POST DISASTER ASSESSMENT REPORT ON KHOTANG EARTHQUAKE, NEPAL

Based on draft report

Overview

- Background
- Objective
- Methodology
- Observations and Findings
- Sector wise summary
- Earthquake induced Geohazards

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Background

- An earthquake measuring 6 Magnitude with epicenter at Mattim Birta, Khotang occurred on 31st July 2022.
- Matim Birta -Khotang Earthquake centered at Sakela Rural Municipality of Khotang district at province-1, Nepal.
- The epicenter was about at 27.140N and 86.670E with focal depth of 10 km.
- The epicenter was close to plate boundary i.e. collision zone of Indian and Eurasian plate.
- Epicenter was 80 km NW of Itahari, Nepal; 87 km NE of Janakpur, Nepal; 145 km SE of Kathmandu, Nepal, 150 km W of Darjeeling, West Bengal, India and 225 Km NE of Patna, Bihar, India.
- From August 5 to 15, 2022, a team of professionals lead by National Disaster Risk Reduction and Management Authority (NDRRMA) accompanied by Build Change, National Society of Earthquake Technology (NSET) and National Housing and Settlements Resilience Platform (NHSRP) visited different municipalities of Khotang district and conducted initial damage assessment of the effects.

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Background

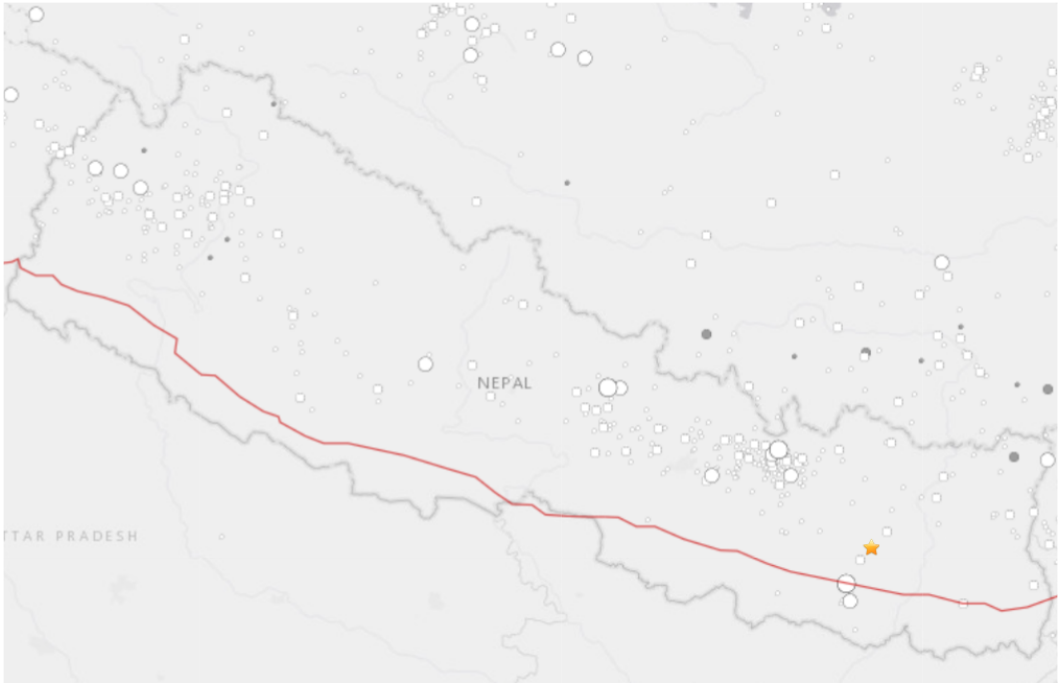

Fig. Map of Nepal with Tectonic plate boundaries and epicenter of Khotang earthquake

Source: https://earthquake.usgs.gov

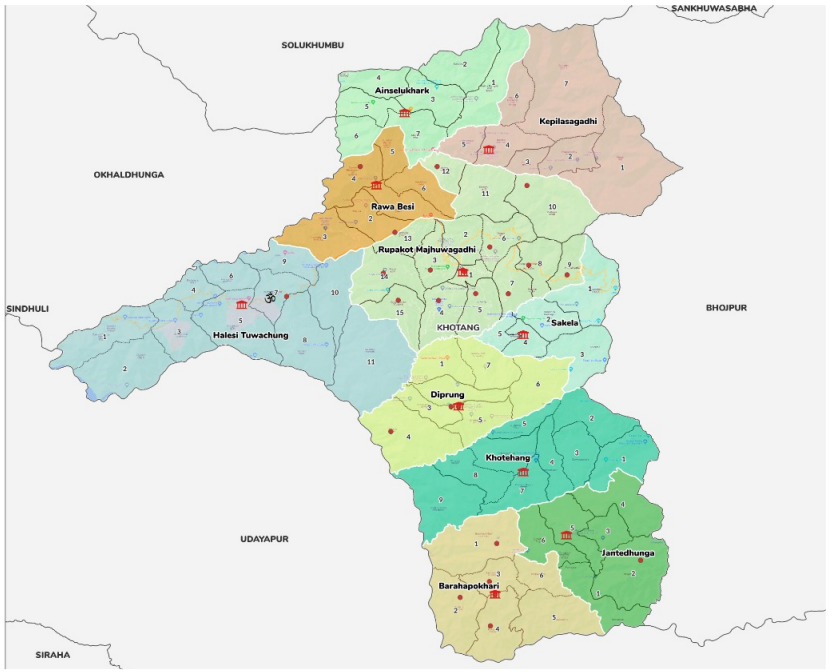

Fig. Map of Khotang district and its municipalities

Source: Survey Department, Government of Nepal

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Objective

- Figure out scale of damage in terms of human casualtie and damage to infrastructural system.
- Extract preliminary information on damage of loss in terms of financial value
- Evaluate Typology of houses, damage pattern in houses
- Evaluate damages to public properties, roads and other geo hazards
- Post Earthquake Survey for Mapping of Earthquake Intensity
- Survey of critical facilities and lifeline agencies
- Survey of Impact vs. Response Activities
- Key Informant Interview to determine initial impact and response activities

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Methodology

- The methodology for the Matim Birta initial assessment was adopted from past similar task done for the September 18, 2011, Himalayan (Sikkim) earthquake.
- 7 different sets of questionnaire were prepared for assessment to cover:-

- *Earthquake Intensity mapping – estimation of intensities of earthquake shaking in Modified Mercalli Intensity Scale (MMI)*
- *Typology wise Building Damage ratio*
- *Post Earthquake building damage assessment*
- *Damage to lifeline structures and critical facilities-Secondary effects of earthquake: landslide, liquefaction, ground rupture, floods, volcanic eruption, fire, crop damage, electric short circuiting etc.*
- *Epidemiology of Human impact- Causes of death and injury,*
- *Situation of response activities in view of the damage and impact*
- *Interaction for Local authority for understanding their planning to response and recover*

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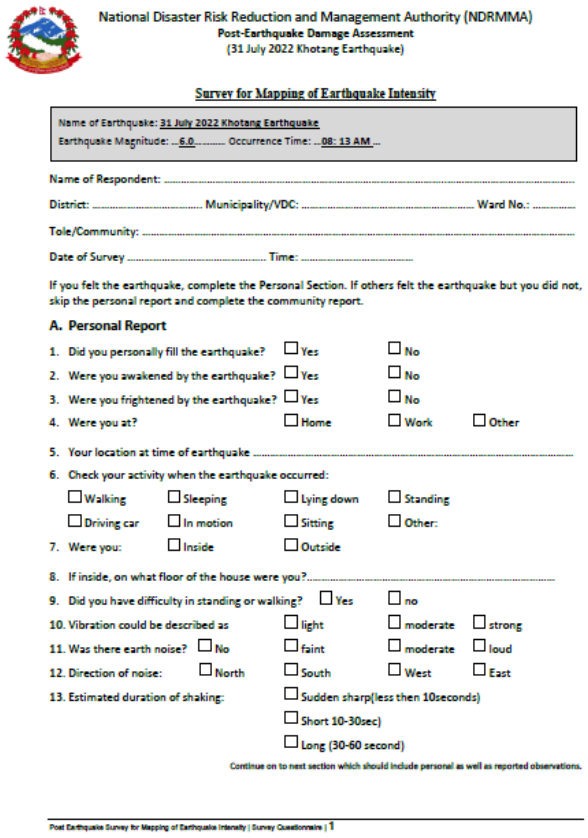
Methodology

- Different questionnaire sets



National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

Survey for Mapping of Earthquake Intensity

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: ...6.0..... Occurrence Time: ...08: 13 AM ...

Name of Respondent: .....

District: ..... Municipality/VDC: ..... Ward No.: .....

Tole/Community: .....

Date of Survey ..... Time: .....

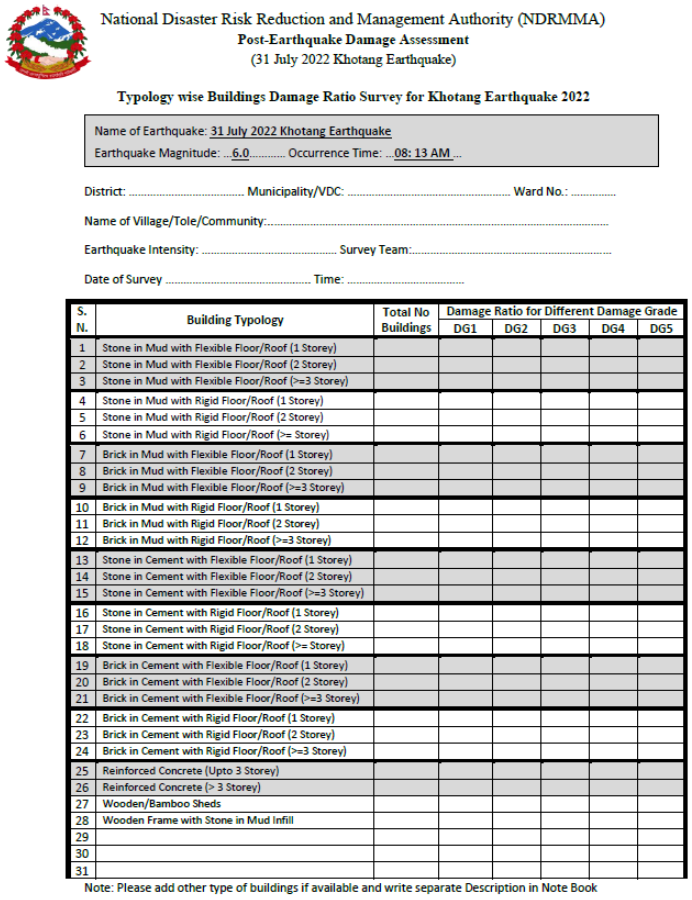
If you felt the earthquake, complete the Personal Section. If others felt the earthquake but you did not, skip the personal report and complete the community report.

A. Personal Report

1. Did you personally fill the earthquake? ☐ Yes ☐ No
2. Were you awakened by the earthquake? ☐ Yes ☐ No
3. Were you frightened by the earthquake? ☐ Yes ☐ No
4. Were you at? ☐ Home ☐ Work ☐ Other
5. Your location at time of earthquake .....
6. Check your activity when the earthquake occurred:
   ☐ Walking ☐ Sleeping ☐ Lying down ☐ Standing
   ☐ Driving car ☐ In motion ☐ Sitting ☐ Other:
7. Were you: ☐ Inside ☐ Outside
8. If inside, on what floor of the house were you?.....
9. Did you have difficulty in standing or walking? ☐ Yes ☐ no
10. Vibration could be described as ☐ light ☐ moderate ☐ strong
11. Was there earth noise? ☐ No ☐ faint ☐ moderate ☐ loud
12. Direction of noise: ☐ North ☐ South ☐ West ☐ East
13. Estimated duration of shaking: ☐ Sudden sharp(less then 10seconds) ☐ Short 10-30sec) ☐ Long (30-60 second)

Continue on to next section which should include personal as well as reported observations.

Post Earthquake Survey for Mapping of Earthquake Intensity | Survey Questionnaire | 1



National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

Typology wise Buildings Damage Ratio Survey for Khotang Earthquake 2022

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: ...6.0..... Occurrence Time: ...08: 13 AM ...

District: ..... Municipality/VDC: ..... Ward No.: .....

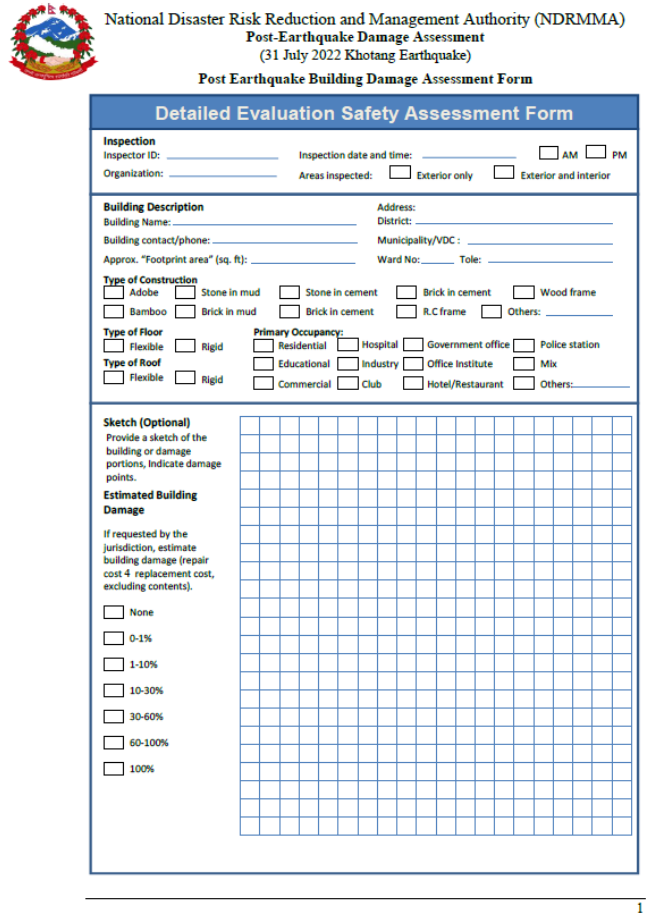
Name of Village/Tole/Community:.....

Earthquake Intensity: ..... Survey Team:.....

Date of Survey ..... Time: .....

S. N.	Building Typology	Total No Buildings	Damage Ratio for Different Damage Grade				
			DG1	DG2	DG3	DG4	DG5
1	Stone in Mud with Flexible Floor/Roof (1 Storey)						
2	Stone in Mud with Flexible Floor/Roof (2 Storey)						
3	Stone in Mud with Flexible Floor/Roof (>=3 Storey)						
4	Stone in Mud with Rigid Floor/Roof (1 Storey)						
5	Stone in Mud with Rigid Floor/Roof (2 Storey)						
6	Stone in Mud with Rigid Floor/Roof (>= Storey)						
7	Brick in Mud with Flexible Floor/Roof (1 Storey)						
8	Brick in Mud with Flexible Floor/Roof (2 Storey)						
9	Brick in Mud with Flexible Floor/Roof (>=3 Storey)						
10	Brick in Mud with Rigid Floor/Roof (1 Storey)						
11	Brick in Mud with Rigid Floor/Roof (2 Storey)						
12	Brick in Mud with Rigid Floor/Roof (>=3 Storey)						
13	Stone in Cement with Flexible Floor/Roof (1 Storey)						
14	Stone in Cement with Flexible Floor/Roof (2 Storey)						
15	Stone in Cement with Flexible Floor/Roof (>=3 Storey)						
16	Stone in Cement with Rigid Floor/Roof (1 Storey)						
17	Stone in Cement with Rigid Floor/Roof (2 Storey)						
18	Stone in Cement with Rigid Floor/Roof (>= Storey)						
19	Brick in Cement with Flexible Floor/Roof (1 Storey)						
20	Brick in Cement with Flexible Floor/Roof (2 Storey)						
21	Brick in Cement with Flexible Floor/Roof (>=3 Storey)						
22	Brick in Cement with Rigid Floor/Roof (1 Storey)						
23	Brick in Cement with Rigid Floor/Roof (2 Storey)						
24	Brick in Cement with Rigid Floor/Roof (>=3 Storey)						
25	Reinforced Concrete (Upto 3 Storey)						
26	Reinforced Concrete (> 3 Storey)						
27	Wooden/Bamboo Sheds						
28	Wooden Frame with Stone in Mud Infill						
29							
30							
31							

Note: Please add other type of buildings if available and write separate Description in Note Book



National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)
Post Earthquake Building Damage Assessment Form

Detailed Evaluation Safety Assessment Form

Inspection
Inspector ID: _____ Inspection date and time: _____ ☐ AM ☐ PM
Organization: _____ Areas inspected: ☐ Exterior only ☐ Exterior and interior

Building Description
Building Name: _____ Address: District: _____
Building contact/phone: _____ Municipality/VDC : _____
Approx. "Footprint area" (sq. ft): _____ Ward No:_____ Tole: _____

Type of Construction
☐ Adobe ☐ Stone in mud ☐ Stone in cement ☐ Brick in cement ☐ Wood frame
☐ Bamboo ☐ Brick in mud ☐ Brick in cement ☐ R.C frame ☐ Others: _____

Type of Floor ☐ Flexible ☐ Rigid
Type of Roof ☐ Flexible ☐ Rigid
Primary Occupancy:
☐ Residential ☐ Hospital ☐ Government office ☐ Police station
☐ Educational ☐ Industry ☐ Office Institute ☐ Mix
☐ Commercial ☐ Club ☐ Hotel/Restaurant ☐ Others:_____

Sketch (Optional)
Provide a sketch of the building or damage portions, Indicate damage points.

Estimated Building Damage
If requested by the jurisdiction, estimate building damage (repair cost ÷ replacement cost, excluding contents).
☐ None
☐ 0-1%
☐ 1-10%
☐ 10-30%
☐ 30-60%
☐ 60-100%
☐ 100%

1

Methodology

- Different questionnaire sets

National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

Survey on Epidemiology of Death and Injury

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: …6.0…… Occurrence Time: …08: 13 AM…

Name of Respondent: ……Gender: ……Age: ……
District: …….. Municipality/VDC:…… Ward No.:……
Tole/Community:……House No.……
Date of Survey …… Time:……

1. **Where were you at the time of the earthquake?**
   OWN HOUSE OTHER'S HOUSE AT WORK OTHER (specify)_____
2. **In what building you were at the time of earthquake?**
   HOUSE
   OFFICE
   FACTORY
   SCHOOL
   OTHER (SPECIFY) _____
3. **How many floors were there in that building?** _____
4. **On which floor were you at the time of the earthquake?** _____
5. **Can you tell what the building was made of?**
   STONE……
   BRICKS……
   WOOD……
   CONCRETE……
   OTHER (SPECIFY) _____
6. **What is the year that the building was constructed?**
   Year built / or age: _____
7. **Where were you when the earthquake started?**
   BEDROOM……
   LIVING ROOM……
   KITCHEN……
   BATHROOM……
   OFFICE……
   BALCONY……
   OTHER(SPECIFY) _____
8. **What were you doing just before the earthquake started ?**
   SITTING……
   WALKING……
   WOKRING……
   SLEEPING……
   IN BED AWAKE……
   OTHER (SPECIFY) _____
9. **When the earthquake started, what was the first thing that you did?**
   STAYED WHERE I WAS……
   SAT DOWN……
   STOOD UP……
   ATTEMPTED TO MOVE BUT COULDN'T……
   MOVED……
   OTHER (SPECIFY) _____

   9a. **Did you move at all while the ground was still shaking?**
   YES……
   NO……

National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

Survey on Impact vs. Response Activities

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: …6.0…… Occurrence Time: …08: 13 AM…

District: …….. Municipality/VDC:…… Ward No.:……
Tole/Community:……Survey Team:……
Date of Survey …… Time:……

1. How many families in this community have been affected by the earthquake?
   No. of families with its member/s dead:
   No. of families with its member/s injured:
   No. of houses with minor damage:
   No. of house with moderate to heavy damage:
   No. of houses collapsed:
2. Was/were there anybody trapped in the damaged building/s?
   Yes No
3. Who rescued the trapped persons?
   Self
   Family members
   Neighbors
   Community volunteers
   Nepal Police
   Armed Police Force
   Nepal Army
   Others (Specify)
4. When was/were the victim/s rescued?
   Day/Time ater earthquake occurred _____
5. With what tools / equipment the rescue was done?
   Hand only
   Locally available tools (Pick, shovel, spade etc.)
   Specialized tools and equipment
   Others (Specify)
6. How many families / persons were displaced from their houses? _____
7. Where did they take shelter?
   Own's cattle shed
   Relative's house
   Neighbor's house
   Tent
   Temporary house
   Other public place (school, VDC office etc.)
   Other (Specify)
8. Did any agency, group or individual from outside arrive to this community to Help? Yes No
   If yes, Who came?
   Red Cross / Nepal Army / Nepal Police/ Armed Police Force/ Other NGO/INGO (Specify Name)_____
   When did they arrive?Day / Time_____
   How long they stayed to provide support Hour/ Days / _____
9. What support did they provide to the affected families and community?

National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

Survey Questionnaire for Critical Facilities and Lifeline Agencies

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: …6.0…… Occurrence Time: …08: 13 AM…

Name of Agency:	
Address:	
Name and Designation of Respondent:	

1. What are the organizational capacities of your organization? (Physical infrastructures, facilities, departments/divisions, human resources/staff etc.)

2. What were the damages due to 18 September Earthquake in the facilities, structures that your organization operates? (Damages to physical facilities, casualties, disruption of services etc.)
   No. of damages:
   Length:
   Injuries/casualties due to damage:
   Duration of disruption of services:

3. How long did it take to restore the services or how long it will take to restore the services?

National Disaster Risk Reduction and Management Authority (NDRMMA)
Post-Earthquake Damage Assessment
(31 July 2022 Khotang Earthquake)

KII with DAO

Name of Earthquake: 31 July 2022 Khotang Earthquake
Earthquake Magnitude: …6.0…… Occurrence Time: …08: 13 AM…

District: **Municipality:** **Ward Number:**
Name: **Date:**

- Have you received any data regarding the recent earthquake If yes, what is the source of Information?
- Do DAO have any plan to support those beneficiaries in cash or NFI?
- Is there any meeting conducted at DAO regarding this Earthquake?
- Is any Partners supported these beneficiaries if yes who and what support they have provided?
- Is there any Human Losses /Casualties recorded till date by the Earthquake?
- Has any of the officials visited the earthquake affected areas so far?

Methodology

- Field mobilization and sample size data collection

4 groups comprising 2 members each were allocated different affected locations

No. of communities per location / teams planned to be surveyed	Sample Size (Nos.) for Different Types of Surveys						
	Intensity Mapping	Detail Building Damage Survey	Building Damage Ratios	Lifeline structures, critical facilities	Casualty (Death and Injury) Survey	Secondary Hazards	Damage and Impact vs. Response Activity Survey
Sakela Rural Municipality all ward and other part	2-3 per community	5-10 per wards	1 per community	As needed	If exist, if not no need	As available	1 per wards
Tentative total numbers	40	50	10				17

- Data Analysis, Photo documentation and Report

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Observations and Findings

- Earthquake Intensity

- *The Earthquake intensity experienced in different part of the Khotang was found to be maximum VI in MMI scale.*
- *The earthquake was felt at Kathmandu, Darjeeling, Ithari and up to Patna city of India having no fatality of life and no reported case of injury.*
- *The physical damage was reported mainly from Khotang and Bhojpur district but more at Khotang district.*

Table. Earthquake intensity at different place of Khotang

Earthquake Intensity (MMI)	Places
VI	Sakela Rural Municipality, Halesi Municipality
V	Haleshi, Diktel rupakot Majuwgadi
IV	Diktel most of the wards, Kathmandu, Ithari
II, III and below	Pokhara, Nuwakot

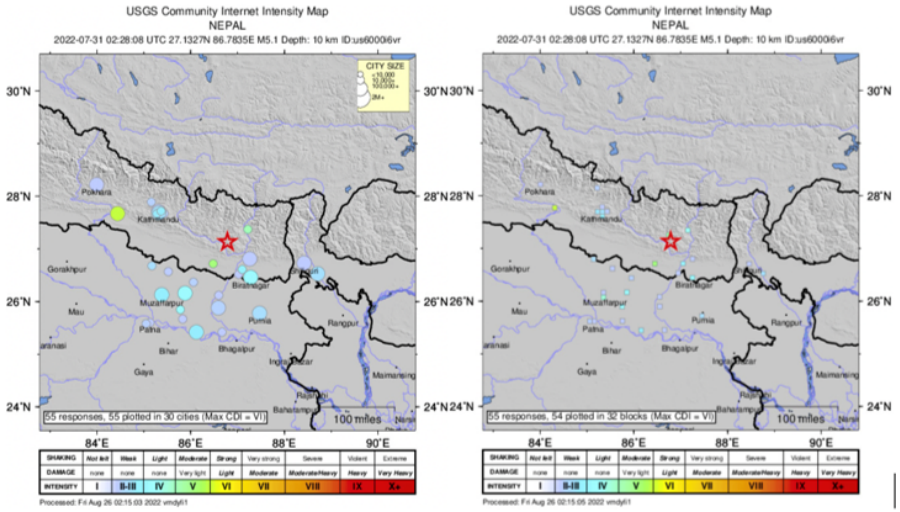

Figure. USGS community Internet Intensity Map; Nepal

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Observations and Findings

- **Building Typology and damages**
  - *Stone in mud mortar (SMM) was extremely prevalent housing typology in Khotang district with minor RCC and other typology houses in market areas.*
  - *Out of 2355 total houses in Sakela; 573 houses are the newly built houses (as per DTCO third tranche record).*
  - *None of the newly built houses were recorded to be damaged by Khotang earthquake.*

Figure. Internal Post, beam and joist layout

Figure. Stone in mud mortar houses, 2+Attic with Thatch roof (left), clay tile roof(right)

BUILD CHANGE

Observations and Findings

- *These buildings do not have neither band throughout the walls or any stitches in the corner. This makes the buildings highly vulnerable even in minor shaking.*
- *Houses, which had previously acquired certain level of damage during Gorkha Earthquake 2015, was found to have suffered most; with enlarged damages by khotang earthquake.*
- *Corner separation, out of plane toppling, gable wall failure and in-plane shear cracks were the major damages observed in the assessed SMM buildings.*

Figure. Stone in mud mortar, 1+Attic with Thatch roof

Figure. Shree khidima Primary School, Hybrid (SMM+Timber)

Figure. Stone in mud mortar houses, 2+Attic with CGI roof

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Observations and Findings

Effect on Buildings

Building typology

Since most of the damage was seen in rural areas of Nepal, almost 98% of 103 total damaged building stock surveyed were made up of stone masonry in mud mortar and remaining 2% were other types (dry stone and Hybrid).

Table. Building Typology

Building typology	Percent
Stone in mud	98.06
Others	1.94

Damage Grade

The damage pattern of Stone masonry in mud mortar shows that almost 21% of these buildings have a Damage Grade of 4 and 5, which means that these buildings could not be used after repairing.

•Building Damage Grade

Damage Grade	Building Typology	
	Stone in mud	Others
DG1	15.84	0.00
DG2	26.73	0.00
DG3	36.63	50.00
DG4	19.80	50.00
DG5	0.99	0.00

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Observations and Findings

- **Modes of Failure**
  - *Out of 103 total buildings surveyed, 101 buildings were load bearing masonry structures.*
  - *Almost 22% of 101 damaged masonry buildings; corner separation and diagonal cracking have been prominently seen.*
  - *Another mode of failure are Delamination and In plane flexural failure accounts to 19% for both following about 18% for the out of plane failure.*

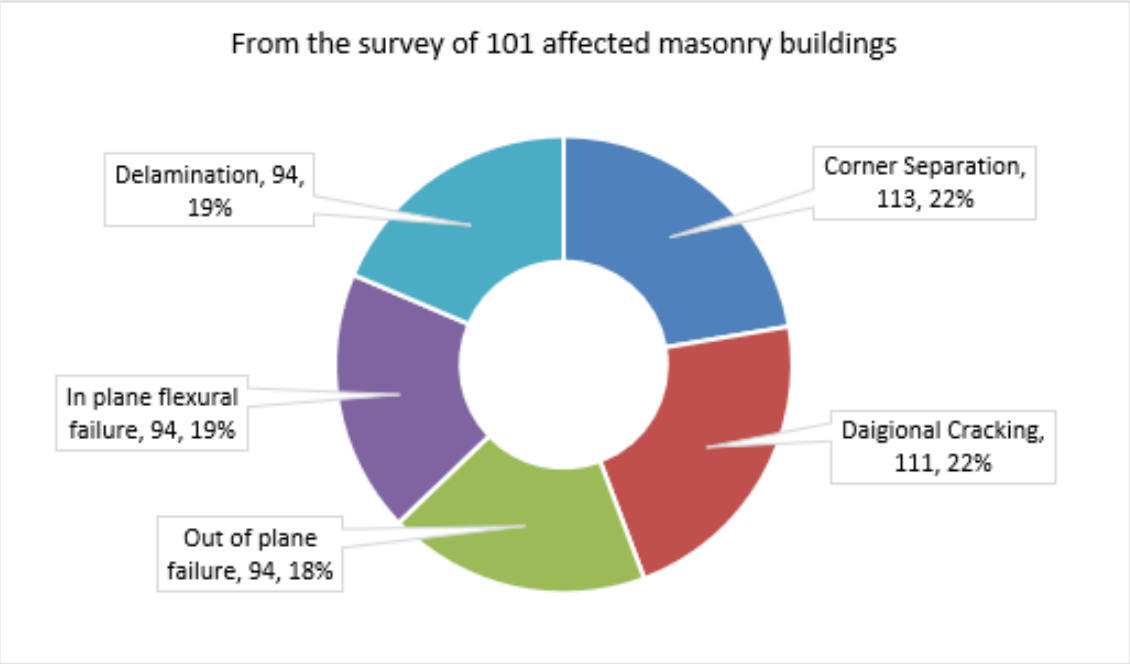

Figure. Modes of failure in Masonry buildings

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Observations and Findings

S.No.	Description	Pictures	
1	Home owner: Navaraj Khadka Stone in Mud Mortar Sakela-4, Allhe, Khotang Marked as Damage Grade -4		
		Side view of house with cracks at corner	Back wall with Vertical Inplane cracks
2	Home owner: Parshuram Chaulagai Stone in Mud mortar Sakela-5, Okhare, Khotang Marked as Damage Grade 5		
		Completely Damaged house	

Observations and Findings

S.No.	Description	Pictures	
5	Home owner: Bhadindra Pariyar Sakela-4, Khotang Marked as Damage Grade -4		
		Front view-Shear cracks & Corner Separation	Vertical in plane cracks in wall
6	Home owner: Bhakta Bahadur Darji Sakela-4, Chhaptole, Khotang Marked as Damage Grade 1		
		Minor cracks in Gable wall at back side	Minor cracks in mud plaster

BUILD CHANGE

Observations and Findings

S.No	Description	Pictures
7	Home owner: Chatur Man Dange Sakela-4, Khotang Marked as Damage Grade -3	 
		Front View: Gable wall failure, Diagonal cracks
8	Home owner: Dhan Bahadur Pariyar Sakela-4, Khotang Marked as Damage Grade 4	 
		Gable wall failure and Diagonal shear cracks at Front wall

Case Study

Properly built SMM house with earthquake resilient elements

Newly built SMM houses with earthquake resilient elements survived Khotang earthquake, with little or no damage at all, where as newly built SMM house without any horizontal bandages nor Vertical reinforcement was severely damaged

Poorly built SMM house without earthquake resilient elements

Observations and Findings

- **Damages to school, critical facilities, public buildings and religious places**
- *Out of 499 schools in Khotang district, 314 schools were primary running from grade I to V.*
- *Most of the school in Khotang district were built with stone masonry mainly those running primary grade and located at rural part of municipalities.*
- *The reported case of school building damage was thirty-four school building at eleven schools within Khotang district.*
- *Hence, estimated loss of school building is about 32 million Nepalese rupees.*

Figure. Inplane diagonal cracks at Shree Pelung Primary School, Diktel-9, Khotang

Figure. Damage at Pokhari School, Diktel -7, Khotang

Observations and Findings

- **Damages to school, critical facilities, public buildings and religious places**
- *SMM building of Nepal Red Cross district office, District Coordination Committee (DCC) guest, house were*
- *Total estimated losses from the damage of public building are about 6 Million Nepalese rupee*

Figure. Damage at Nepal Red Cross District office, Diktel Municiplaity, Khotang

Table. Summary of damage details of public buildings

Description of Public Building	**No**	**Location**	**Estimated losses (NPR)**
Nepal Red cross District office	1	Diktel Rupakot majuwagadi, Ward 1	15,00,000
DCC Guest House	1	Diktel Rupakot majuwagadi, Ward 1	25,00,000
Office Institute	1	Khotang	10,00,000
Police station	1	Aaiselukharka, Khotang	10,00,00
Total	**4**		**60,00,000**

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Observations and Findings

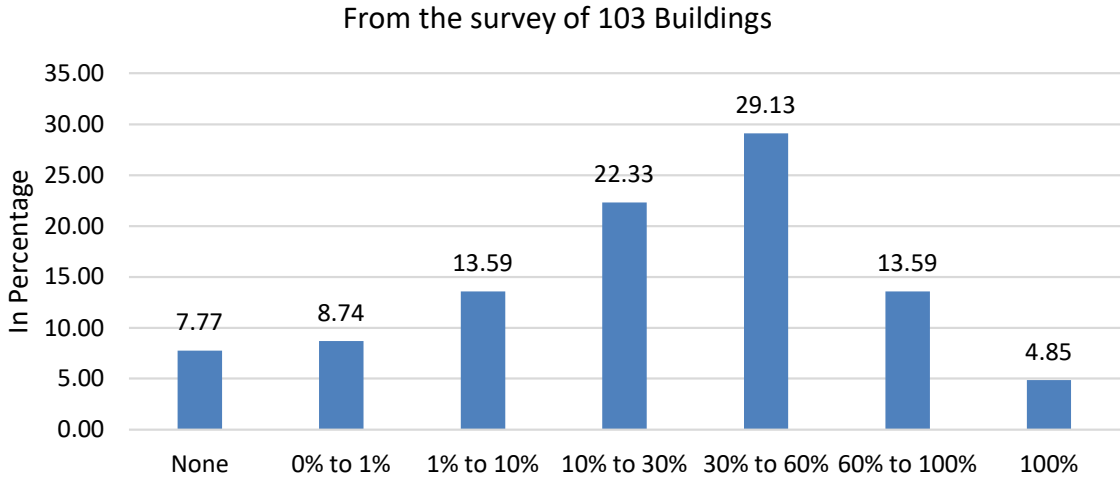
Overall Hazards

- *A study of overall hazards showed that almost 58% of the surveyed buildings showed collapse or partial collapse while 38% showed building or storey leaning.*

- *The study further showed that most of the surveyed building suffered damage in the range of 30-60% followed by 10-30% and 60-100%.*

•Table. Collapse or Partial collapse of building damage

Overall, Hazards	Numbers	Percentage
Collapse or Partial Collapse	45	57.69
Building or Story leaning	30	38.46
Others	3	3.85
Total	78	100.00



BUILD CHANGE

Observations and Findings

- **Damages to school, critical facilities, public buildings and religious places**

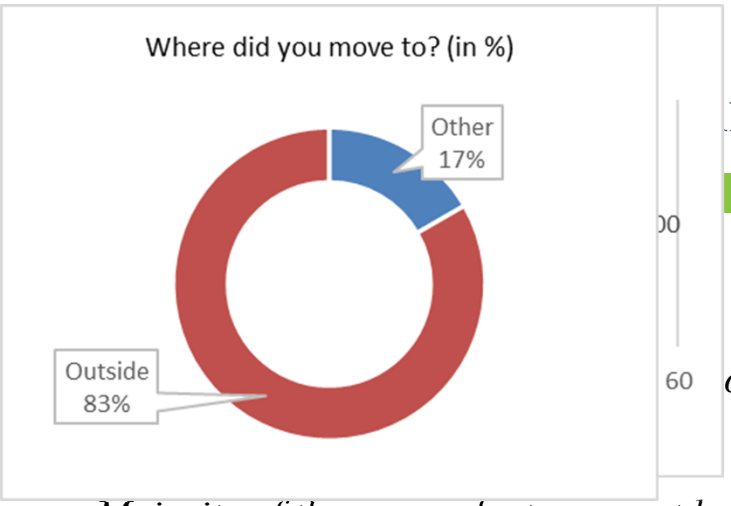
- *Few Temples and church suffered a significant damages due to Khotang earthquake.*
- *Estimated loss of religious structure was about 0.8 million Nepalese rupees.*

Table. Damage and loss estimation for religious structures

S. No.	District	Name of the place	Address	Damage description	Loss due to damage
1	Khotang	Church	Ward 5, Diktel Municipality	60% damage on walls	5,00,000
2	Khotang	Temple	Diktel Municipality Ward -1	Simple damage	3,00,000
				Total	**8,00,000**

Figure. Wall collapsed at Church in Diktel-5, Khotang

BUILD CHANGE



ndings

that there was no any physical or killed as a result of the

- *Majority of the respondents were at houses. About 34% of surveyed respondent reported that they were at bedroom & working at field following by the balcony and living room with same proportion of 17%.*

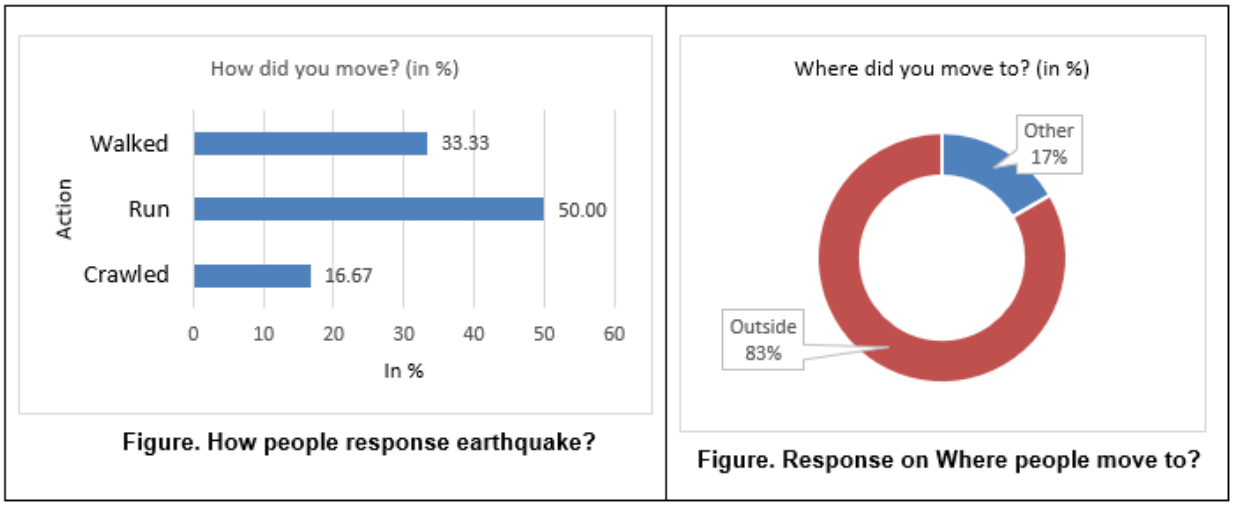


Figure. How people response earthquake?

Figure. Response on Where people move to?

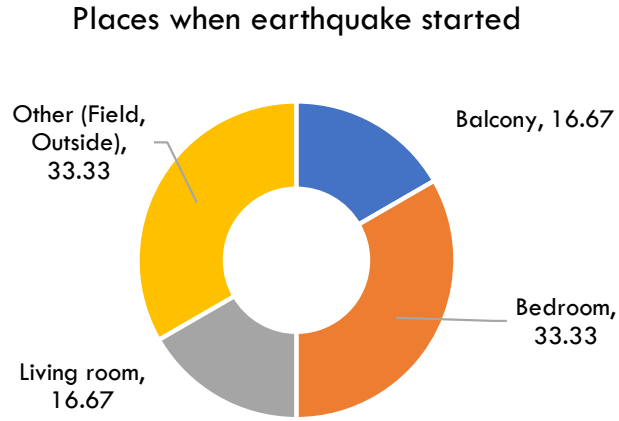


Figure. Peoples position during the time of Earthquake

Table. Immediate reaction of people during the time of earthquake

First action	Percentage
Attempted to move but could not	16.67
Moved	33.33
Stayed where I was	16.67
Stood up	33.33

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Observations and Findings

- Interactions with Local Authority

- *District level coordination meeting with Chief District Officer helped to figure out the ongoing process and identify the area that need to be focused for initial assessment.*
- *The IRA templates were shared with the municipalities by the DDMC to collect the damage data from all local authority.*
- *Despite difficult geographical terrain and road access, NRC has managed to distribute 168 tarpaulins in Sakela rural municipality and non food items for 18 households*
- *Due to monsoons there was delay in distribution of relief materials.*

Table. Summary of KII with districts government and local authority

Expectations	**Major causes**
Financial support from Province and Federal Government for reconstruction of damages structures and houses	Municipality budgets are very limited and need support form province and federal government particularly on Housing reconstruction and school reconstruction.
Relief items support particularly shelter Kits	Relief distribution is not sufficient,
Awareness & Trainings for reconstruction	Can be done from the local authority but required resource persons

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Sector wise summary

- Summary of damages incurred

Table. Summary of Damage due to Khotang Earthquake

Particulars	Casualty
Death	No
Injured	No
Damage to Private Residential Houses	187(Complete), 192(Partial)
Displaced Family	24 HH
Displaced Population	About 600
Damage to Public Property	4
Educational Institutions	32(Completely), 2(Partial); Building units
Health Institutions	No
Government Buildings	2 (Completely), 2 (Partial)
Others (religious place)	2(Partial)
Damage to Cattle sheds	No.
Tentative Damage	NRs **196,607,912**
Relief Distributed	NFI for 18 HH and 168 tarpaulins to Households

Sector wise summary

- Summary of sector wise damage and loss
  - *The loss estimation is a preliminary information to figure out the scale of damage loss in terms of financial value.*
  - *The unit cost of houses is detailed as per the cost estimation of current district rate and other sector unit of cost is estimated on expert judgement.*
  - *From preliminary assessment, estimated loss is 196 million Nepalese rupees, for actual losses detail survey and sectoral analysis is required*

Table. Summary of Damage due to Khotang Earthquake

S.N	Sector	Estimated Sector wise Losses
1	Private Housing	153,107,912
2	**Public Buildings**	
	Schools/Education institutions	32,400,000
	Government Buildings	6,000,000
	Religious places/Heritage	800,000
3	Critical facilities	2,000,000
4	Agriculture sector	600,000
5	Land loss due to landslide	1,700,000
Total estimated losses		**196,607,912**

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Limitations

- The scope of this study is very limited and based on expert judgement to estimate the tentative losses and damage due to earthquake.
- The information collected from the field is processed to increase the accuracy of data collected by using different statistical tool for projection, there are not any specific formula to project the data.
- The presented fact helps to develop the further planning for recovery and reconstruction design, since it is just a preliminary assessment; actual damage loss estimate can be assured only after detail damage assessment.

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Learnings

- Disaster Risk Reduction and Management authority (NDRRMA) needs to standardize the guidelines to conduct post disaster assessment for damage estimation.
- The tools used(Kobo- application) used for data collection needs to improvised as per the current requirements.
- Development of earthquake intensity mapping and its use.
- Need to work towards sustainable retrofit approach

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Pictures

Overview of Earthquake induced Geo-hazards

- Earthquake induces many geohazards like ground shaking, surface faulting, landslides, liquefaction, rock avalanches, rapid soil flows, rock falls, Tsunamis and ground subsidence.Strong and moderate earthquakes in mountainous regions like Nepal trigger chains of events that modify mountain landscapes over days and years.
- Earthquake shaking can cause many landslides on steep mountain slopes.
- Some of these sudden slope failures can block rivers and form temporary lakes that can later collapse and cause huge floods. Other landslides move more slowly, in some cases in a stop-start fashion during heavy rains or earthquake aftershocks. Debris from these landslides can clog channels, and during heavy rainfall, the debris can be transported downstream for many kilometers with catastrophic consequences.
- The most notable geohazard caused by Khotang earthquake is **Landslide** and caused loss to the road facility, destroyed cultivable ground, endangered buildings nearby to the slope, affected irrigation facilities, incurred losses of crops and threatened settlements.

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Landslide affecting road

Landslide causing blockage of road joining Diktel from Diktel Rupakot Majuwagadi Municipality, Dumli, Ward No-07

Landslide affecting road

Ground subsidence in road in Sakela Rural Municipality Ward No -04

Landslide affecting critical facilities; here school

Gabion wall failure below Shree Janakalyan Adarbhut Bidhyalaya at Sakela Rural Municipality Ward No-04

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Landslide affecting critical facilities; here school

Extended cracks seen in premises of Pelung Prathamik Bidhdyalaya in Diktel Rupakot Majuwagadi Municipality, Ward No-09

Landslide affecting settlement area and cultivable land

Cracks seen in Diktel Rupakot Majuwagadi Municipality - Buwalung area

Loss Estimation / Cost of reconstruction

Observation No	Location	Event	Description	Mitigating Measures (if any)	Loss due to Damage or replacement cost in NPR
1	Diktel Rupakot Majuwagadi Municipality, Dumli, Ward No-07	Landslide causing blockage of road	About 25-35 m long length of road and 4 m width has slided down to 3-4 m height below causing obstruction of earthern road from Dumli to Diktel	Backfilling of the slided mass with Gabion wall of length 25 m and height 3 m	1300000.00
2	Diktel Rupakot Majuwagadi Municipality, Dumli, Ward No-07	Landslide in harvesting area	About 6 to 7 ropanies of land as well as harvested crop (Kodo) was destroyed by slope failure	-	364000.00
3	Diktel Rupakot Majuwagadi Municipality, Buwalung, Ward No- 09 - (27°12'54.60"N 86°51'18.55"E)	Ground cracks above the crown of past landslide	About 200 m ground cracks of about 200 m in an arc was observed in an entire area at the crown of past mega landslide zone	Resettlement of two houses may be required near to the crack zone	1652000.00

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Loss Estimation / Cost of reconstruction : Continued…

4	Diktel Rupakot Majuwagadi Municipality, Buwalung, Ward No- 09 - Pelung Prathamik Bidhdyalaya	Ground cracks seen above the cut slope of the hill	About 100 m long cracks distinctly observed of 10 - 15 cm long which may slide down below the hill of height 3-5 m may cause blockage of roads below and making school inaccessible	Retaining structures required	100000.00
5	Sakela Rural Municipality, Ward No-04	Road Subsidence	About 3-4 m long length of earth road subsided; inoperable road	Compaction and filling with soil, gravels and boulders	3200.00
6	Sakela Rural Municipality, Ward No-04, Shree Janakalyan Adarbhut Bidhyalaya	Gabion retaining wall failure	Gabion retaining wall has got malfunctioned causing threat to school building where cracks are increasing	Bioengineering with plantation and restrengthening of gabion walls after detail investigation	700000.00
7	Sakela Rural Municipality, Ward No-4, Okharbote, Paraang	Landslide in cultivable land	Destruction of land and harvested crops and blockage to the irrigation facilities	-	342000.00
				Total	4,461,200.00

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Limitations of our study

- Our study is limited to the observable landslides just seen after the earthquake.
- Further more landslides are susceptible due to cracks present underneath the soil layer which can be encountered due to precipitation.
- Post disaster risk assessment wasn't carried out in detail.
- Detail geological assessment of the entire district wasn't done which could have been alarm bell for upcoming disasters.

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Learnings

- Mapping of landslides and vulnerable zones can be done prior to the earthquakes and can be avoided for development of settlement and structures.
- Strict implementation of building codes related to building construction in mountainous terrain.

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