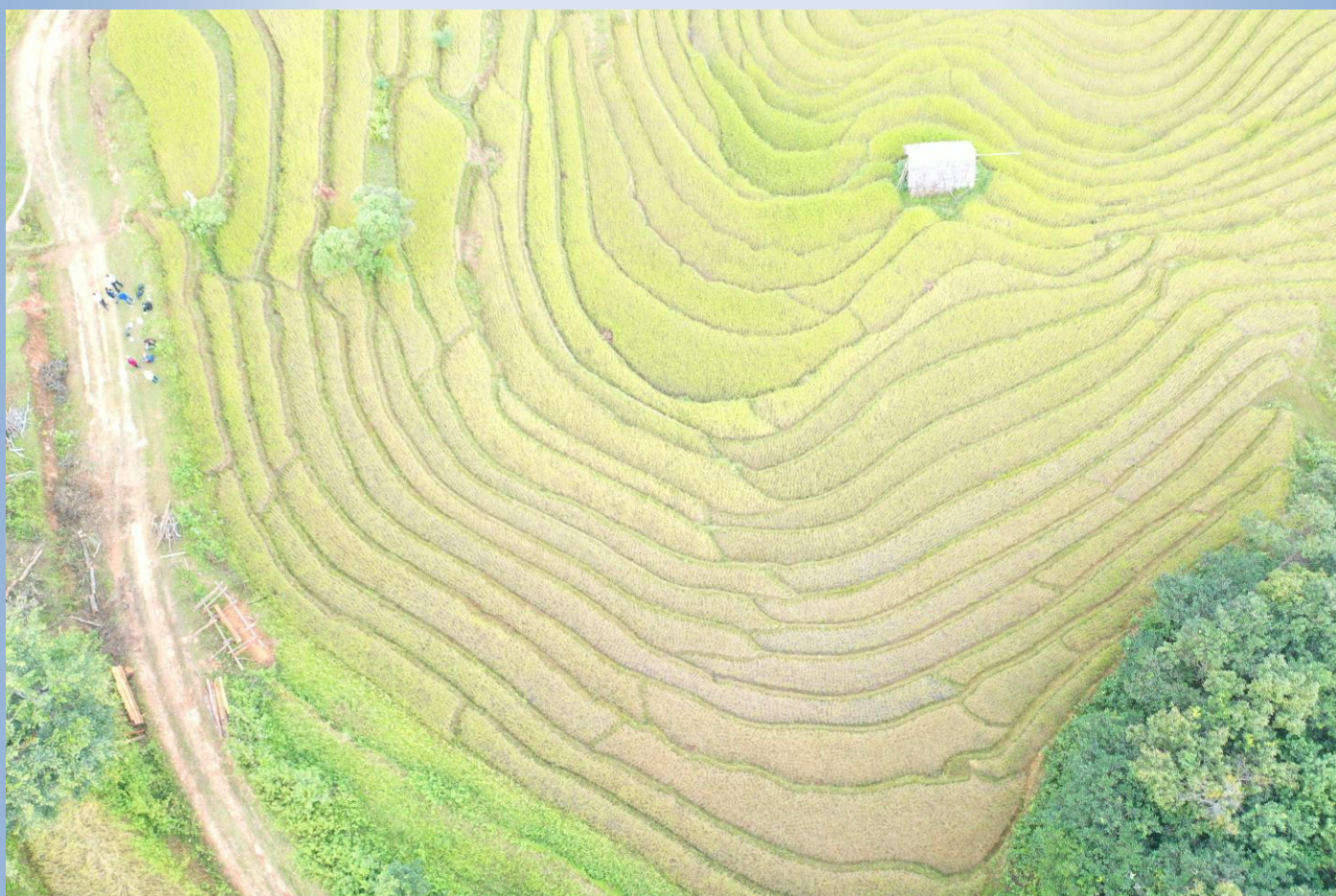


**REPORT**  
**ON**  
**SITE SELECTION FOR REHABILITATION OF LANDSLIDE AFFECTED RESIDENCES OF**  
**SILICHONG RURAL MUNICIPALITY AT KHANDBARI MUNICIPALITY, SANKHUWASABHA**  
**DISTRICT,**  
**PROVINCE NO 1**



**By**

**Thakur Prasad Kandel, Senior Divisional Geologist**

**Krishna Pandey, Geologist**

**Khagendra Kumar Chaudhary, Surveyer**

Government of Nepal  
Ministry of Industry, Commerce and Supplies  
Department of Mines and Geology  
Lainchaur, Kathmandu, Nepal  
2078 (2021)

# Contents

सारांश .....	2
1. INTRODUCTION .....	3
1.1 Background .....	3
1.2 Objectives .....	4
1.3 Limitations .....	4
1.4 Methodology .....	4
2. OBSERVATION .....	5
2.1 Overall hazard condition in the observation site.....	5
2.1.1 Geological Setting.....	5
2.1.2 Land-use.....	5
2.1.3 Nature of Hill slope (Slope angle and slope aspect) .....	6
2.1.4 Topography and Drainage.....	7
2.2 Study of stability for resettlement.....	8
2.2.1 Observation Site-01.....	8
2.2.2 Observation Site-02.....	10
2.2.3 Observation Site-03.....	12
2.2.4 Observation Site-04.....	14
2.2.5 Observation Site-05.....	14
2.2.6 Observation Site-06.....	15
3. DISCUSSION AND CONCLUSION.....	17
3.1 Discussion .....	17
3.2 Conclusion .....	17

## सारांश

२०७७ सालको मनसुनी वर्षाका कारण संखुवासभा जिल्लाको सिलिचोड गा. पा. वडा नं. १ बेसिन्दाका पहिरो विस्थापित ५५ परिवारहरूको पुनर्स्थापनाको लागि खाँदबारी नगरपालिकाका उप प्रमुखको संयोजकत्वमा गठित ७ सदस्यीय जग्गा खोजविन पुनर्निर्माण तथा पुनर्स्थापना उपसमितिले सदरमुकाम छेउका ९ स्थानका जग्गा छनौट गरि सिफिरिस गरको मध्ये पुनर्स्थापनाको लागि उपयुक्त स्थान छनौटको लागि राष्ट्रिय विपद जोखिम न्युनीकरण तथा व्यवस्थापन प्राधिकरणको पत्र संख्या ०७८/०७९, च. नं. ३०१ अनुसार माग भई आएकोमा, जग्गा खोजविन पुनर्निर्माण तथा पुनर्स्थापना उपसमितिको प्राथमिकतामा रहेका ६ वटा स्थानहरूको छोटो स्थलगत भौगर्भिक अध्ययन गरी यो प्रतिवेदन तयार गरिएको छ ।

- १। पहिरो प्रभावित वस्ती पुनर्स्थापनाको लागी जग्गा खोजविन, पुनर्निर्माण तथा पुनर्स्थापना उपसमितिको सिफारिसमा रहेका ५५ रोपनी भन्दा माथीका ३ र ३० देखि ५५ रोपनीका ३ गरी जम्मा ६ वटा जग्गा वरीपरीको स्थलगत भौगर्भिक अध्ययन गर्दा तुलनात्मक रूपमा Observation site-3 (उपसमितिले ५५ रोपनी भन्दा माथी को प्रथम प्राथमिकतामा रहेको हित बहादुर मगर र डम्बर बहादुर मगरको जग्गा) अन्य जग्गाभन्दा उपयुक्त रहेको देखिन्छ । Observation site-3 को बिकल्पको रूपमा Observation Site-2 लाई दोस्रो प्राथमिकतामा (उपसमितिले ५५ रोपनी भन्दा माथी को दोस्रो प्राथमिकतामा रहेको जग्गा) राखिएको छ।
- २। सिफारिस गरिएको जग्गाको सम्पूर्ण भाग बस्ती विकासको लागि उपयुक्त नरहेकोले जग्गाभित्र पर्ने तुलनात्मक कम भिरालो जग्गामा बस्ती निर्माण गर्ने र बाकी रहेको क्षेत्रमा कृषी तथा अन्य कार्यको निम्ति प्रयोग गर्न उपयुक्त देखिन्छ ।

# 1. INTRODUCTION

## 1.1 Background

During every monsoon, Nepal suffers from huge properties loss by the landslides, mostly induced by heavy rainfall in different parts of the country. Due to the rainfall-induced landslide event of monsoon season 2077, settlements in ward no. 1 in Silichong Rural Municipality is at high risk. This landslide destroyed lives and properties, while many houses had already been abandoned, and people have been taking shelter in the nearest schools. Local government conducted resettlement process for those landslide affected families. Few families were resettled in safer place in same Rural Municipality and remaining 55 families are still in shelters.

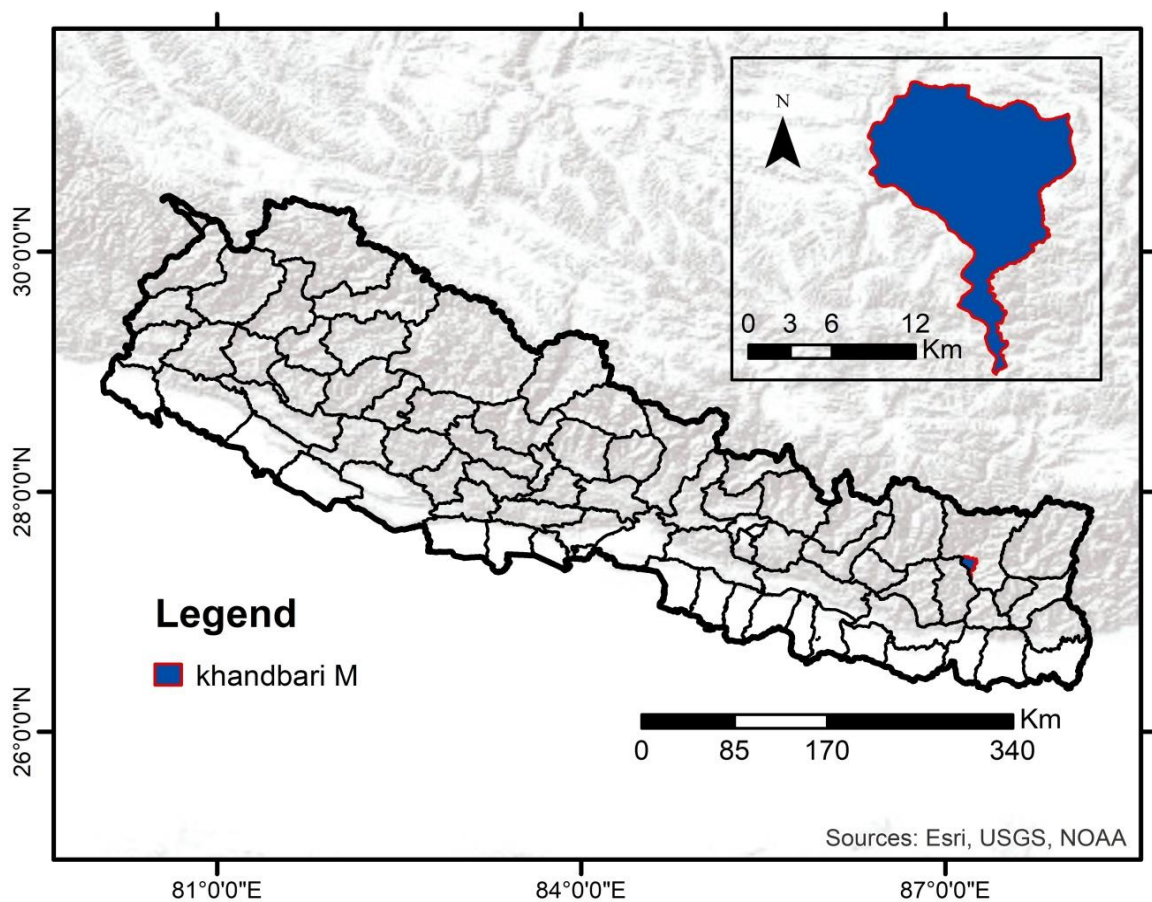


Fig. 1: Location map of the study area.

To select the low risk area near Khandbari Municipality for resettlement of those landslide affected families, a survey team was deployed by the Department of Mines and Geology (DMG) on request from the National Disaster Risk Reduction and Management Authority (NDRRMA) which carried out short emergency field assessment in the Khandbari Municipality. Fig. 1 shows the location map of the study area. Khandbari Municipality is the head quarter of Sankhuwasabha district. We observed six different sites in Khandbari Municipality, which is selected by Land searching,

reconstruction and rehabilitation sub-committee of Sankhuwasabha district. This sub-committee was formed under the chair of Deputy Mayor of Khandbari Municipality.

### ***1.2 Objectives***

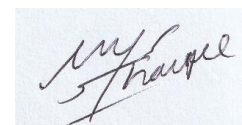
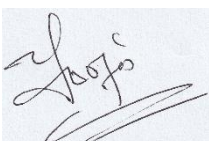
- To study the stability of the selected lands and investigate the relatively low risk area for resettlement of landslide affected people, based on the visual inspection and field data analysis.
- To suggest the relatively safe locality for residential development among the areas selected by the local sub-committee.

### ***1.3 Limitations***

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

### ***1.4 Methodology***

It includes desk study, field observation and field data analysis. Desk study includes studying of the topo-sheet, geological maps, landslide hazard maps, study of scientific papers related to the geology of the study area and related and other similar literatures. The geological investigation, brief rock and soil types and drone topography survey was carried out during this field observation to study the hazardous condition of the area. The DMG database digital elevation model (DEM) was used to generate slope, aspect map of the study area, which was used to evaluate the relatively low risk zone for resettlement. 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 risk zone. The field program was conducted in a short time with basic geological instruments. Therefore, this study cannot fulfill the need for a detailed geological and geotechnical survey required for each observation sites. However, the recommendations are based on the walk-through survey and drone mapping.



## 2. OBSERVATION

### 2.1 Overall hazard condition in the observation site

#### 2.1.1 Geological Setting

Regionally, the study area lies lesser Himalaya group in the Arun Window of the eastern Nepal. The Nuwakot Nappe is formed by the erosion of Higher Himalayan Rocks by the Arun River. The north trending thrust has resulted the formation of the rugged topography. The geological map in and around the study area is shown in Fig. 2. (DMG, 2020). According to DMG, 2020, the rocks of this area lies in Seti Formation of Pokhara Sub-Group. Study area is composed of grey to greenish grey Phyllite, gritty quartzites with minor conglomeratic layer. Basic intrusions are also noted in this area. Some Phyllite layers are also common in the area.

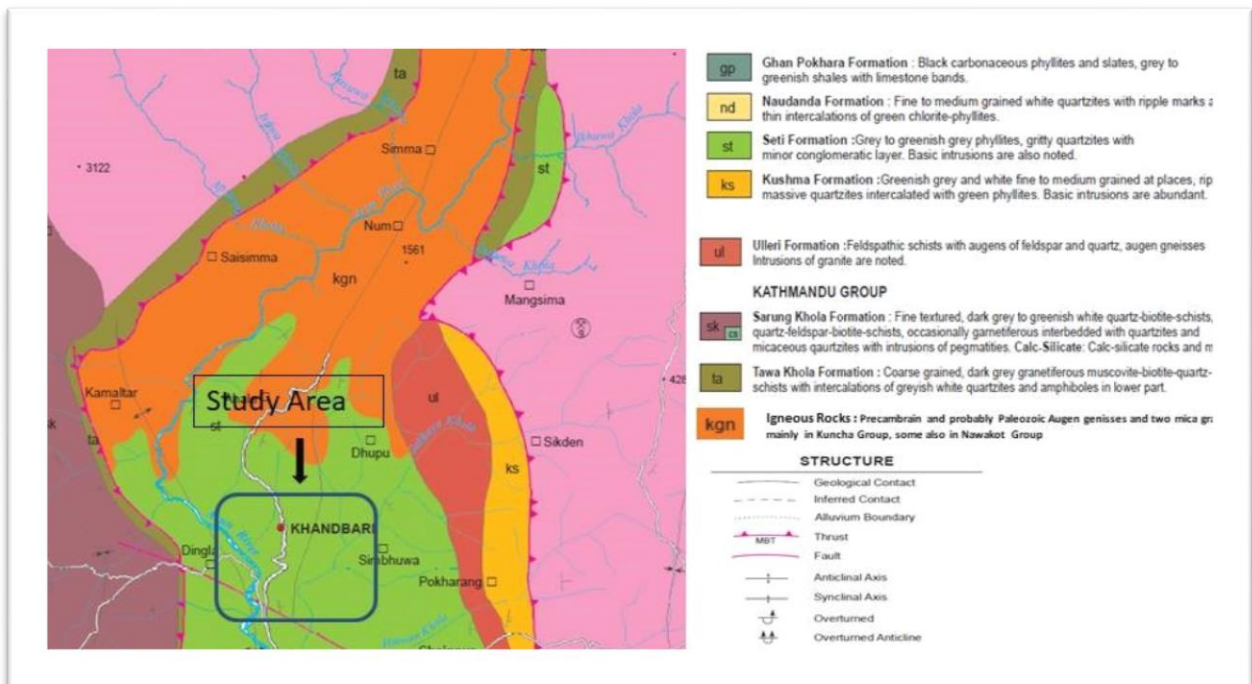


Fig. 2: Geological Map of the study and surrounding Area (DMG: 2020)

#### 2.1.2 Land-use

The observation site comprise basically of agricultural land. Four sites are fully covered by agricultural land (Paddy cultivation) and remaining two are agricultural land with forest. In general, the cultivation in the area is wet type (less wet in observation site-03) during summer due to availability of ample amount of water from ephemeral springs.

### 2.1.3 Nature of Hill slope (Slope angle and slope aspect)

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.

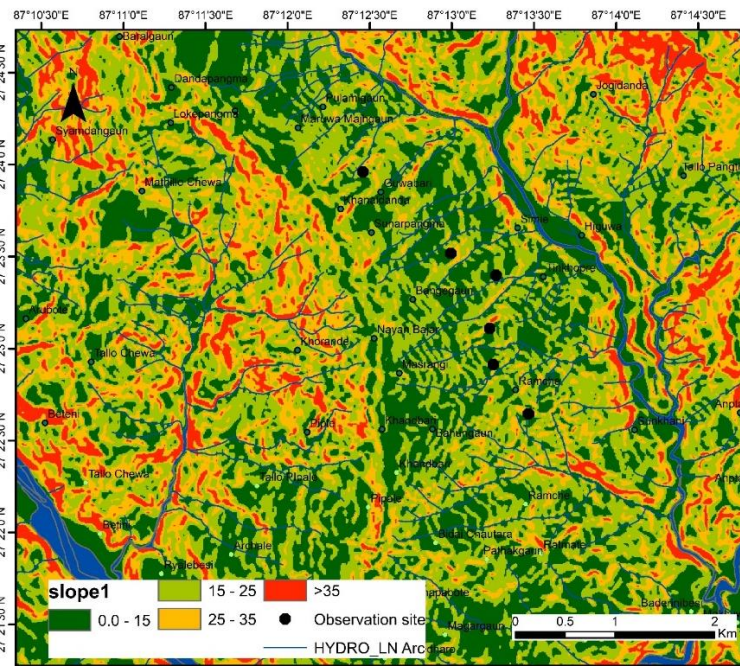


Fig. 3: Slope map of the study and surrounding Area. Black solid circle shows the observation site of this study.

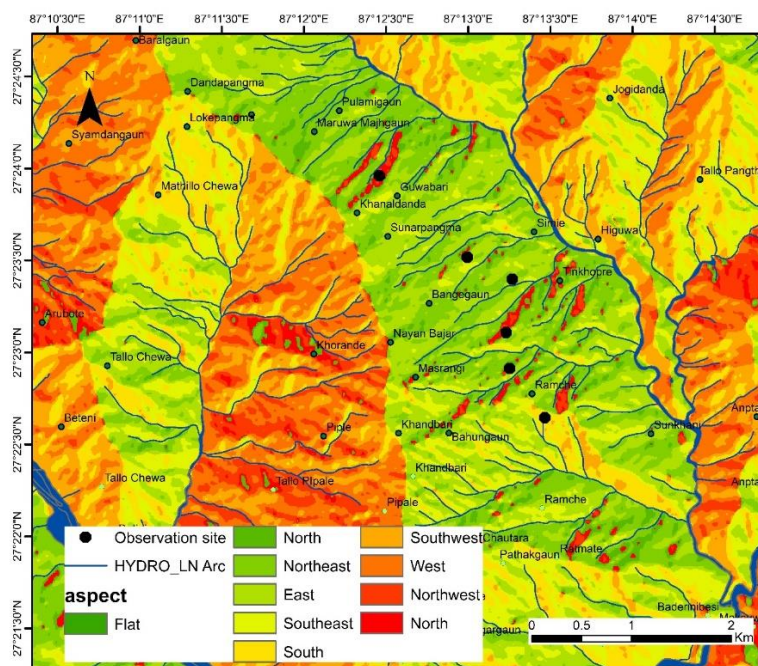


Fig. 4: Aspect map of the study and surrounding Area. Black solid circle shows the observation site of this study.

*[Handwritten signature]*

*[Handwritten signature]*

Fig. 3 and Fig. 4 show the Slope and aspect map in and around the observation area respectively. 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 evapo-transpiration 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.

#### 2.1.4 Topography and Drainage

The observation site area lies in mountainous region, North to North-east from office of Khandbari Municipality. The area comprises the steep topography of the Lesser Himalaya. The maximum and minimum elevation around study area is 965 m in observation site-04 and nearly 700 m in the observation site-06. North to Northeast sides of the Khandbari Municipality is drained by numerous streams which all confluences in Panma Khola and ultimately confluences to Arun River. The topography rises abruptly on either side of the river with small tributaries in dendritic drainage fashion, shown in Fig. 5.

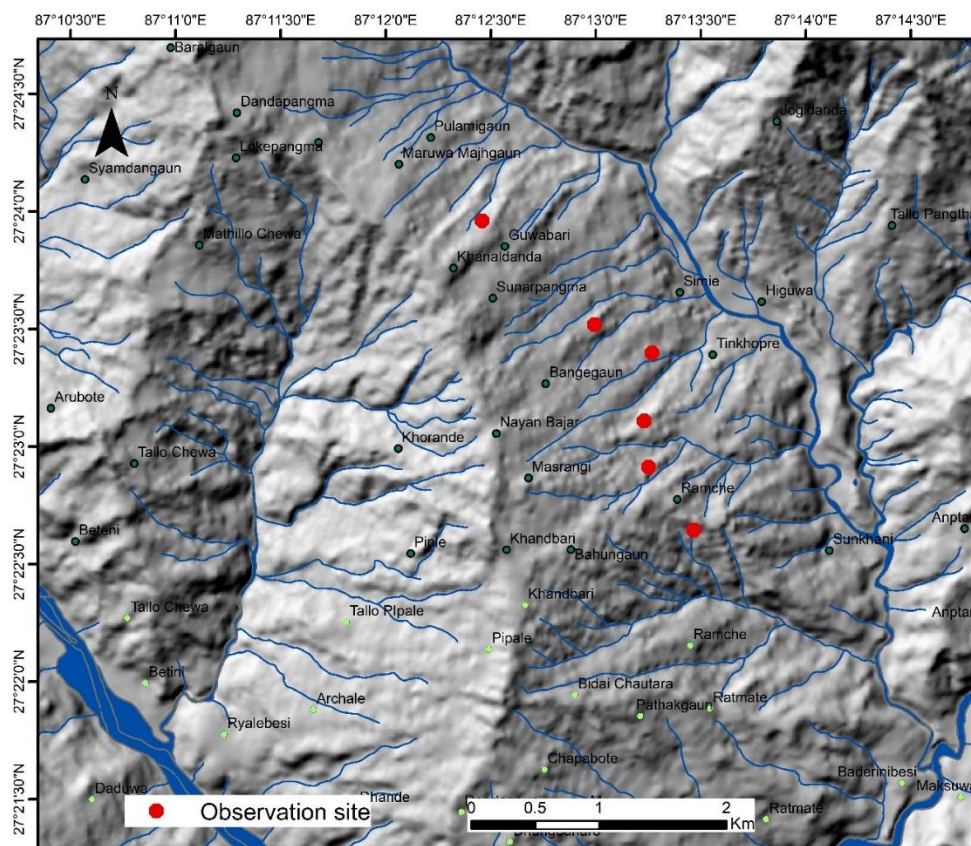


Fig. 5: Drainage map of the study and surrounding Area. Red solid circle shows the observation site of this study.

*[Handwritten signature]*

*[Handwritten signature]*



## 2.2 Study of stability for resettlement

We observed six different site for this purpose, most of these lies north to north-east side of the office of Khandbari Municipality. Fig.6 shows the six different sites in Khandbari Municipality. We focused on rock and soil types, aspect, slope, groundwater conditions, paleo-landslide, and so on. Most of the sites have similar lithology, aspect and slope also. The detailed description through observation site are describe below.

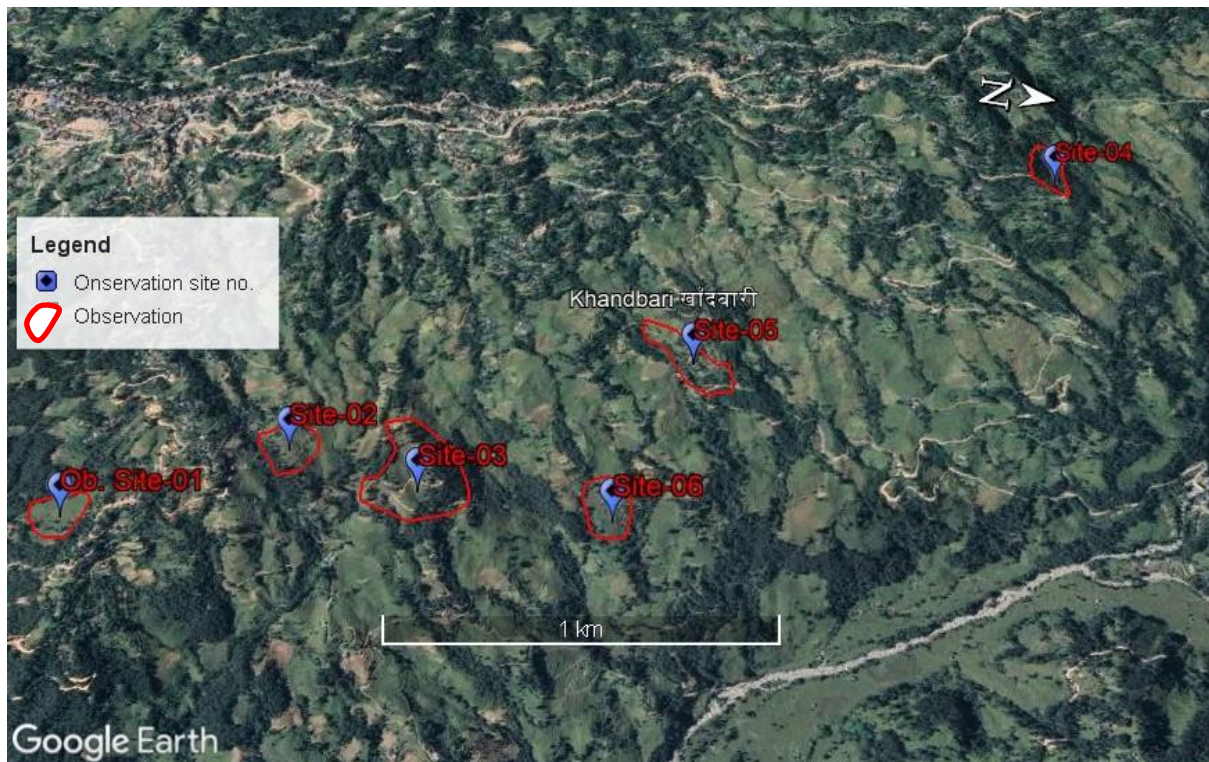


Fig. 6: Google image of all observations site in this study.

### 2.2.1 Observation Site-01

This observation site lies in Khandbari Municipality ward no.7, existing manakamana-01, and eastern side of Municipality's office, around the coordinates 27.37977, 87.22133. It covers around 72.18 Ropani area, but there is few Ropani inside this land. The slope map and aspect map of this area has  $> 25^\circ$  slope angle and east to southeast aspect. This area has a good paddy cultivation, having irrigation water. There is also water spring with well inside this area. This area has wet, having kholsi connected western side of this area. Fig. 7 shows the Google Earth map in and around the observation site-01.



*Fig. 7: Google image of in and around the observation site-01.*



*Fig. 8: Photograph of paddy cultivation with spring well, taken by drone, inside the observation site-01.*

### 2.2.2 Observation Site-02

This observation site lies in Khandbari Municipality ward no.7, existing manakamana-01, and northeast side of Municipality's office, around the coordinates 27.38449, 87.218428. It covers around 79.02 Ropani area. The slope map and aspect map of this area has  $> 20^\circ$  slope angle and north to northeast aspect. Most of this area has a good paddy cultivation, having irrigation water. It also contain some forest towards kholsi with high slope and some slides by Kholsi cut. There is also groundwater spring eastern side of this area. This area has wet (besides central part), good for cultivation. Fig. 9 shows the Google Earth map in and around the observation site-02.

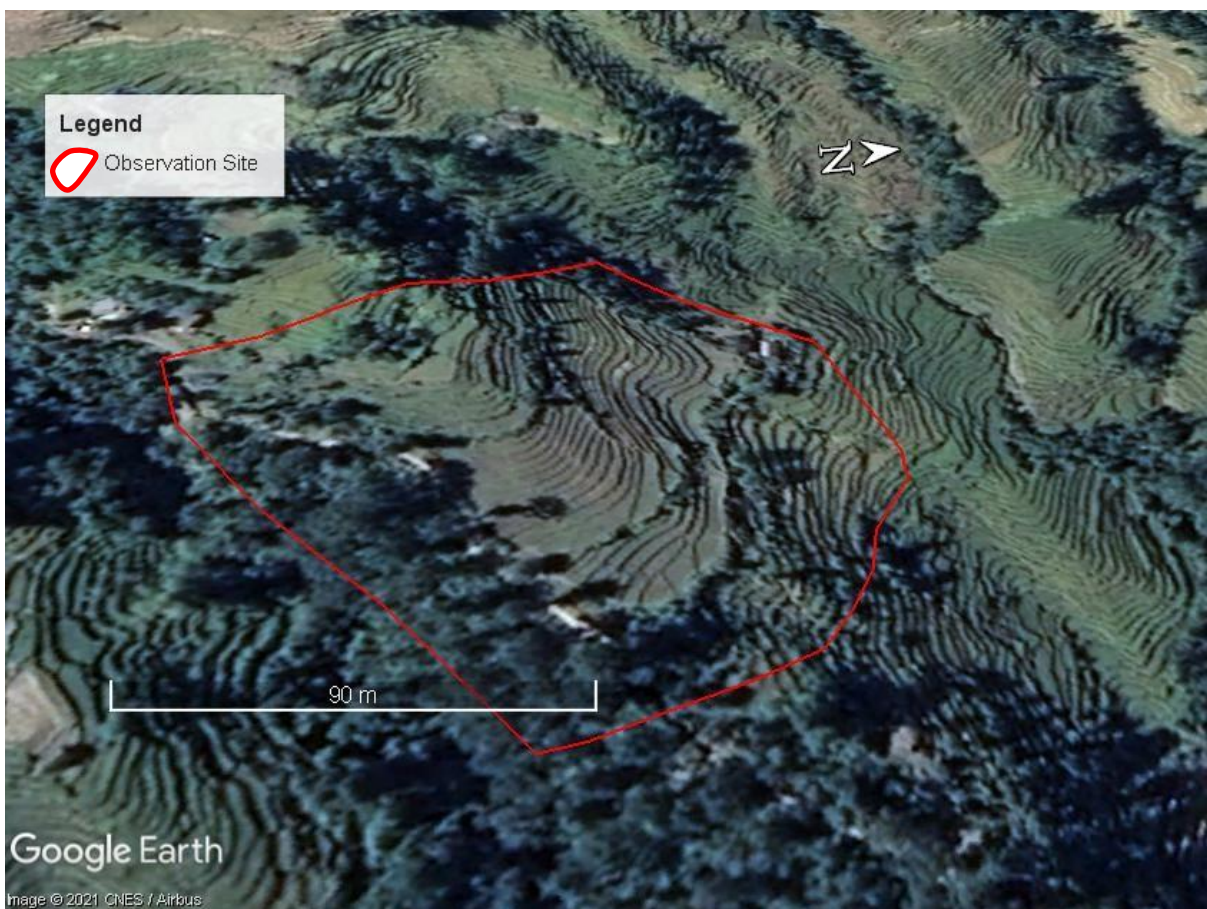


Fig. 9: Google image of in and around the observation site-02.

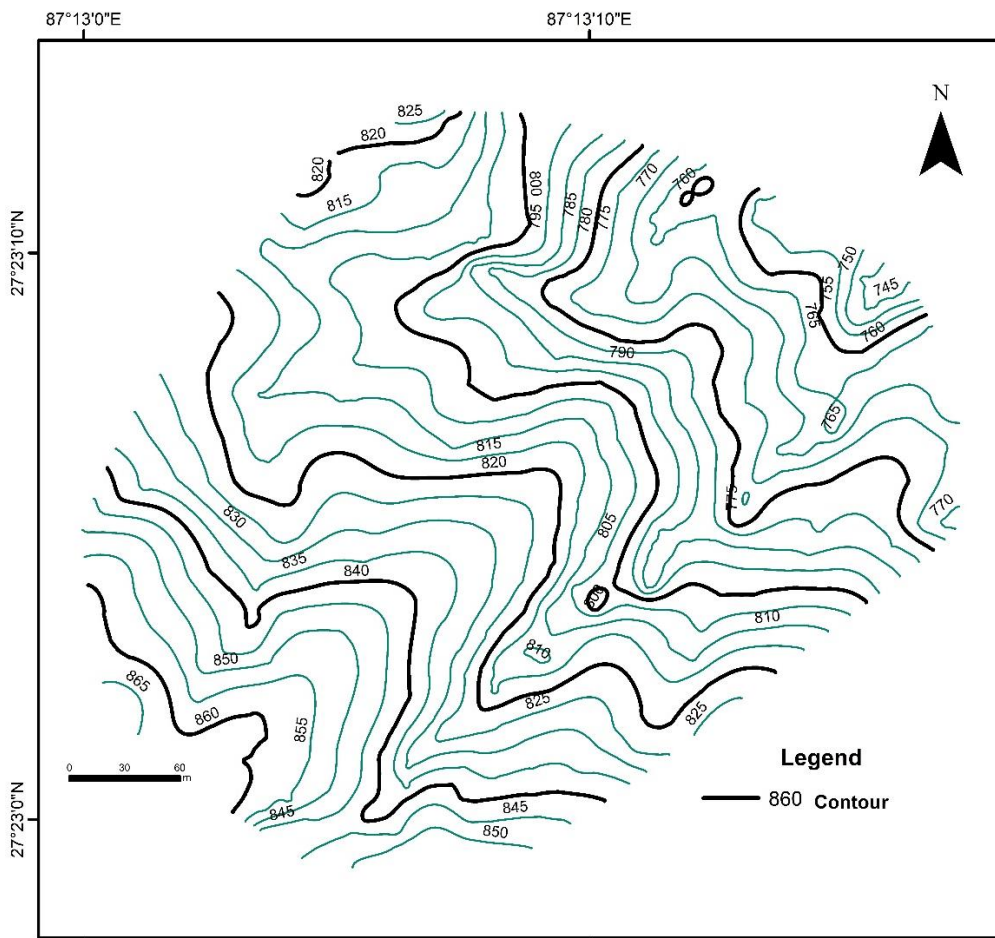
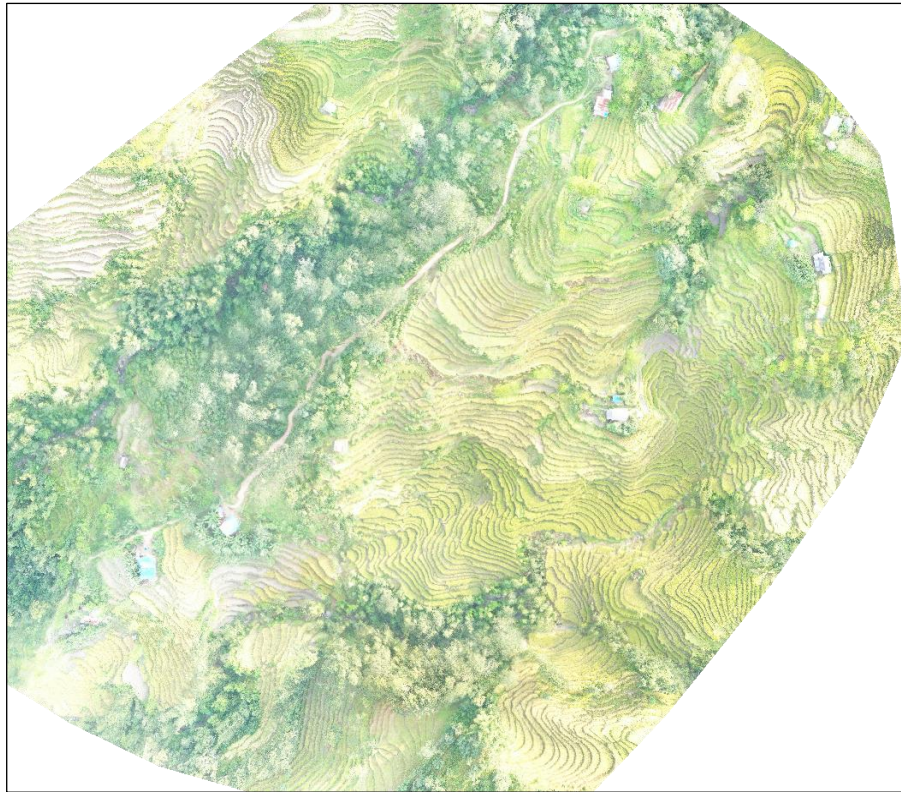


Fig. 10: Ortho-mosaic image of observation site-02, taken from drone (upper) and contour maps (lower) of observation site-02, taken from DSM of drone images.

*Handwritten signature*

*Handwritten signature*

### 2.2.3 Observation Site-03

This observation site lies in Khandbari Municipality ward no.7, existing manakamana-01, and northeast side of Municipality's office, around the coordinates 27.3878, 87.2185. It covers around 69.71 Ropani area. The slope map and aspect map of this area has  $> 25^\circ$  slope angle and north to northeast aspect. Most of this area has a paddy cultivation, having less wet than observation site-01 and site-02, having brown to reddish residual soils. It also contain some forest towards northeast part with high slope. Land searching, reconstruction and rehabilitation sub-committee of Sankhuwasabha refers this site as a first priorities, having more than 55 Ropani. We do not find any spring inside of this area. Fig. 11 shows the Google Earth map in and around the observation site-03.



Fig. 11: Google image of in and around the observation site-03.



87°13'0"E

87°13'10"E

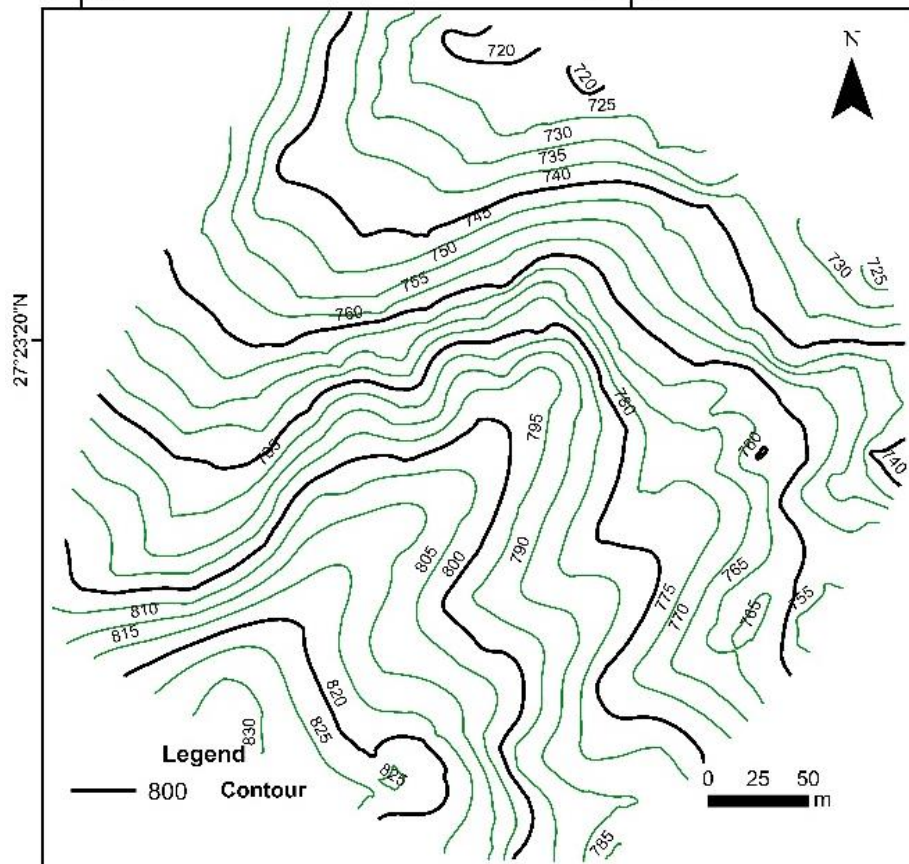


Fig. 12: Ortho-mosaic image of observation site-02, taken from drone (upper) and contour maps (lower) of observation site-02, taken from DSM of drone images.

*Handwritten signature*

*Handwritten signature*

### 2.2.4 Observation Site-04

This observation site lies in Khandbari Municipality ward no.3, existing pamma-01, and northeast side of Municipality's office, around the coordinates 27.40239, 87.2055. It covers around 30.54 Ropani area. The slope map and aspect map of this area has  $> 30^\circ$  slope angle and north aspect. Most of the area of this site has forest, having high slope. Bed rocks also exposed in this area. Fig. 13 shows the Google Earth map in and around the observation site-04.

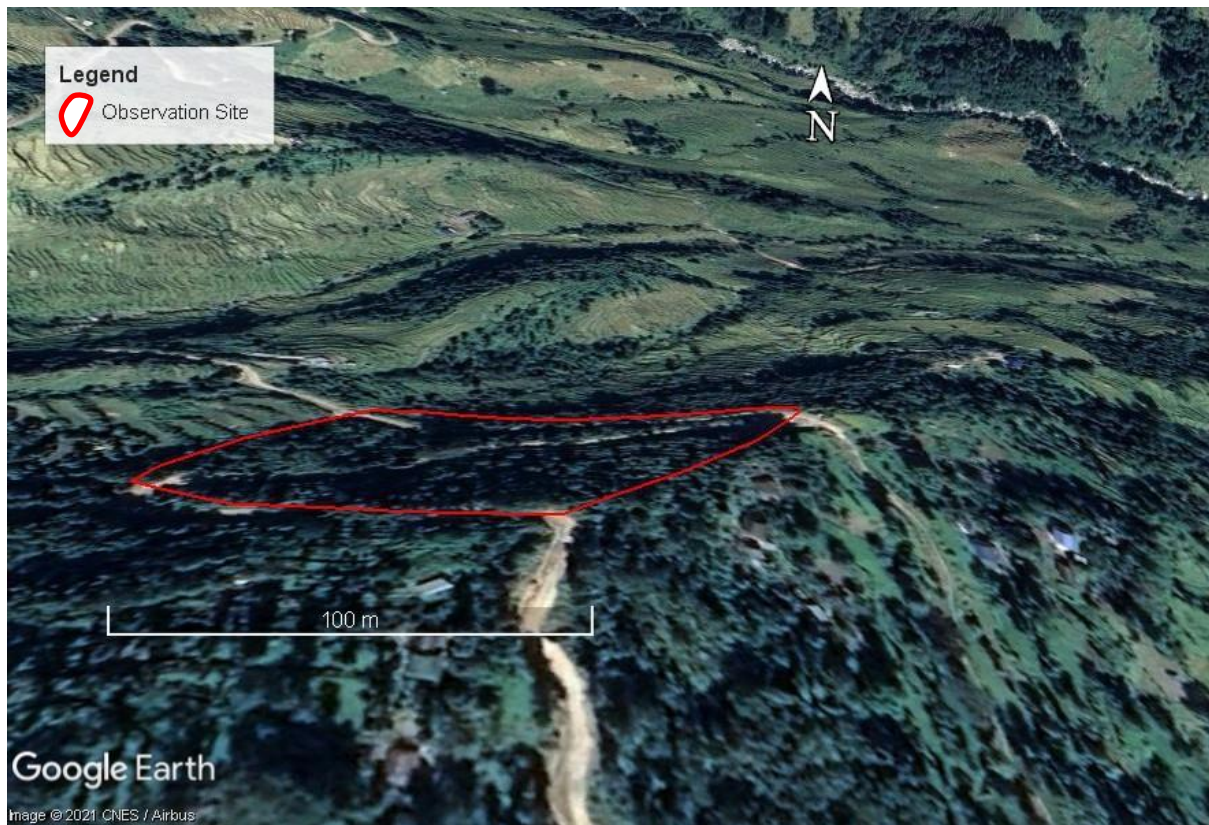
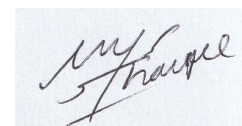
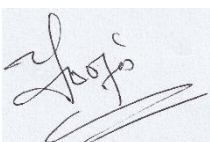


Fig. 13: Google image of in and around the observation site-04.

### 2.2.5 Observation Site-05

This observation site lies in Khandbari Municipality ward no.7, existing Manakamana-01, and northeast side of Municipality's office, around the coordinates 27.39387, 87.214256. It covers around 45.17 Ropani area. The slope map and aspect map of this area has  $> 25^\circ$  slope angle and north aspect. Most of the area of this site has forest, some has paddy cultivation. Bed rocks also exposed in this area. Fig. 14 shows the Google Earth map in and around the observation site-05.





*Fig. 14: Google image of in and around the observation site-05.*

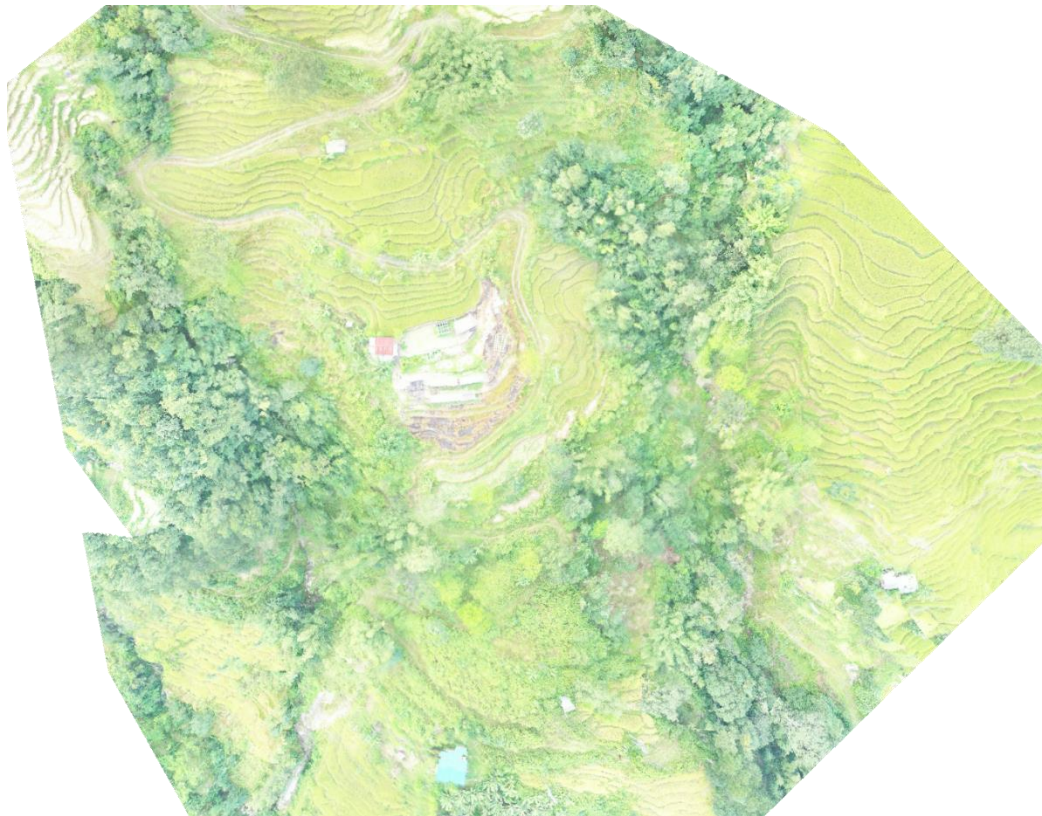
### **2.2.6 Observation Site-06**

This observation site lies in Khandbari Municipality ward no.7, existing Manakamana-01, and northeast side of Municipality's office, around the coordinates 27.392574, 87.218886. It covers around 47.35 Ropani area. Land searching, reconstruction and rehabilitation sub-committee of Sankhuwasabha refers this site as a first priorities, having less than 55 Ropani. The slope map and aspect map of this area has  $> 20^\circ$  slope angle and north aspect. Most of the area of this site has wet and good for paddy cultivation, having gentle slope. This area is rich in groundwater. Fig. 15 shows the Google Earth map in and around the observation site-06.





*Fig. 15: Google image of in and around the observation site-06.*



*Fig. 16: Ortho-mosaic image of observation site-06, taken from drone.*

### 3. DISCUSSION AND CONCLUSION

#### 3.1 Discussion

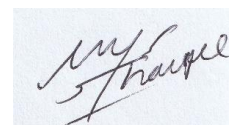
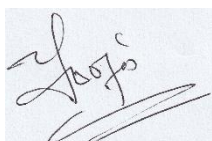
A team of two geologists and a surveyor approached the destination to carry out the geological status of adjoining area. 6 different places being selected by the committee were surveyed. Out of those, one primary place suitable for the settlement was selected. The first location shows the abundance of the paddy farming and presence of spring inside the area. The area also possess high intensity gully erosion. Moreover, the area has high erosion and no traces of bedrock. In Location-II, the area is suitable for settlement but has no direct access to the road infrastructure. The area contains wet cultivation and numerous springs are present in the area. It lies between two prominent streams running parallel. The area has relative gentle slope in the ridge section that is probable for the development of settlement. The basement of the area possess a small landslide also.

Location-III contains agricultural land towards the west and forest area towards the east. It is good access to road, electricity and lies at nearest location from the Ward Office and Health Post. Also, the area has no presence of bad-land and erosion is also very less. Springs are located at a short distance. In the lower portion, there is the access to forest also. Bed rock is also exposed at the locality. For agricultural propose, the area is fertile and has chance for being the source of income for the residents. Location 4 contains area that has less than 55 Ropani. The area has access to road but the slope angle is high. So, the area is not suitable for integrated settlement development.

Location 5 contains the area with rice cultivation, presence of badland and high intensity erosion covered by forests. The area is also possess small scale landslides. Location 6 lies relatively far from the other area. Wet cultivation is practiced. Most of the area faces eastern aspect and experiences sunlight. The slope angle lies from flat land to more than 40<sup>0</sup>. Criteria for integrated settlement were taken in consideration during the report preparation. Existing land-use and infrastructures shows the presence of road in most of the location. No prominent disasters area observed during the field study.

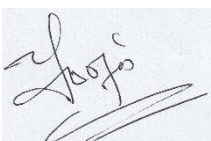
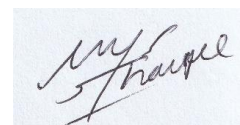
#### 3.2 Conclusion

Nepal is mountainous country and landslides occur in the young mountains. Most of the places contains risk. This report is a near approach to aim in disaster risk reduction through recommendation of suitable locality for integrated development of displaced people of



Shilichong RM. The geological parameters taken for the report preparation includes presence/absence of groundwater, presence/absence of bedrock, soil depth, and presence/absence of disasters nearby. From the field observation, for the integrated settlement development, Location-III is comparatively favorable due to less soil depth, presence of bedrock and free from groundwater. Location-II is in second position due to the presence of groundwater in its south and north.

From the selected locations, it is recommended for developing settlements at low slope angle area, relatively flat and lying in immediate eastern aspect. Agricultural development is recommended for the other locations. Proper cut and fill is recommended. Also, the foundation of the houses are recommended in the bedrock.

A handwritten signature in black ink on a light blue background, appearing to read 'Zhang'.A handwritten signature in black ink on a light blue background, appearing to read 'Zhang'.