active river erosion. They have a higher slope angle, covered by colluvium or alluvial material prone to erosion or sliding, and should be avoided as far as possible for relocation purpose.

Table 1: Expert based weightage for different factors used in landslide susceptibility analysis

Factor	Class	Meaning	Assigned Weight
Slope (degree)	0-5	Gentle	1
	5-15		2
	15-25		2
	25-35		3
	35-45		3
	>45		2
Slope Aspect (Azimuth)	-1	Flat	1
	337.5-22.5	North	3
	22.5-67.5	North East	4
	67.5-112.5	East	3
	112.5-157.5	South East	2
	157.5-202.5	South	2
	202.5-247.5	South West	2
	247.5-292.5	West	2
	292.5-337.5	North West	2
Distance to drainage	100 to 200m		2
	More than 200m		1
	Upto 100m		2
Rock and Soil	Alluvium		4
	Colluvium		3
	Rock		2
	River		1

3.2 Field-based hazards

Based on the field observation, the study area's hazards can be categorized from high to low severity as 1) Soil slide 2) Bank erosion, 3) Flood, and 4) Rockfalls.

Soil slides in the study area occur on loose colluvium that forms moderate to steep slope and is often assisted by bank cutting. The hazard level depends on the dimension of the landslide and depth of colluvium on which it resides. Although the area has numerous soil slides, the severity of two major soil slides at 1) Aulaghat-Sodna and 2) downhill of the Alleri are relatively high. This is also indicated by crown cracks above the landslide and the increasing separation of these cracks. The hazardous houses and cultivation in these areas should be immediately evacuated and resettled to the relatively low-risk area such as Jantolla (for Aulaghat-Sodna Dhanesalla landslide) and safer parts of the Allerigaun (for lower parts of Allerigaun).

The exposed bank cuts are places where another new cut may occur. Usually, the terraces with paddy farms (which have the possibility of water seepage) are more prone to bank cutting. Especially the alluvial terraces with more than 3m high from the flood plains of the Kailash and Balle Khola are at places of possible bank cutting. Some bank cuttings can also be minimized by technically supervised river training works and dikes construction.

Usually, flood hazard in the hills depends on the intensity of the rainfall and the watershed's catchment size. Measured from the confluence, the catchment area of Kailash Khola is ~100 sq. km, and Balle Khola is ~40 sq km. Therefore, the relative flood hazard for Kailash Khola is higher than the Balle Khola. The area usually gets an average annual rainfall of over 1900mm, and there may be chances of extreme rainfall every 50 to 100 years. The amount of extreme rainfall can be estimated using 50 to 100 years of rainfall data, which can be used to flood risk evaluation. The haphazard construction on the flood plains of Kailash Khola should be discouraged by implementing proper construction code. Furthermore, towards the Kailash Khola's upper reaches, some tributaries have the potential of outburst floods due to landslide damming. For example, the Kinimini Khola (Aulaghat Khola) has a narrow river channel that passes through a topographic transition where even small landslides can block the narrow channel and create an outbursting flood. Therefore, the landslides around the area should be monitored, and an early warning system should be practiced.

In the study area, it is seen that settlements are usually away from the rocky parts. However, there are trails and roads (for example: along the trail to Allerigaun and gorge along on the Balle Khola below Jiunerawa), which pass beneath the rocky cliffs. Mechanisms for trapping such rockfall or channeling to a safe direction, such as using nets or walls or removing unstable rocks from the top, can prevent damage to the road and daily travellers. In the future, new roads, if constructed, should be designed to minimize the rockfall hazard.

4. CONCLUSION AND RECOMMENDATION

The brief field assessment of risky settlements of Shaini, Patal, Bandatal, Sodna, Aulaghat, Baksad, Tadigaira, Sallesain, Allerigaun, Jethari, Santada, Mujabagar, and Malata has been done in this study. The study area has different degrees of hazards of Soil slide, Bank erosion, Flood, and Rockfalls.

- Based on the field observation, Lab GIS analysis, and group discussion, we recommend immediate evacuation of some vulnerable houses at Alleri and Sodna-Aulaghat-Dhanesalla and Bandatal area. Other settlements, especially on the cut banks of rivers or at high-risk zone discussed, should be aware of possible hazards in the future.

- We request the locals to observe and monitor the advancement of existing landslides and associated cracks and evacuate if displacement is noticed. Detail geophysical and geotechnical investigation of the area around Bandatal, Ramaroshan, and Jigale Lakes could be useful to understand the depth of soil and possible leakage of the lakes.

- Many landslides in the study are aggravated by leakage from the paddy fields that lie above the terrace, so we suggest dry cultivation in those areas.

- We also recommend engineering structures aimed to train river, and trap rock falls wherever needed.

- An early warning and communication system for flash flood in the streams fed by lakes could save lives downstream.

- Most of the landslides due to road cut can usually stabilize naturally in ~5 years if the drainage is managed properly, and the cut slope is designed properly. Therefore, we demand the best possible construction practice with side drains, culverts, retaining walls, cross drains for rural roads.

ACKNOWLEDGEMENT

We have deep sorrow for losing 17 people due to the Ramaroshan disaster. We hope that our recommendations will help reduce such unfortunate loss of life and property in the future. We express our thanks to enthusiastic and brave locals of the Ramaroshan VDC, who, despite their loss, comforted us by helping in the field and our stay. Local political representatives from different parties who facilitated the fieldwork are highly acknowledged. We also thank Chandra Prabha Pandey (Department of Hydrology and Meteorology, Nepal) for her generous help to provide us the useful data. We would like to say special thanks to Ganesh Bohara (Sub-engineer, Ramaroshan Local municipality), and Krishna Thagunna (Overseer of office of Ramaroshan Local municipality) for accompanying us during fieldwork.

REFERENCES

Department of Mines and Geology (2020) Geological map of Sudurpaschim province, Nepal.

Department of Hydrology and Meterology, (2020) Rain fall data of July-August 2020, Shugali station, Achham.

Varnes, D. J., 1978, Slope movement and types and processes.

Schuster, R. L., and Krizek, R. J. (eds), Landslides: Analysis and Control. Special Report 176, Washington, DC: National Academy of Sciences,11–33.

Depositional environment of the Phanerozoic Dhaubadi Oodial iron stone (DOIS) of Hupsekot area, Gandaki Province

Saunak Bhandari (Geologist)

ABSTRACT

Geological time of sedimentary iron deposit not only control the characteristics of the iron ore but it also determines suitable method of ore dressing. Dhaubadi Hematite deposit is clearly ooidal ironstones although there can be debate whether it is fluvial channel iron deposits or marine ooilitc ironstone. However, published sedimentological studies show the host rock unit (the middle unit of Amile Formation) was deposited in the Late Mesozoic era (late Cretaceous to early Tertiary time) in shallow-inland sea environment. Hence, it more resembles with Phanerozoic shallow-inland sea iron formation SCOS-IF or Ooilitc ironstone and this iron deposit is named as Dhaubadi Oodial iron stone (DOIS). Mineralogical, geochronological, petrographical, geochemical and microscopy analysis along with detail sedimentological and geological field works are recommended for the further study of genesis of DOIS.

Keywords: Oolitic; Sedimentological Studies; Iron stone.

1. INTRODUCTION

Oolitic hematite is the common sedimentary iron ore of Phanerozoic age which were deposited in shallow, near-shore marine sedimentary environment (Diab et al., 2020; McGregor et al., 2013; Song et al., 2013). It contains accretionary masses of pinhead-sized small and rounded ooids. Such kind of ooidal Phanerozoic Dhaubadi oodial iron stone (DOIS) has been reported from the Upper Gondwana sequence of the Lesser Himalaya of the Central Nepal Himalaya, Hupsekot area, East Nawalparasi district, Gandaki Province (Banskota and Maharjan, 2019). Although detail geological study and substantive revision of published geological map is necessary, general geology, lithological characteristics with columnar sections and chemical characteristics of the DOIS has been already published in the previous bulletins of Department of Mines and Geology (DMG). Here, I have briefly reviewed regional geological setting, sedimentological characteristics, depositional time and environment of the DOIS along with the ore characteristics and its response to ore beneficiation.

2. REGIONAL GEOLOGICAL SETTING OF THE DOIS

The Himalaya has been divided into four major lithotectonic units (Heim & Gansser, 1939). From south to north they are; the synorogenic sedimentary sequence of the Sub-Himalaya, the Lesser Himalaya, the Greater Himalaya and the Tethys Himalaya (Figure 1). The Paleoproterozoic and the Neoproterozoic rock succession of the Lesser Himalaya are supposed to be the northern continuation of the VindhyanSupergroup of the Indian Craton along with the subsurface Ganga Supergroup(Xiao et al., 2016). However, the Lesser Himalaya is defined as the tectonic unit between the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT), thereby comprising the Gondwana unit, the post Gondwana unit and even much younger sedimentary strata of the older Himalayan foreland basin of the Miocene age (DeCelles et al., 2001; Gehrels et al., 2011; Robinson and Pearson, 2013; Sakai, 1983; Sakai, 1991; Upreti, 1999). Therefore, the Lesser Himalaya is divided into four units (Figure 2), the Lower Lesser Himalaya, the Upper Lesser Himalaya, the Gondwana Sequence and the Foreland Basin Sequence (Robinson and Pearson, 2013). Depositional age of the metasedimentary rocks of the Lower Lesser Himalaya with igneous intrusion must be before 1831 Ma (DeCelles et al., 2000). In the central Himalaya (Nepal Himalaya) these rocks are included within the Kuncha Formation, the Fagfog Formation and the Robang Formation with phyllite, metasandstone and amphibolites (Pearson and DeCelles, 2005). From the Bhutan Himalaya, strata with detrital zircon age as young as 500 Ma is named as the Upper Lesser Himalaya (McQuarrie et al., 2008). Across the Himalaya the distribution of the Upper Lesser Himalaya is very heterogeneous, for example; only the Mesoproterozoic rock can be found in Nepal Himalaya (Robinson & Pearson, 2013). Discrete patches of the Gondwana and allied rocks deposited in paralic facies (neritic) and overlying Foreland Basin Sequence are reported from frontal part of the Himalayan Thrust Fold Belt (Sakai, 1983).

Discrete patches of the Gondwana and allied rocks deposited in paralicfacies are reported from frontal part of the Himalayan Thrust Fold Belt in different geographical locations. Although their occurrences are implicated for involvement of the Indian Craton in the Himalayan orogeny (Dhital, 2015), their depositional basin seems to be developed by rifting of the Himalayan crust (Valdiya, 1997) and differ from the Gondwanan basin of the Indian Craton. Number of isolated bodies of such rock units are reported from western Nepal, central Nepal, eastern Nepal, Sikkim/ Darjeeling, Kameng, Subansiri and Siang section (Bashyal, 2001, (1980b); Sakai, 1983; Tripathi and Singh, 1987; Valdiya, 1997). All of them comprise the Lower Gondwana (Permian) sequence but only central Nepal section preserves the upper Gondwana (Jurassic-Lower Cretaceous) (Sakai, 1983; Tripathi and Singh, 1987). Sakai (1983) did detail mapping of his Tansen Group with relatively complete sequence of Gondwana and post-Gondwana sequence of the Himalaya from central Nepal. He divided this Permian to Miocene sequence into five stratigraphic units with unconformaties. He discovered alkaline volcanism the Aulis Volcanics intercalated with the shale and sandstone of the upper Jurassic to lower Cretaceous Taltung Formation.

Sakai (1983) identified five clastic sedimentary units from the western Nepal Lesser Himalaya with the Gondwanan and younger affinity and named as the Tansen Group. The lowest unit of this group, the Sisne Formation overlies the Precambrian carbonate unit with distinct disconformity. The formation constitutes diamictite bed with sandstone intercalations. Fossil occurrences of the Carboniferous to Permian age have been reported from this formation. The Taltung Formation with upper Jurassic to Cretaceous fossils assemblage rests over the SisneFormation with marked discontinuity. Three succeeding units overlying the Taltung Formation are the upper Cretaceous to Paleocene Amile Formation, Eocene Bhainskati Formation and Miocene Dumri Formation. All of these units are characterized by clastic fluvial sediment and the Bhainskati Formation is the most spectacular unit of the Tansen Group with distinct fossil assemblage of large foraminiferal fossils of the Middle Eocene. The Miocene Dumri Formation is the older Himalayan foreland basin with sandstone and mudstone.

DOIS is a ~30m thick stratabound sedimentary ironstone layer, hosted in the Late Cretaceous fluvial quartz arenite. Locally, the DOIS is located on the both flank of the syncline that is oriented in the E-W direction.

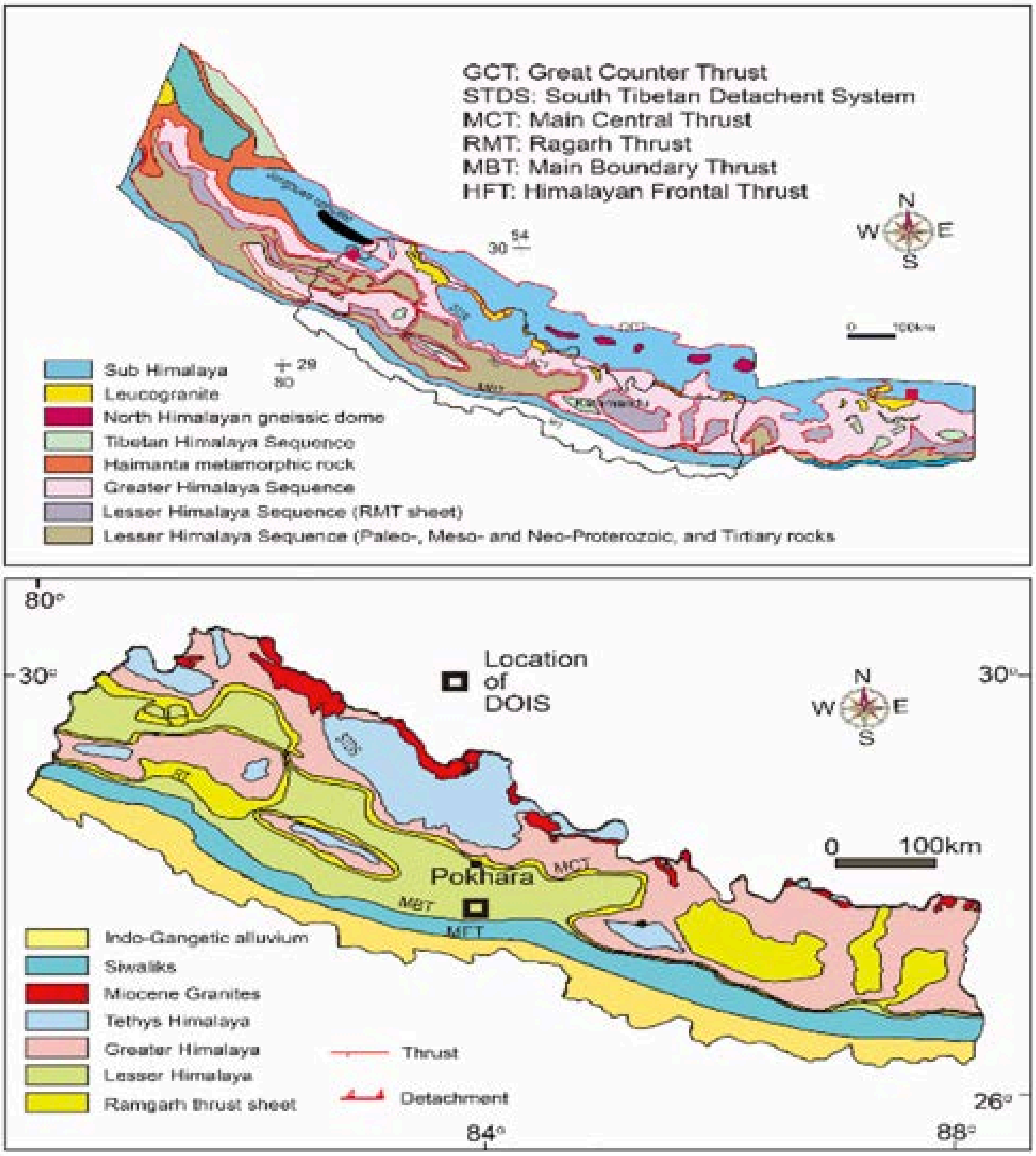

Figure 1. Himalayan arc with boundary of Nepal and Geological map of Nepal with the DOIS location modified from Robinson & Pearson (2013) and(Robinson et al., 2006).

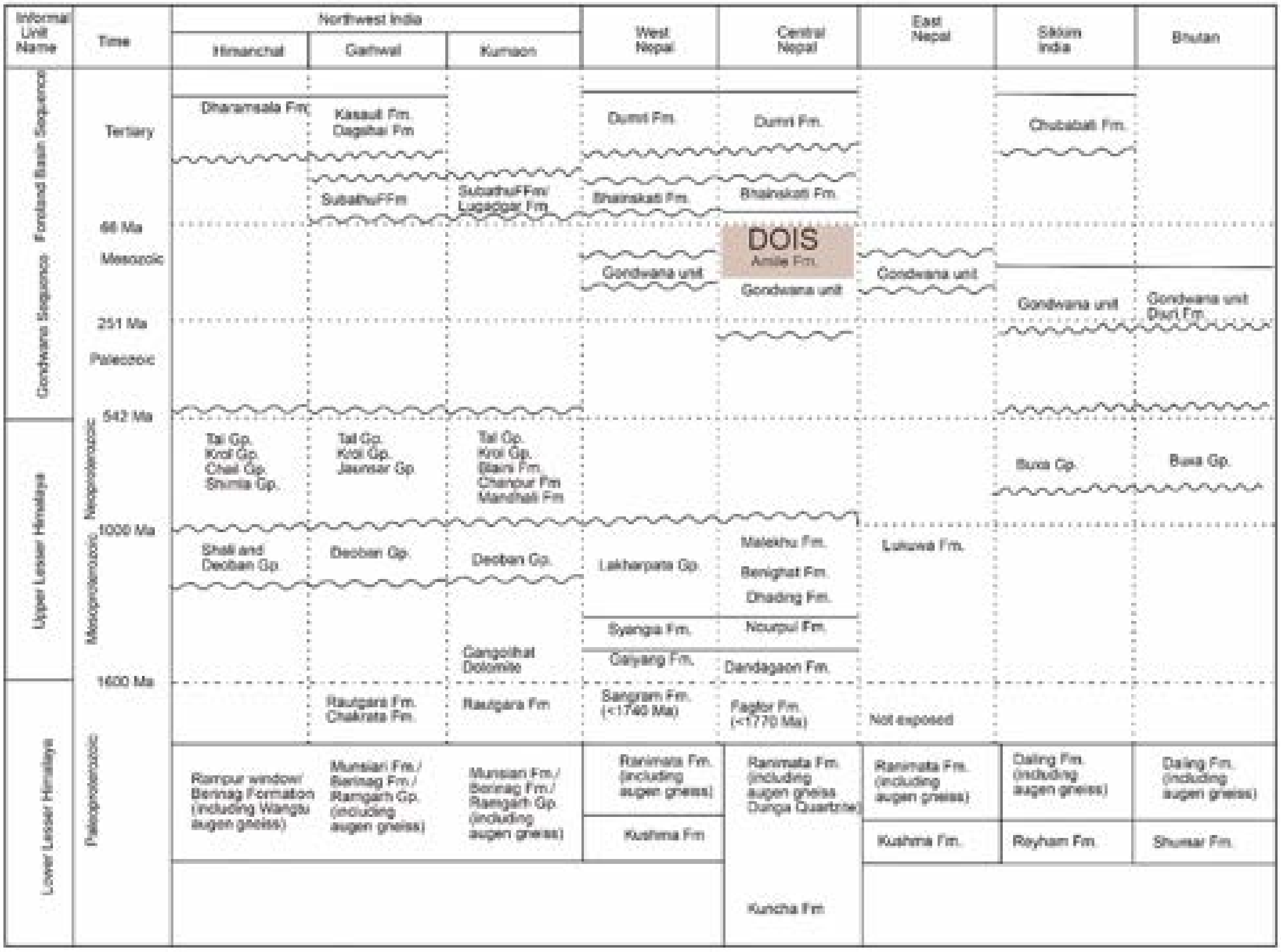

Figure 2. Lithostratigraphic divisions of the Lesser Himalaya in different geographical locations with the position of DOIS. Modified after Robinson & Pearson (2013)

3. SEDIMENTARY ENVIRONMENT OF THE HOST ROCK AND DOIS

The long depositional break is reported throughout the Lesser Himalaya before the deposition of Gondwana Sequence(Robinson and Pearson, 2013). This unconformity between the Upper Lsser Himalaya and the Gondwana sequence is being implicated for the Pan-African orogeny (Upreti, 1999; Valdiya, 1997). Development of separate independent depositional basin for the Gondwana sequence that differ from the Gondwanan basin of the Indian Craton in the Lesser Himalaya has been described by (Valdiya, 1997).Along a narrow elongated depression (that might have formed due to subsidence or failed rifting) sea encroachment took place in the Early Permian time in the Lesser Himalaya. Subsequently, glacio marine sedimentation took place which is the Sisne Formation. Deposition and erosion took place in this basin alternately. The deposition of the Sisne Formation was followed by Cretaceous Taltung Formation consists of fining-upward fluvial cycles of alternating cross-bedded sandstones and mudstones with Ptillophylum, Pterophyllum, Cladopherebis and Elatocladus fossils that were assigned a late Jurassic to early Cretaceous age(Kimura et al., 1985; Sakai, 1983). The overlaying Amile Formation comprises sandstones, shales, and limestones. Three distinct members are identified. It is divided up into the following three members (Sakai 1983). It is essentially a nonmarine unit however the middle member consists of few limestone beds and marine fossils. The fossiliferous argillaceous limestones characterized with fossils like gastropods, echinoids and corals. Lenses of calcareous sandstone, pink colored limestones are reported from this unit along with hematitic oolites and pisolites. The upper and lower members are nonmarine quartoze sandstone and siltstone. Primary sedimentary structures confirm the sediment was sourced from southern Indian side(Sakai, 1983).Ooids develop in extremely shallow water depths with terrigenous sedimentation and organic-rich waters.

4. CHARACTERISTICS OF DOIS

DOIS is characterized by rounded sand particle (silica) surrounded by fine ferrous material that is the oolidal structure (Nar Nar). These ooids formed by 'snowball' accretion of ferrous material in the rim around the core of silica particle in shallow sea environment.

5. ORE BENEFICIATION OF DOIS

Oolitic hematite ore is typically characterized by a special oolitic texture (Banskota and Maharjan, 2019). Oolitic iron ores are formed from ooids that composed of 3 to 6 concentriclayers and a silica particle in center.Liberate iron minerals from oolitic ores is major concern for the beneficiation of DOIS (Song et al., 2013). Suspension roasting followed by magnetic separation is an effective technology to upgrade oolitic hematite iron ores (Li et al., 2015).

6. DISCUSSION

Generally, there are three kinds of sedimentary iron ores (Chieoutimi, 1975; KIMBERLEY, 1979; McGregor et al., 2013), (1) the Precambrian, hundreds of meter thick, conveniently economic Banded Iron Formation (BIF), 2. The Phanerozoic Sandy, clayey, and oolitic, shallow-inland sea iron formation (SCOS-IF) or Ooilitc ironstone (OI), 3. Oligocene to Miocene continental/fluvial ooidal ironstones channel iron deposits (CIDs). Phanerozoic Ooilitc ironstone is characterized by ooidal characteristics, intimately mixed iron oxide and silicate in single ooid, relatively thin strata and sub-economic (low grade) nature.

The depositional basin for DOIS and its host rock was developed in the present day Lesser Himalaya due to the rifting of the Lesser Himalayan crust and development of narrow depression where sea incursion took place in that half graben (might be failed rift). The DOIS is alternating with the metasandstone and shale of the middle member of Amile Formation. The Amile Formation is mainly a non-marine quartz arenite sequence but its middle member is characterized by marine fossiliferous sequence of bluish pinkish limestone, bioterbated beds of shale and oolitic to psilotic hematite beds. Hence, the Middle member of the Amile Formation (=Melpani Formation) of the Cretaceous to Early Tertiary age comprises the DOIS which was deposited in shallow marine environment.

7. CONCLUSION

The sedimentation of DOIS has been guided and controlled by transgressive-regressive cycles and shallow sea encroachment to the present day Lesser Himalaya. Possible source of the iron might be the southern part of the DOIS, where Fe enrichment in seawater could be due to the weathering of adjacent continental formations.

REFERENCE

Banskota, N., and Maharjan, N., 2019, Geological Study of Iron Mineralization Zone Pokhari Area, Hupsekot Rural Municipality, Nawalpur District, Gandaki Province, Nepal: Annual Reports of Departent of Mines and Geology, v. 11, p. 21-31.

Bashyal, R. P., 2001, Gondwana Formations of Nepal Himalayas and Their Regional Significance: Gondwana Research, v. 4, no. 4, p. 572-573.

-, (1980b), Potassic volcanics from the Permo□ Carboniferous Nepal Himalayas: Mem Geol Soc India, Bangalore, v. 3, p. 472–474.

Chieoutimi, E. D., 1975, Paleo-Environment of Iron-Rich Sedimentary Rocks: Minister of Natural Resources of Quebec.

DeCelles, P. G., Gehrels, G. E., Quade, J., LaReau, B., and Spurlin, M., 2000, Tectonic implications of U-PL zircon ages of the Himalayan orogenic belt in Nepal: Science, v. 288, no. 5465, p. 497-499.

DeCelles, P. G., Robinson, D. M., Quade, J., Ojha, T. P., Garzione, C. N., Copeland, P., and Upreti, B. N., 2001, Stratigraphy, structure, and tectonic evolution of the Himalayan fold-thrust belt in western Nepal: Tectonics, v. 20, no. 4, p. 487-509.

Diab, H., Chouabbi, A., Chi Fru, E., Nacer, J.-E., and Krekeler, M., 2020, Mechanism of formation, mineralogy and geochemistry of the ooidal ironstone of Djebel Had, northeast Algeria: Journal of African Earth Sciences, v. 162, p. 103736.

Gehrels, G., Kapp, P., DeCelles, P., Pullen, A., Blakey, R., Weislogel, A., Ding, L., Guynn, J., Martin, A., McQuarrie, N., and Yin, A., 2011, Detrital zircon geochronology of pre-Tertiary strata in the Tibetan-Himalayan orogen: Tectonics, v. 30.

KIMBERLEY, M. M., 1979, ORIGIN OF OOLITIC IRON FORMATIONS: Journal of sedimentary petrology, v. 49.

Kimura, T., Bose, M. N., and Sakai, H., 1985, Fossil plant remains from Taltung Formation, Palpa district, Nepal Lesser Himalaya: Bulletin National Science Museum,, v. 11, p. 141-150.

Li, Y.-j., Wang, R., Han, Y.-x., and Wei, X.-c., 2015, Phase transformation in suspension roasting of oolitic hematite ore: Journal of Central South University, v. 22, no. 12, p. 4560-4565.

McGregor, F., Ramanaidou, E., and Wells, M., 2013, Phanerozoic ooidal ironstone deposits – generation of potential exploration targets: Applied Earth Science, v. 119, no. 1, p. 60-64.

McQuarrie, N., Robinson, D., Long, S., Tobgay, T., Grujic, D., Gehrels, G., and Ducea, M., 2008, Preliminary stratigraphic and structural architecture of Bhutan: Implications for the along strike architecture of the Himalayan system: Earth and Planetary Science Letters, v. 272, no. 1-2, p. 105-117.

Pearson, O. N., and DeCelles, P. G., 2005, Structural geology and regional tectonic significance of the Ramgarh thrust, Himalayan fold-thrust belt of Nepal: Tectonics, v. 24, no. 4, p. n/a-n/a.

Robinson, D. M., DeCelles, P. G., and Copeland, P., 2006, Tectonic evolution of the Himalayan thrust belt in western Nepal: Implications for channel flow models: Geological Society of America Bulletin, v. 118, no. 7-8, p. 865-885.

Robinson, D. M., and Pearson, O. N., 2013, Was Himalayan normal faulting triggered by initiation of the Ramgarh-Munsiari thrust and development of the Lesser Himalayan duplex?: International Journal of Earth Sciences, v. 102, no. 7, p. 1773-1790.

Sakai, H., 1983, Geology of the Tansen Group of the Lesser Himalaya in Nepal Memoirs of the Faculty of

Science, Kyushu University, v. Series D 25, p. 27– 74.

Sakai, H., 1991, The Gondwanas in the Nepal Himalaya: Nainital, India: Gyanodaya Prakashan.

Song, S., Campos-Toro, E. F., and López-Valdivieso, A., 2013, Formation of micro-fractures on an oolitic iron ore under microwave treatment and its effect on selective fragmentation: Powder Technology, v. 243, p. 155-160.

Tripathi, C., and Singh, G., 1987, Gondwana and associated rocks of the Himalaya and their significance: American Geophysical Union, v. 41, p. 195-205.

Upreti, B. N., 1999, An overview of the stratigraphy and tectonics of the Nepal Himalaya: Journal of Asian Earth Sciences, v. 17, no. 5-6, p. 577-606.

Valdiya, K. S., 1997, Himalaya, the Northern Frontier of East Gondwanaland: Gondwana Research, v. 1, no. 1, p. 3-9.

Xiao, S., Tang, Q., Hughes, N. C., McKenzie, N. R., and Myrow, P. M., 2016, Biostratigraphic and detrital zircon age constraints on the basement of the Himalayan Foreland Basin: Implications for a Proterozoic link to the Lesser Himalaya and cratonic India: Terra Nova, v. 28, no. 6, p. 419-426.

Geological Mapping of the Higher Himalaya of Nepal: The next task of the Department of Mines and Geology

Saunak Bhandari (Geologist)

ABSTRACT

Almost half decade of the geological mapping and other geoscientific activities carried out by Department of Mines and Geology (DMG) were focused on the Lesser Himalayan litho-tectonic unit. Except some Higher Himalayan nappes, large area of Higher Himalayan litho-tectonic unit is obscured in regional geological maps published by DMG. Accessibility, rugged topography and unpromising nature for mineral occurrence due to high grade metamorphism might be the cause of this focused work in the Lesser Himalaya. Here, I have reviewed briefly recent advances and future aspect in the study of the Higher Himalaya.

Keywords: High grade metamorphism; Nappes; Regional geology; Mapping.

1. INTRODUCTION

The Higher Himalaya represent metamorphic core of the Himalaya. It comprises quartzite, schist, orthogneiss, paragneiss, marble and migmatites with major detrital age of 800 to 1000 Ma (DeCelles et al., 2000; Parrish and Hodges, 1996). Intrusion of Paleozoic granite and tertiary leucogranite resemble with Paleozoic and Himalayan orogeny respectively. The Higher Himalayan thrust sheet thrust over the Lesser Himalaya along the Main Central Thrust (MCT). Higher Himalayan Klippe are common in the Mahabharat range of the western Nepal Himalaya whereas windows are frequent in the eastern Nepal Himalaya. Inverted nature of metamorphism of the Higher Himalaya, extrusion mechanism and position of the lower bound MCT are the long lived controversies of this unit.

Higher Himalaya was supposed to start to exhume after the early Miocene (DeCelles et al., 2004), but recent studies show it was already exposed at the Eocene (Carosi et al., 2016) or even in the Permian Period it might have not been covered (Grujic et al., 2017). Similarly number of discontinuities within the Higher Himalaya is being reported from different sections of the Himalaya (Ambrose et al., 2015; Carosi et al., 2016; Iaccarino et al., 2017; Kohn et al., 2004; Larson et al., 2015). The lower Paleozoic granite related to the early Paleozoic orogeny (Gehrels et al., 2006) and the Miocene leucogranite (Lefort et al., 1987) assist reconstruction of the Himalayan evolutionary history by basin analysis with its distinct age character.

Metamorphic grade and lithological composition across the Higher Himalaya is not identical in different geological section. Likewise, as the position of the MCT is in dispute the extent of the Higher Himalaya is controversial.

2. POSITION AND DEFINITION OF THE LOWER BOUND OF THE HIGHER HIMALAYA

The lower bound of the Higher Himalaya, the Main Central Thrust (MCT) has been mapped along the entire Himalayan range but the position and definition are always being matter of debate. The MCT is being defined by protolith boundary (DeCelles et al., 2000; Parrish and Hodges, 1996), high strain zone (Searle et al., 2008), a single thrust (Robinson et al., 2006), a system of thrust (Larson et al., 2015), a thick ductile thrust zone (Paudel and Arita, 2000). These explanations not only shift the position and thickness of the shear zone but also alter the amount of convergence of the Himalayan crust (Robinson et al., 2006; Schelling, 1992). Therefore, position of the MCT need to be revised along with the emplacement mechanism of the metamorphic core.

3. EMPLACEMENT MECHANISM OF THE HIGHER HIMALAYA AND DISCONTINUITIES WITHIN THE GREATER HIMALAYA

Two popular school of thoughts for the extrusion of the Higher Himalaya are critical taper model (Kohn, 2008) and Channel flow (Beaumont et al., 2001). Discoveries of tectono-metamorphic discontinuities within the Higher Himalaya led to reconsideration of the understanding of the emplacement and exhumation history of metamorphic core of continent-continent collision orogeny (Ambrose et al., 2015; Carosi et al., 2018; Kohn, 2008). Moreover, major role of duplexing for the mountain building process of Himalaya are being invoked by recent advances (He et al., 2016) instead of conventional different models of extrusions such as channel flow (Beaumont et al., 2001) or Critical taper (Kohn, 2008). Observed PT profiles from different parts of the Himalaya do not match famous models for the Higher Himalayan exhumation such as channel flow or critical taper. The footwall with prograde burial PT path and hanging wall with retrograde PT path is reported from the Likhu River region east central Nepal (Shrestha et al., 2017). Similar kind of discontinuities within the Higher Himalaya has been reported from different parts of the Himalaya. These discontinuities are being implicated for critical taper model (Kohn, 2008), the Eocene exhumation of the Higher Himalaya or progressive imbricate stacking of the MCT system. Granulitized eclogite have been reported from the Higher Himalaya of eastern Nepal (Corrie et al., 2010), Bhutan and Tibet. Emplacement mechanism of such high-pressure rock is still unknown. Hence, structural as well as metamorphic criteria should be integrated to study the metamorphic core emplacement.

4. AVAILABLE STUDIES AND GEOLOGICAL MAPS / ROUTES MAPS, RECENTLY PUBLISHED BY FOREIGN WORKERS

Most of the researh works done by foreigners in the Higher Himalaya are focused on metamorphic paragenesis and thermobaroetric studies. However, they have prepared map or at least route map of the respective area. Here, I have retrieved important geological maps published by foreign workers. These maps are mostly prepared for tectonometamorphic studies of the Higher Himalaya. These maps can be base maps for DMG to conduct detail and intigrated study of the Higher Himalaya.

4.1 Mahakali River section

Heim and Gansser (1939) assigned two crystalline zones above the MCT from the far-western Nepal Himalaya. They are, the Lower Crystalline Zone and the Upper Crystalline Zone. Their Lower Crystalline Zone (with the sedimentary zone of Sirdang) consists of medium to coarse grained, white to green quartzite of the Kushma Formation, green chloritic schist of the Ranimata Formation and medium grained, foliated, L-tectonite Ulleri augen gneiss. The Upper Crystalline zone comprises relatively high-grade metamorphic rocks with leucogranite dikes and sills.

Heim and Gansser (1939) divided Upper Crystalline unit into 7 compositionally distinct packages (Figure 1). The Zone consists of garnetiferous two-mica schist. The Zone b comprises garnetiferous schist with few aplitic layers and psamatic schist. This zone is partially migmatized schist with several layers of biotite orhtogneiss and sills of amphibolites. Large augens of feldspar gneiss signifies the obvious southward movement of the thrust sheet. Zone c is characterized by migmatitic, banded psamatic gnesis, lime silicate bands at its upper part. The conspicuous the Zone d is made up of thick quartzite series and kyanite-garnet-biotite gneiss. Kyanite bearing quartzite was found in Gati Bagad area. First leucogranite dikes found in this zone. The Zone e is distinguished from underlying zone by the appearance of augen gneiss and more frequent dikes of pegmatite. Big snowball garnet reappears in this zone alike Zone a and Zone b. The Zone f is characterized by intercalation of biotite psammitic gneiss and marble bands. The conspicuous unit with porphyroblastic biotite schist represents the Zone g or Budhi Schist.

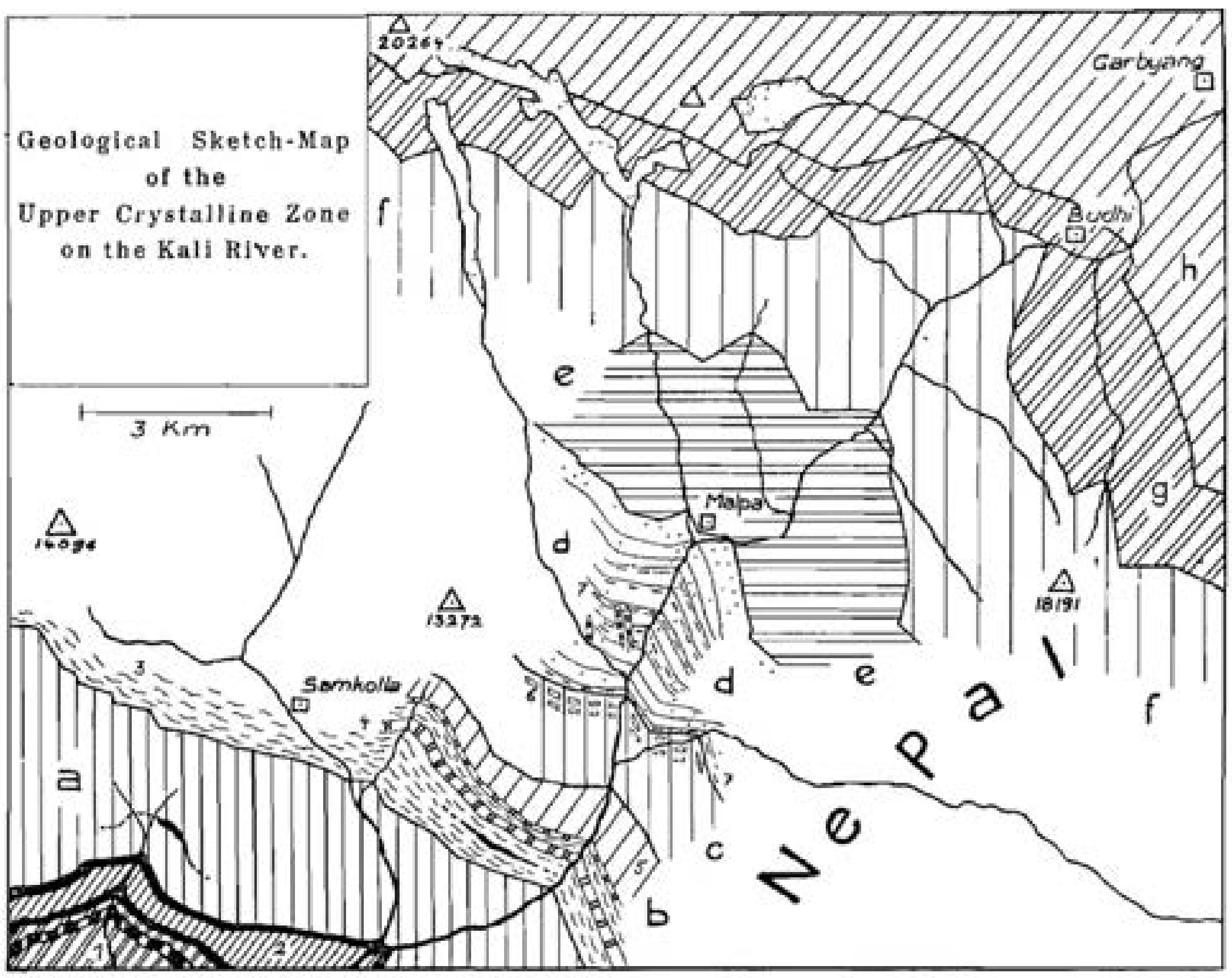

Figure 1: Geological map of the Higher Himalaya of the Mahakali river section retrieved from Heim and Gansser (1939)

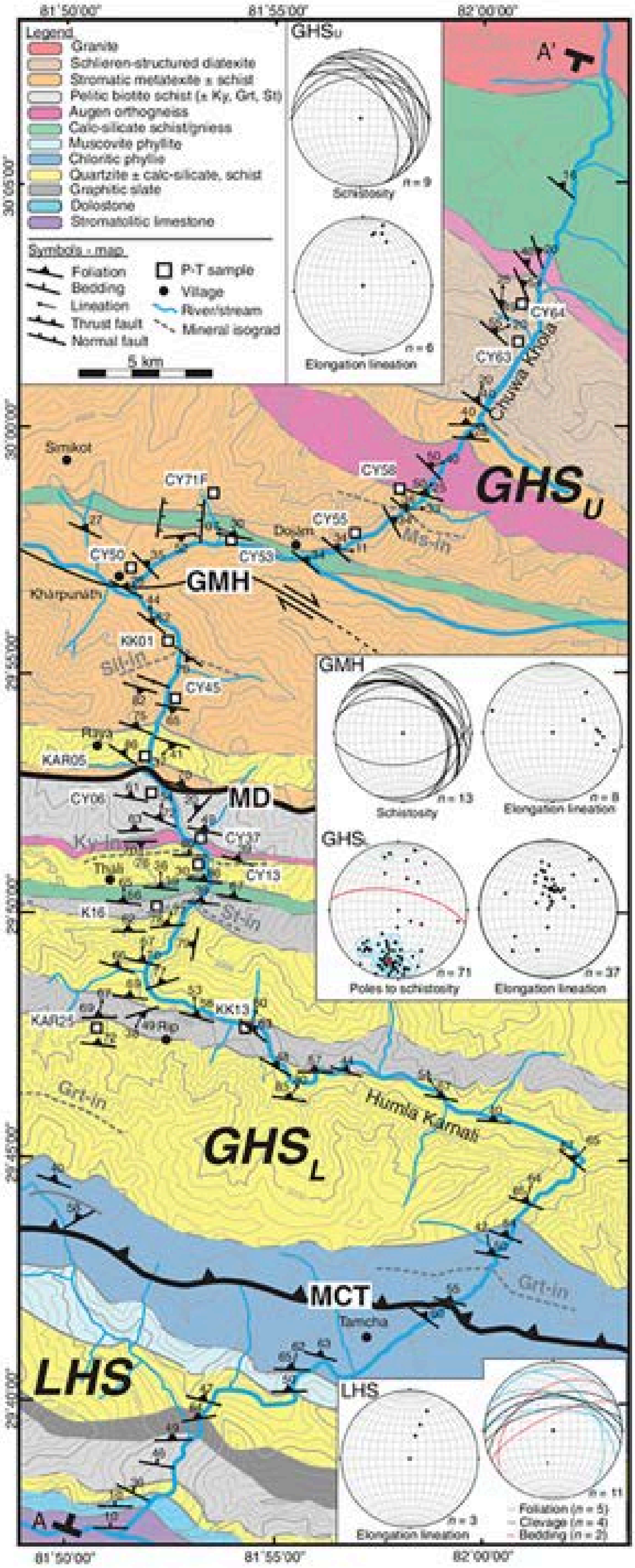

Figure 2: Geological map of the Higher Himalaya of the Humla Karnali section retrieved from Yakymchuk and Godin (2012)

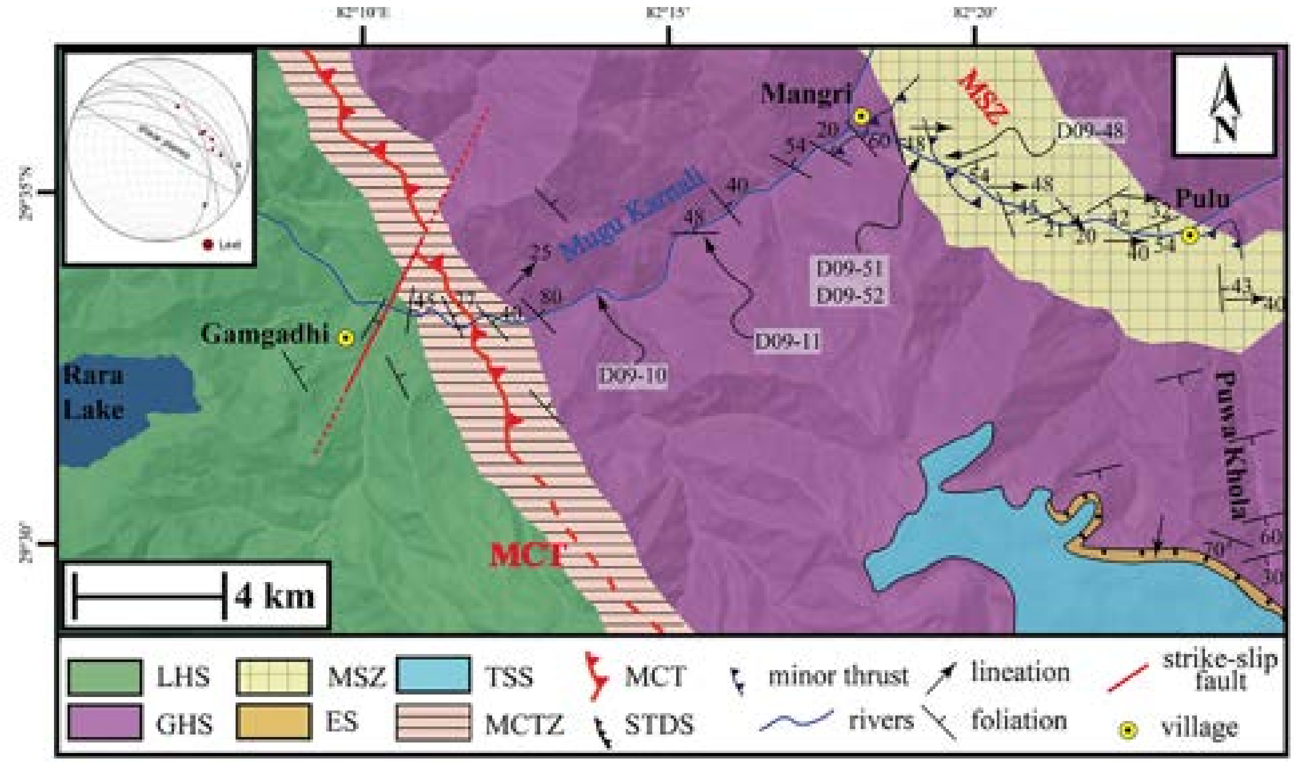

Figure 3: Geological map of the Higher Himalaya of the Mugu Karnali section retrieved from Montomoli et al. (2013)

4.2 Seti River section

Higher Himalaya from the Seti River section is less studied compared to other sections. The western Nepal section has been well mapped and structural setting has been analyzed (Robinson et al., 2006). However, these studies are focused on the Lesser Himalaya and their Ramgarh Thrust sheet (Robinson et al., 2006). These studies adopted 3-fold classification of Central Nepal Kaligandaki section. Unit I, Unit II and Unit III are distuingshed by pelitic gneiss, calc-silicates, and granitic orthogneiss respectively. Robinson et al. (2006) has prepared the regional geological map of the Far-western Nepal Himalaya which can be the base map to study the geology of the Higher Himalaya of Far-western Nepal Himalaya.

4.3 Karnali River section

Yakymchuk and Godin (2012) divided the Highrer Himalaya of Humla Karnali into two tectonometamorphic units, lower structural unit is characterized by garnet-kyanite gneiss whereas Upper Unit comprises silliminite grade magmatic gneiss (Figure 2). The attitude and lithological analysis of Humla Karnali section has been provided by this study.

A thick shear zone has been reported from Mugu-Karnali section (Montomoli et al., 2013). Montomoli et al. (2013) made implication for earlier 28 Ma exhumation of Higher Himalaya along this shear zone. The geologicl route map along the Mugu Karnali section can be the base map for the study of Higher Himalaya of this zone (Figure 3).

4.4 Kaligandaki river section

This section is classical section for the Higher Himalaya in the Nepal Himalaya. Clasically, the Kaligandaki river section the Higher Himalaya has been divided into 3-Formations (Figure 4). The Formation I comprise quartzite and mylonitic schist (Rai et al., 2005). The Formarion II overlies Formation I and is characterized by calcareous gneiss and impure marbles. The Formation II is followed upward by Formation III and represented by augen gneiss, pegmatite and leucogranite.

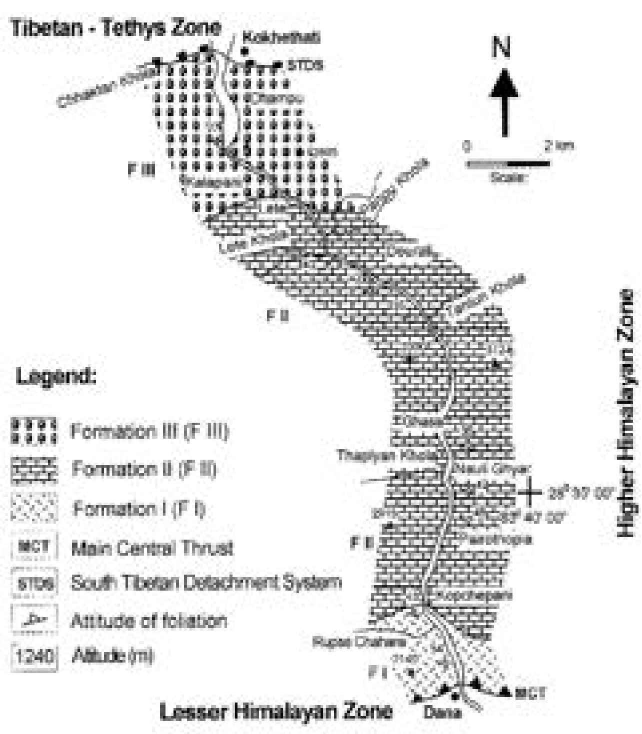

Figure 4: Geological map of the Higher Himalaya of the Kali Gandaki river section retrieved from Rai et al. (2005)

4.5 Modi Khola section

Martin et al. (2010) divied Higher Himalaya into 3-Units in Modi Khola section (Figure 5). Unit 1 of lower structural level comprises pelitic and psammitic schist and gnesiss with interlayered quartzite. Unit 2 comprises calcareous gneiss with few marble bands. Unit 3 is characterized by granitic augen gnesiss.

4.6 Gorkha-Manaslu area

This section is explored by many authors and controversy remains on tracing the MCT. Larson et al. (2010) traced MCT structurally above the rocks of the Lesser Himalayan sequence with sub-biotite-grade chlorite phyllite or phyllitic slate with abundant sand grains of K-feldspar and quartz (Figure 6). The Ulleri augen orthogneiss occurs as a lenticular mass within the metasedimentary rocks is considered as the lower part of the Higher Himalaya. It is followed by metasedimentary rock, with minor igneous intercalations. It is overlain by kyanite gneiss, sillimanite paragneiss Granitic orthogneiss, Greater Himalayan sequence is amphibolite-grade, diopside-bearing calcsilicate schist with locally abundant phlogopitic marble.

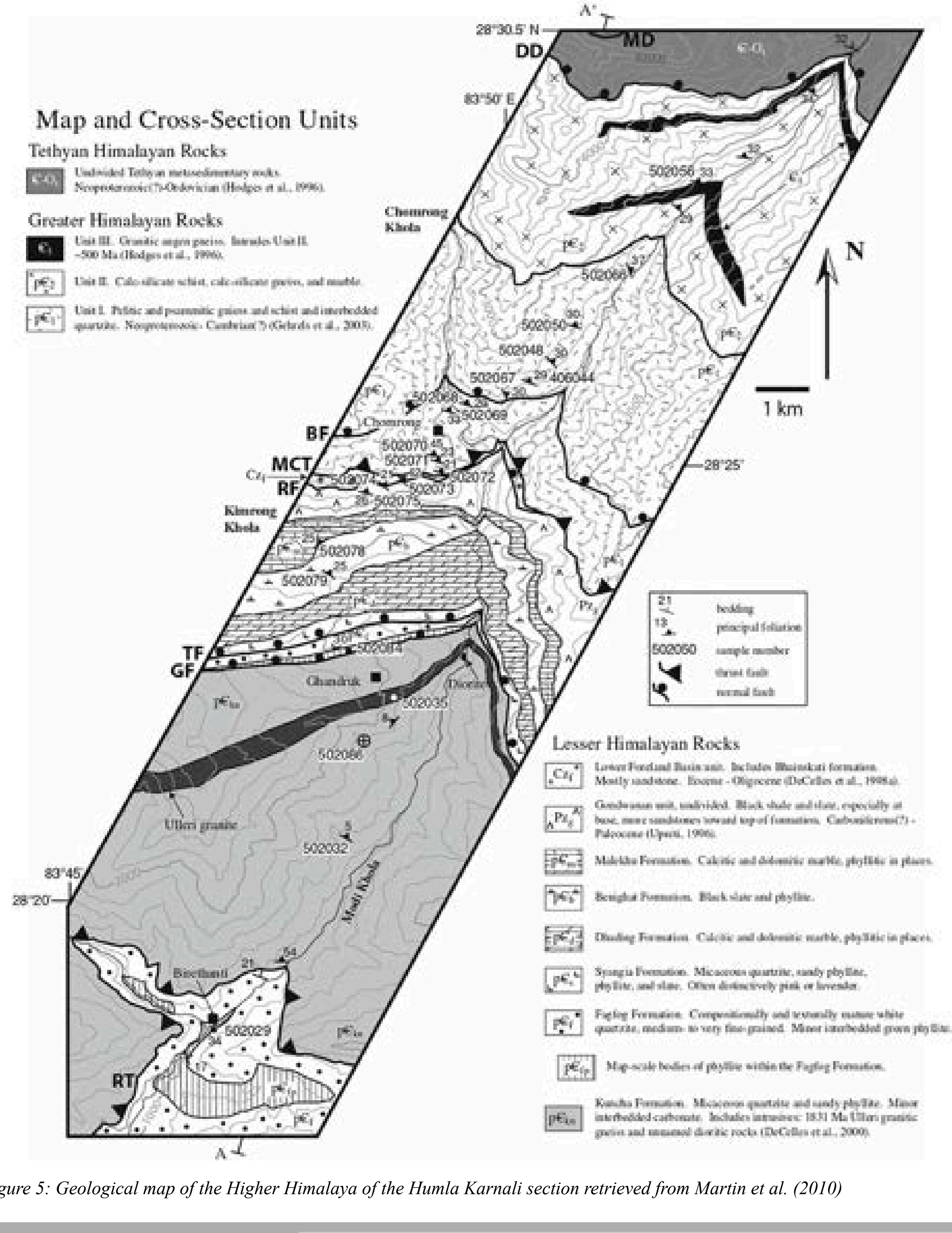

Figure 5: Geological map of the Higher Himalaya of the Humla Karnali section retrieved from Martin et al. (2010)

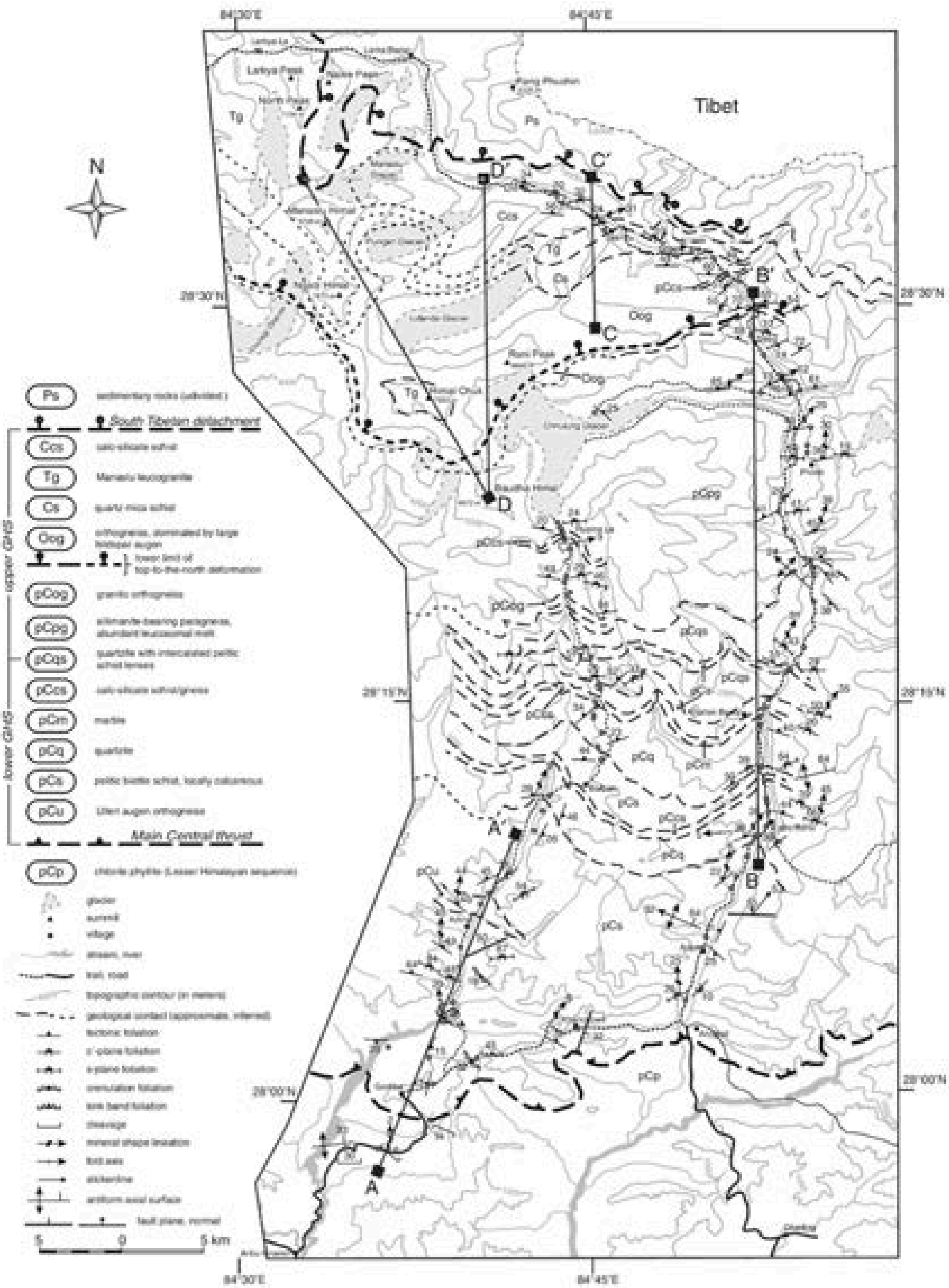

Figure 6: Geological map of the Higher Himalaya of the Gorkha-Manaslu are retrieved from Larson et al. (2010)

4.7 Langtang area

Kohn et al. (2004) have classified rock units of the Langtang area on the basis of metamorphic characteristics (Figure 7). Metamorphic zonation from lower to upper part is shown as kyanite–muscovite, sillimanite–muscovite and sillimanite– K-feldspar zones, and metamorphic grade increases structurally upward.

4.8 Dolakha area

Wang et al. (2013) has divided the Higher Himalaya of this area into lower, upper and uppermost units. (Quxiang Formation, Jiangdong Formation, Rouqiechuan Formation). These units are lithologically distinct and bound by discontinuies. Uppermost unit is characterized by biotite paragneiss, upper unit comprises cordierite bearing migmatitic gneiss and lowermost non migmatitic kyanite-silliminite bearing paragneiss. Sudip ensured presence of thrust sense discontinuity within the Higher Himalaya. Likewise, their field observation divided the Higher Himalaya into four metamorphic zones. From south to north they are Garnet zone I, Garnet zone II, Kyanite zone and sillimanite zone (Figure 8)

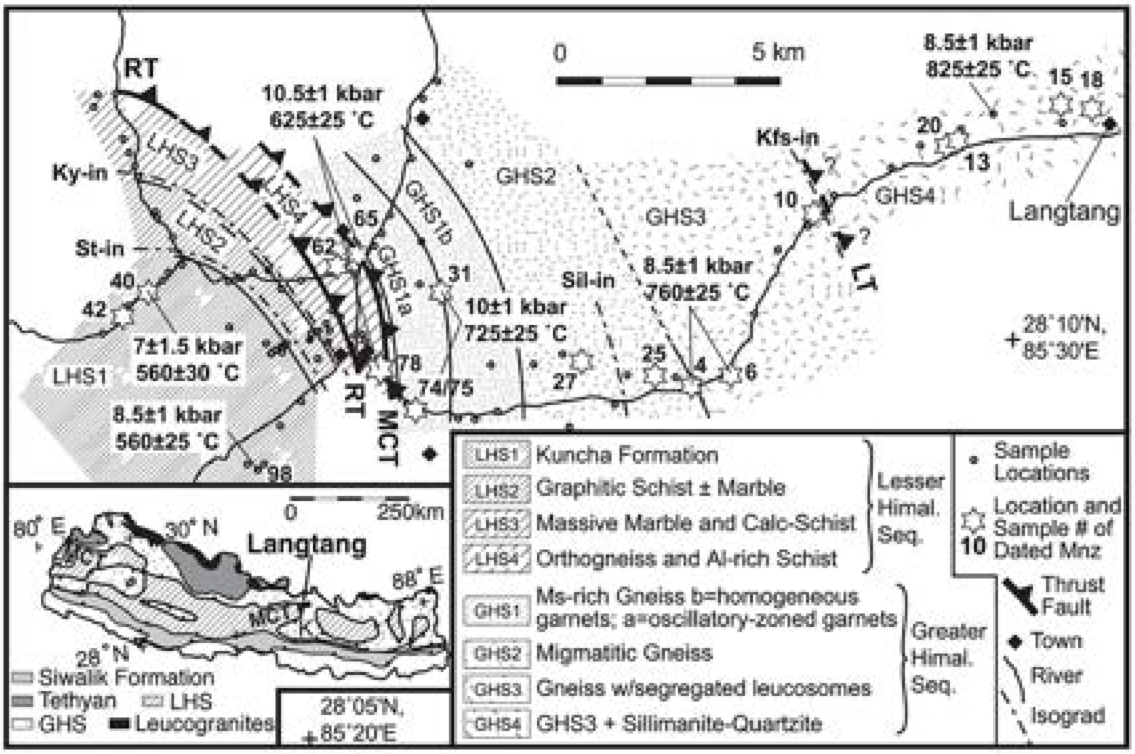

Figure 7: Geological map of the Higher Himalaya of the Langtang retrieved from Kohn et al. (2004)

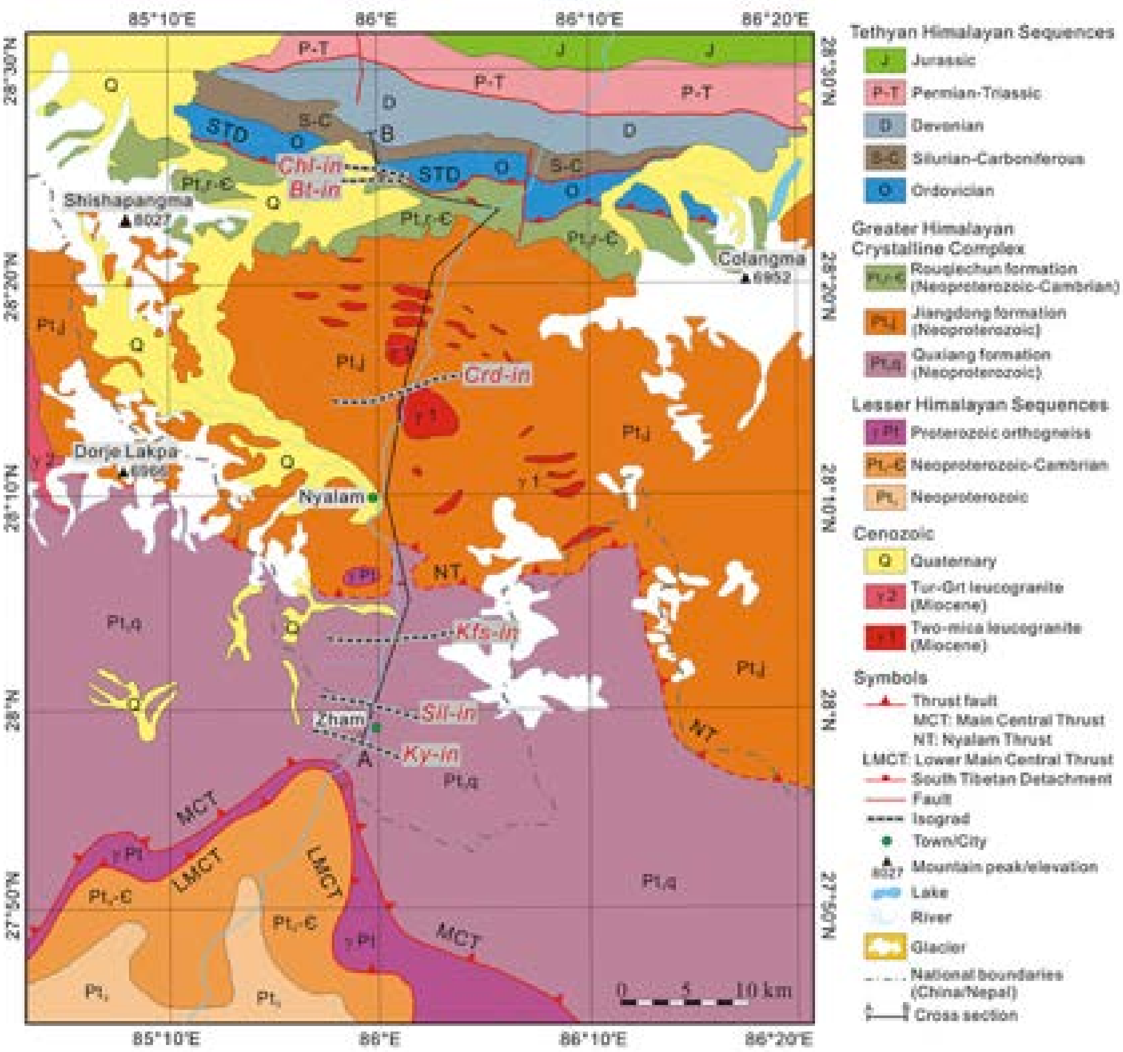

Figure 8: Geological map of the Higher Himalaya of Nyalam area retrieved from Wang et al. (2013)

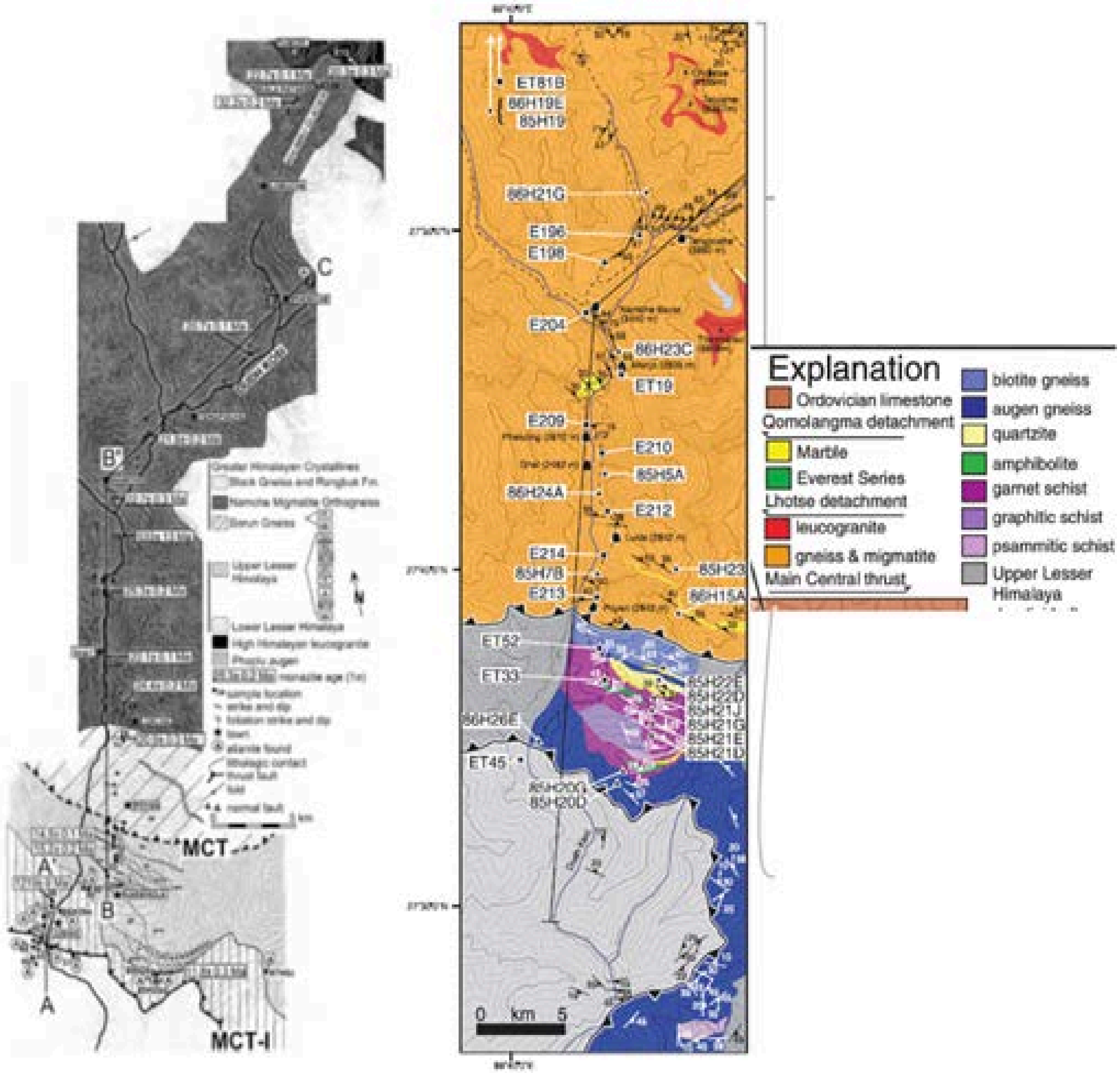

Figure 9: Geological map of the Higher Himalaya of the Doodh Koshi river section retrieved from Catlos et al. (2002) left and Jessup et al. (2008) right

4.9 Dudh Koshi section

Detail map along the Dudh koshi section is available in Jessup et al. (2008). They have prepared cross section along the Everest transect. Lower transect of this section has been mapped and studies by (Catlos et al., 2002) (Figure 9).

4.10 Arun River section

Many studies have been conucted around the Arun valley (Corrie et al., 2010; Groppo et al., 2007; Schelling, 1992). The most pioneer work of this area is (Lombardo et al., 1993). Similarly, many metamorphic studies are done along Chainpur-Gufapokhari section and Num-Makalu track. Goscombe and Schelling prepared geological map of eastern Nepal with respect to metamorphic character (Figure 10).

4.11 Taplejung River Section

Larson et al. (2017) and Ambrose et al. (2015) carried out route mapping along the Basantapur-Terathum-Gufapokhari-Taplejung (Dobhan) –Olangchunggola –Yangma. There studies are focused on kinematic evolution of Higher Himalaya. A thrust sense structures (tectonometamorphic discontinuties) within the Higher Himalaya and demonstrate complex internal structure.

Silliminite bearing migmatitic gneiss of northernmost structural level to chloritic phyllitie of lowermost level is divided into different lithotectonic units. The map shows thrust bound units are lithologically distinct. The geological map of the Higher Himalaya prepared by Larson et al. (2017) is shown in the Figure 11.

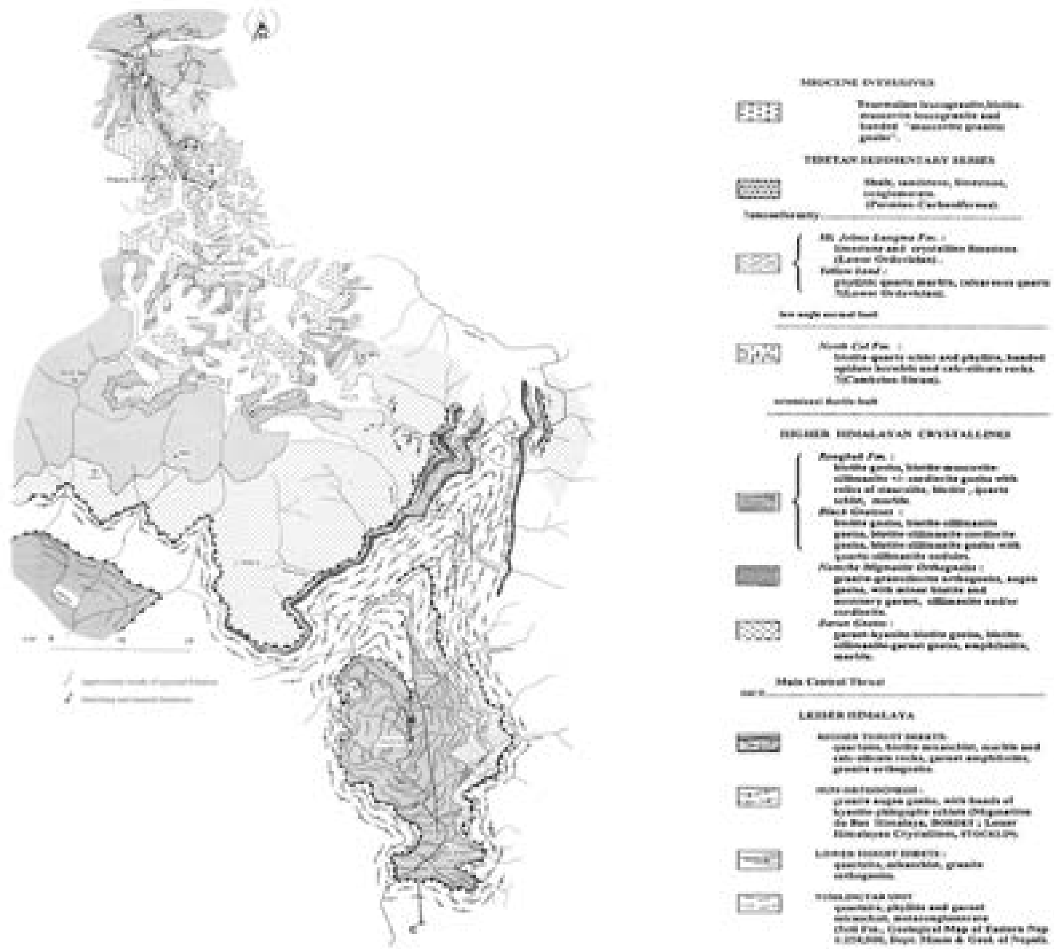

Figure 10: Geological map of the Higher Himalaya of the Arun-Makalu section retrieved from (Lombardo et al., 1993)

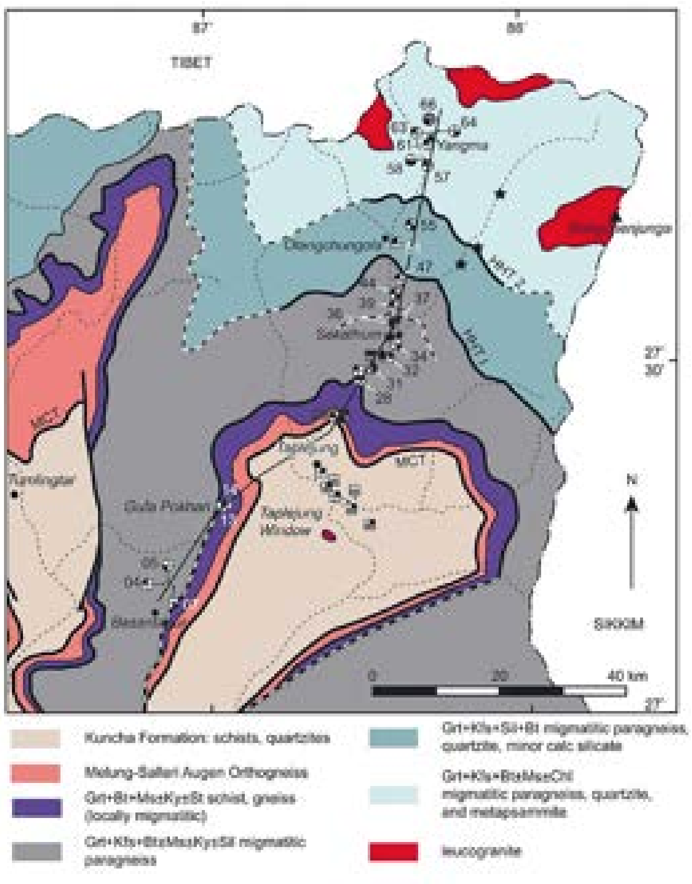

Figure 11. Geological map of the Higher Himalaya of the Tamor river section retrieved from Larson et al. (2017)

5. CONCLUSION

Here, I have discussed few geological studies and maps available and can be the base map for geological mapping of the Higher Himalaya of Nepal. Except these, there are many research works carried out by national and international scientists available and useful for planning and subsequent studies. DMG should compile all of these available maps and prepare priliminary map of the Higher Himalaya of Nepal Himalaya and set some hypothesis for further studies. Studies depicts that Higher Himalaya can be divided with metamorphic parameters, with the shear sense structures and lithological characteristics. Basic parameters for clasification of rock units should be ensured before fieldwork. Geological mapping can be done by obtaining data from virgin area compiling with data frome already studied sections.

Rare metal (Be, Li etc), REE and other metals (Zn, Ag) are possible metallic deposits in the Higher Himalaya whereas gemstone (garnet, tourmaline, kyanite, quartz, aquamarine, ruby, saphire etc.), talc, marble have been reported from various part of the Higher Himalaya. Hence, integrated fieldworks can be carried out for Higher Himalayan mapping and mineral deposit ientification.

REFERENCES

Ambrose, T. K., Larson, K. P., Guilmette, C., Cottle, J. M., Buckingham, H., and Rai, S., 2015, Lateral extrusion, underplating, and out-of-sequence thrusting within the Himalayan metamorphic core, Kanchenjunga, Nepal: Lithosphere, v. 7, no. 4, p. 441-464.

Beaumont, C., Jamieson, R. A., Nguyen, M. H., and Lee, B., 2001, Himalayan tectonics explained by extrusion of a low-viscosity crustal channel coupled to focused surface denudation: Nature, v. 414, no. 6865, p. 738-742.

Carosi, R., Montomoli, C., and Iaccarino, S., 2018, 20 years of geological mapping of the metamorphic core across Central and Eastern Himalayas: Earth-Science Reviews, v. 177, p. 124-138.

Carosi, R., Montomoli, C., Iaccarino, S., Massonne, H.-J., Rubatto, D., Langone, A., Gemignani, L., and Visonà, D., 2016, Middle to late Eocene exhumation of the Greater Himalayan Sequence in the Central Himalayas: Progressive accretion from the Indian plate: Geological Society of America Bulletin, v. 128, no. 11-12, p. 1571-1592.

Catlos, E. J., Harrison, T. M., Manning, C. E., Grove, M., Rai, S. M., Hubbard, M. S., and Upreti, B. N., 2002, Records of the evolution of the Himalayan orogen from in situ Th-Pb ion microprobe dating of monazite: Eastern Nepal and western Garhwal: Journal of Asian Earth Sciences, v. 20, no. 5, p. 459-479.

Corrie, S. L., Kohn, M. J., and Vervoort, J. D., 2010, Young eclogite from the Greater Himalayan Sequence, Arun Valley, eastern Nepal: P–T–t path and tectonic implications: Earth and Planetary Science Letters, v. 289, no. 3-4, p. 406-416.

DeCelles, P. G., Gehrels, G. E., Najman, Y., Martin, A. J., Carter, A., and Garzanti, E., 2004, Detrital geochronology and geochemistry of Cretaceous–Early Miocene strata of Nepal: implications for timing and diachroneity of initial Himalayan orogenesis: Earth and Planetary Science Letters, v. 227, no. 3-4, p. 313-330.

DeCelles, P. G., Gehrels, G. E., Quade, J., LaReau, B., and Spurlin, M., 2000, Tectonic implications of U-PL zircon ages of the Himalayan orogenic belt in Nepal: Science, v. 288, no. 5465, p. 497-499.

Gehrels, G. E., DeCelles, P. G., Ojha, T. P., and Upreti, B. N., 2006, Geologic and U–Pb geochronologic evidence for early Paleozoic tectonism in the Dadeldhura thrust sheet, far-west Nepal Himalaya: Journal of Asian Earth Sciences, v. 28, no. 4-6, p. 385-408.

Groppo, C., Lombardo, B., Rolfo, F., and Pertusati, P., 2007, Clockwise exhumation path of granulitized eclogites from the Ama Drime range (Eastern Himalayas): Journal of Metamorphic Geology, v. 25, no. 1, p. 51-75.

Grujic, D., Coutand, I., Doon, M., and Kellett, D. A., 2017, Northern provenance of the Gondwana Formation in the Lesser Himalayan Sequence: constraints from Ar-40/Ar-39 dating of detrital muscovite in Darjeeling-Sikkim Himalaya: Italian Journal of Geosciences, v. 136, no. 1, p. 15-27.

He, D., Webb, A. A. G., Larson, K. P., and Schmitt, A. K., 2016, Extrusion vs. duplexing models of Himalayan mountain building 2: The South Tibet detachment at the Dadeldhura klippe: Tectonophysics, v. 667, p. 87-107.

Heim, A., and Gansser, A., 1939, Central Himalaya: geological observations of the Swiss expedition 1936: Denkschriften der Schweizerischen Naturforschenden Gesellschaft, Band LXXIII, Abh. 1, p. 245.

Iaccarino, S., Montomoli, C., Carosi, R., Massonne, H. J., and Visonà, D., 2017, Geology and tectono-metamorphic evolution of the Himalayan metamorphic core: insights from the Mugu Karnali transect, Western Nepal (Central Himalaya): Journal of Metamorphic Geology, v. 35, no. 3, p. 301-325.

Jessup, M. J., Cottle, J. M., Searle, M. P., Law, R. D., Newell, D. L., Tracy, R. J., and Waters, D. J., 2008, P-T-t-Dpaths of Everest Series schist, Nepal: Journal of Metamorphic Geology, v. 26, no. 7, p. 717-739.

Kohn, M. J., 2008, P-T-t data from central Nepal support critical taper and repudiate large-scale channel flow of the Greater Himalayan Sequence: Geological Society of America Bulletin, v. 120, no. 3-4, p. 259-273.

Kohn, M. J., Wieland, M. S., Parkinson, C. D., and Upreti, B. N., 2004, Miocene faulting at plate tectonic velocity in the Himalaya of central Nepal: Earth and Planetary Science Letters, v. 228, no. 3-4, p. 299-310.

Larson, K. P., Ambrose, T. K., Webb, A. A. G., Cottle, J. M., and Shrestha, S., 2015, Reconciling Himalayan midcrustal discontinuities: The Main Central thrust system: Earth and Planetary Science Letters, v. 429, p. 139-146.

Larson, K. P., Camacho, A., Cottle, J. M., Coutand, I., Buckingham, H. M., Ambrose, T. K., and Rai, S. M., 2017, Cooling, exhumation, and kinematics of the Kanchenjunga Himal, far east Nepal: Tectonics, v. 36, no. 6, p. 1037-1052.

Larson, K. P., Godin, L., and Price, R. A., 2010, Relationships between displacement and distortion in orogens: Linking the Himalayan foreland and hinterland in central Nepal: Geological Society of America Bulletin, v. 122, no. 7-8, p. 1116-1134.

Lefort, P., Cuney, M., Deniel, C., Francelanord, C., Sheppard, S. M. F., Upreti, B. N., and Vidal, P., 1987, Crustal Generation of the Himalayan Leukogranites: Tectonophysics, v. 134, no. 1-3, p. 39-57.

Lombardo, B., Pertusati, P., and Borghi, S., 1993, Geology and tectonomagmatic evolution of the eastern Himalaya along the Chomolungma-Makalu transect: Geological Society, London, Special Publications, v. 74, no. 1, p. 341-355.

Martin, A. J., Jibamitra, G., and DeCelles, P. G., 2010, Metamorphism of Greater and Lesser Himalayan rocks exposed in the Modi Khola valley, central Nepal: Contrib Mineral Petrol.

Montomoli, C., Iaccarino, S., Carosi, R., Langone, A., and Visonà, D., 2013, Tectonometamorphic discontinuities within the Greater Himalayan Sequence in Western Nepal (Central Himalaya): Insights on the exhumation of crystalline rocks: Tectonophysics, v. 608, p. 1349-1370.

Parrish, R. R., and Hodges, K. V., 1996, Isotopic constraints on the age and provenance of the Lesser and Greater Himalayan sequences, Nepalese Himalaya: Geological Society of America Bulletin, v. 108, no. 7, p. 904-911.

Paudel, L. P., and Arita, K., 2000, Tectonic and polymetamorphic history of the Lesser Himalaya is central Nepal: Journal of Asian Earth Sciences, v. 18, no. 5, p. 561-584.

Rai, S. M., Upreti, B. N., Yoshida, M., and Bhattarai, T. N., 2005, Geology of the Lesser and Higher Himalayan zones along the Kaligandaki Valley, central-west Nepal Himalaya: Proceeding of JICA Regional Seminar on Natural Disaster Mitigation.

Robinson, D. M., DeCelles, P. G., and Copeland, P., 2006, Tectonic evolution of the Himalayan thrust belt in western Nepal: Implications for channel flow models: Geological Society of America Bulletin, v. 118, no. 7-8, p. 865-885.

Schelling, D., 1992, The Tectonostratigraphy and Structure of the Eastern Nepal Himalaya: Tectonics, v. 11, no. 5, p. 925-943.

Searle, M. P., Law, R. D., Godin, L., Larson, K. P., Streule, M. J., Cottle, J. M., and Jessup, M. J., 2008, Defining the Himalayan Main Central Thrust in Nepal: Journal of the Geological Society, v. 165, p. 523-534.

Shrestha, S., Larson, K. P., Guilmette, C., and Smit, M. A., 2017, The P-T-t evolution of the exhumed Himalayan metamorphic core in the Likhu Khola region, East Central Nepal: Journal of Metamorphic Geology, v. 35, no. 6, p. 663-693.

Wang, J. M., Zhang, J. J., and Wang, X. X., 2013, Structural kinematics, metamorphicP-Tprofiles and zircon geochronology across the Greater Himalayan Crystalline Complex in south-central Tibet: implication for a revised channel flow: Journal of Metamorphic Geology, v. 31, no. 6, p. 607-628.

Yakymchuk, C., and Godin, L., 2012, Coupled role of deformation and metamorphism in the construction of inverted metamorphic sequences: an example from far-northwest Nepal: Journal of Metamorphic Geology, v. 30, no. 5, p. 513-535.

Geology and Mineral Prospection Using Gamma Ray Spectrometer in Parts of Gorkha District, Nepal

Dharma Raj Khadka (Senior Divisional Mining Geologist) and Madhav Lamsal (Geologist)

ABSTRACT

According to the annual plan of Department of Mines and Geology for the FY 2073/74, the gelological mapping for mineral exploration in parts of Gorkha district has been carried over an area of 325 Sq.km. Geological mapping was carried out based on the ridge and river section walkover survey. The mineral prospecting work considers the identification of possible mineral prospects for further exploration activities were conducted using geophysical survey consisting of Radiometric survey and assessment of old workings. Geologically, the study area comprises Nawakot group of rocks represented with Kuncha Formation, Dhading Dolomite and Benighat slates of Proterozoic age. The phyllites and quartizes in the lower stratigraphic level is intruded with nephelin syenite whereas garnetiferous schists, metasandstones, psammitc schists and quartzites in the upper stratigraphic level of the Kuncha formation are intruded with Ulleri augen gneiss. The dolomites, graphitic schists and calcareous beds are exposed in the north eastern part of the mapped area. The mineral prospectivity of the area has been established with identification of three prospects of Slab stone, radioactive mineral U/Th and copper. The data shows that the maximum U content was 476ppm and Th 736ppm in nepheline syenite and saprolite. The phalamkhani area shows magnetite ore body injected in the host rock, is radioactive. The fracture porosity and alteration halos are magnetic and radioactive. The Ampipal radioactive mineral prospect has been accepted as an IAEA/DMG TC Project for cycle 2020-21. The follow-up U/Th prospecting is recommended in Ampipal Nepheline syenite and preliminary follow-up exploration of slab stone and copper prospects is recommended to define the prospects.

Keywords: Geology; Mineral prospectivity; U/Th; Slab stone; Copper prospects.

1. INTRODUCTION

According to the annual plan of Department of Mines and Geology for the FY 2073/74, the gelological mapping for mineral exploration in parts of Gorkha district has been carried out from 2073.9.14 to 2073.10.29 for 45 days. The prospecting area is also a part of DMG/IAEA TC project NEP 2006 for prospecting of U and Th in parts of Ampipal area of Gorkha district based on Ground Radiometric Survey. The working area for the geological mapping for mineral exploration lies in the Toposheet no 2884 15C and 2884 15 D at the scale of 1: 25000. The area covers about 325 Sq Km, Figure 1. The study area is about 150km from Kathmandu. Figure 2.

Physiographically, the Lower reaches of Daraudi khola area consist of about 457m height. The highest elevation of 1687m lies around Sirkot area in the eastern part of the mapped area. The mapped area is drained by Daraudi Khola and its tributaries such as Kher Khola, Bhusundi Khola, Khahare Khola, Masel Khola, Jaran Khola, Hudi Khola, Khani Khola, Ladi Khola, Syagdi Khola, Dhundure Khola. The north western part of the study area is drained by Chepe khola and its tributaries such as Khar khola. The topography of the area is more or less gentle. The northern parts are more rugged than southern parts. The topographic expression of nepheline syenite is gentle to scarp forming at places. The area has tropical to sub-tropical climate.

Geologically, Pecker and Le Fort, 1975 discovered alkaline gneiss. Lasserre, 1977 did geochemical studies of the alkaline massif. Bhandari, 1980 did geological mapping of the area. Koide et al, 1992 carried out geochemistry of Ampipal pluton and characterized it with clinopyroxinite shonkinite, malingite and nepheline syenite within the Kuncha Formation. Adhikari, 1993 did palaeomagnetic study of the area to ascertain age of the pluton which was 54-49 Ma (Early Eocene) is doubtable. Dhital, 1995 mapped the study area to reveal the lithostratighaphy and structure of the area and discussed the mode of occurrence of Nepheline Syenite in Gorkha- Ampipal area. Gautam et al, 1998 carried out gamma ray spectrometry and magnetometry of alkaline rock area in Ampipal-Bhulbhule area. Le Fort and Rai ,1999 studied the area and concluded that the Ampipal alkaline gneiss is a small elongated body appearing as a window at the base of the Lesser Himalayan Formations of central Nepal and originated as a Precambrian Nepheline Syenite pluton contaminated by lower continental crust.

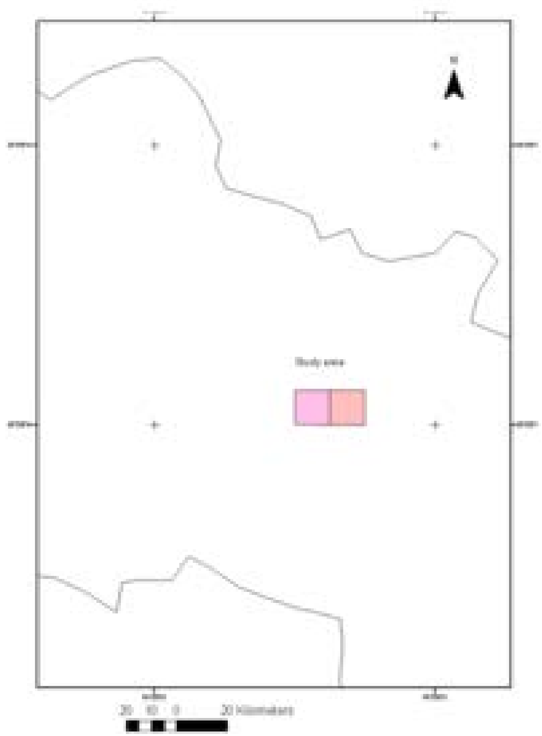

Figure 1: Location map of the study area

This project incorporates geological mapping of the area in 1:50000 scale and mineral peospection in parts of Gorkha District based on the annual field program of Department of Mines and geology for the Fiscal year 2073/74, Table 1. Ampipal Nephelin Syenite is the only alkaline massif so far reported in Nepal Himalaya and is susceptible for radioactive and REE mineralization. The mineral prospecting has been carried out to prospect U and Th and radiation intensity mapping in the area using Scintillation counter and Gamma Ray Spectrometer RS-125. The others are Gyazi Copper and slabstone prospects in the study area.

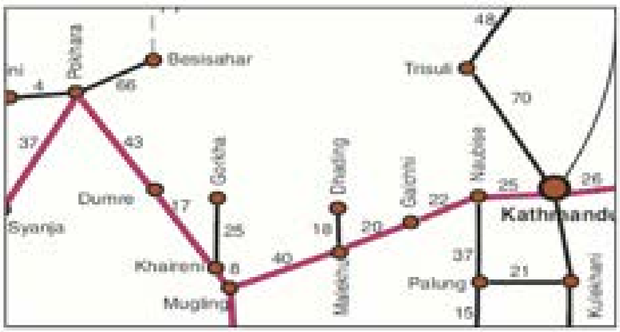

Figure 2: Road network up to Gorkha from Kathmandu

Table 1 : Target area

SN	Toposheet No.	District	Working area	Total area
1	15C 2884 and 2884 15 D	Gorkha	Ampipal, Daraudi Kh, Ghyampesal, Jaubari, Gyazi	325 Sq km

2. MATERIALS AND METHODS

The available Topographic maps and geological map of the area were used as base maps for the geological mapping and mineral prospecting program. Other relevant literature was reviewed before departing the field work. All published and unpublished literature of the area related to the Uranium mineralization were reviewed. IAEA publication STI/PUB/434 related to exploration for uranium ore deposits have been reviewed. IAEA-TECDOC-595 related to guidebook on the development of projects for uranium mining and ore processing has been reviewed. Cunney M and Kyser K edited short course series (2008), Recent and not- so- recent developments in uranium deposits and implications for exploration, V. 39, by Mineralogical Association of Canada has been reviewed. The field study covers geological mapping, mineral prospecting and geophysical survey in the area. Geological mapping was carried out based on the ridge and river section walkover survey on the topographic base map of 1: 25000 scale. The outcrops were studied with due care to establish the lithological units and structure of the area. The equipments and materials used during the field work were Brunton Compass, GPSMAP-62-GARMIN, Geological hammer, Measuring tape, Magnifying glass etc. The Mineral Prospecting work considers the identification of possible mineral prospects for further exploration activities using geophysical survey consisting of Radiometric survey and assessment of old workings. Ground radiometric survey was carried out for detecting radioactive beds of the area. To trace the mineralized beds, Scintillation Counter was used. The respective scintillation counter values were noted down and plotted on the map. The measurement is in a total count value. The Gamma Ray Spectrometer has been used to measure U (ppm), Th (ppm), K% and absorbed dose rate (uGy/hr) of the area. Arc Map 10.2 was used to prepare maps and sections. After all, collection of primary as well as secondary data has been analyzed. Final report has been prepared along with geological, mineral prospectivity and anomaly maps.

3. RESULTS

3.1 Regional Geology

Nepal Himalaya is the central sector of the Himalayan range. Morpho-tectonically it has been divided into Indo Gangatic Plain, Sub-Himalaya, Lesser Himalaya, Higher Himalaya and Tibetan Tethys Himalaya as per regional structural units described by Gansser in 1964. The Himalayan Frontal Thrust (HFT) separates low lying Terai plain in the south with the overriding Tertiary molasses sediments of Sub-Himalaya. The Main Boundary Thrust (MBT) separates the overriding meta-sedimentary rocks of the Lesser Himalaya with the Sub-Himalayan sedimentary rocks. Similarly, broadly, the Main Central Thrust (MCT) separates the Lesser Himalayan meta-sediments with Higher Himalayan crystalline rocks. Recent past results show that the South Tibetan Detachment System (STDS), normal faulting system, separates the Tibetan Sedimentary rocks with the Higher Himalayan rocks.

Systematic mineral exploration activities have been started since 1950's in Nepal. The geochemical, geophysical and systematic geological mapping has delineated the potential mineral targets and deposits. Department of Mines and Geology (DMG) in its own efforts and UNDP/DMG have established the metallic mineral scenario of the central sector of Nepal in 1980's. The ongoing mineral exploration programs of DMG have established some of the potential metallic deposits all over the country. Metallic and non-metallic mineral commodities are explored as economic, sub-economic, occurrences and showings. Some of the potential deposits for further development such as Iron, Copper, Lead, Zinc and Gold are identified in different parts of the country.

However, the national mineral resource potential remains poorly defined due to geographic, infrastructural, financial and technological obstacles. The modernization of the mineral endowment is still waiting.

This incorporates the geological mapping and mineral prospecting work in study area. The study area is a part of the Lesser Himalayan meta-sedimentary units Figure 3.

3.2. Geology of the Study Area

Geologically, the study area comprises Lesser Himalayan meta-sediments. The observation points are shown in

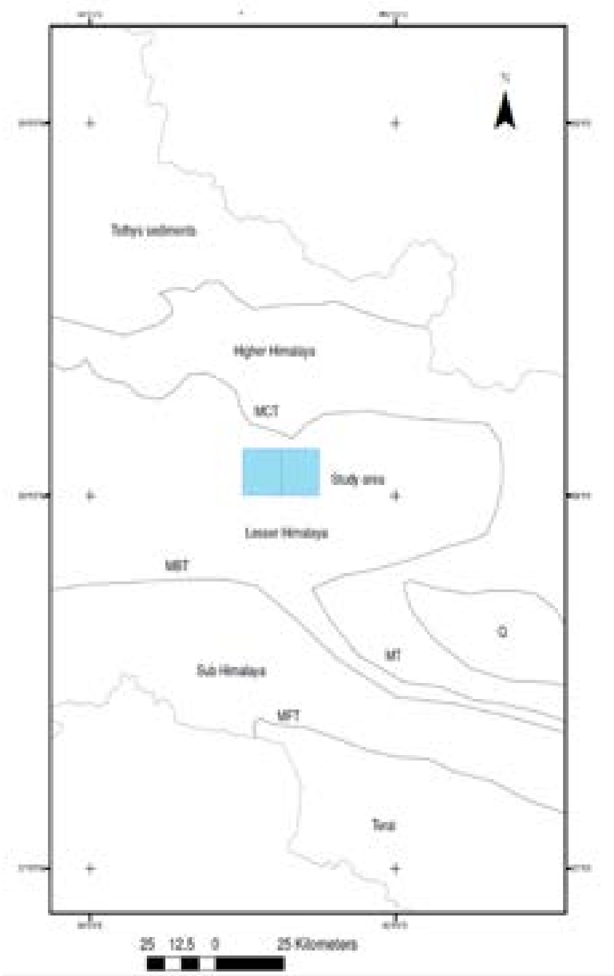

Figure 3: Regional geological map of the area, modified after DMG, 1994.

outcrop location map, Figure 4. Altogether, 508 locations were observed during field work as part of Lesser Himalayan Sequence.

Lesser Himalaya Sequence

In central Nepal, the Lesser Himalaya sequence is divided into two groups, Lower and Upper Nawakot Groups of Proterozoic age. The Lower Nawakot group is represented by Kuncha Formation phyllite and quartzites, is the oldest formation so far found in Lesser Himalaya in Nepal, intruded by Ulleri augen gneiss and Nepheline Syenite whereas overlying Schist intercalated dolomite at the north eastern part of the study area. The upper Nawakot Group is represented with graphitic schists interbedded with dolomite and limestone resembling Benighat Slates in the north eastern part of the study area, Figure 5. The basic rocks are intruded at places within the Kuncha Formation in Table 2.

Kuncha Formation

The basal part of the formation is nowhere exposed in the study area. Based on the lithological positions of the rock strata, the formation could be divided into lower and upper units. The age of the formation is considered to be of Proterozoic.

The Lower unit of the formation crops out in the Luitel Bhanjyang, Bhogteni, Bhaguwa, Kher Khola, Adhmare, Baraigaun, Chepe lower part and Hermi etc. It consists of gray to green phyllite, thin to medium bedded metasandstone and quartzite all around the axial part of the anticline in the southern part of the mapped area, Figure 5. Phyllites and metasandstones are well exposed in the Ligligkotand

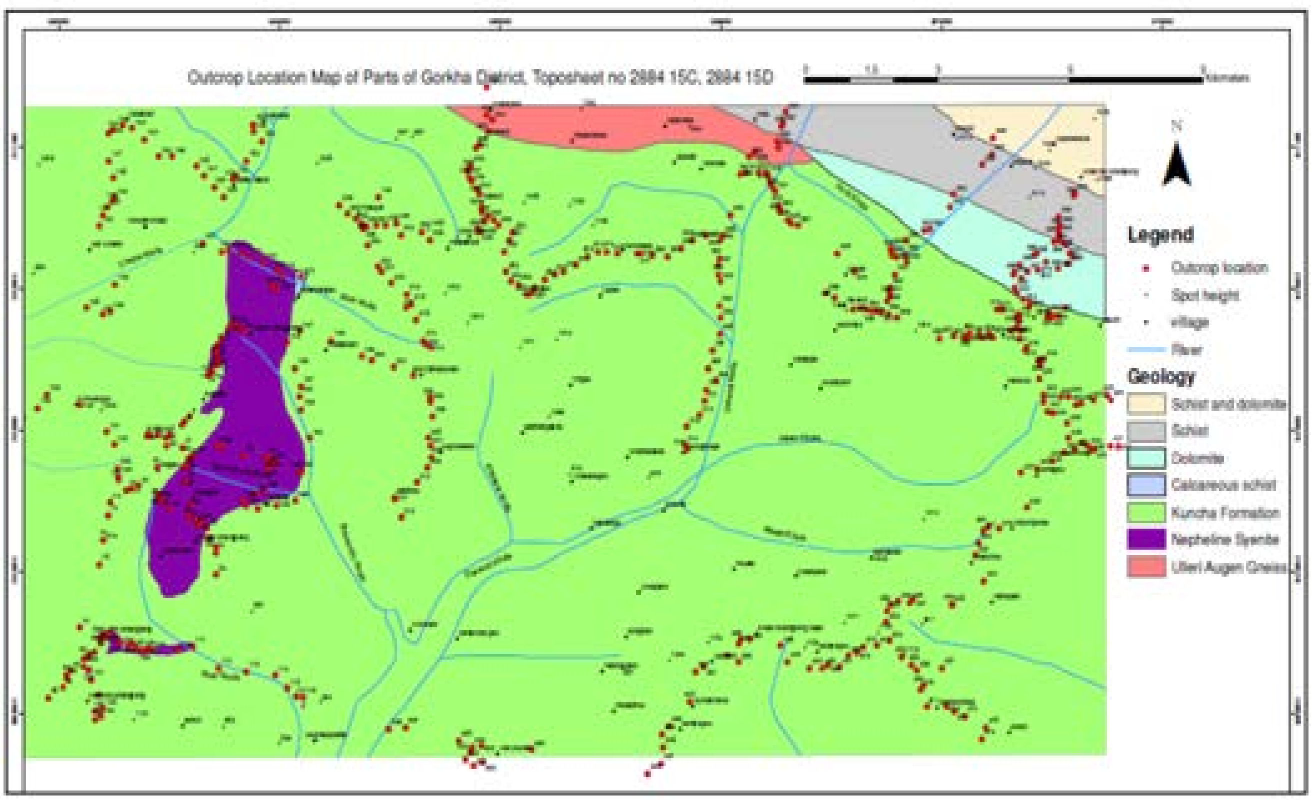

Figure 4: Outcrop location map

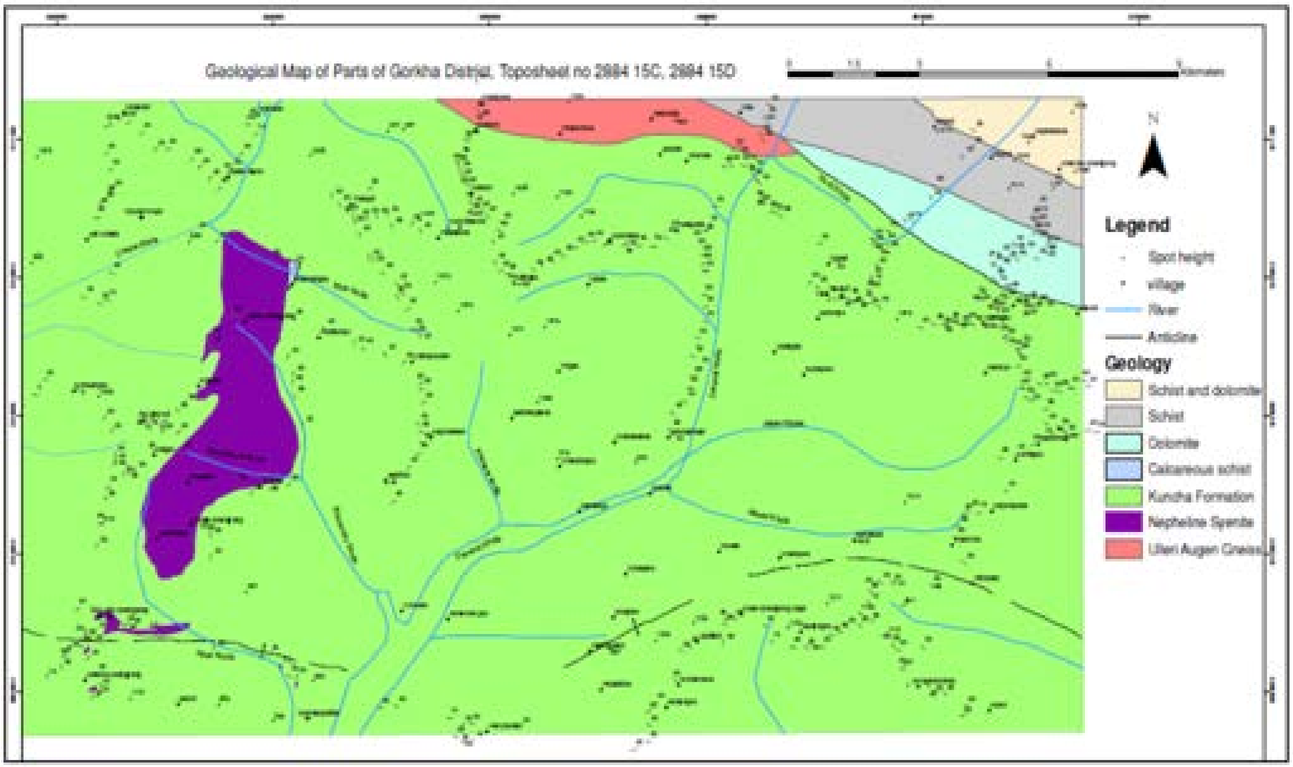

Figure 5: Geological map of the study area

Table 2: Litho-units of the study area

Group	Sub-Group	Formation	Lithology	Age
Nawakot	Upper Nawakot	Benighat	GraphiticSchist, Gt-bt- schist, dolomite and limestone	Proterozoic
	Lower Nawakot	Dhading Dolomite	Dolomite , pelitic and psammitic schist interbands	
		Kuncha	Ulleri augen gneiss Upper unit: Gt-bt-schist, Psammitic schist, biotite quartzite, amphibolites, Cu mineralization Nepheline Syenite- radioactive Lower Unit: Phyllite, metasandstone, quartzite	

Hermibhanjyang area, Photo-1, 4. The nepheline syenite body intrudes within the host rocks of this unit, Photo-2, 3, 5. The clinopyroxene dominated nepheline syenite is found in the Khar Khola section and middle part of the pluton, Photo-8. The dipping direction of the rocks diverges away from the pluton. Small pods and bodies of nepheline syenite are exposed in Luitel bhanjyang area, Figure-5. Calcareous rocks, marble? are exposed in the northern part of the pluton around Bhandarigaon, Figure 5, Photo-6. A hotspring having sulphur odour has been located at the terrace of Kher Khola, Photo-7. The metasandstone and phyllite used for slabstone is observed nearby suspension bridge of Chepe Khola access for Baraigaon, Photo-10.

The Upper unit of the formation exposed in the northern part of the study area around Panthedada, Ratmate, Chitrepokhari, Thalajung, Chipleti, Jaubari, Shreenathkot, Gairagaon, Arukule, Pakhu, Deurali and Baluwa. It consists of Gt-bt schist, Psammitic schist, pelitic green schist and quartzite. Gritty schist was observed around Jaubari, Photo-9. Garnetiferous schist was found in Panthedada area, Photo-11. Gyazi Cu deposit site is adulterated with landslide and no prominent visible surface indications of mineralization, Photo-12. However, a rock fragment having chalcopyrite and malachite staining ore has been found in the area, Photo-13. Amphibolite dykes are exposed around Amile. Upper part of Gyazi has Gt-bt schist but no visible garnet in schists of Gyazi area which has Cu mineralization. The Gyampesal area has schists and bluish quartzite. Amphibolite dykes are also reported from the other parts of the area. The exposures are mostly seen in the road cut sectios, river sections and ridge sections, Figure 5. The Ulleri augen gneiss intrudes within the host rocks of this unit, Figure 5, and crop out significantly in the confluence areas of Daraudi and Hudi Khola and northern part of Jaubari area near by Bharare and Dharapani.

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Photo-1: Historic military trench location in phyllite outcrops, Ligligkot. Photo-2: Radioactive nepheline syenite, Ampipal. Photo-3: Ash coloured weathered nephelin syenite, Ampipal. Photo-4: Medium to thick bedded metasandstone, Hermi. Photo-5: Overview of alkaline massif area, Hermi to Luitel. Photo-6: Calcareous schist, Marble?, Bhandarigaon

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Photo-7: Sulphur odour, spring water, Kher Khola. Photo-8: Clinopyroxene dominant nephelin syenite. Photo-9: Gritty schist, Jaubari area. Photo-10: Metasandstone used as slabstone, Baraigau. Photo-11: Garnetiferous schist, Panthedada. Photo-12: Gyazi Cu deposite area, schist and metasandstone outcrops

Photo-13: Cu ore, Gyazi

Photo-14: Brick molding, Nawalpur

Ulleri augen gneiss

Porphyroblastic K-feldspar augen gneiss is well exposed along the Daraudi khola and Hudi khola confluence and nearby areas, Figure 5. Small pods and dykes are also found within the garnetiferous schist in the Thale, Garigaon areas. It also crops out in the northern part of the Jaubari area nearby Bharare and Dharapani. It also consists of, occasionally, mylonitized gneiss. The host rocks of the augen gneiss are Gt-bt-schist. The age of the Ulleri gneiss is considered to be of Paleoproterozoic.

Nepheline syenite

The nephelin syenite crops out in the Ampipal, Kharkhola in the north to Kher khola in the south of the study area, Figure 5. Small pods and bodies of nephelin syenite are also found in Luitel Bhanjyang areas. The nepheline syenite alkaline body is intruded in the lower unit of the Kuncha formation hosted with phyllites, metasandstone and quartzites. The N-S elongated main body has a length of about 7 km and width 2km. The shape of the main body is regular and rimmed by light gray minerals and dark minerals like clinopyroxenes are found in the core part of nepheline syenite. It is radioactive in most of the places. It consists of magnetite mineralization in the secondary porosity manifested by fracture and alteration halos. The magnetite seam injected in the host rock in Phalam Khani area is highly radioactive, could be related to late stage hydrothermal activity. The saprolite of the pluton is also radioactive at places. The host rocks relation is discordant and dipping direction of foliation of the host rocks diverges away from the pluton, Figure 5. The age of the pluton is debatable but considered to be of Precambrian contaminated by lower continental crust, Le Fort and Rai 1999.

Dhading Dolomite

Dolomites beds are exposed in Ekle areas of Hudi khola section and eastward towards northern part of Gyazi area. The beds are dipping due NE. Light gray to light blue, thin to thick bedded dolomites and interbedded thin limestone beds are occasionally intercalated with pelitic and psammitic schists, Figure 5. The age of the rocks is considered to be of Proterozoic.

Benighat Slates

Graphitic schists are exposed in the Suliket to Kharchok Bhanjyang section variably dipping due NE-NW. They are also exposed in the Hudi khola sections around Bogdal areas. Tar area of Daraudi Khola section has NE dipping Gt-bt schist. The prominent dolomite beds are exposed around Kharchok Bhanjyang and Chundada areas of Hudi khola section. The calcareous beds are interbedded with Gt-bt schist and graphitic schist, Figure 5. The age of the rocks is considered to be of Proterozoic.

The southern part of the area has an anticline passes through Baguwa-Bogteni-Luitel Bhanjyang. Other minor anticlines and synclines are dominantly radiated away from the pluton.

3.2 Mineral Prospecting

The mineral prospecting work of the study area has been conducted based on the Ground radiometric survey in nepheline syenite body, outcrop hunting by geological traverses and old working information.

Ground Radiometric Survey

Justification of using radiometric survey methods for uranium prospecting based on physical properties of uranium are as follow-

Electrical resistivity: metal uranium 2.8x10-7Ωm(good conductivity), uranium minerals 1-200Ωm(low conductivity)

Paramagnetic

Density19100kg/m3(but no gravity anomaly)

Radioactive: gamma ray survey and radon survey

Limitation: low penetration of gamma rays

Possibility: detection of uranium halos, mostly 4-20ppm U

Radiometric methods: direct U exploration

Other geophysical methods: indirect U exploration

The radiometric survey, using Scintillation Counter and Gamma Ray Spectrometer RS 125, has been conducted in the nepheline syenite pluton area both in the out crops, boulders and saprolites. Altogether, 90 instrumental readings were taken. The Radiation Intensity (RI) values were measured in cps by Scintillation Counter and U(ppm), Th(ppm), K%, Dose rate (uGy/hr) have been measured by Gamma Ray Spectrometer RS-125.

The radioactive intensity (RI) value recorded so far show that the highest value upto 3000 cps, Figure 6. The maximum dose rate is 459 uGy/hr, Figure 7. The maximum uranium concentration is 476 ppm, Figure 8. The maximum Th concentration is 732 ppm, Figure 9. The K% concentration map is shown in Figure 10. The Kher khola section is non-radioactive whereas Ampipal area, Dhundure khola area, Phalam khani area and Chap Bhanjyang areas are radioactive. The nephelin syenite bodies nearby Luitel Bhanjyang area are radioactive. The handheld XRF shows the concentration of Ti, V, Cr, Mn, Fe%, Co, Ni, Cu, Zn, As, Se, Cd, Sb, Pb.

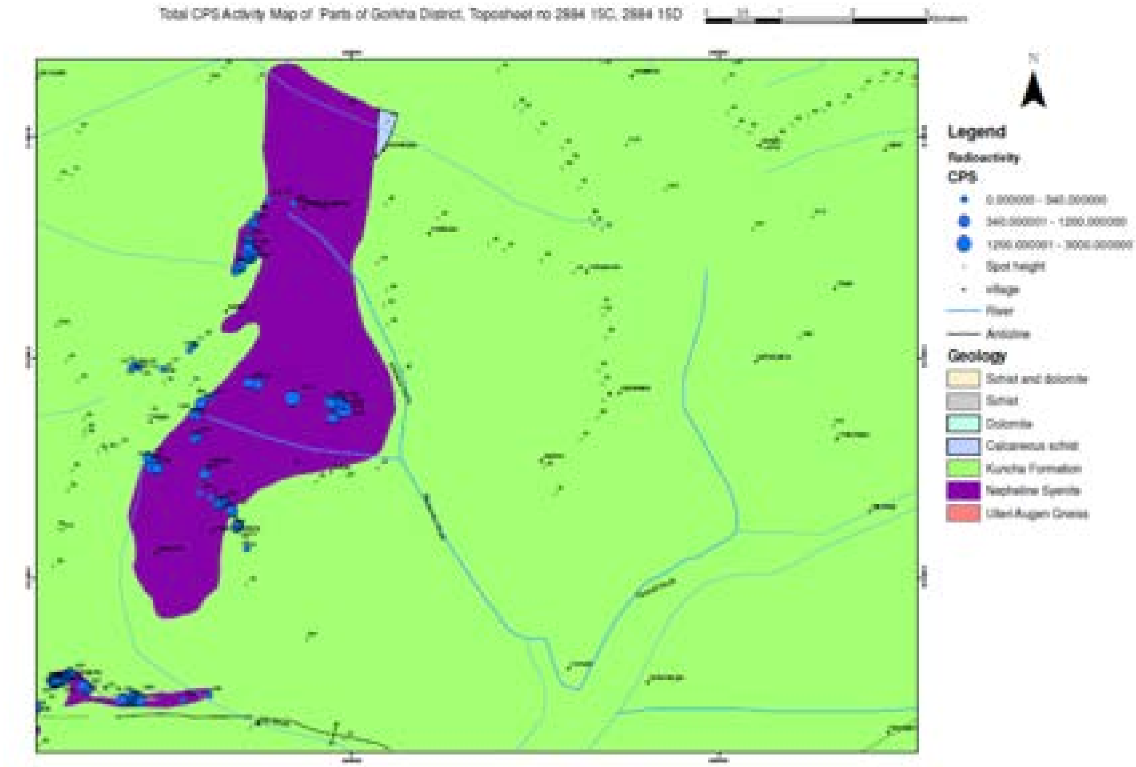


Figure 6: Radiation Intensity (RI), cps, Scintillation Counter

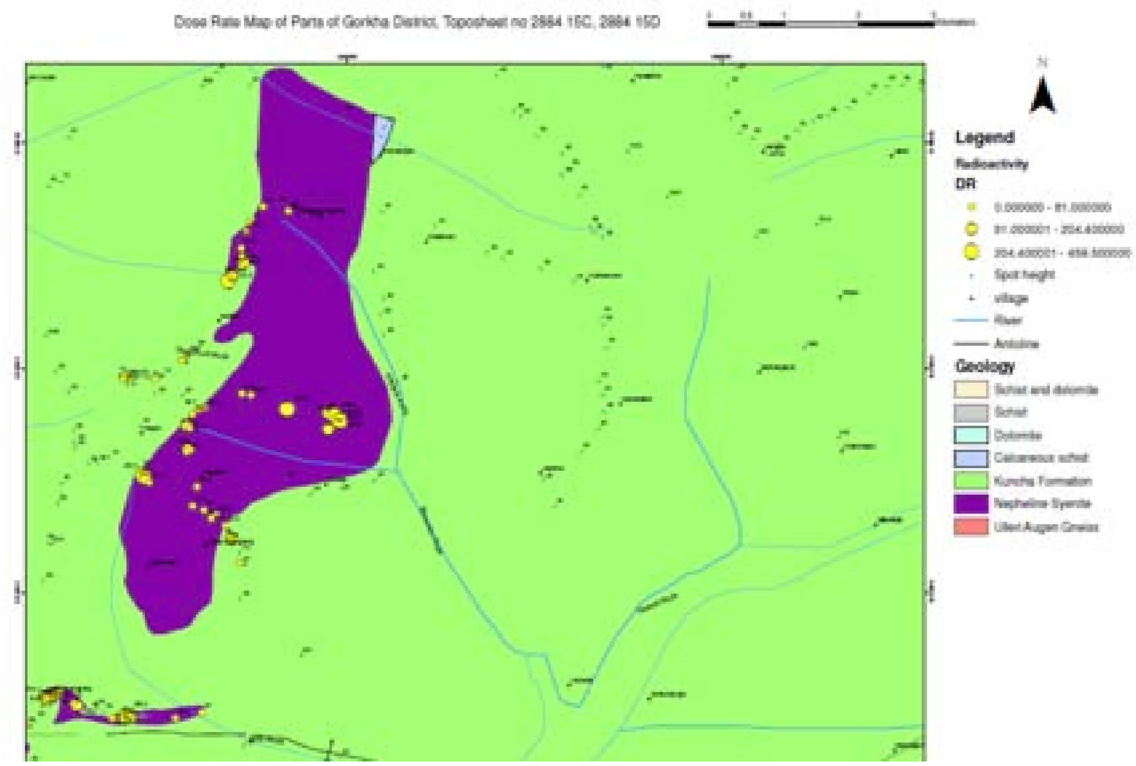


Figure 7: Dose rate (uGY/hr) anomaly map

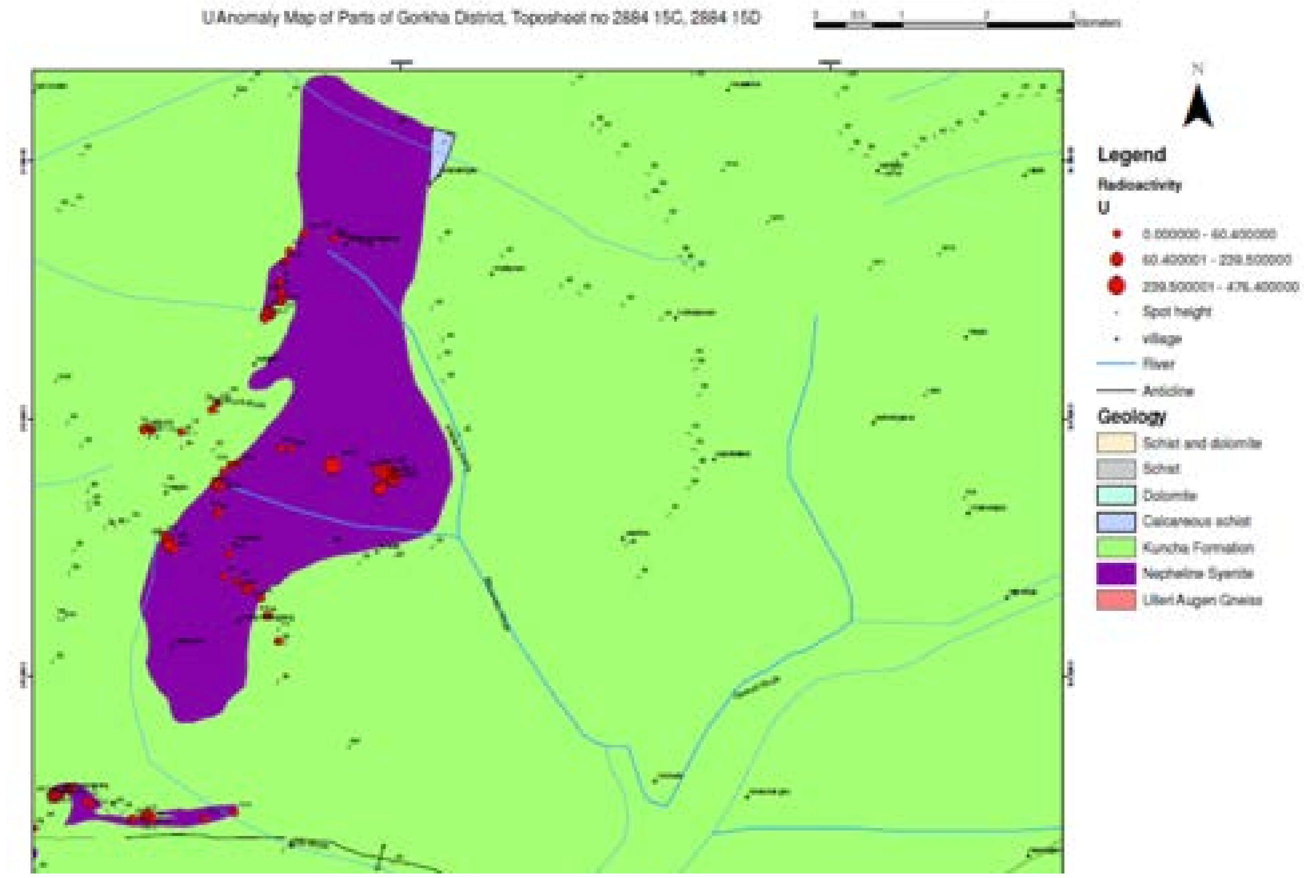


Figure 8: U (ppm) anomaly map

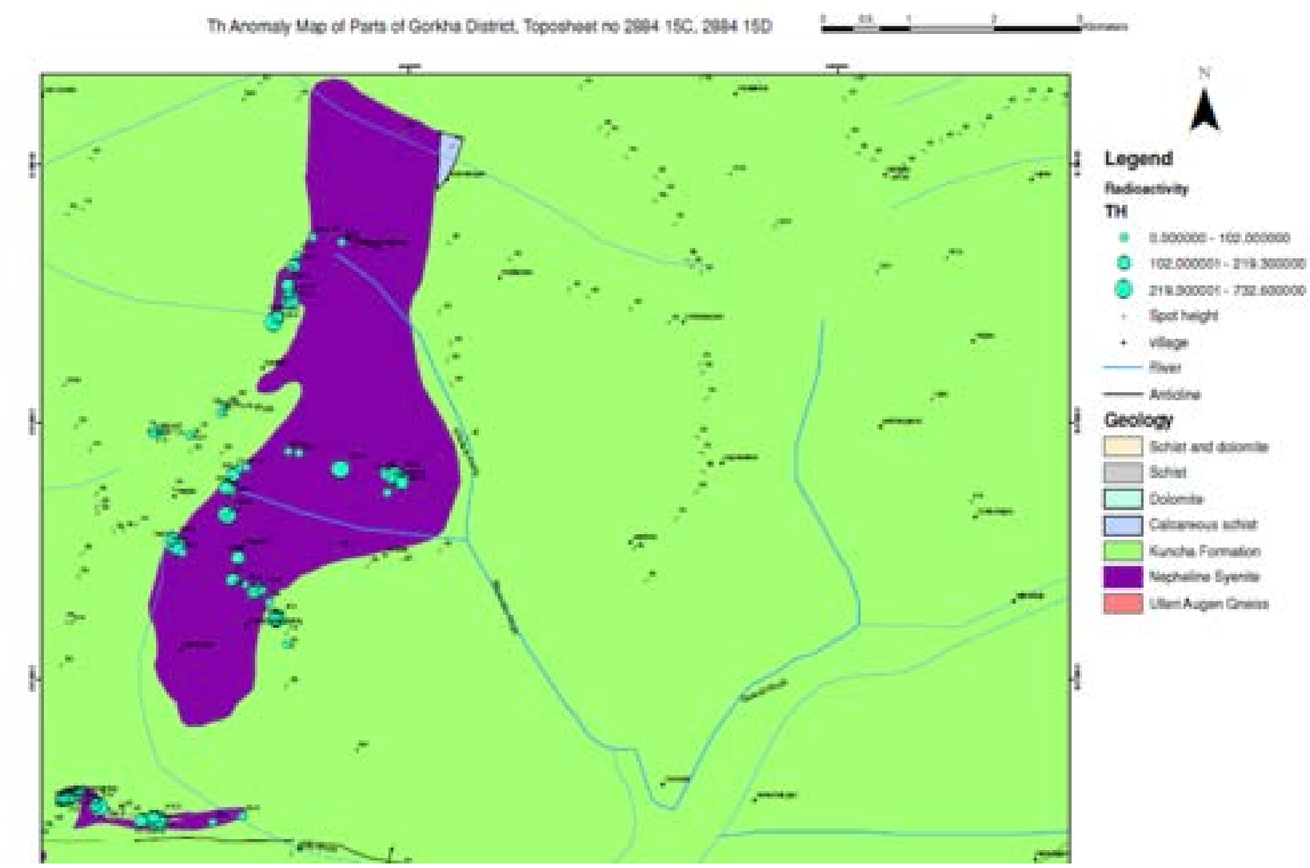


Figure 9: Th (ppm) anomaly map

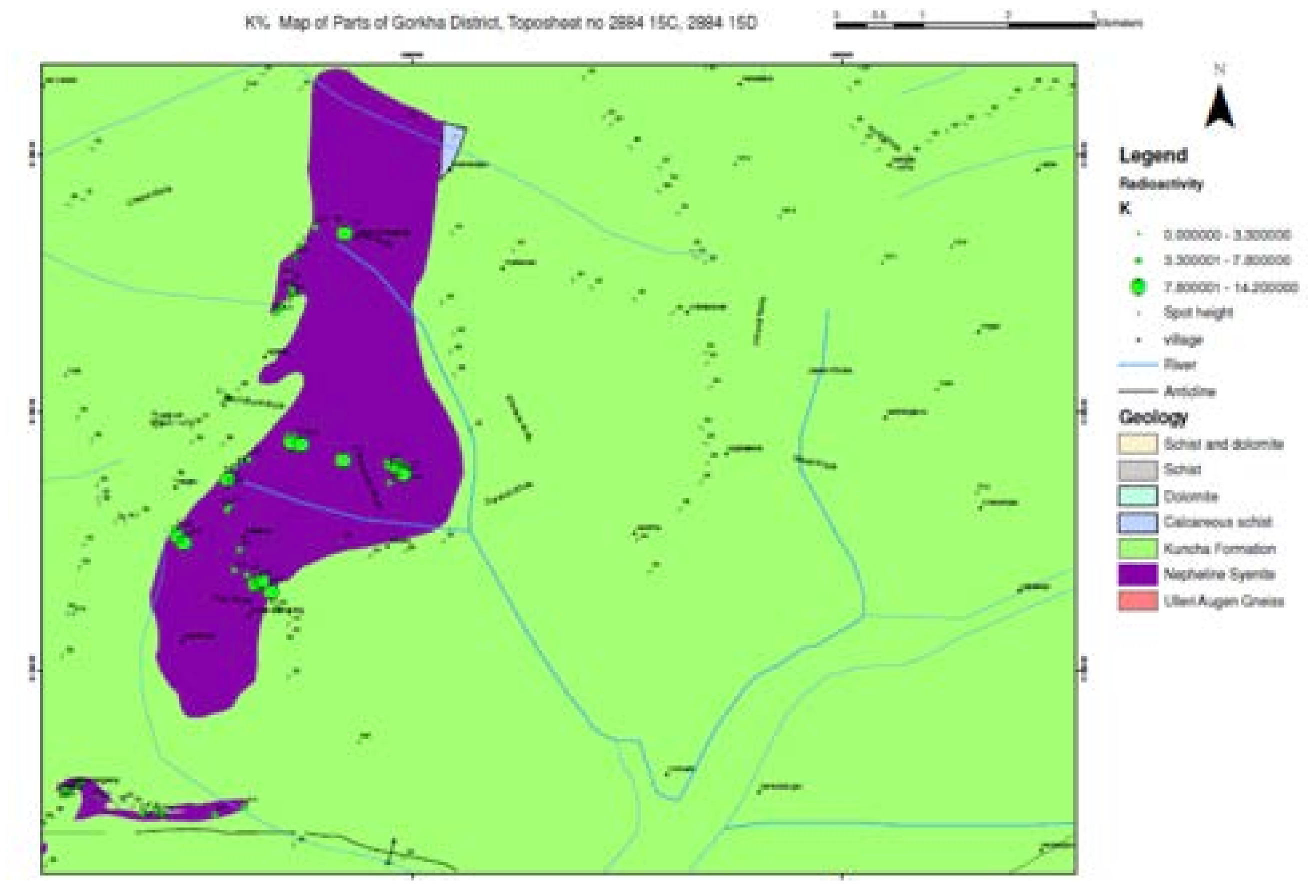


Figure 10: K% anomaly map

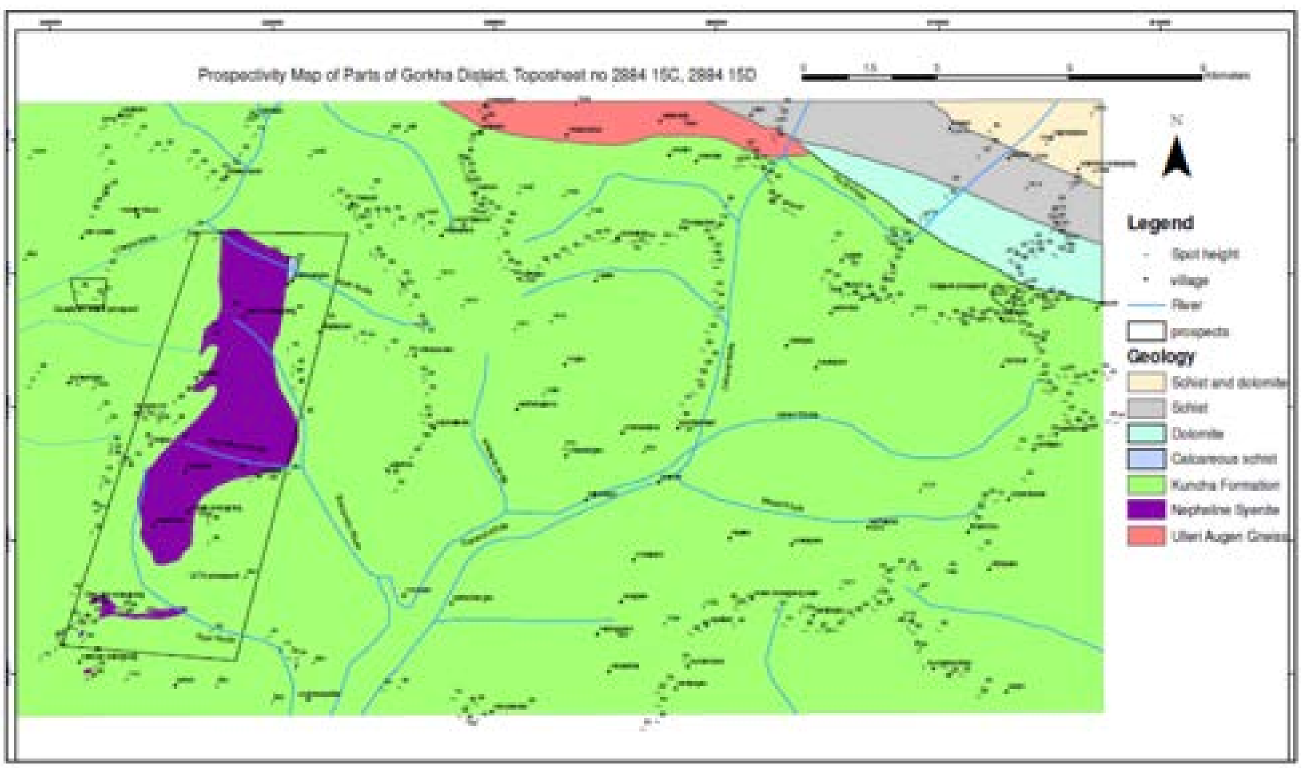


Figure 11: Mineral prospectivity map of the study area

3.3 Mineral Prospectivity

The mineral potential of the area is represented in the mineral prospectivity map, Figure 11. The prospects so far identified in the area are slab stone, radioactive mineral U/Th, Copper ore and Brick molding in Nawalpur area, Photo-14.

Slab stone prospect

It is located at the lower part of Barai gau nearby Suspension bridge of Chepe Khola, L-134. It consists of metaquartzite and phyllite. The slab stone produced is locally used. The attitude of beds is $30^0/40^0$. The aperture is 2-3cm. It has three sets of joints, J1 $30^0/20^0$, J2 $352^0/80^0$, and J3 $310^0/71^0$. Block size ranges with dimension (3.2mx2.2mx0.3m). The thickness of the outcrop is about 70m. Strike length is about 500m. Slab stone dimension is about 80cmx25cmx10cm. It splits easily along the bedding fissility.

Radioactive minerals, U/Th, prospect

It is located within the nepheline syenite in Ampipal area i.e. Khar khola to Kher khola area. The prospect dimension is about 10kmx2km. The preliminary results of GRS show some anomalies of U/Th minerlization in the area.

Copper prospect

The copper old working of Gyazi area has no signs of old workings as it is swept away due to huge landslide. We try to unfold the history of the deposit, but it's quite scary to climb down and up inside the slided mass. There is no surface signature of any mineralization except some malachite staining rock outcrops south of the slide and fragments at the base of the slope.

4. CONCLUSION

Geological mapping was conducted over an area of 325 sq km. The radiation intensity mapping was carried out over an area of 20 sq. km. in Ampipal area. The instrumental data were collected from 90 locations. The total no of outcrop observations was 508. About 30 samples were collected to represent the lithology of the area. The samples were meant for display and thin section purposes.

Geologically, the study area comprises Nawakot group of rocks represented with Kuncha Formation, Dhading Dolomite and Benighat slates of Proterozoic age. The Kuncha phyllites and quartizes in the lower stratigraphic level is intruded with nepheline syenite. The Kuncha garnetiferous schists, metasandstones, psammitc schists and quartzites in the upper stratigraphic level of the formation is intruded with Ulleri augen gneiss. The dolomites of Dhading Dolomite and graphitic schists and calcareous beds of Benighat Slates are exposed in the north eastern part of the mapped area. The southern part of the area has an anticline passed through Baguwa-Bogteni-Luitel Bhanjyang. The dip direction of the host rocks of Nephelin syenite diverges away from the pluton. The geological map of the area has been prepared in the scale of 1:50000.

Mineral prospectivity of the area has been established. Three prospects have been identified so far i.e. Slab stone, radioactive mineral U/Th and copper. The Ampipal radioactive mineral prospect has been accepted as an IAEA/DMG TC Project for cycle 2020-21. The ground radiometric survey gave instrumental values of U (ppm), Th(ppm), K%, RI(cps) and Absorbed dose rate (uGy/hr). Each data were presented with GPS locations. The data were plotted to prepare anomaly maps. The data shows that the maximum U content was 476ppm and Th 736ppm in nepheline syenite and saprolite. The Phalmkhani area shows magnetite ore body injected in the host rock, is radioactive. The fracture porosity and alteration halos are magnetic and radioactive. The magnetite injection and alterations with in nepeheline syenite in the Appipal area is promising for radioactive mineralization.

5. RECOMMENDATION

Follow-up U/Th prospecting is recommended in Ampipal Nepheline syenite pluton.

Preliminary follow-up exploration of slab stone and copper prospects is recommended.

REFERENCES

Adikari DP, 1993, Paleomagnetism of the dyke rocks of the Ampipal Massif, Lesser Himalaya, central Nepal, Unpublished M Sc Thesis, Central Dept of Geology, TU, Kathmandu, P 70

Amatya K.M, and Jnawali B.M, 1994: Geological map of Nepal, DMG

Bhandari AN, 1980, Geological map around the Daraudi and Chepe Khola, HMG/UNDP Mineral Development Project

Cunney M and Kyser K, (2008), Recent and not- so- recent developments in uranium deposits and implications for exploration, V 39, Mineralogical Association of Canada

Dhital MR, 1995, Mode of occurrence of nepheline syenite in the Gorkha-Ampipal area, central Nepal Lesser Himalaya, J of Nepal Geological Society, V.11, pp 159-170.

Gautam P, Sharma MP, Dhakal S, 1998, Gamma ray spectrometry and magnetometry of the alkaline rock area in Ampipal-Bhulbhule, Nepal Lesser Himalaya, J of Nepal Geological Society, V.18, pp. 71-83.

IAEA, (1976), Proceedings Series, Exploration for uranium ore deposits, Vienna, STI/PUB/434

IAEA, (1991), Guidebook on the development of projects for uranium mining and ore processing, Vienna, IAEA-TEC DOC-1991

Koide Y, Arita K, Toyoshima T, and Sharma MP, 1992, Geochemistry of Ampipal Pluton, preliminary report, Bull. of Dept. of Geology, TU, Kathmandu, V 2(1), pp 11-23.

Lasserre JL, 1977, Amphibolites and alkaline gneisses in the midland formations of Nepal, petrography, geochemistry, geodynamic involvements, Coll Internaux du CNRS No 268, pp 213-236

Le Fort, P and Rai, SM, 1999, Pre-Tertiary felsic magmatism of the Nepal Himalaya: recycling of continental crust, J of Asian Earth Sciences, V 17, pp. 607-628.

Pecker and Le Fort, 1977, Origin and significance of the Lesser Himalayan augen gneiss, Coll, Int, CNRS No 268, pp 319-329.

Stocklin J and Bhattrai KD, 1977, Geology of Kathmandu and Central Mahabharat Region, Nepal, HMG/ UNDP/MEDB Project report

ISO-17025 (International Standard Guideline) Application and Accuracy in Analytical Results

Gajendra Pradhan (Sr Div. Chemist)

ABSTRACT

ISO-17025 International Standard is an important directive (General Requirement for the Competence of Testing and Calibration Laboratories) to almost all performing lab activities i.e., Chemical, Physical, and Medical for the competence, impartiality and consistent operation. If any of the laboratories are managed in fulfilling the terms of requirements as given in this ISO-17025 directives, the laboratories shall be capable of performing testing activities with consisting achievement and assuring the quality test results. Analysts always attempt to obtain an analytical results as near to true value or accuracy as possible by the correct application of the analytical procedure employed. The level of confidence could develop by the analysts during laboratory activities if the implementation of ISO-17025 (International Standards) was already established in the laboratory which is still very essential so that there is accuracy in test results is expected with very less error may be introduced. Furthermore, the laboratory also specifically gets accredited from any of the internationally recognised accreditation board as well as quality test data will significantly be accepted internationally too.

Keywords: Standards; Laboratory; Analytical; Accuracy; Error

1. METHODOLOGY

Generally, it is tough to establish at once every terms of crucial requirements as given in the ISO-17025: directive for making a laboratory competent of testing and calibration. In the succession of establishment of this standard, the laboratory management body has taken initiation steps like training on ISO 17025:2005 on last couple of year before and recently got updated 2017 version as well. It is vital to take important terms of requirements of this standard for implantation level even from laboratory itself in use of tools which are available in the laboratory.

The aim of analysing unknown sample is to get almost accurate results using required procedure and with available devices. Simply, for expecting quality test result, the use of electric instruments like digital balance, muffle furnace, glasses apparatus also must work accurately. Well operation of those devices is not enough to get back quality result of test, the instruments must be frequently calibrated from known standard tools. For instance a digital balance employed in laboratory in which minimum amount of sample (say 0.5 gm) is weighed for a parameter, is it assured that the content of sample weigh is actually weighed 0.5 gm or balance has really weighted 0.5 gm? To eliminate the doubt in this case, FI class weights box (International Standard) is used which contains a series of Class F1 weights are designed to check scales used in laboratory applications where an accuracy of 0.1% or lower is required. It has triangle shape for 1 mg, 5, 10, 50 and 100 mg to 2 gm stainless steel weights. All these weights are used to check reading scales or to know balance is working properly. They help ensure that lab balances are giving you accurate readings. Similarly, for checking the set value of Muffle furnace, say 10000C temperature for igniting a sample; is there really the heating of 10000C inside the furnace? To make assure of these problem, a standard tool-Thermocouple is used to measure the temperature inside the muffle. These are the examples of the steps of calibration of devices used in the lab. In this way, glassware are also need to be calibrated to produce expected quality result.

Furthermore, the laboratory has taken initiation as a part of implementation of ISO-17025 are

- participating in proficiency testing practice (Inter laboratories comparison)
- arrangement of certified reference materials (CRMs) for quality control
- methods validation practices
- running a duplicate of sample of one of a batch samples
- Updating skill of man power through training on measurement uncertainty, method validation, traceability of measurement etc.
- still need to improve the laboratory environment or hazardous free workplace environment as possible
- restructuring of laboratory infrastructure
- still need to provide maintenance services of employed instruments on right time

These are the basic steps of attempting from laboratory itself to follow up to establish ISO-17025 International standard in the DMG-Laboratory.

Although the DMG-chemical laboratory is yet to implement ISO-17025 (General Requirement for the Competence of Testing and Calibration Laboratories), the laboratory management body has committed to produce valid quality result near to true value or accuracy as possible as assigned constituent is found in given sample. Probably, accurate or cent percent correct result value (Theoretical value) cannot be produced even by the ISO-17025 established laboratory. The ISO-17025 established laboratory produce quality result with very minimum tolerance errors associated with it however, non-adopted of standard produce little more error based results from laboratory.

2. ACCURACY

Accuracy is the correctness of the measurement or the actual value present in the given sample. Accuracy is how close a measurement is to the correct value for that measurement. It is almost impossible to generate the true value due to small or hidden errors may be introduced during analytical works.

For ex: a sample of haematite (Iron -ore) actually contains 50.50 % of total iron (TFe) element, is known. If two analysts perform chemical analysis of same ore sample separately using same testing procedure. The results obtained by those two analysts performing three times reproducibility measurement are-

Analyst (1) produces three results 50.45%; 50.65%; 50.52%

Mean: 50.54%

Relative mean error = (50.54 – 50.50)/50.50 = 0.079 %

Analyst (2) produces three results 50.84%; 50.88%; 50.86%

Mean: 50.86%

Relative mean error = (50.86 – 50.50)/50.50 = 0.71 %

The analyst (1) is accurate possibly and near to true value with less % of relative mean error introduced in chemical analysis process than those of analyst (2) with more error value of 0.71%. Therefore, less error leads to the results of near to actual constituents (TFe) of known value of the sample. This test result does not imply accuracy however close to true or known value. The unwanted errors which affect the test result need to be accounted.

3. ERROR

Error refers to the difference between a measured test value and true value present in sample. There are some errors that might be introduced in the testing process can be classified as determinate or indeterminate errors-

Determinate Error: It is the systematic error which can be determined at any stage and can be corrected at once. It can be avoided as well. It includes -

Personal Error (Incapability and Ignorance) and Operational Error (Mechanical loss, Incorrect temperature and Unfollowed Procedure):

Instruments Error (Uncalibrated Balance, Glassware, Muffle furnace, Non-functioning Fume hood etc.):

Method Error (Incorrect sampling, Incomplete reaction, Dilution error, Titration error):

Indeterminate Error or Accidental error: It is the random error which is difficult to determine or indefinite. It appears rarely and not get eliminated. When an analyst is performing given task of testing, an accident occurs with no control of work load or due to unconsciousness condition or due to hazardous lab environmental leads to poor analysed result.

3.1 Minimization of errors

1. Determinate Errors can be minimised by application of the methods as followed:
2. Calibration of using apparatus and instruments
3. Running a duplicate sample determination of at least one sample of a batch
4. Running a control determination (using CRMs or primary standards)
5. Running a blank determination
6. Standard addition for recovery of amount added

4. CONCLUSION

Every analyst attempt to create quality results data with proper attention and with very minimum introduction of errors to generate the value near to correctness measurement or accuracy using all determinations need for. This definitely brings value customer /client's satisfaction and support build up confidence of analyst/chemists with pleasure as well. The top management level are requested to encourage and give priority to make a reliable lab support with application of requiring terms of ISO-17025 directive gradually in the laboratory. Simply, making sufficient qualified man powers, sufficient maintenance of instrument/ equipment, arrangement of advanced/digital instruments, adequate safety measure and making positive work environment for motivation, sufficient training to lab personnel to handle and use specialised instrument properly, give opportunity to lab personnel for observation tour or exposure visit for observing works of same nature (Complete Testing Parameters of Limestone) performing in high sophisticated lab of neighbouring countries, making coordination with other professional as a teamwork, encourage internal calibration of equipment, participation in proficiency testing and management system requirement are basic factors for catering quality analytical service and assure accurate quality data as possible. These data might be used support to decision making program, help taking proper action, formulating policies and international trade and regulatory requirements. Therefore, adoption of international standards ISO-17025 for establishment in the chemical laboratory, no doubt produce almost or near to accuracy as internationally acceptance analytical results.

REFERENCES

Bassett J, Denney R C, Jeffery G H, Mendham J (Fourth edition 1978) Vogel's Textbook of Quantitative Inorganic Analysis

ISO/IEC 17025:2017(E) (International Standard) Third edition 2017-11

Geological study of Landslides in Isma Rural Municipality- 1, 4, Musikot Municipality- 2 and Ruru Rural Municipality, Gulmi District, Lumbini Province

Suresh Shrestha (Senior Divisional Geologist), Sulav Kayastha (Geologist) Basant Adhikari (Research Officer)

ABSTRACT

Study of geological and engineering geological condition of the landslide affected area of Isma Rural Municipality - 1,4 Musikot Municipality – 2, Ruru Rural Municipality - 5 of Gulmi district has been done based on geological, geomorphological, and engineering geological and pertinent social parameters of the villages/settlements affected by intense rainfall. Geological investigation, brief rock and soil study and drone survey of the area was done during this field study for the assessment of the area's hazard condition. This study's recommendations are based on the field observation (walkthrough survey) and, drone surveymapping. We recommend temporary relocation of some vulnerable houses at Jukepani, Dadaphat, Ratapani, Musikot and Bamgha area till mitigation and preventive measures are not carried out. Other settlements, especially on the cut banks of rivers or at high-risk zonediscussed, should be made aware of possible hazards in the future. We also recommend avoiding river bank areas as far as possible for relocation purpose.

Keywords: Drone Mapping; Cut banks; Slope Failure; Geomorphology

1. INTRODUCTION

Due to the water-induced landslide event of 20th June 2020 (06th Asadh, 2077) in Ratapani village of Isma Rural Municipality (hereafter RM) – 4, 2nd July 2020 (18th Asadh, 2077) in villages of Isma RM–1, 4 and Musikot municipality- 02. 1st August 2020 (17th Shrawan, 2077) in Bamgha village of Ruru RM–5, Gulmi district, remarkable loss of lives and property had occurred. Geological study has been carried out by the Department of Mines and Geology as per the request letter from Ministry of Home Affairs (MOHA) for the geological assessment of those areas. This field work aimed to study the general geological condition of the study area and assessment of the hill slope of the affected area based on the rapid field observation. The field programme was conducted for a very short time. Hence, detailed geological and geotechnical setting of the study area is beyond the scope of this study. The recommendations presented from the study are based on the walk-through survey and thus do not replace any instrument added investigation.

The study area is easily accessible from Kathmandu and is at about 500 km. One can reach up to Tamghas of Gulmi district from Kathmandu by travelling along the Prithvi Highway till Muglin and along Madan-Ashrit Highway to Narayangarh and along Mahendra (East-West) Highway to Butwal and then along Siddhartha Highway to Tansen and from Tansen to Tamghas by Tansen-Ridi-Tamghas Road (Figure 1).

The study area lies in mountainous region. The area comprises the rugged and steep topography of the Lesser Himalaya. The maximum and minimum elevation around the area is 1600 m north of Doholi and nearly 850 m along the bank of Nisti river downhill of Hastichaur and Musikot respectively.

Isma RM- 1, 4 and Musikot Municipality is drained by numerous streams which all confluences in Nisti Khola that ultimately which in end confluencesjoins theto Badigad Khola. River terraces are common in Nisti riversides of both Isma RM and Musikot Municipality. The topography rises abruptly on either side of the river with small tributaries in dendritic drainage fashion. An N-S trending ridge along Deurali-Patalkot-Musikot of Musikot Municipality divides the area into two watersheds of Badigad River and Nisti Khola on east and west respectively (Figure 2).

1.1 Landuse

Isma, Musikot and surrounding area has diverse landuse pattern. However, the part of Isma- 1, 4 and Musikot- 2 that suffered from landslides has dominantly cultivated land in the lower part and forest to barren land in upper part. The lower part of the colluvial slope is being utilized for the purpose of settlement and the cultivation purpose. There were many old stream and gully (small to medium size) prior to the landslide event but large gullies were carved out allowing surface runoff to flow through it (Figure 3).

1.2 Geological setting

The study area lies in the Robang Formation, Malekhu Limestone and Benighat Slate of the Lesser Himalaya. The area is composed of black,to yellowish grey to black slate, dark grey to light grey limestone along withalong with green to grey calcareous phyllite. Some quartzite bands are also common in the area. A synclinal structure and couple of thrusts passes through the nearby the landslide affected area according to the published geological map of that area by Department of Mines and Geology (Figure 4). The rock exposed in the landslide and surrounding area of Isma RM-1 has strike of NW-SE in general with varying dip amount of 15° to 40° dipping towards SW.

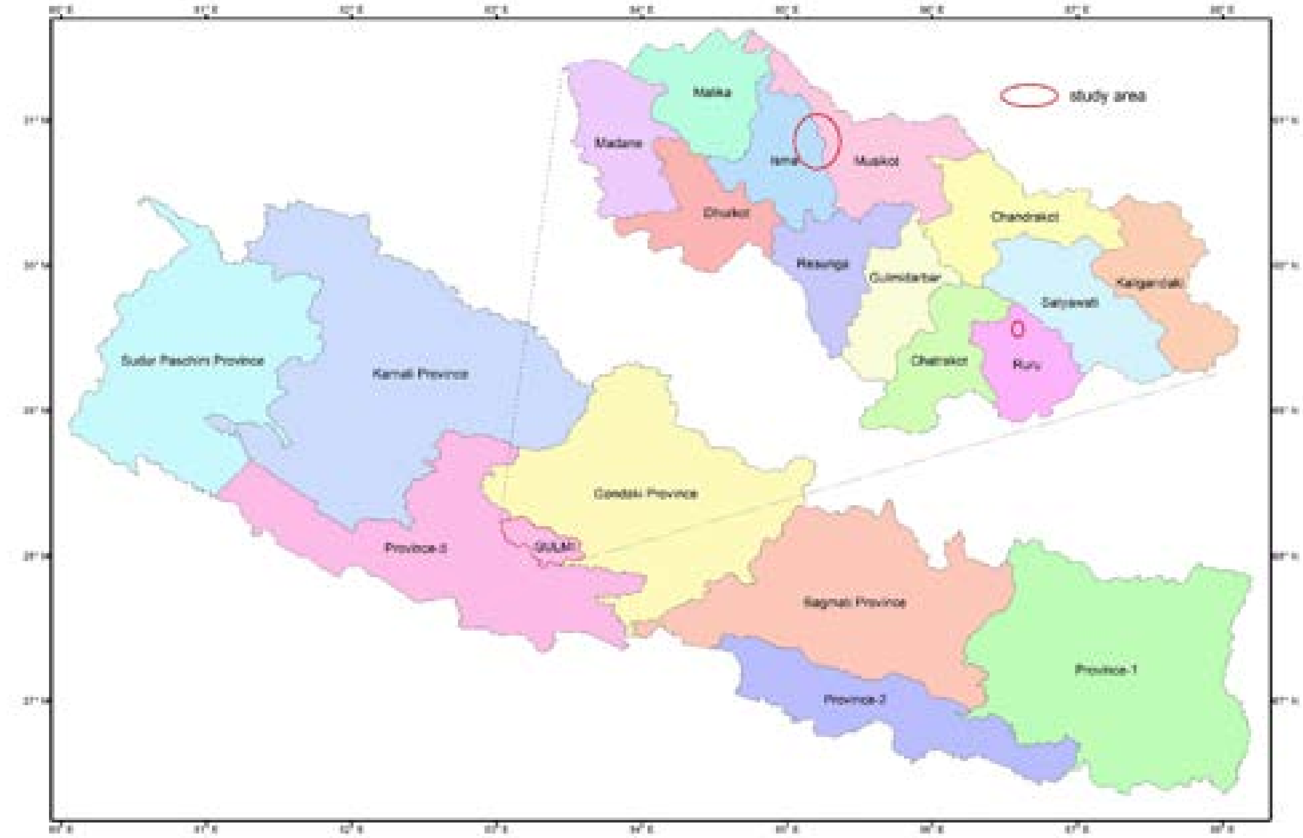


Figure 1: Location of the Study area.

Figure 2: Drainage Map of Isma area.

Figure 3: Topo map of the study area with location of landslides (published by survey Department,, parts of topo sheet 2883 13 B and 14 A).

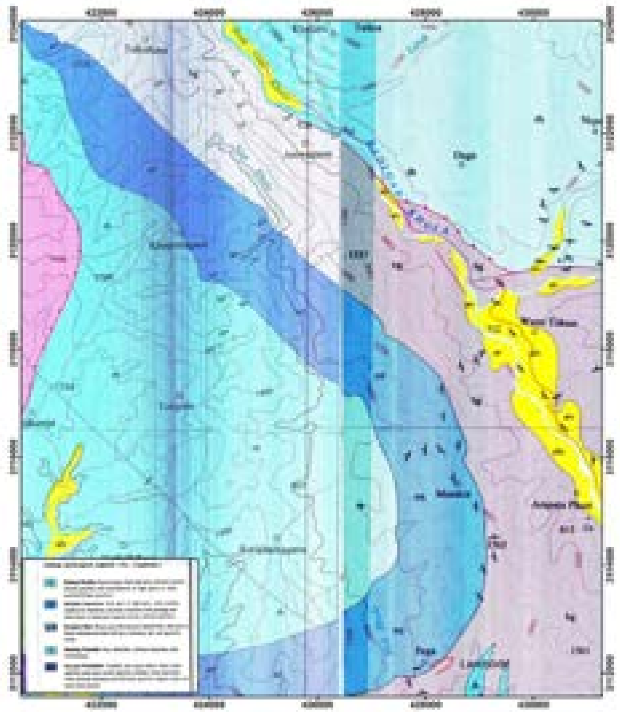


Figure 4: Geological Map of Isma and Surrounding Area (DMG, 2000)

1.3 Slope

The gravity is the force that causes the material to move downward. The steeper the slope, higher is the shear induced by gravity and the more risk of landslide. Hence, slope is the principle factor affecting the landslide occurrence. The slope map (Figure 5) shows most of the landslides affected area with steep slope (>36°) which is mostly unstable during heavy rainfall conditions.

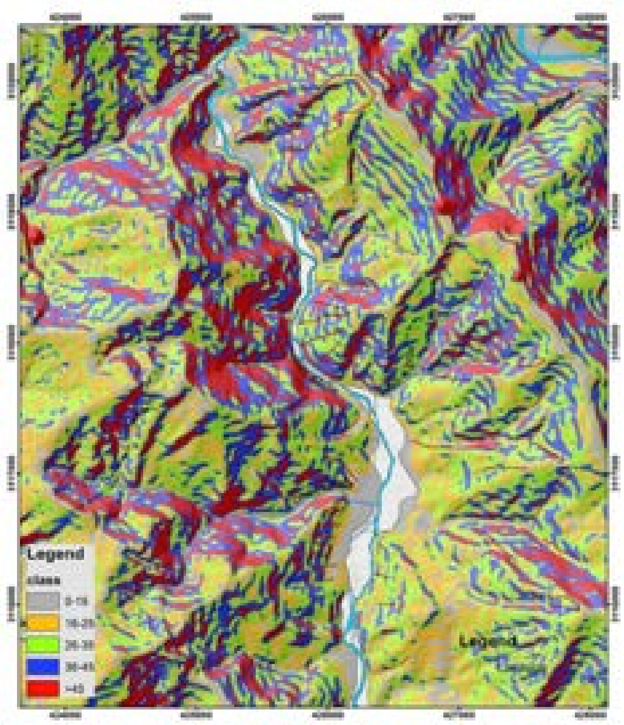


Figure 5: Slope Map of Isma area.

1.4 Aspect

The effect of the slope aspect on the landslide occurrence may be direct or the indirect. The slope aspect determines the amount of the soil moisture content in different direction or aspect of the hill slope of same region. Slope aspect strongly affects hydrologic processes by the process of the evapotranspiration and thereby affecting the weathering processes and vegetation root development.

The direction of slope faces with respect to the sun has a profound influence on vegetation. The aspect map shows landslide-affected area has mostly north and northeast aspect to south and southeast aspect (Figure 6). North facing slope has relatively higher moisture content and vegetation. Soil in this aspect may saturate quickly during rainfall.

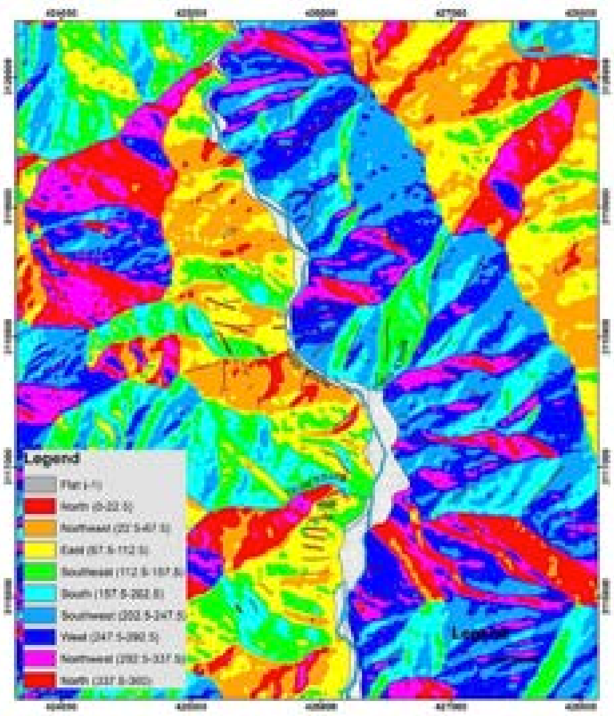


Figure 6: Aspect Map of Isma area.

2. GEOLOGICAL HAZARD ASSESSMENT OF ISMA RURAL MUNICIPALITY – 1

2.1 General Overview

Due to the heavy rainfall of the 18th Ashad 2077, many parts of the Isma RM – 1 werewas badly affected by the slope failure. Many small, shallow seated landslides, debris flow, rill and gully erosion were triggered by the continuous heavy cloudburst that occured for more than 4 hours (according to the people of that area). Due to that event two people had lost their livesfe, large cultivated lands, fishing ponds, brick factory, somefew houses are completelytotally damaged and a few were partially damaged leaving lots of other houses and lands at risk mainly in Saru tole, Nisti gaon, Dhadphat, and Jukepani area.

2.2 Geomorphology

The landslide was occurred in a very steep sloppy terrain with gradient of more than 35 degree generally facing toward East with thin to very thin i.e., less than 0.5 m to 1.5

m residual soil cover and colluvial soil in the Isma RM- 1. Similarly, the small stream that drains the area have high gradient with the high potential energy during the heavy rain fall which can easily erode the weathered rocks and its peripheral area creating the debris flow in the downstream parts.

2.3 Geology and Soil Type

The study area consists of grey to dark grey phyllites with intercalation of thin calcareous bands and white to grey thin bedded quartzites. Quartz veins are common in phyllites. Quartzite observed in the area are highly fractured that may be due to syncline core nearby area. The rock exposed are slightly to highly weathered, the phyllites with thin calcareous bands are highly weathered than the quartzite. The rock exposed in the landslide and surrounding area of Isma RM- 1 has strike of NW-SE in general with varying dip amount of 30° to 65° dipping towards SW.

Mainly in the upper steep slope, the residual soil and colluvium thickness seems to be very thin approximately less than 0.5m to 1.5m and covered by forest land in many parts of the study area. The lower parts near the Nisti Khola have thick soil deposit used for cultivation and that landform seems to formed by the soil slides from the adjacent slope.

2.4 Causes of landslides and probable risk

The study areas have steep slope and most of the settlementsareas are within steep slope or in the peripheral areas. Although the slope seems to be stable during dry season but during the monsoon period due to precipitation the soil becomes saturated which increases the shear stress. If the shear stress overcomes the resisting force then the materials resting on the slope starts to move downwards creating slope failure so the rainwater plays a very crucial role in the slope stability. Heavy cloudburst for more than 4 hours at the date 2077/3/18 oversaturate the soil and is the major cause for series of landslide in the Isma area. Other causes which are also responsible for the landslides can be listed as below:

Haphazard road construction in the steep slope withoutthe proper drainage management for surface runoff is the cause for the landslides in some places. The landslides were triggered by the surface run off from the road to the steep slope just above the Saru Tole, Nisti gaon and upper part of Dhadphat areas.

Houses constructeding on the steep slope or nearby areas are always vulnerablesites for to the landslides during heavy rainfall. The slope angle of the affected area is more than 35° so series of small to very small landslide occurred in the Jukepani area.

The study area consists of weak and weathered rocks like phyllites with intercalation of calcareous bands and highly fractured quartzites. Loose soil in the area is easily erodible and it creates debris flow in the downstream. The debris flow in the Dhad khola is caused by the damming of stream due to landslide in the upstream area for some time and outburst creating huge debris flow. This debris flow damaged fishing ponds, brick factory, poultry farm, cultivated lands and few houses near the confluence of Dhad Khola and Nisti Khola.

2.5 Probable risk

Rainfall-induced landslides in the Isma area are small-scale, shallow seated landslides mostly in steep slope. The soil/ colluviums on the steep slope are wet so whenever there is heavy rainfall there is probability of landslide as before. Rill and gully erosion might occur on the bare slope created by the slope failure and the debris could affect the downhill houses. The houses in Saru Tole (Figure 7) are at high risk of landslides as the debris accumulated by the landslide might again flow during heavy rain. Similarly, there is probability of slope failure above the Nisti gaon (Figure 8) and surrounding areas of Isma during heavy rain. So people living on the steep slope or in the peripheral area of previous slides should stay alert and aware. Mitigation and preventive measures with recommendation are given in the Table no 1.

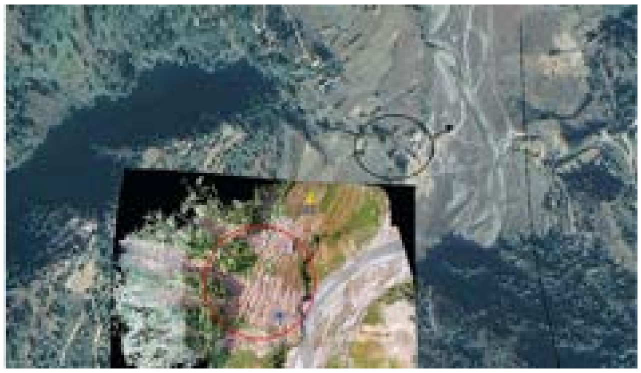


Figure 7: Google image of Nisti gaon and Dhadphat draped with drone image

Figure 8: Vulnerable houses at Nistigaon

3. GEOLOGICAL HAZARD ASSESSMENT OF ISMA RURAL MUNICIPALITY – 4

3.1 General Overview

Due to the rainfall of the 6th Ashad 2077, in Ratapani area and 18th Asad 2077 nearby Nwala area, many parts of the Isma RM – 4 were affected. Numerous small landslides were occurred in this area along Nwala Gaun, Chhoredanda, Ratapani. Although human casualty was not reported, many houses were fully and partial damaged, many cultivated lands and forestland were destroyed and the landslides swept few cattle away. Similarly, many houses and lands were left at risk after those landslide events. Around 15-20 houses are at risk in this area (mainly Nwala Gaun, Ratapani and Chhoredanda).

Table 1. Location wise mitigation and preventive measures with recommendation

S.N.	Site	Latitude/ Longitude	Problem	Probable Risk	Mitigation and Preventive Measures	Recommendations
1	Saru Tole and nearby area	28.160°/ 83.238°	Landslides on the steep slope above the settlement area taking life of a person, damaging few houses due to the cloudburst that occurs for more than 3 hours.	Further soil erosion with widening of rill and gullies, debris flow might occur along the slope threatening the downhill houses during rainfall. The soil/ colluviums on the steep slope are wet so whenever there is heavy rainfall there is probability of landslide as before.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure. Constructions of proper drainage for surface run off. Sealing the cracks with mud/clay to prevent water entering to the ground.	Temporary relocation of people from that area is recommended until mitigation and preventive measures are implemented.
2	Nisti Gaon	28.166°/ 83.245°	Slope failure due to heavy rainfall affecting the downhill-cultivated land and houses with one causality and one injured.	Further soil erosion with widening of rill and gullies and debris flow might occur along the slope threatening the downhill houses during rainfall. The houses on the slope might be pulled by landslide.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure. Constructions of proper drainage for surface run off. Sealing the cracks with mud/clay to prevent water entering to the ground.	The places are not safe until the recommended mitigation and preventive measures are implemented. The houses on the steep slope should be relocated as landslides could pull those houses.
3	Dhadphat area	28.168°/ 83.245°	Debris flow along Dhad Khola occurs due to daming of Dhad Khola for some time in the upstream by landslide and outburst creating huge debris flow in downstream damaging the houses, fish farm, poultry farm, brick factory and cultivated lands.	Dhadphat area is an alluvial fan deposit. Frequent debris flow could occur during heavy rain in such area.	Gabion wall on the both bank can be constructed to guide the debris flow and to protect cultivated lands. Safe distance (at least 50) from the stream at both banks should be maintained to construct infrastructure.	The alluvial fan in the Dhadphat is prone to debris flow during rainfall so it is recommended not to build houses and other infrastructure.
4	Jukepani area	28.175°/ 83.239°	Series of shallow and small landslides with numerous rill and gully erosion took place affecting few houses and many cultivated lands. Rill and gully erosion are also common in those areas.	Jukepani area has steep slopes i.e. >35 degree with thin soil or colluvial soil deposit. Those high slope areas are always vulnerable sites for slope failure during heavy rainfall. Further widening and erosion of rill and gullies with erosion in bare slope.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure. Constructions of proper drainage for surface run off. Sealing the cracks with mud/clay to prevent water entering to the ground.	The houses near the landslides in the steep slope are not safe during precipitation. It is recommended to relocate those houses, which are at steep slope and near the slides.

3.2 Geomorphology

Around the Isma R.M. - 4 areas, most of the hill slopes are greater than 45°. Slope direction is generally towards East to northeast. Hill slope are steep. Some of the areas of this RM is residing in previously formed landslide. The relief of lower part of the slope near Nisti River area has moderate to steep gradient. The relief of upper part of this area has high gradient. The steepness of hillslope, high relief of terrain gully erosion is common in these areas.

3.3 Geology and Soil Type

The study area consists of grey to dark grey phyllites with intercalation of thin calcareous bands and white to grey thin bedded quartzites. Quartz veins are common in phyllites and quartzite observed in the area are highly fractured that may be the because of syncline core nearby area. The rock exposed are slightly to highly weathered, the phyllites with thin calcareous bands are highly weathered than the quartzite. The rock exposed in the landslide and surrounding area of Isma RM- 1 has strike of NW-SE in general with varying dip amount of 30° to 65° dipping towards SW.

In many parts of studied area, mainly in the upper steep slope the residual soil and Colluvium thickness seems to be very thin less than 0.5 m to 1.5 m and covered by forest land. The lower parts near the Nisti Khola have thick soil deposit that is used for cultivation

3.4 Causes of landslides and probable risk

The study areas have steep slope and most of the settlement areas are within steep slope or in the peripheral areas. Although the slope seems to be stable during dry season but during the monsoon period due to precipitation the soil becomes saturated which increases the shear stress. If the shear stress overcomes the resisting force then the materials resting on the slope starts to move downwards creating slope failure so the rainwater play very crucial role in the slope stability. Heavy cloudburst for more than 4 hours at the dateon 2077/3/18 B. S. is the major cause for series of landslides in the Isma area, other causes that are also responsible for the landslides is listed as below:

Haphazard road construction in the steep slope without the proper drain management for the surface run off and adding of extra weight on the stable slope are the other causes for the landslides in some places. The landslides occurred in Ratapani area was because of the debris dumped on the steep slope during road construction and the rainwater flowing from the road to the steep slope. Due to this landslide, more than 14 houses are at high risk. People living in those houses are displaced and are staying in the nearby school.

Houses constructeding on the steep slope or nearby areas are always vulnerable sites for the landslides. The slope angle of the affected area is more than 35 degree so series of landslides small to very small with gully erosion occurred in the study area. More than 8 houses are partially or fully damaged by the landslides induced by rainfall. In many cases slides occurred from uphill but pulling of downhill slope with tension cracks and slides in the near the houses could be observed in Nwalagaon and Chorepatan area.

The study area consists of weak and weathered rocks like phyllites with intercalation and interlayering of calcareous bands i.e. dolomite and limestone. Loose soil in the area is easily erodible. Due to high gradient of small stream gully erosion are common in this area.

3.5 Probable risk

Rainfall induced landslides in the Isma area are small-scale shallow seated landslides mostly in steep slope. The soil/colluviums on the steep slope are wet so whenever there is heavy rainfall there is probability of landslide as before. The debris deposited in the slope due to landslide in Nwalagaon (Figure 9) have potential to form debris flow during rainfall. So the people living downhill of those area should be careful during heavy rain. The houses in the Ratapani area below the landslides are at high risk as the debris accumulated on the steep slope can move any time. Similarly, there is probability of slope failure in the Nwalagaon and Chorepatan/danda areas of Isma during heavy rain so people living on the steep slope or in the peripheral area of previous slides should be aware. Mitigation and preventive measures with recommendation are given in the Table no 2.

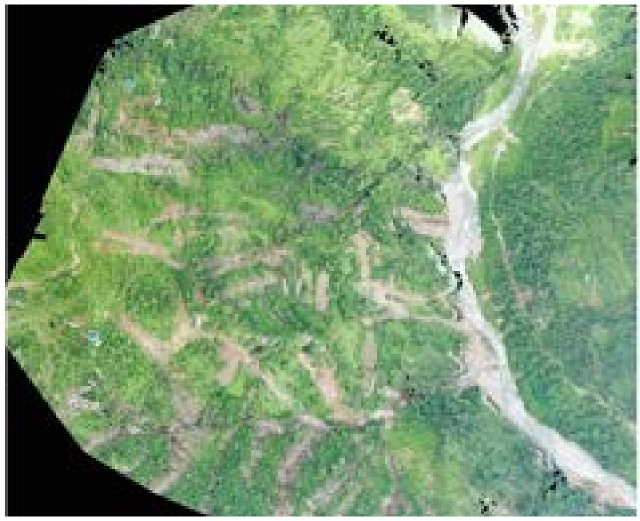


Figure 9: Series of landslides, rill and gully erosion at Jukepani and Nwala area

Table 2. Location wise mitigation and preventive measures with recommendation

S.N.	Site	Latitude/ Longitude	Problem	Probable Risk	Mitigation and Preventive Measures	Recommendations
1	Choredanda area	28.180°/ 83.234°	Landslides on the steep slope above and below the settlement area damaging few houses and cultivated lands due to the cloud burst for more than 3 hours.	Further widening of gullies due to rain and debris flow might occur along the slope threatening the downhill houses. The debris deposited by the slides might reactivated and flow causing damage to the downhill houses.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure. Constructions of proper drainage for surface run off and diverting the runoff from the landslide prone area. Sealing the cracks with mud/clay to prevent water entering to the ground.	Temporary relocation of people from that area is recommended until mitigation and preventive measures are implemented.
2	Nwala gaon area	28.182°/ 83.236°	Landslides on the steep slope above and below the settlement area damaging few houses and cultivated lands due to the cloud burst for more than 3 hours.	Further widening of gullies and slope failure might occur due to rain and debris flow might occur along the slope threatening the downhill houses. The houses on the steep slope might be pulled by landslide .so the place are not safe until the implementation of recommended mitigation and preventive measures.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure. Constructions of proper drainage for surface run off and diverting the runoff from the landslide prone area. Sealing the cracks with mud/clay to prevent water entering to the ground.	Temporary relocation of people from that area is recommended until mitigation and preventive measures are implemented.
3	Ratpani area	28.188°/ 83.237°	Series of Slope failure due to heavy rain fall, toe cutting during road construction and overloading of slope by muck soil that comes from road construction. Few houses at downhill are damaged by the slide and other houses are left at risk. So people are staying at nearby school.	The colluviums on the steep slope can move down at any time during rain and affect the settlement areas of downstream by the debris. The houses in those areas are vulnerable.	Construction of retaining wall/Gabion wall along the road and apply bioengineering technique like jute netting, wattling , bush layering, grass planting and mulching can be used to prevent surface erosion on the slope. Constructions of proper drainage for surface run off to divert the water entering to the vulnerable slope.	Temporary relocation of people from that area is strongly recommended until mitigation and preventive measures are implemented.

4. GEOLOGICAL HAZARD ASSESSMENT OF MUSIKOT MUNICIPALITY – 2

4.1 General Overview

Due to the rainfall of the 18th Ashad 2077, many parts of the Musikot Municipality – 2 were highly affected by shallow seated landslides. Numerous small landslides occurred in this area. Around 25- 30 houses are partially damaged and huge loss of cultivated lands at Dorlung, Boksi Odar, Gorthumka, Khukara Poli, Deurali, Burhathok, Kundala, Khasthok and few other parts of Musikot municipality. One casualty has recorded near Hadi Khola due to debris flow.

4.2 Geomorphology

Around the Musikot Municipality - 2 areas, most of the hill slopes are greater than 35°. Slope direction is generally towards west. Hill slope is generally steep. The relief of lower part of the slope near Nisti River area has moderate to steep gradient. The steepness of hillslope, high relief of terrain is also the reason for landslide. There are many old landslides in the study area.

4.3 Geology and Soil Type

The rock exposed in the landslide and surrounding area of Musikot Municipality- 2 has general strike of NW -SE with varying dip amount ranging from 20° to 50° dipping towards SW. The upper part of the steep hill slope consist of limestone and dolomites and lower part near Nisti khola consist of dark-grey to grey phyllites with intercalation of calcareous bands and few thin to medium bedded light grey to white quartzite. The rocks exposed in the study area are moderately to highly weathered. Most of the slope consists of residual soil. Thickness of soil varies from 0.5m to 5m thick according to the steepness of slope. The steep slope area consist of less soil or colluviums but the lower land area near Nisti Khola consist of thick soil deposit which were used for cultivation

4.4 Causes of landslides and probable risk

Topographically the study areas have steep slope and most of the settlement areas are within steep slope or in the peripheral areas. Heavy cloudburst for more than 4 hours at the date 2077/3/18 is the major cause for series of landslide in the Musikot area and other causes that are also responsible for the landslides is listed as below:

Haphazard road construction in the steep slope without the proper drain management for the surface runoff is other cause for the landslides in some places. When water flowing from the roads to the steep slope it scours gullies and slope become instable creating landslides and debris flow to the downstream.

The orientation of the bedrock also play vital role in the Musikot (Figure 10) area. The dipping of the beds of rock and hill slopes are at the same direction so there are lots of plane failure in the road cuts and other slopes.

Houses are constructing on the steep slope or nearby areas are always vulnerable sites for the rainfall-induced landslides. The slope angle of the affected area is more than 30 degree so series of landslides small to very small with gully erosion occurred in the study area. Many houses are partially and few fully damaged by the landslides induced by rainfall. In many cases, slides occurred from uphill but pulling of downhill slope with tension cracks and slides near the houses are also common in few places.

4.5 Probable risk

Rainfall induced landslides in the Musikot area are small-scale shallow seated landslides mostly in steep slope. The soil/ colluviums on the steep slope are wet so whenever there is heavy rainfall there is probability of landslide as before. The debris deposited in the slope due to landslide in many places, have potential to form debris flow during rainfall. So the people living downhill of those area should be careful during heavy rain. Mitigation and preventive measures with recommendation are given in the Table no 3.

Figure 10: Series of Landslide observed from Isma at Musikot area.

5. GEOLOGICAL HAZARD ASSESSMENT OF RURU RURAL MUNICIPALITY - 5

5.1 General Overview

A landslide at Ruru RM – 5 near Bamgha was studied on the verbal request from the District Administration Office of Gulmi during fieldwork in Gulmi district. From the study of google images the slope was quite stable with dense vegetation cover up to 2018 January but slowly small slides in the affected slope started to occur and the major failure was triggered by the rainfall of the 17th Shrawan 2077(according to the local people). Due to the failure of the slope, many tension cracks developed on the road and small part of road was already pulled by the slide, a temple was partially damaged and about to pull by the landslide, forestland and few cultivated land were damaged. Similarly, cultivated lands and few houses near the slide are at the risk. The major concern of local people is to stabilize the landslide and protect the road.

5.2 Geomorphology and drainage

Around the Ruru R.M. area, most of the hill slopes are greater than 40°. Slope direction is generally towards Northwest (Figure 11). Hill slope is quite steep (Figure 12). The relief of lower part of the slope has moderate to steep gradient. The relief of upper part of this area has high

Table 3. Location wise mitigation and preventive measures with recommendation

S.N.	Site	Latitude/ Longitude	Problem	Probable Risk	Mitigation and Preventive Measures	Recommendations
1	Musikot area	28.173° / 83.256°	Landslides on the steep slope above and below the settlement area damaging houses and cultivated lands due to the cloud burst for more than 3 hours. Similarly, debris flow in the Hadi Khola killed a man and damaged houses. Plain failure of rocks in the steep slope and along the road.	Further widening of gullies due to rain and debris flow might occur along the slope threatening the downhill houses. As the dip direction of the rocks and hill slope are at the same direction plane failure of rocks in many places mainly at road cut might occur.	Bioengineering measures like fascine, contour grass planting, vegetative rip rap, Bush layering, brushwood check dams, wattling, lose stone check dam can be used to prevent soil erosion from slope and further widening of rill and gullies. Retaining wall/ gabion wall along the road should be constructed to prevent slope failure and plane failure. Constructions of proper drainage for surface run off and diverting the runoff from the landslide prone area should be done. Sealing the cracks with mud/clay to prevent water entering to the ground.	Temporary relocation of people from the highly affected area is recommended until mitigation and preventive measures are implemented. Technical advice from the concerned person for the road construction is recommended.

gradient. The steepness of hillslope, high relief of terrain is also the reason for landslide. The study are is drained to the Ulli Khola and ultimately to the Barigad Khola (Figure 13).

5.3 Geology and Soil Type

The rock exposed in the landslide and surrounding area of Ruru RM- 5 has strike of NW -SE in general with varying dip amount of 20° to 50° dipping towards SW. The upper part of the steep hill slope is partially covered by the forest and is made up of black to yellowish grey band slate with some calcareous phyllite and some quartzite bands along with purplish shale and slate. The rocks in the study are belongs to the Nourpul Formation (Figure 14) according to the published Geological map of Gulmi and Baglung Districts (topo sheet: 2883 14B) by Department of Mines and Geology (2000). The rocks exposed are highly fractured and sheared with quartz veins. There is a Barigad thrust near the study area and passes along the Barigad khola. Thick Residual soil is developed in the studied area, mostly used for cultivation but only colluviums /rock fragments could be observed in the failed slope.

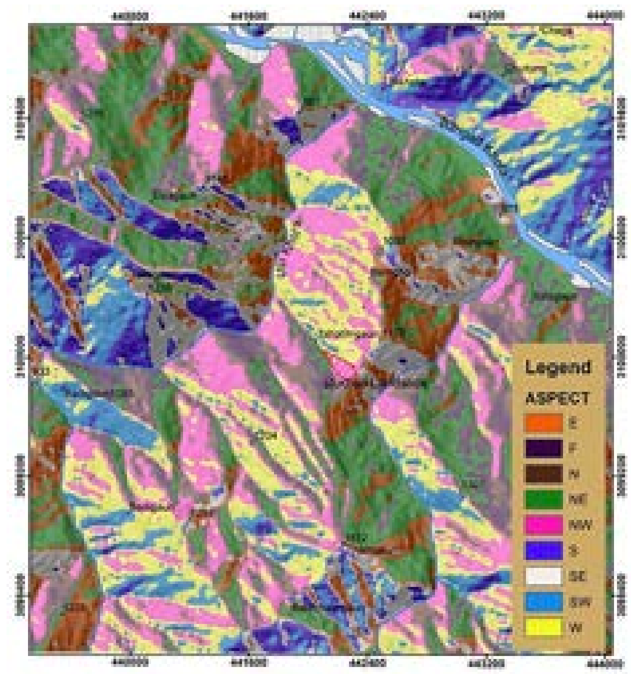


Figure 11: Aspect map of Bamgha

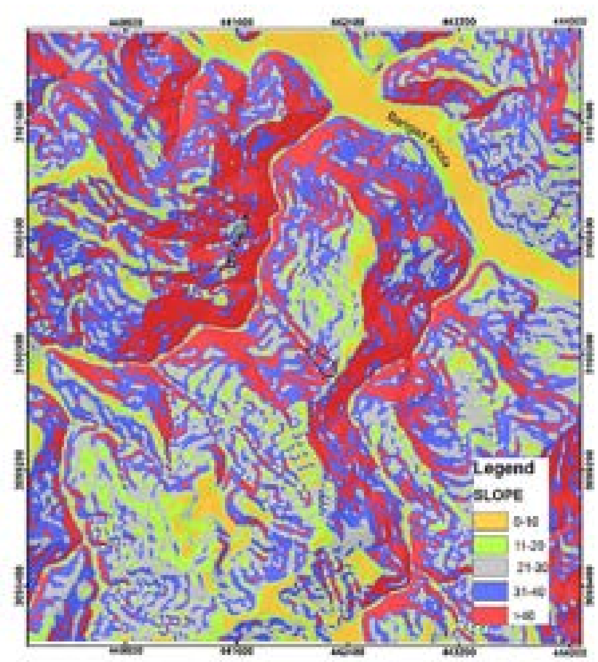


Figure 12: Slope map of Bamgha area

Figure 13: Drainage and topography of Bamgha, Ruru area

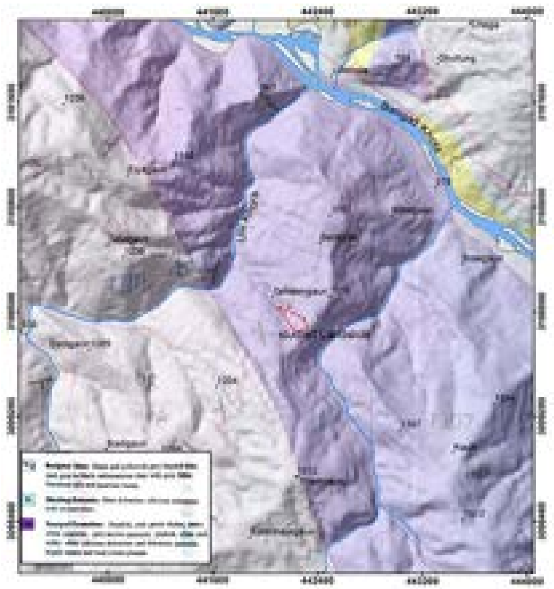


Figure 14: Geological map of Bamgha area (source DMG, 2000)

5.4 History and Cause of the Landslide

The slope at Bamgha was stable until the January, 2018 with dense vegetation cover (Figure 15 and 16). A small landslide was initiated by the discharge of excess irrigation water and surface run off through the slope according to the local people. Slowly the slides become larger and larger as the surface run off from the road could not be diverted from the slide. A gabion wall was also constructed at the toe part of the landslide but it cannot stop the sliding of the materials from the slope. Due to the precipitation of 1st August 2020, many tension cracks are developing in the road and some parts of road has been pulled down by the slide.

The major causes of landslide in Bamgha area are the improper management of surface runoff and steep slope. Geologically the area consist of fractured, weathered and sheared light grey to grey phyllites and purple shale/phyllite with intercalation and interlayering of white quartzite which is also partially responsible for the slide as the weathered and disintegrated rocks have low shear strength .

5.5 Mitigation and preventive measures

Surface drainage management technique i.e. construction of proper drainage for the surface run off along the side of road which can divert the surface run off from the cracks and the landslide area so that water could not seepage to the affected area.

Construction of series of gabion/retaining walls from the toe of the landslide including bioengineering technique can control the further sliding of materials from the slope (Figure. 17). Mitigation and preventive measures are given in the Table no.4.

Figure 15: Image of the Bamgha before the landslide

Figure 16: Image of Bamgha area after the beginning of landslide

Figure 17: Google image of Bamgha area with mitigation measures.

Table 4. Location wise mitigation and preventive measures with recommendation

S.N.	Site	Latitude/ Longitude	Problem	Probable Risk	Mitigation and Preventive Measures	Recommendations
1	Bamgha area, Ruru	28.017°/ 83.410°	Landslides on the steep slope mainly due to the improper management of surface runoff and weathering of the rocks. Due to the failure of the slope, Many tension cracks developed on the road and small part of road was already pulled by the slide, a temple was partially damaged and about to pull by the landslide, forestland and few cultivated land were damaged	Surface runoff, entering through the tension cracks or flowing to the crown part of landslide might further create huge slide risking the roads, houses and cultivated lands nearby the landslide.	Constructions of proper drainage for surface run off and diverting the runoff from the landslide prone area. Vegetative stone pitching of the drainage line and construction of series of low height check dams to drain the surface runoff safely to the natural drainage could be beneficial bioengineering tool to manage gully erosion. Sealing the cracks with mud/clay to prevent water entering to the ground. Construction of Retaining walls/ gabion walls along the sides of the road to prevent sliding. Bioengineering measures like wattling, Diagonal grass planting, jute netting, bush layering etc. can be effective to control the surface erosion on barren slope.	Implementation of mitigation and preventive measures to stabilize the slope and to stop the sliding of materials from the slope.

6. CONCLUSIONS AND RECOMMENDATION

A short field visit was made in the landslide-affected area in different parts of Gulmi district to study the geology and cause of slope instability of the area. The study area Isma and Musikot consist of grey to dark grey moderately to highly weathered phyllites with intercalation of thin calcareous bands with quartz veins, thinly bedded fractured white quartzite, light brownish grey limestone and dolomite as the major rocks types. Most of the landslides affected areas have steep slope i.e. >35 degree with forest and cultivated land. The residual soil or colluviums developed in the slope are thin from 0.5m to less than 2m.

In most cases, cause of landslide is the cloudburst for about 3 to 4 hours at the date 2nd July 2020. The colluviums and the residual soil, in the steep slope are already moist due to monsoon rainfall become over saturated by the heavy precipitation and surface run off through the roads. Because of that the soil on the slope could not resist the stress/pressure exerted by the over saturated soil and series of landslides occurred. Few landslides in the Ratapani area was caused by muck deposited in the steep slope during the road construction. Similarly the poor management of drainage for the surface run off along the haphazardly constructed road in the steep slope also play vital role in initiating the slope failure.

Some houses at Ratapani area are still at high risk due to colluvial slide from the steep slope. So it is recommended not to stay in those areas until the preventive and mitigation measures are applied. Similarly, houses at Saru Tole, Nisti gaon, Jukepani, Chorepatan and Nwalagaon are also at risk due to the debris deposited by the landslide in the steep slope, which might again flow down affecting the downhill houses and the houses at the steep slope could be pulled by landslides. Therefore, the people living in those areas should be temporary relocated until the recommended preventive and mitigation measures are applied. The houses at the alluvial fan near the bank of Dhad Khola are also not safe as the debris flow in the future might affect those areas.

Alluvial fans like Dhadphat are deposition zone where debris are deposited by the stream (Dhad Khola) so safe distance at least 50 to 100m from the stream should be maintain for the infrastructure development.

Dip direction of foliation plane of rocks and natural hill slope are almost same or similar in Musikot area so there is high probability of Plain failure of rocks in the road cuts. It is recommended to take technical support for the construction of road in that area.

Lastly, the settlements in the steep slope or nearby the steep slope more than 35 degree are always vulnerable sites for rainfall-induced landslides so it is recommended to build the integrated settlement area in safe place for relocation of the vulnerable communities.

Implementation of Mitigation and preventive measures already given in the table can reduce the landslide in the future.

Preliminary Assessment of Construction Matarial Agrregates in Marin Khola , Sindhuli District.

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

ABSTRACT

Preliminary geological survey of Marin Khola area (Topo sheet no: 2785 11C, D, 2785 15A, B, 2785 12C & 2785 16A) of Sindhuli district was carried out for construction materials availability as per the departmental programme of the Fiscal year 2077/78. Marin Khola origins at Bhukikhatar at the confluence of Simle Khola and Padhere Khola and ends at Shripur where it confluence with Bagmati River. Large amount of aggregates has been deposited along the bank of Marin Khola. In order to classify different sediment zones of deposition of river material, trenching and pitting method was used and the river sediments are classified into different river sections which classifies into four groups as per the percentage of sand in volume. River sediments are divided into either Boulder dominant if boulder volume is 80 percent, or more and Sandy area if sand percentage is 80 percent or above. Also, Sand and gravel Mixed area if contains 40-80 percent sand and Gravel while Gravel area for those with less than 40 percent sand. The bar diagram is plotted to visualise the material volume in particular area. The estimated reserve is around 28550980 m3 for gravel while around 2883176029 m3 for sand.

Keywords: Marin Khola; Construction materials; pitting method; Gravel; Sand Reserve

1. INTRODUCTION

With growing construction in country, demand of construction material has become so high that limited quarry sites are not sufficient to meet the requirements.92 quarry sites within 14 districts for construction materials has been identified (DMG, 2020). Construction aggregates like gravel and sand obtained from mining of river deposits from Terai region is not sufficient to meet the growing demand. As a result, people have also started mining aggregates from the hills and rivers of Chure region. In this regard, search of construction material has become vital to meet the current and future demands of construction material. Therefore, this work tries to assess the geological reserve through preliminary geological survey along the Marin Khola, Sindhuli District, and Bagmati Province.

The study area covers parts of the Marin Khola from Dandi to its confluence with Bagmati Khola at Shripur Bazar in Sindhuli district, Bagmati Province. The study area lies within Topo-sheets no. 2785 11 C, 2785 11 D, 2785 15 A, 2785 15 B, 2785 12 C and 2785 16 A. Geologically, this region lies within the Siwalik.

The study area is easily accessible via motor able road from Kathmandu to Dhulikhel (26km along Araniko highway), Dhulikhel to Sindhulimadi (89km which along BP highway) and from Sindhulimadi to Dandi (11km rural gravel road) to Marin Khola confluence and finally to Shripur (43 km Madanbhabdari highway).

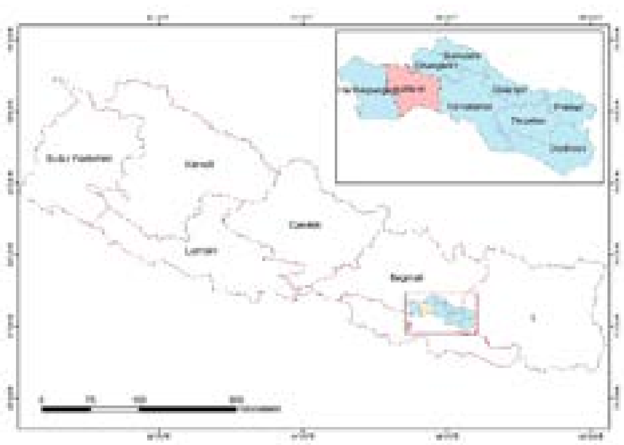


Figure 1: Location map of the study area

2. TOPOGRAPHY, DRAINAGE AND LANDUSE PATTERN

The study area lies mainly in the Siwalik region, with altitude ranging from 180m to 450m and making a gentle topography. Marin bazar and Sindhulimadi bazar are the nearest bazar area in the study area, whereas the places of dense settlement in Kamalamai Municipality are Dandi, Chap, Waibatar, and in Marin rural Municipality are Darbetar and Hakpada, Mathauli and Boteni.

Marin Khola has a low gradient and is usually highly flooded by many tributaries which create variation in transport of sediment and its distribution. Some of the major tributaries are Phulbari Khola, Gaghar Khola, Maidi Khola which hugely affects flow of the river. Many of the tributaries are seasonal rivers carrying sediments as flash flood only in rainy seasons and usually remain dry rest of the year. The area is mostly covered by dense forest except along the national highway where local bazar is developing.

3. METHODOLOGY

Topographic maps of scales 1:25,000 were acquired and used as a base map for the field data collection together with Google maps. At the field, different field equipment such as Brunton compass, GPS, hammer, hand lens, bucket, measuring tape, pig, shovel and other necessary equipment were used in the field. Pits of different size were excavated at regular interval of around 1 km using local tools with help of local people. Litho-logs have been noted and sediments have been classified into gravel or sand dominant. Finally, volumetric percentage of sand and gravel (pebble, cobble) have been measured after screening the sand and gravel in situ using 10 liter bucket.

Plate 1: Method used to separate Gravel and Sand excavated from the pit

3.1 Classifying And Zoning River Sediment Distribution

The study shows various percentages of sand and gravel in different locations. Quartzite and meta-sandstone are the main dominant rock type (>80%) that constitute the gravel while rest are schist, gneiss, granite, marble and others. These sediments must have been deposited by flash floods during the rainy season and represents eroded and reworked sediments from old terraces of Siwalik or bed rocks from Lesser Himalaya.

After recording the percentages of construction material of the all pits, the materials are classified into four groups (Table no 1) and their pits position are mapped (Plate 1). The thickness of the deposit at Marin Khola, as estimated from the height/elevation difference between lowest surface of river channel and top of the terrace is on average 2m.

Table 1: Classification of sediments based on sediment volume

S.N	Sediment volume	Classified Group
1	sand 1-40%	Gravel Area
2	sand 40-80%	Sand and Gravel Mixed Area
3	or more sand 80%	Sandy Area
4	or more Boul- 80% ders	Boulder Area

Boulder Dominant

The percentage of sand and gravel of Marin river section around Dadi area is plotted in 2-D bar chart (Figure 3). It shows that percentage of sand is more than the gravel in this river section. The volume of sand is more than 50% making volume of gravel below 50% only (Figure 7 and Appendix I). However, the chart does not account the boulder which dominates the area. The Boulder dominance may be linked to low gradient of river at this place favorable for bed load transport of sediments in the river bank (Plate 2).

Sand and Gravel Mixed

The percentage of sand in this section is in between 40 to ~70 % with nearly equal amount of gravel (Figure 4). Sand and gravel percentage calculated from the Pits no.31 to 35, no. 16 to 20, no. 7-10 and no. 1-4. The sediment distribution of sand and gravel has been shown in Figures no 8 and 9 .The dimension of a representative pit is shown in Plate 3 while calculated volume of sand and gravel in each pit is shown in Appendix I.

Sand Dominant area

The percentage of gravel in these areas remains below 20%, so dominance of sand is clear (Figure 5). Sand and gravel percentage has been calculated based on observation from the Pits no. 21-23. The sediment distribution has been shown in Figure 10. The pit is shown in Plate 4 and volume of sand and gravel in each pit is shown in Appendix I.

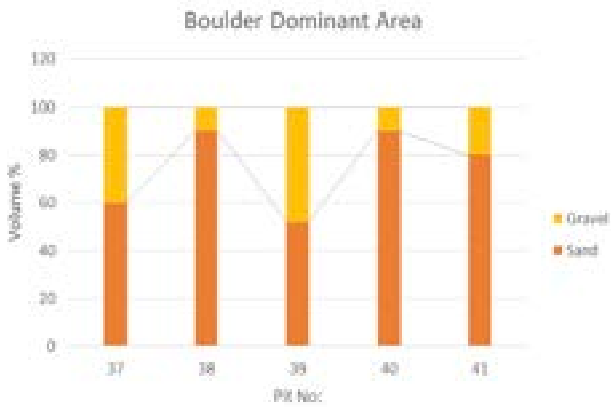


Figure 3: Calculated volumetric percentage of sand or gravel for pits 37-41 representing Boulder Dominant area.

Figure 4: Calculated volumetric percentage of sand or gravel for pits representing sand and Gravel Mixed area.

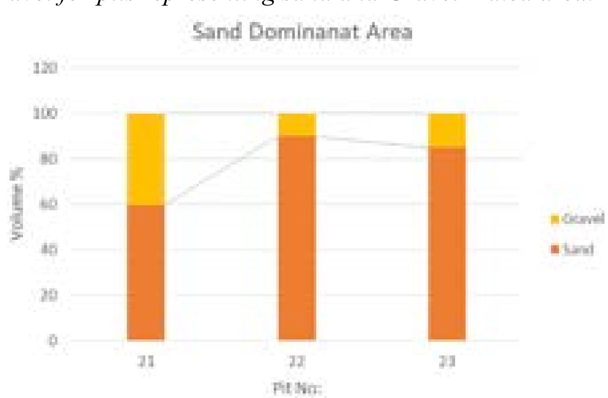


Figure 5: Calculated volumetric percentage of sand or gravel for pits representing Sand Dominant area.

Gravel Dominant area

The percentage of sand is less than 40 % so gravel dominates over 60% of the total volume (Figure 10). Sand and gravel percentage has been calculated from the Pits no.24-30, no. 11-15, and no. 5-6.The sediment distribution of gravel has been shown in Figures 11, 12 and 13. The pit dimension is shown in Plate 5 while volume of sand and gravel in each pit is shown in Appendix I.

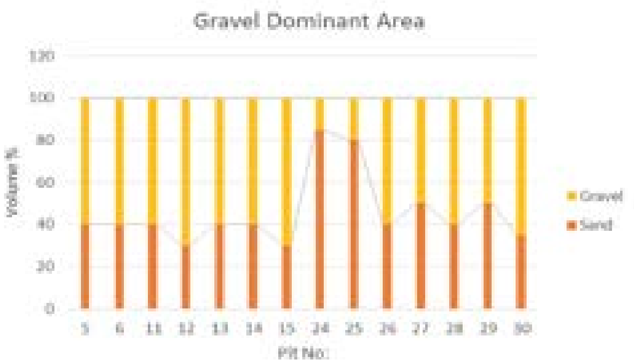


Figure 6: Calculated volumetric percentage of sand or gravel for pits representing Gravel Dominant area.

4. RESERVE ESTIMATION

The tentative geological reserve was calculated by surface area and depth method (L*B*D), considering around 2m depth (usually minable limit for excavation) from the observed surface. On the basis of the calculated proportions of sand and gravel from the representative pits and the area covered by the sediment deposit sections (Table 2 and Plate 6). The total volume estimate for gravel is around 28,550,980m3 and sand is 2,883,176,029m^3.

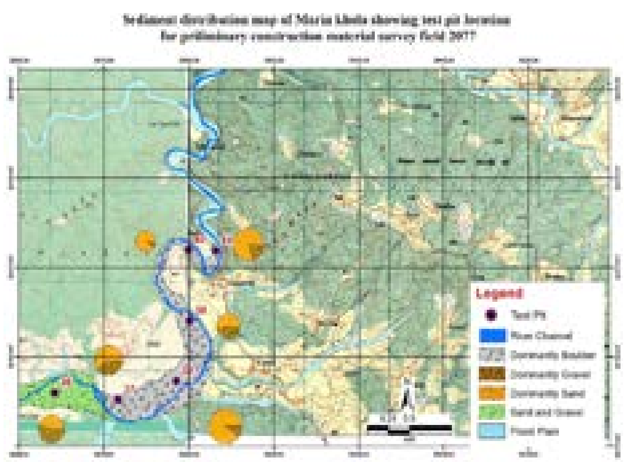


Figure 7: Sediment distribution map along the Boulder dominant section of Marin Khola represented by Pits 36-41

Figure 8: Sediment distribution map along the Boulder dominant section of Marin Khola represented by Pits 29-35

Figure 9: Sediment distribution map along Marin Khola represented by Pits 1-5

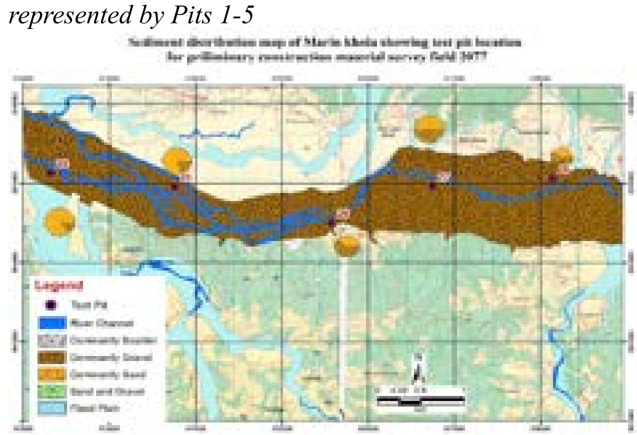


Figure 10: Sediment distribution map Marin Khola represented by Pits 25-28

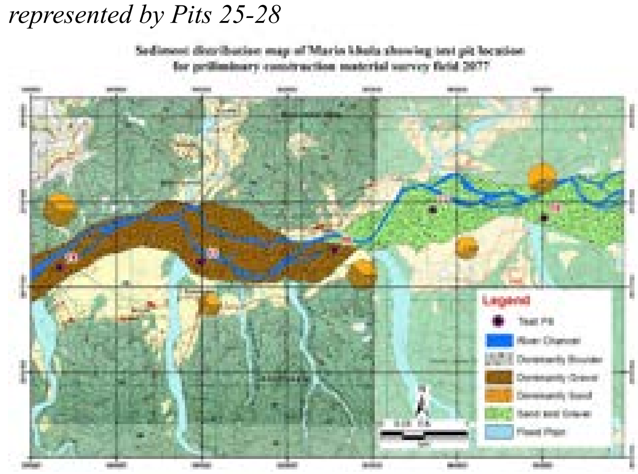


Figure 11: Sediment distribution map Marin Khola represented by Pits 14-18

Table 2: Estimation of reserve of Sand and Gravel in the study area

S.N	AREA (m2)	Meaning	Average depth (m)	Volume (m3)	Gravel Average (%)	Sand Average (%)	Gravel volume (Average) m3	Sand Volume (Average) m3
1	889640.6	Dominantly Boulder	2	1779281.2	26	74	462613.1	131666805.3
2	2486433.9	Sand and Gravel	2	4972867.8	46	54	2287519.1	268534856.3
3	7445187.7	Dominantly Gravel	2	14890375.3	54	46	8040802.7	684957265.1
4	2982461.7	Dominantly Sand	2	5964923.5	28	72	1670178.6	429474489.9
5	4155053.1	Dominantly Gravel	2	8310106.1	64	36	5318467.9	299163820.8
6	1484688.9	Sand and Gravel	2	2969377.8	40	60	1187751.1	178162667.1
7	3799258.1	Sand and Gravel	2	7598516.3	54	46	4103198.8	349531749.7
8	1379697.1	Dominantly Gravel	2	2759394.2	60	40	1655636.5	110375767.2
9	4068949.1	Sand and Gravel	2	8137898.3	47	53	3824812.2	431308607.4
						Total	28550980.0	2883176029

Figure 12: Sediment distribution map Marin Khola represented by Pits 25-28

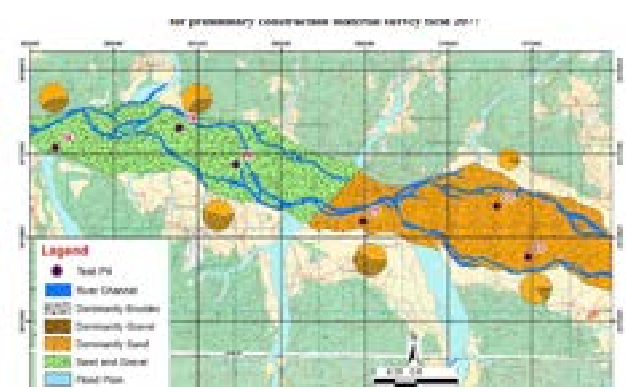


Figure 13: Sediment distribution map Marin Khola represented by Pits 18-23

4.1 Quality of Material

Based on the visual inspection the sand in the Marin Khola is normally of good quality as most of the constituent mineral are of quartz and feldspar with very minor amount of mica. Similarly, the most of the gravels are of quartzite which usually has good engineering properties.

4.2 Mining Condition

Since the sediments are deposited along the river flood plain and flat alluvial terraces that are easily accessible, mining should be easy.

5. CONCLUSION

There is plenty of good quality construction material in Marin Khola river flood plain terrace.

The physical properties and other characteristics of sediments studied is suitable for construction material as the sediments left are mostly of quartzite, gniess and sandstone.

The river deposited heavy bed load towards the upstream of river at Dandi which shows the area is boulder dominant. Immediately after boulder, there is the area of mixed sand and gravel and then after gravel deposit and sand deposit.

6. RECOMMENDATIONS

Further detail topo-geological survey is recommended to map exact river terrace, to separate the present river channel

More pits need to be excavated to know details about the percentage and other characteristics of sand and gravel and finally to know the quality and find actual volume of the construction materials, especially in other tributaries along Marin Basin and upstream of river basin.

Plate 2: Upper section showing dominant of boulder material

Plate 3: Sand and Gravel mixed sediment

Plate 4: Wire mesh is used to separate the gravel from sand

Plate 6: Layers of sediments deposited at the bank of Marin Khola

Plate 5: An exposure of layer of sand inside the pit

7. ACKNOWLEDGMENTS

The authors acknowledge the Director General of DMG for providing opportunity to conduct the field programme. Authors are grateful to section chief Mr. Jaya Raj Ghimire for his observations and comments over the outcome of field activities. Thanks, are also due to Dr. Gautam Prasad Khanal for review and special thanks to editor in chief Dr. Rajendra Bhandari for publishing the report.

REFERENCES

Khadka K. and Adhikari B., Brief Description of Proposed Sites for Construction Materials, 2020, Annual Report of Department of Mines and Geology, Vol 12, p19-35.

Appendix I

Marin Khola Pit Table									
Pit_No	X	Y	Sand	Gravel	Length	Breadth	Height	Volume	m3
1	351239.2	3013099	50	50	110	110	100	1210000	1.21
2	352594	3011713	45	55	100	100	200	2000000	2.00
3	353099.1	3012532	50	50	145	90	150	1957500	1.96
4	352997.5	3010523	40	60	145	95	150	2066250	2.07
5	352386.3	3013897	40	60	140	95	120	1596000	1.60
6	352943	3014690	40	60	160	100	160	2560000	2.56
7	354803	3014892	70	30	140	100	160	2240000	2.24
8	356349.8	3014462	50	50	130	95	200	2470000	2.47
9	356420.8	3015260	50	50	140	90	180	2268000	2.27
10	355823.5	3017007	70	30	140	100	110	1540000	1.54
11	356794.3	3016793	40	60	150	100	170	2550000	2.55
12	357686.1	3018019	30	70	120	100	110	1320000	1.32
13	358723.6	3017702	40	60	110	120	130	1716000	1.72
14	360158.5	3018018	40	60	150	100	170	2550000	2.55
15	361911	3017060	30	70	120	100	110	1320000	1.32
16	363710.2	3017277	35	65	140	90	180	2268000	2.27
17	364932	3017622	60	40	110	100	120	1320000	1.32
18	365821.6	3018569	60	40	155	95	150	2208750	2.21
19	367535.6	3018514	64	36	150	120	130	2340000	2.34
20	367787.4	3017163	45	55	145	90	190	2479500	2.48
21	369607	3016686	40	60	155	120	160	2976000	2.98
22	371266.5	3017832	90	10	110	110	190	2299000	2.30
23	371590.9	3016278	85	15	130	100	200	2600000	2.60
24	372976.7	3015592	85	15	150	100	150	2250000	2.25
25	374337.2	3016350	80	20	155	90	150	2092500	2.09
26	376307.8	3015168	40	60	120	100	120	1440000	1.44
27	377265.4	3016639	50	50	150	120	120	2160000	2.16
28	378800.5	3016420	40	60	120	85	120	1224000	1.22
29	380273.5	3015143	50	50	150	120	120	2160000	2.16
30	381148.8	3016264	35	65	100	100	200	2000000	2.00
31	382386	3015069	56	44	150	95	100	1425000	1.43
32	383369.2	3016018	42	52	120	110	120	1584000	1.58
33	384688	3016012	55	35	145	100	150	2175000	2.18
34	385671.6	3016136	52	48	160	160	120	3072000	3.07
35	386446.1	3016076	70	30	140	100	120	1680000	1.68
36	387012.4	3015338	45	55	145	150	130	2827500	2.83
37	387689.1	3016107	60	40	130	90	170	1989000	1.99
38	389064.3	3015527	90	10	145	100	110	1595000	1.60
39	389097.6	3016429	52	48	110	120	150	1980000	1.98
40	388123.7	3017439	90	10	120	95	120	1368000	1.37
41	389335.7	3017402	80	20	145	110	150	2392500	2.39
									83.27

आर्थिक वर्ष २०७३/७४ देखि २०७७/७८ सम्मको लागि खानी तथा भूगर्भ विभागको कार्यक्रम र बजेटको समिक्षा

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

१. परिचय

नेपालमा भौगर्भिक अध्ययन, अनुसन्धान तथा खनिज सम्पदाको प्रबर्धन एवं बिकासको लागि एक मात्र सरकारी निकायका रुपमा खानी तथा भूगर्भ विभाग क्रियाशील रहे को छ । नेपालको संभवत सबैभन्दा पुरानो बिभागहरु मध्ये एउटा विभागको रुपमा आफ्नो परिचय बनाउन सफल यस विभागको विकासक्रमको ऐतिहासिक पृष्ठभूमि केलाएर हेने हो भने बि. सं. १९८६ मा नहर तथा जियोलजि अड्डा, बि. सं. १९९९ मा खानी अड्डा, बि. सं. २०२४ मा भौगभिक सभे क्षण बिभाग हुंदै बि. सं. २०३३ मा आएर यसको नामाकरण खानी तथा भूगर्भ विभाग हुन पुगेको हो ।

नेपाल सरकार (मन्त्रीपरिषद्) को मिति २०७४।१२।१४ तथा २०७५/०१/०४ को निर्णय अनुसार 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 पेट्रेलियम अन्वेषण परियोजनाको व्यवस्था गरिएको छ ।

२. उद्देश्यहरु

२.१ भू-विज्ञान महाशाखा;

- भौगर्भिक, भू-इन्जिनियरिङ्ग तथा भू-वातावरणीय नक्साहरु प्रकाशन;
- पूर्वाधार विकास, वातावरणीय सुधार तथा प्रकोप व्यवस्थापन कार्यका लागि आवश्यक पर्ने भौगर्भिक तथ्याङ्कहरु उपलब्ध 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 सम्बन्धि 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 हुन सक्ने संभावित क्षेत्रमा अन्वेषण गरी राष्ट्रिय (अन्तराष्ट्रिय लगानीकर्तालाई पेट्रोलियम अन्वेषण एवं उत्पादन गर्न आकर्षण गर्ने ।

२.५ खनिज प्रवर्द्धन तथा प्रशोधन केन्द्र;

- खनिज सम्पदाहरुको अन्वेषण, मूल्याङ्कन तथा प्रवर्धन गरी खनिज भण्डारहरुमा आधारित खनिज उद्योगहरुको विकास , खानी नियमन
- खनिज खोजतलास एवं उत्खनन अनुमतिपत्र प्रदान, नियमन, साधारण निर्माण खनिज उत्खननको सहमति प्रदान गर्ने

२.६ राष्ट्रिय भूकम्प मापन तथा अनुसन्धान केन्द्र;

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

३. सीमितता

सीमित जनशक्ति र सवारी साधनका कारण सम्पूर्ण फिल्ड कार्यक्रम समयमा नसकिनु जसले गर्दा भौतिक प्रगति र वित्तिय प्रगति नहुनु यस विभागको ठुलो सीमितता हो ।

४. आ.व. २०७३/७४ को मुख्य मुख्य कार्यक्रम र त्यसको प्रगति

- धौवादी फलाम खनिजको भौगर्भिक अन्वेषण १५ वर्ग. कि. मि. तथा ड्रिलिङ्ग कार्य १०५ मि. सम्पन्न ।
- युरेनियम अन्वेषण, मुस्ताङ (फलोअप) १० वर्ग. कि. मि., टोपोजियोलजिकल तथा ग्राउण्ड रेडियोमेट्रिक सर्भे २०० हेक्टर तथा नमुना संकलन कार्य सम्पन्न ।
- काठमाण्डौं प्राकृतिक ग्याँस अन्वेषण - इमाडोल ग्याँस उत्पादन परिक्षण कार्य सम्पन्न तथा टेकु क्षेत्रमा ३५० मि. ड्रलिङ्ग कार्य सम्पन्न ।
- भौगर्भिक सर्भेक्षण म्यापिङ्ग (ताप्लेजुङ, पाँचथर, नुवाकोट, धादिङ्ग, तनहुँ, गोरखा, लम्जुङ्ग, रुकुम, रोल्पा, अछाम, दैलेख, बैतडी, डडेलधुरा, खोटाङ्ग, ओखलढुङ्गा र कालिकोट जिल्लाका विभिन्न क्षेत्र) - ६,१७५ वर्ग. कि. मि. क्षेत्रमा भौगर्भिक सर्भेक्षण कार्य सम्पन्न ।
- गुल्मी, अछाम, प्यूठान, पोखरा, धादिङ्ग, गोरखा र संखुवासभा जिल्लाको भू-प्रकोप अध्ययन फिल्ड कार्य सम्पन्न ।
- चुनढुङ्गा अन्वेषण महादेवस्थान धादिङ्ग - प्रारम्भिक

अन्वेषण- २५ वर्ग. कि. मि. क्षेत्रमा तथा विस्तृत अन्वेषण- १०० हेक्टर ।

- फोस्फोराइट अन्वेषण बझाङ्ग- भौगर्भिक म्यापिङ्ग २० वर्ग कि. मि. विस्तृत अन्वेषण- २०० हेक्टर, ६१ मि. च्यानल स्याम्पलिङ्ग ।
- फलाम तथा तामा अन्वेषण, मल्लादेबी, बैतडी १०० हेक्टर क्षेत्रमा फिल्ड कार्य सम्पन्न ।
- ८० वटा खानीहरुको वातावरणिय अनुगमन तथा निरिक्षण ।

५. आ.व. २०७४/७५ को मुख्य मुख्य कार्यक्रम र त्यसको प्रगति

- भौगर्भिक म्यापिङ्गः नुवाकोट, धादिङ्ग, रामेछाप, दोलखा, ओखलढुङ्गाको १३०० वर्ग. कि. मि. क्षेत्रमा भौगर्भिक म्यापिङ्ग कार्य सम्पन्न ।
- भू-ईञ्जिनयरिङ अध्ययनः पोखरा, विदुर र विरगञ्ज को २०० वर्ग कि. मि. क्षेत्रमा भू-ईञ्जिनियरिङ, भू-वातावरणिय तथा माईक्रोट्रिमर अध्ययन कार्य सम्पन्न ।
- नामटार चुनढुङ्गा, मकवानपुर- भौगर्भिक अन्वेषण १० वर्ग कि. मि. क्षेत्रमा तथा ३०० मि. च्यानल स्यामपलिङ्ग कार्य सम्पन्न ।
- महादेवस्थान चुनढुङ्गा, धादिङ-३१० मि. ड्रिलिङ कार्य सम्पन्न, १० वर्ग कि. मि. क्षेत्रमा भौगर्भिक अन्वेषण तथा ३०० मि. च्यानल स्याम्पलिङ कार्य सम्पन्न ।
- फोस्फोराइट अन्वेषण बझाङ्ग तथा बैतडीः २५ वर्ग कि. मि. क्षेत्रमा भौगर्भिक नक्साङ्कन तथा च्यानल स्याम्पलिङ कार्य सम्पन्न ।
- फलाम अन्वेषण किटभञ्ज्याङः ५० वर्ग कि. मि. ।
- घौवादी फलाम अन्वेषणः सर्भे ४०० हेक्टर, ३०० मि. च्यानल स्याम्पलिङ ।
- घौवादी फलामको :भतबर्गिचनष्अर्बा त्भकत अन्वेषणः फलाम खनिजको ८५० के.जी. नमुना चीनको Southwest Metallurgical and Geological Testing Centre, Chengdu df Metallurgical Test को कार्य सम्पन्न ।
- खनिज अन्वेषणको लागी भौगर्भिक म्यापिङः ताप्लेजुङ्ग, पाँचथर, गोरखा, तनहुँ, लमजुङ्ग, नुवाकोट, धादिङ्ग, रसुवा, रुकुम, कालिकोट, दैलेख, अछाम, रोल्पा, १९५० वर्ग कि. मि. क्षेत्रमा अन्वेषणको लागी भौगर्भिक म्यापिङ्ग कार्य सम्पन्न ।
- खनिज जन्य उद्योग प्रवर्धनः ८ वटा खानीहरुको खोजतलास अनुमती प्रदान गरिएको तथा काभ्रेपलाञ्चोक, ठुम्की चुनढुङ्गा खानीको उत्खनन् अनुमती प्रदान गरिएको ।
- विभागमा रहेका २३० रिपोर्ट तथा ३००० नक्सा स्क्यान तथा डिजिटाइजेशन कार्य सम्पन्न ।
- भूकम्प सम्बन्धी छिटो छरितो सुचना प्रवाह कार्यको लागी Mobile Apps निर्माण तथा ध्भदकष्तभ को अपग्रेड कार्य सम्पन्न ।
- ७८ वटा खानीहरुको वातावरणिय अनुगमन तथा निरिक्षण ।

६. आ.व. २०७५/७६ को मुख्य मुख्य कार्यक्रम र त्यसको प्रगति

- जाजरकोट, दैलेख जिल्लाको ज्ञण्ण वर्ग कि. मि. क्षेत्रमा बहुमूल्य तथा मूल्यवान पत्थर अन्वेषण ।
- युरेनियम अन्वेषण, गोरखा तथा मुस्ताङ ।
- फलाम अन्वेषण, मकवानपुर, धौवादी (ERT Survey) - ५० वर्ग. कि.मि. ।
- खनिज उद्योग प्रवर्धन (१५ वटा) ।
- चुनढुङ्गा ड्रिलिङ्ग कार्य, खोटाङ तथा महादेवस्थान, -६०० मी. ।
- धौवादी फलाम अन्वेषण, channel sampling 300 मी. ।
- प्रारम्भिक फोस्फोराईट अन्वेषण, बैतडी -५० वर्ग. कि.मी. ।
- तामा अन्वेषण, मिनामकोट, तनहुँ (भौगर्भिक म्यापिङ, च्यानल स्याम्पलिङ)- १७५ मी. ।
- पाल्पा जिल्लामा संचालित २ खानीहरुको वातावरणिय तथा प्राविधिक अडिट कार्य सम्पन्न ।
- मेटालर्जिकल परिक्षण कार्यको २ नमुना परिक्षण कार्य सम्पन्न भई प्रतिवेदन प्राप्त, उत्पादन परिक्षणको लागि MOU सम्झौता सम्पन्न, ५ टन नमुना संकलन भई पठाईएको ।
- ६५० वर्ग कि. मि. क्षेत्रमा म्यापिङ्ग कार्य सम्पन्न ।
- जलेश्वर, सिन्धुलीको भू-ईञ्जिनियरिङ्ग अध्ययन- ८० वर्ग. कि. मि. ।
- बाग्लुङ्ग, लम्जुङ्ग, काभ्रे, सिन्धुपाल्चोक, काठमाण्डौंमा आकस्मिक पहिरो अध्ययन कार्य सम्पन्न ।
- भू-ईञ्जिनियरिङ्ग जियोलोजी तथा वातावरणिय नक्सा प्रकाशन (जनकपुर, भरतपुर, महेन्द्रनगर)- ४०० प्रति ।
- भौगर्भिक नक्सा प्रकाशन (१:५००००) (३९०० वर्ग कि. मि.)- ६ क्षेत्र ।
- ३ नं. प्रदेशको Landslide Inventory Database, सात प्रदेशको १:२५०००० स्केलमा भौगर्भिक नक्सा ञ्पफउषबितष्यल कार्य सम्पन्न ।
- किमती तथा अर्ध किमती पत्थर प्रसोधन केन्द्रको भवन तयार ।
- खनिज अनुमती सम्बन्धी विवरणः १०८ वटा नयाँ खोजतलास अनुमती प्रदान तथा २६५ नविकरण; ९ वटा नयाँ उत्खनन् अनुमती जारी तथा ९९ वटा नविकरण; नामसारी भएको १५ वटा ।

७. आ.व. २०७६/७७ को मुख्य मुख्य कार्यक्रम र

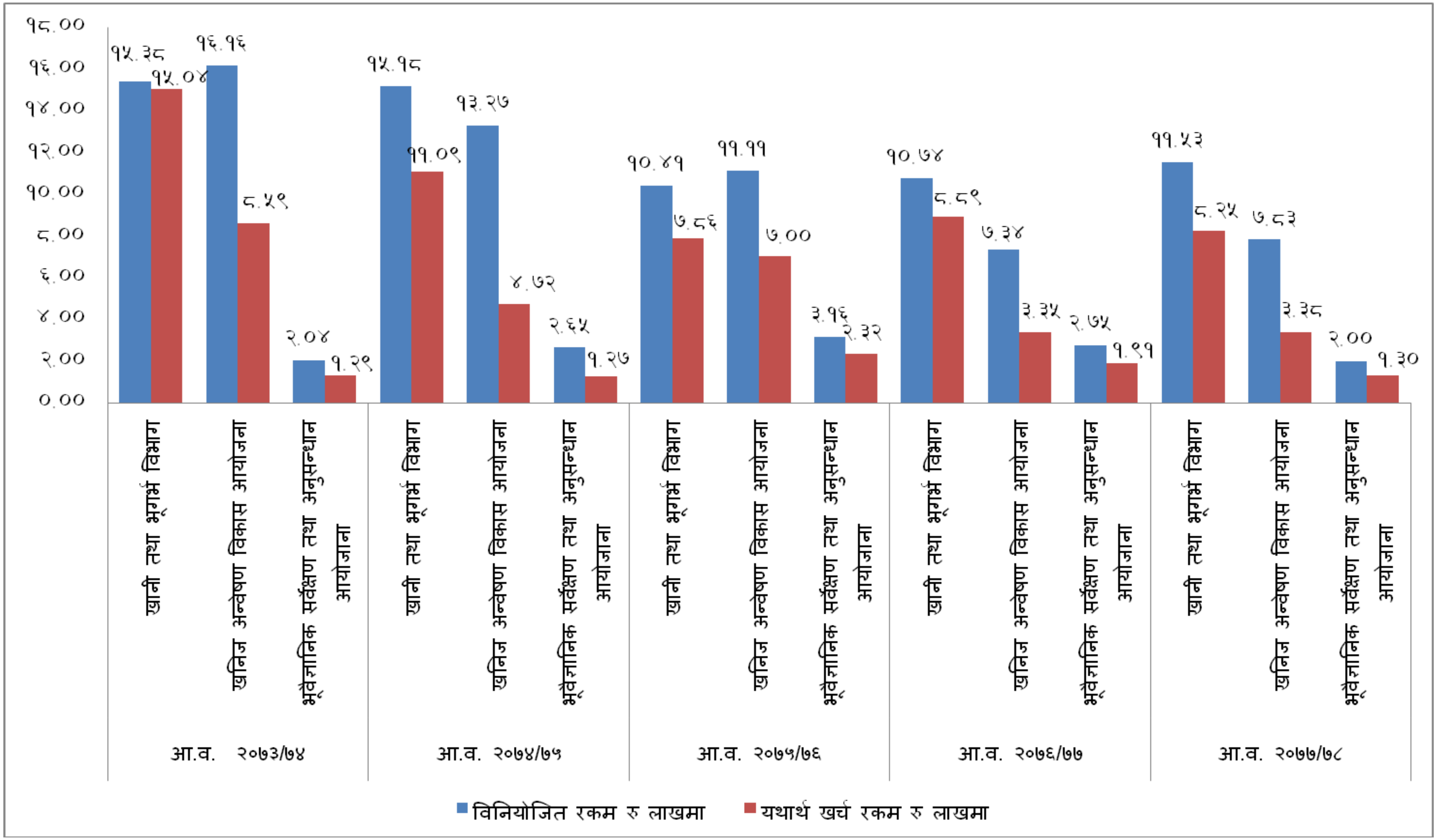
त्यसको प्रगति

- दमक १०० वर्ग कि.मि. तथा दमौली ३० वर्ग कि.मि. क्षेत्रमा भू-ईञ्जिनियरिङ तथा भू-वातावरणिय अध्ययन तथा नमुना संकलन कार्य सम्पन्न ।
- प्रदेश १, गण्डकी प्रदेश तथा प्रदेश ५ को Landslide Inventory Database तयार गर्ने कार्य सम्पन्न ।
- पर्वत, म्याग्दी, गुल्मी तथा संखुवासभा जिल्लामा आकस्मिक पहिरो अध्ययन कार्य सम्पन्न ।
- गोरखा, तनहुँ, चितवन, धादिङ, १३०० वर्ग कि.मि. क्षेत्रको भौगर्भिक नक्सा प्रकाशन कार्यको लागी चितवन, तनहुँ, धादिङ्ग, गोरखा जिल्लामा प्रमाणिकरण फिल्ड कार्य सम्पन्न ।
- अम्लेखगञ्ज-रसुवागडी सडक क्षेत्रको भौगर्भिक तथा भू-प्रकोप अध्ययन कार्य सम्पन्न ।
- विदुर, जलेश्वर, विरगञ्जको भू-ईञ्जिनियरिङ तथा भू-वातावरणिय नक्साको कार्टोग्राफी तथा डिजिटल नक्सा तयार गर्ने कार्य सम्पन्न ।
- ७ प्रदेशको भौगर्भिक नक्सा प्रकाशन कार्य सम्पन्न ।
- उदयपुर, ओखलढुङ्गा, सिन्धुली, खोटाङ जिल्ला र गोरखा, लमजुङ्ग जिल्लाको ६५० वर्ग कि. मि. क्षेत्रमा भौगर्भिक नक्साङ्कन कार्य सम्पन्न ।
- मिनामकोट पोलीमेटल तनहुँ क्षेत्रमा २५ वर्ग कि.मि., क्षेत्र भू-भौतिक सर्भे सम्पन्न ।
- तामा खानी ,पर्वत २५ वर्ग कि. मि. क्षेत्र भूभौतिक सर्भे सम्पन्न भई आबुखैरेनी, तनहुँ (२१ वर्ग. कि. मि. क्षेत्र भू-भौतिक सर्भे सम्पन्न भई खानी डाँडा,तामा, ओखलढुंङ्गा २५ वर्ग कि.मि. क्षेत्रमा भूभौतिक सर्भे कार्य सम्पन्न भई डाटा प्रोसेसिङ कार्य सम्पन्न । प्राप्त नतिजा अनुसार Mineral Anomaly खनिजको सम्भाब्यता देखिएको ।
- निर्माणमुखी खनिज अन्वेषण अन्तर्गत वारा, मकवानपुर, कास्की जिल्लाको ९५ वर्ग कि.मि. क्षेत्रमा भौगर्भिक अन्वेषण कार्य सम्पन्न ।
- सुर्खेतमा ३०० मि. चुनढुङ्गाको अन्वेषणात्मक ड्रिलिङ्ग कार्यमा १९० मि. ड्रिलिङ् कार्य सम्पन्न ।
- ११ वटा खनिज उद्योग प्रवर्द्धन कार्यको लागि नीजी लगानीकर्तासँग सम्झौता गर्न आशयकको सूचना प्रकाशित भए बमोजिम हाल सम्म चूनढुङ्गा ५ (उत्खनन् ४, खोजतलास १), सून, तामा, कोइला तथा ग्रेनाइट गरी ९ वटा सम्झौता सम्पन्न भएको ।
- १० वटा नयाँ खनिज जन्य उद्योग प्रवर्धनकार्यको लागी Data Package तयार गरी प्रस्ताव आह्वानको सुचना प्रकाशन गरिएको ।
- चीनीया सहयोगमा स्थापना भएको ८ वटा भूकम्प मापन स्टेशन तथा डाटा सेन्टर चीनिया राष्ट्रपती सि जिडपिङ को नेपाल भ्रमणको क्रममा हास्तान्तरण कार्य सम्पन्न ।

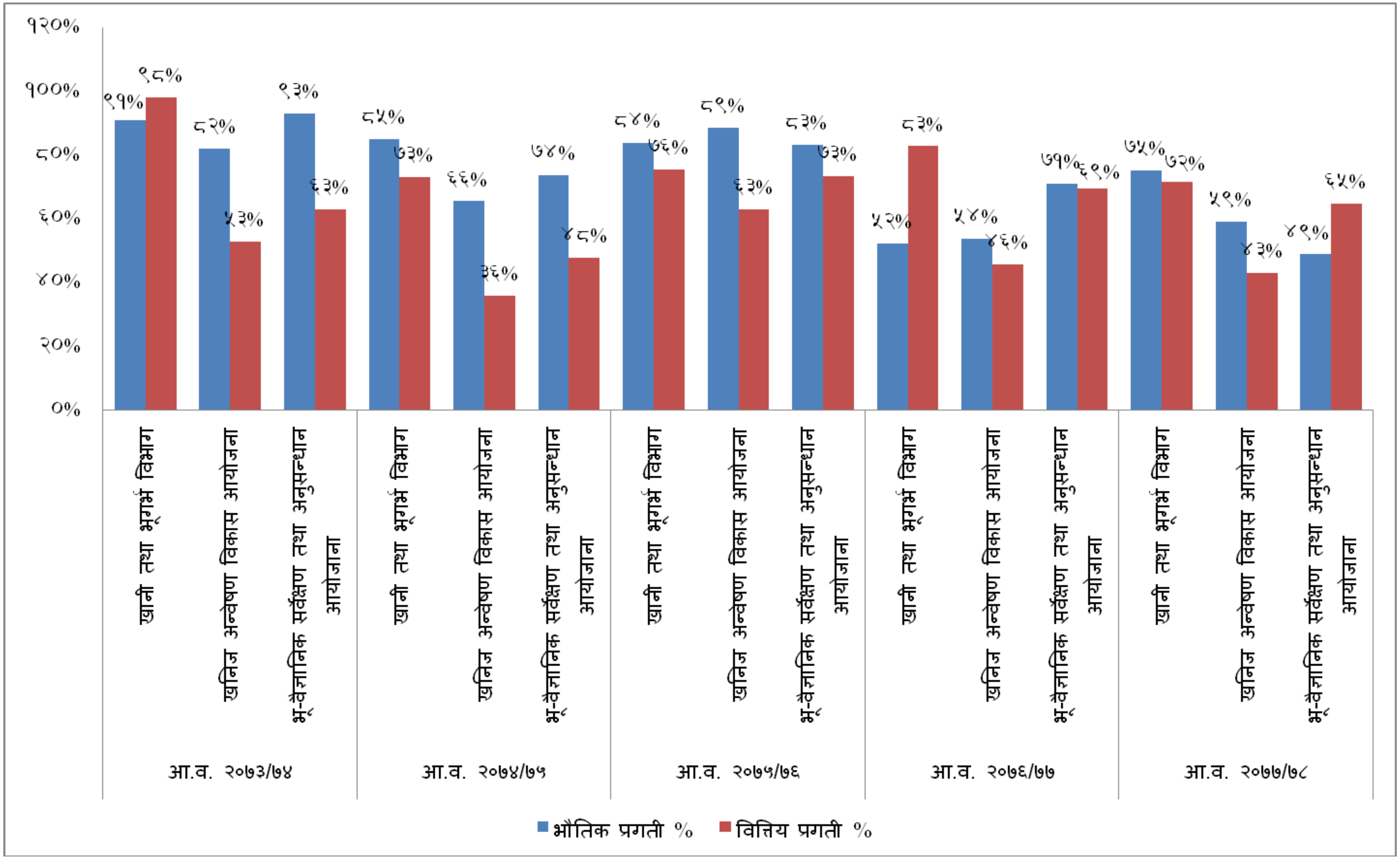
८. आ.व. २०७७/७८ को मुख्य मुख्य कार्यक्रम र त्यसको प्रगति

- झापाको भद्रपुर मा १०० वर्ग कि. मि. क्षेत्रमा र कैलालीको टिकापुरमा ७० वर्ग कि. मि. क्षेत्रमा भूईञ्जिनियरिङ तथा भूवातावरणिय अध्ययन तथा नमुना संकलन कार्य सम्पन्न ।
- कुश्मा न. पा., फलेबास न. पा., जलजला गा. पा. र मोदी गा. पा. पर्वत जिल्ला, शितगंगा न. पा. र सन्दिखर्क न. पा.अर्घाखाँची, कालीगण्डकी गा. पा. र बिरुवा गा. पा. न. स्याङ्जा, मण्डनदेउपुर न. पा. काभ्रे, रामारोशन-अछाम, दुवारगाँउ-लमजुङ र दुप्चेश्वर-नुवाकोट जिल्लाका विभिन्न स्थानमा आकस्मिक पहिरो अध्ययन कार्य सम्पन्न ।
- फस्फोराइट अन्वेषणका लागि १५० मि. अन्वेषणात्मक ड्रिलिङ कार्य सम्पन्न भई संकलित नमुनाहरुको रसायनिक परिक्षण कार्य सम्पन्न भई अन्तिम प्रतिवेदन प्राप्त ।
- विभिन्न ६० वटा ऊत्खनन अनुमति प्राप्त खानीहरुको अनुगमन तथा निरिक्षण कार्य सम्पन्न ।
- ग्याजी, गोर्खाको छ वर्ग कि. मि. क्षेत्रमा तामाको प्रारम्भिक भौगर्भिक अन्वेषण कार्य सम्पन्न ।
- ओखरवोट, म्याग्दीको ५ वर्ग कि. मि. क्षेत्रमा तामाको प्रारम्भिक भौगर्भिक अन्वेशण कार्य सम्पन्न ।
- लुङ्गिखोलाको ५० हेक्टर क्षेत्रमा सुनको लागि टोपो सर्भे तथा १० वर्ग कि.मि. जियोकेमिकल नमुना संकलन फिल्ड कार्य सम्पन्न ।
- कम्पुघाटको १५ वर्ग कि. मि. क्षेत्रमा म्यासगनेसाइटको प्रारम्भिक भौगर्भिक अन्वेषण तथा नमुना संकलन कार्य सम्पन्न भई संकलित नमुनाहरुको रसायनिक परिक्षण कार्य हुदै ।३०० मि. च्यानल स्याम्पलिङ्ग कार्य साथै १०० हेक्टर क्षेत्रफलमा टोपो सर्भे कार्य सम्पन्न। खनिजको सम्भाव्यता रहेको प्रतिवेदन प्राप्त भएको र ३०० मि. अन्वेषणात्मक ड्रिलिङ कार्यमा ज्ञद्धछ मि. सम्पन्न ।
- स्याङ्गजा जिल्लाको नौडाँडा क्षेत्रमा २० वर्ग कि.मि. भौगर्भिक अन्वेषण कार्य सम्पन्न ।
- ईलाम जिल्लामा खनिजजन्य निर्माण सम्बन्धी खनिज भौगर्भिक अन्वेषणात्मक फिल्ड कार्य सम्पन्न ।
- अर्घाखाँची जिल्लाको ज्ञण वर्ग कि.मि. क्षेत्रमा विभागको टोलीवाट बहुमुल्य पत्थर (ज्यास्पर) सर्भे तथा सम्भाव्यता अध्ययन कार्य सम्पन्न ।
- वागमती प्रदेशको १० वर्ग कि.मि. क्षेत्रमा निर्माणमुखी खनिजको भौगर्भिक अन्वेषणात्मक फिल्ड कार्य सम्पन्न ।
- जेमोलोजी मिनरलोजी प्रयोगशाला सम्बन्धी उपकरण खरिद कार्य सम्पन्न ।
- प्युठान, गोर्खा, स्याङ्जा, सिन्धुपाल्चोक र ताप्लेजुङ जिल्लाका साईस्मिक स्टेसनको मर्मत संभार सम्पन्न

९. आयोजना अन्तर्गत विनियोजित रकम र यथार्थ खर्च वित्तिय तथा भौतिक प्रगति



१०. आयोजना अन्तर्गत वित्तिय तथा भौतिक प्रगति



११. वार्षिक कार्यक्रम / क्रियाकलापको निरन्तरता

सि.नं.	क्रियाकलाप	आ.व. २०७३/०७४	आ.व. २०७४/०७५	आ.व. २०७५/०७६	आ.व. २०७६/०७७	आ.व. २०७७/०७८
	खनिज अन्वेषण					
१.	चुनढुङ्गा अन्वेषण (सभे क्षण तथा च्यानल स्याम्पलिंङ्ग), महादेवस्थान धादिंङ्ग	२५ वर्ग कि.मि. प्रारम्भिक तथा १०० हेक्टर विस्तृत	३०० मि. स्याम्पलिङ्ग कार्य तथा १०० हेक्टर क्षेत्रमा टोपोग्राफिकल सभे, १० वर्ग कि.मि. क्षेत्रमा विस्तृत भौगर्भिक अन्वेषण ३१० मि. ड्रिलिङ्ग कार्य	३०० मि. च्यानल स्याम्पलिङ्ग कार्य सम्पन्न, ३०० मि. ड्रिलिङ्ग कार्य		खनिज प्रवर्धन कार्यका लागि प्रस्ताव आव्हान भएको
२.	चुनढूङ्गा अन्वेषण, बोझे, खोटाङ			१५० मि. च्यानल स्याम्पलिङ्ग, २८७ मि. ड्रिलिङ्ग कार्य		
३.	चुनढूङ्गा अन्वेषण, भैसे, धादिङ्ग				३१० मि. ड्रिलिङ्ग कार्य	खनिज प्रवर्धन कार्यका लागि प्रस्ताव आव्हान भएको
४.	चुनढूङ्गा अन्वेषण, लखर पाटा, सुर्खेत				१९० मि. ड्रिलिङ्ग कार्य	
५.	फोस्फोराइट अन्वेषण बझाङ्ग, बैतडी	२० वर्ग. कि. मि. क्षेत्रमा भौगर्भिक म्यापिङ्ग २०० हेक्टर क्षेत्रमा खनिज अन्वेषण ६१ मी. च्यानल स्याम्पलिङ्ग-बझाङ्ग	२५ वर्ग कि.मि. क्षेत्रमा विस्तृत अन्वेषण - बैतडी	१६० मि. च्यानल स्याम्पलिङ्ग - बैतडी, १०० हे. टोपोग्राफिकल सर्भे		१५० मि. अन्वेषणात्मक ड्रिलिङ्ग कार्य र ५० मि. च्यानल स्याम्पलिङ्ग
६.	फलाम तथा तामा अन्वेषण	मल्लादेवी, बैतडीको १०० हेक्टर क्षेत्रमा	किट भन्ज्याङ्गको ५० वर्ग कि.मि. अन्वेषण, कालिटार तामा प्रवर्धन, मकवानपुर लब्दी फलाम अन्वेषण प्रवर्धन कबिलास तामा अन्वेषण प्रवर्धन, चितवन/तनहुँ	किट भन्ज्याङ्गको २५ वर्ग कि. मि. क्षेत्रमा भू-भौतिक सर्भे (ERT) कार्य	फलाम खानी-पर्वत, मिनामकोट पोलिमेटल-तनहुँ, खानीडाँडा तामा-ओखलढुङ्गा, आबुखैरेनी तामा-तनहुँ भूभौतिक फिल्ड तथा डाटा प्रोसेशिङ कार्य	ग्याजी-तामा, गोर्खाको (भू-भौतिक सर्भे) ५ वर्ग कि. मि. क्षेत्रमा प्रारम्भिक भौगर्भिक अन्वेषण, ओखरवोट-तामा, म्याग्दीको ५ वर्ग कि. मि. क्षेत्रमा प्रारम्भिक भौगर्भिक अन्वेषण भई प्रवर्धन कार्य

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७.	धौवादी फलाम अन्वेषण, विस्तृत भौगर्भिक नक्साङ्कन, सर्भे, Hematite Band Tracing, नवलपरासी	१५ वर्ग कि.मि. १०५ मि. ड्रिलिङ्ग चिप स्याम्पल- १०८ वटा	३०० मि. स्याम्पलिङ कार्य तथा ४०० हेक्टर क्षेत्रमा टोपोग्रोफिकल सर्भे	३०० मि. च्यानल स्याम्पलिङ्ग कार्य तथा भू-भौतिक सर्भे	चीन स्थित प्रयोगशालामा करिव ५ टन नमुनाहरुको परिक्षण कार्य सम्पन्न भई अन्तिम प्रतिवेदन प्राप्त	खनिज प्रवर्धन भई धौवादी फलाम कम्पनीलाई २ वटा खोजतलास कार्यको अनुमतीपत्र प्रदान
८.	यूरेनियम अन्वेषण तथा रेडियोमेट्रिक सर्भे, मुस्तांङ	१० वर्ग कि.मि. टोपोजियोलोजिकल तथा रेडियोमेट्रिक सर्भे २०० हेक्टर सर्भे		युरेनियम अन्वेषण, मुस्ताङ्ग		
९.	यूरेनियम थोरियम अन्वेषण, गोरखा		२५ वर्ग कि.मि. अन्वेषण	साइट निरिक्षण फिल्ड कार्य		
१०.	नामटार चुनढुङ्गा		१० वर्ग कि.मि. क्षेत्रमा भौगर्भिक अन्वेषण तथा ३०० मि. च्यालन स्याम्पलिङ		खनिज प्रवर्धन कार्य	
११.	सर्भे तथा सम्भाव्यता अध्ययन- बहुमुल्य पत्थर			जाजरकोट, दैलेख जिल्लाको १०० वर्ग कि.मि. क्षेत्रमा बहुमुल्य पत्थर अन्वेषण	जाजरकोट जिल्लामा भौगर्भिक नक्साङ्कन तथा टोपोग्राफिकल सर्भे कार्य	अर्घाखाँची जिल्लाको १० वर्ग कि.मि. क्षेत्रमा बहुमुल्य पत्थर (ज्यास्पर) को भौगर्भिक सर्भेक्षण कार्य
१२	कम्पुघाट-म्याग्नेसाइट विस्तृत अन्वेषण					१५ वर्ग कि. मि. क्षेत्रमा प्रारम्भिक भौगर्भिक अन्वेषण, २५० मि. च्यानल स्याम्पलिङ्ग, १०० हे. टोपो सर्भे, १४५ मि. अन्वेषणात्मक ड्रिलिङ कार्य

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	भौगर्भिक नक्साङ्कन					
१.	खनिज पदार्थ अन्वेषणको लागी भौ गर्भिक नक्साङ्कन	३२५० वर्ग कि.मि. (परामर्श बाट)	१९५० वर्ग कि.मि. क्षेत्रमा भौगर्भिक म्यापिङ (ताप्ले जुङ्ग, पाँचथर, गोरखा, तनहुँ, लम्जुङ्ग, नुवाकोट, धादिङ्ग, रसुवा, रुकुम, कालिकोट, दैलेख, अछाम, रोल्पा)	६५० वर्ग कि.मि. क्षेत्रमा भौगर्भिक म्यापिङ (धादिङ, चितवन, गोरखा, तनहुँ)	उदयपुर, ओखलढुङ्गा, सिन्धुली, खोटाङ जिल्ला र गोरखा, लमजुङ् जिल्लाको ६५० वर्ग कि.मि. क्षेत्रमा नक्साङ्कन कार्य	उदयपुर, सिन्धुली, ओखलढुङ्गा, नुवाकोट, रसुवा र सिन्धुपाल्चोक जिल्ला अन्तर्गतको क्षेत्रहरुमा ६५० वर्ग कि. मि. भौगर्भिक नक्सांकन कार्य
२.	भौगर्भिक नक्साङ्कन	२९२५ वर्ग कि.मि. (बैतडी, अछाम, सुर्खेत, गोर्खा, लमजुङ) धादिङ, ओखलढुङ्गा, नुवाकोट, डडेलधुरा, जाजरकोट, खोटाङ	१३००वर्ग कि.मि. क्षेत्रमा भौगर्भिक म्यापिङ (नुवाकोट, धादिङ, रामेछाप, ओखलढुंङ्गा)			
३.	भौगर्भिक नक्शा स्क्यान तथा डिजिटाइजेशन कार्य		२००० नक्सा तथा २०० रिपोर्ट स्क्यानिङ कार्य		भौगर्भिक नक्शा स्क्यान तथा डिजिटाइजेशन कार्य	भौगर्भिक नक्शा स्क्यान तथा डिजिटाइजेशन कार्य

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भू-विज्ञान, भू-ईन्जिनियरिङ् तथा भू-प्रकोप अध्ययन						
१.	आकस्मिक पहिरो अध्ययन	गुल्मी, अछाम, प्यूठान, पोखरा, धादिङ्ग, गोरखा र संखुवासभा जिल्लाका पहिरो प्रभावित स्थान	कास्की, संखुवासभा, बाग्लुङ्ग जिल्लाका पहिरो प्रभावित स्थान	काठमाडौं, सिन्धुपाल्चोक, लमजुङ्ग, काभ्रे, डोटी, बाग्लुङ्ग, र अछाम जिल्लाका पहिरो प्रभावित स्थान,	गुल्मी तथा संखुवासभा, पर्वत, म्याग्दी, अछाम जिल्लाका पहिरो प्रभावित स्थान	कुश्मा , फलेबास न. पा., जलजला र मोदी गा. पा. पर्वत जिल्ला, शितगंगा र सन्दिखर्क न. पा.अर्घाखाँची, कालीगण्डकी र बिरुवा गा. पा. न. स्याङ्जा, मण्डनदेउपुर न. पा. काभ्रे, रामारोशन-अछाम, दुवारगाँउ-लमजुङ र दुप्चेश्वर-नुवाकोट, डडेलधुरा जिल्लाका विभिन्न स्थानमा आकस्मिक पहिरो अध्ययन कार्य
२.	जियोटुरिजम तथा भौगर्भिक तथा भूईञ्जिनियरिङ नक्सांकन तथा अध्ययन	७७ कि. मि. सडक क्षेत्र बेनी- जोमसोम	बेनी-कागबेनि क्षेत्र		अम्लेखगञ्ज देखी रसुवागढी सडक खण्ड	
३.	भू-ईन्जिनियरिङ तथा माइक्रोट्रिमर अध्ययन फिल्ड		पोखरा, विदुर र विरगञ्ज को २०० वर्ग कि. मि. क्षेत्रमा भू-ईञ्जिनियरिङ, भू-वातावरणिय तथा माईक्रोट्रिमर अध्ययन कार्य	जलेश्वर ५० वर्ग कि.मि. क्षेत्रमा अध्ययन कार्य सम्पन्न, सिन्धुली ३० वर्ग कि. मि. क्षेत्रमा फिल्ड कार्य	दमक १०० वर्ग कि.मि. क्षेत्र तथा दमौली ३० वर्ग कि.मि. क्षेत्रमा गरी कुल १३० वर्ग कि.मि. क्षेत्रमा कार्य	झापाको भद्रपुर मा १०० वर्ग कि.मि. क्षेत्रमा र कैलालीको टिकापुरमा ७० वर्ग कि.मि. क्षेत्रमा भूईञ्जिनियरिङ तथा भूवातावरणिय अध्ययन तथा नमुना संकलन कार्य
४.	Collaborative Projects -SATREPS, EOS) फिल्ड कार्य				महोत्तरी, पर्सा, तनहुँ, बाग्लुङ, मुस्ताङ, कपिलबस्तु, रुपन्देही, सल्यान, रुकुम, स्याङ्जा जिल्लामा GPS station अनुगमन तथा डाटा संकलन फिल्ड कार्य	जलेश्वर स्थित GPS station को मर्मत भई पुनः संचालन

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भूकम्पिय अध्ययन अनुसन्धान						
१.	Paleo Seismic Field Study, सुर्खेत	१ जिल्ला				
२.	नियोटेक्टोनिक अध्ययन					दाङ्ग तथा सुर्खेत जिल्लामा फिल्ड कार्य
३.	Active Fault Mapping	चितवन देखी रुपन्देही, करिव १०० कि.मि.			मकवानपुर देखि कपिलवस्तु सम्म चुरे को फेदीमा Active fault सम्वन्धी अध्ययन फिल्ड कार्य	
४.	जि.पि.एस. स्टेशन क्यालिब्रेशन तथा मर्मत फिल्ड			सिन्धुपाल्चोक जि.पि.एस. स्टेशन क्यालिब्रेशन तथा मर्मत फिल्ड	ओडारे, धनकुटा जि.पि.एस. स्टेशन मर्मत फिल्ड	ककनी-नुवाकोटमा जि.पि.एस. स्टेशन क्यालिब्रेशन तथा मर्मत फिल्ड कार्य
५.	साईस्मिक स्टेशन, रिले स्टेशन क्यालिब्रेशन तथा मर्मत फिल्ड	रा.भू.मा. तथा अ.के. अन्तर्गतका सबै साईस्मिक स्टेसनहरुको क्यालिब्रेशन तथा डाटा प्राप्ति तथा सूचना संकलन र सम्प्रेषण	रा.भू.मा. तथा अ.के. अन्तर्गतका सबै साईस्मिक स्टेसनहरुको क्यालिब्रेशन तथा डाटा प्राप्ति तथा सूचना संकलन र सम्प्रेषण	सबै स्टेसनहरुको क्यालिब्रेशन मर्मत र डाटा प्राप्ति तथा सूचना संकलन र सम्प्रेषण		प्यठान, गोर्खा, स्याङ्जा, सिन्धुपाल्चोक, ताप्लेजुङ, दोलखा (जिरी), कास्की, पाल्पा, मकवानपुर जिल्लाका साईस्मिक स्टेसनहरुको क्यालिब्रेसन तथा सुचना संकलन कार्य

Government of Nepal
Ministry of Industry, Commerce and Supplies
DEPARTMENT OF MINES AND GEOLOGY
Lainchaur, Kathmandu, Nepal
Te. +977-1-4414740, 4412065, Fax: +977-1-4414806
Email: info@dmgnepal.gov.np, website: www.dmgnepal.gov.np