

Community based Landslide Early Warning System: An approach to Landslide Risk Reduction

A case study from Sahajpur VDC of Kailali District of Nepal

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Mission East Nepal

- Special thanks to Dr. Basanta Raj Adhikari, Landslide Expert, Institute of Engineering
- Some slides have been prepared by Dr. Adhikari.

About Mission East Nepal

- Mission East is an international relief and development organization founded in Denmark
- Began its operation in Nepal since 2001
- Works to help vulnerable people and supporting communities' capacity to organize and help themselves through activities from emergency aid during disasters to long-term development assistance
- Works in Karnali and Earthquake affected districts



Five priority areas of Mission East Nepal

1. Eco-system management including DRR/CCA
2. Livelihood diversification and business development
3. Empowerment of vulnerable and excluded groups
4. Water, sanitation and hygiene
5. Agriculture development and food security

Let's begin with some pictures of landslides...

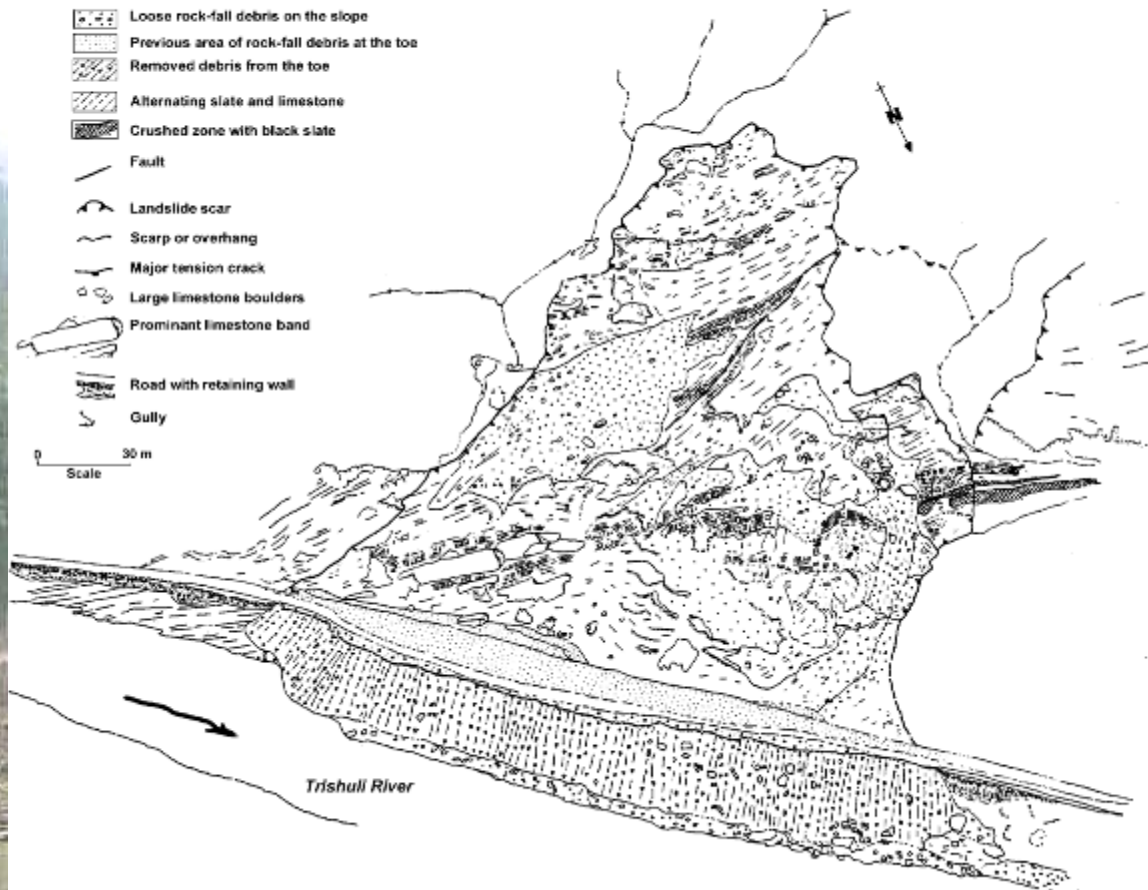
Khariswara (Dolakha) Landslide (Photo: S. Devkota, 2011)



Jogimara Landslide (Source: M.R. Dhital, 2011)



Jogimara Landslide 1993 (Source: M.R. Dhital, 2011)



Krishnabhir (as of before and now)



Does any one know where this landslide is located?



Somewhere in farwest....



Bangabagar, Baitadi (2013)

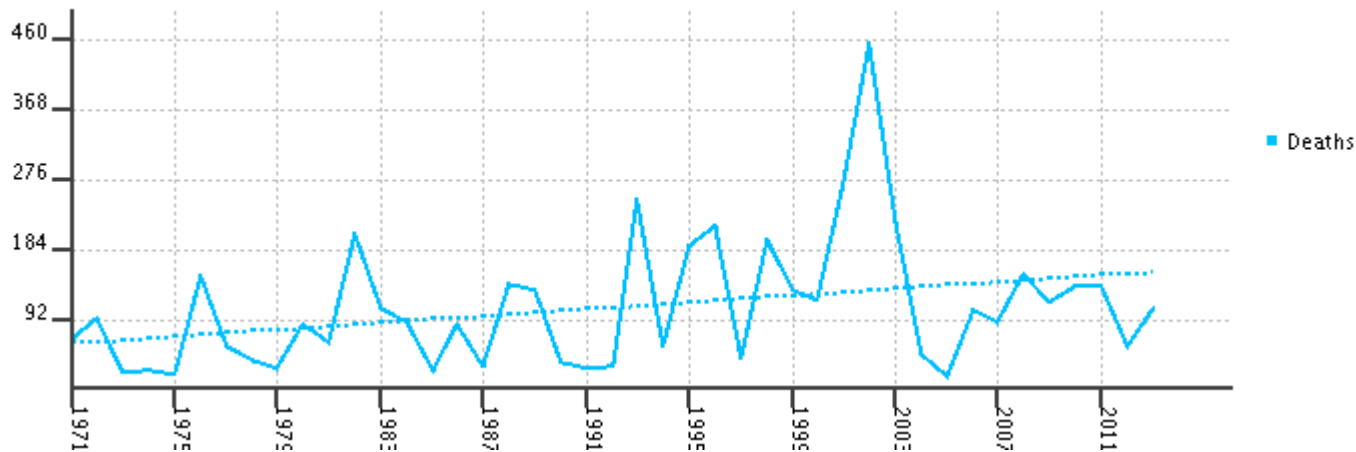


Bangabagar view from the other side of Chamelia River.



Landslide and Nepal: *Some figures...*

- Database from 1971 to 2013 maintained by Desinventar suggests the average annual number of deaths due to landslide is 210
- A database of 397 fatal landslides of 1978-2005 compiled and analyzed by Petley *et al.*, 2007 suggests the upward overall trend, although there is a high variability in the occurrence of landslides from year to year.



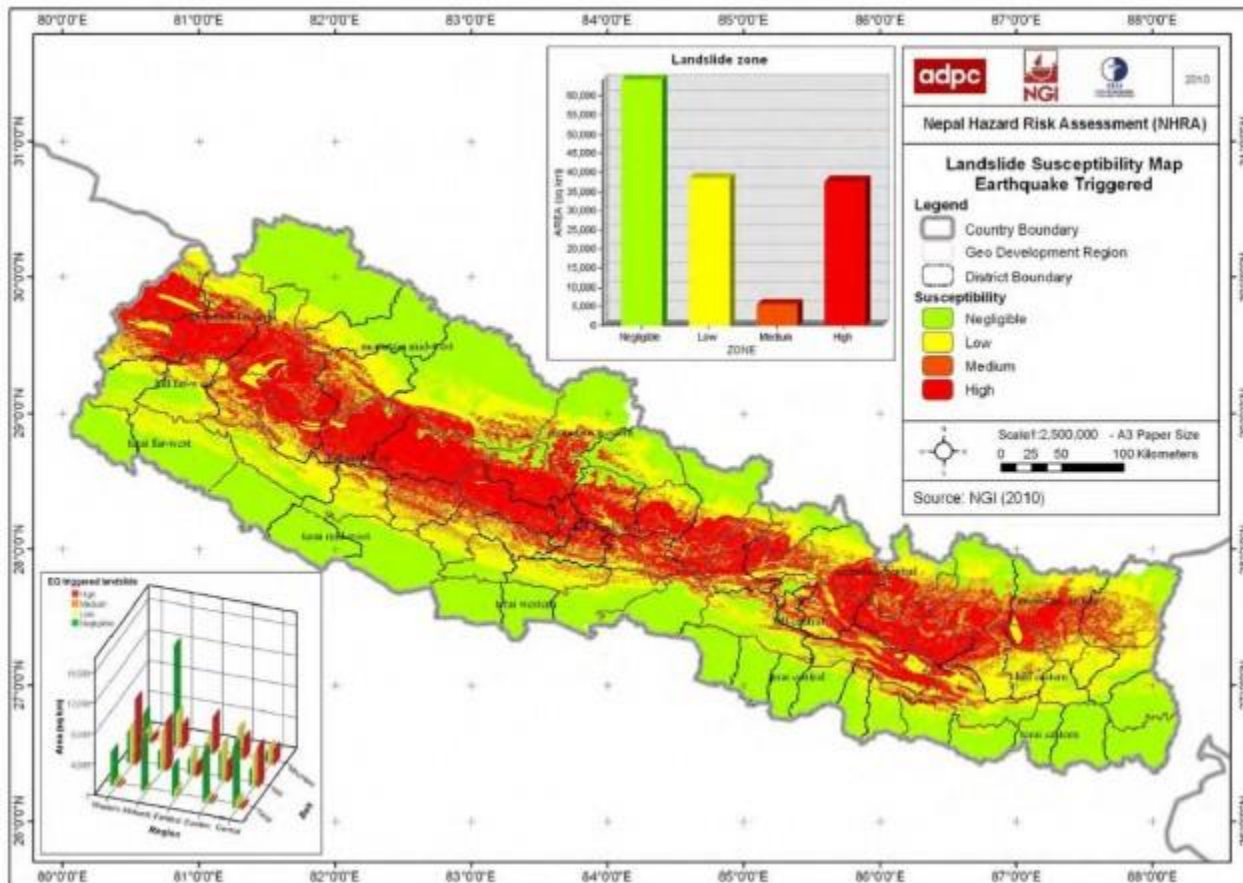
Landslide and Nepal: *Some figures... Contd...*

- Some of the studies conducted in the past reveal that landslide density in the Nepal Hills ranges from 0.2 per linear kilometer on stable land to 2.8 per linear kilometers on susceptible areas fully exposed to human influence
- More than 19,332 landslides have been identified covering 61.5 km² of land in about 20,500 km² area of investigation using Google Earth imagery (Gnyawali K.R., Adhikari B.R. (2017))

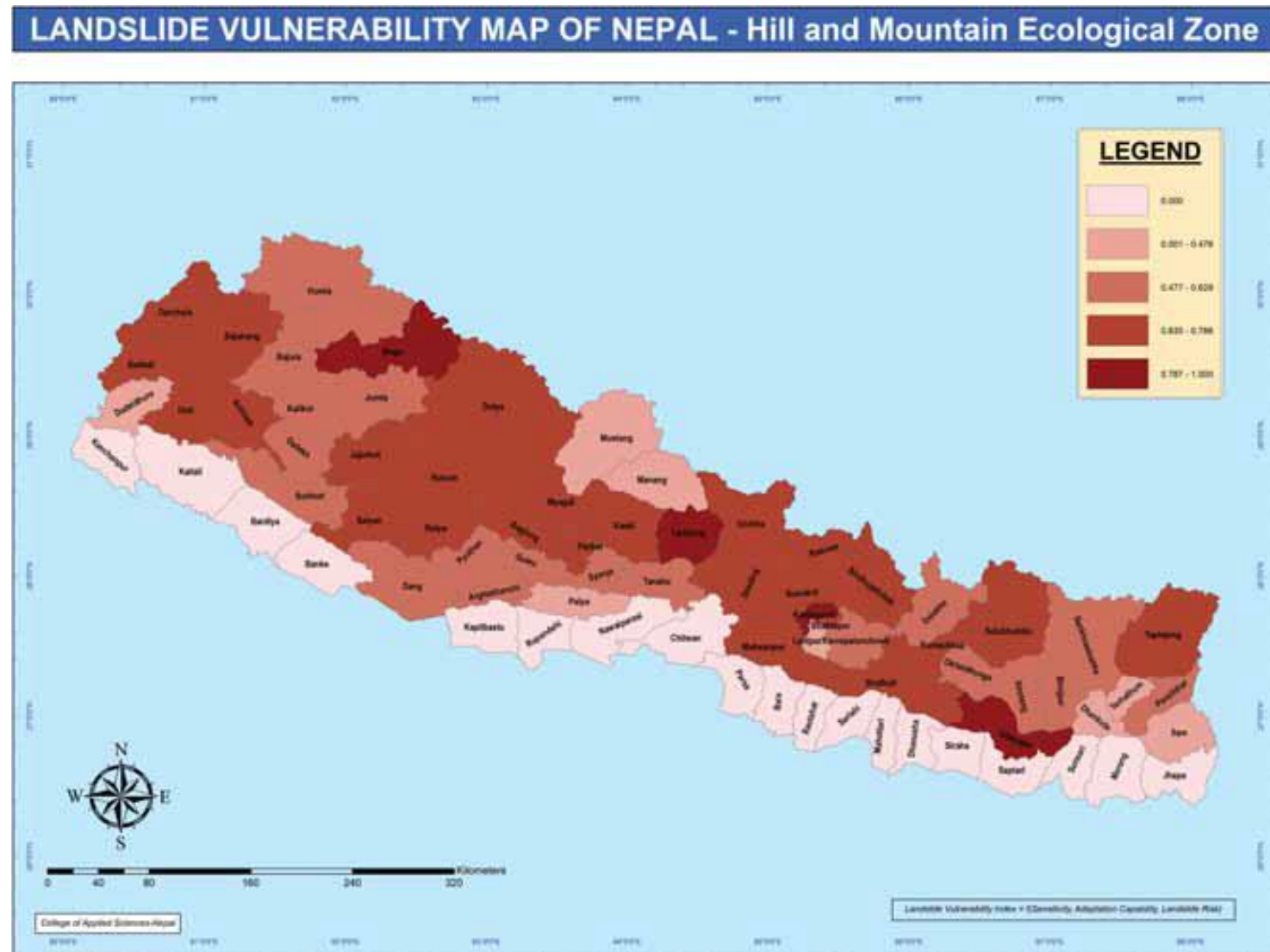
Landslide and Nepal: *Some figures... Contd...*

- More than 80% of annual precipitation occurs in summer due to monsoon (Sigdel and Ikeda, 2010).
- Monsoon period accounts for 92% of landslide fatalities and 90% of the fatal landslides (Petley *et al.*, 2007).
- Road construction and associated changes seem to be the major cause of increase in the number of fatal landslides (Petley *et al.*, 2007)
- Studies and past records have shown that mid hills and Churia regions are more susceptible to landslides (Mercy Corps, 2014).

Landslide Susceptibility map of Nepal, NHRA-I, ADPC



Landslide vulnerability map of Nepal, Source: NAPA, 2010



- There might be inconsistencies in these maps but the message is we all either live or work in landslide prone areas.
- Hence, preparedness and mitigation is must.

Then, what are landslides?

- The term 'landslide' includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another.
- Definition (Cruden, 1991): ***“The movement of a mass of rock, debris or earth down a slope”***

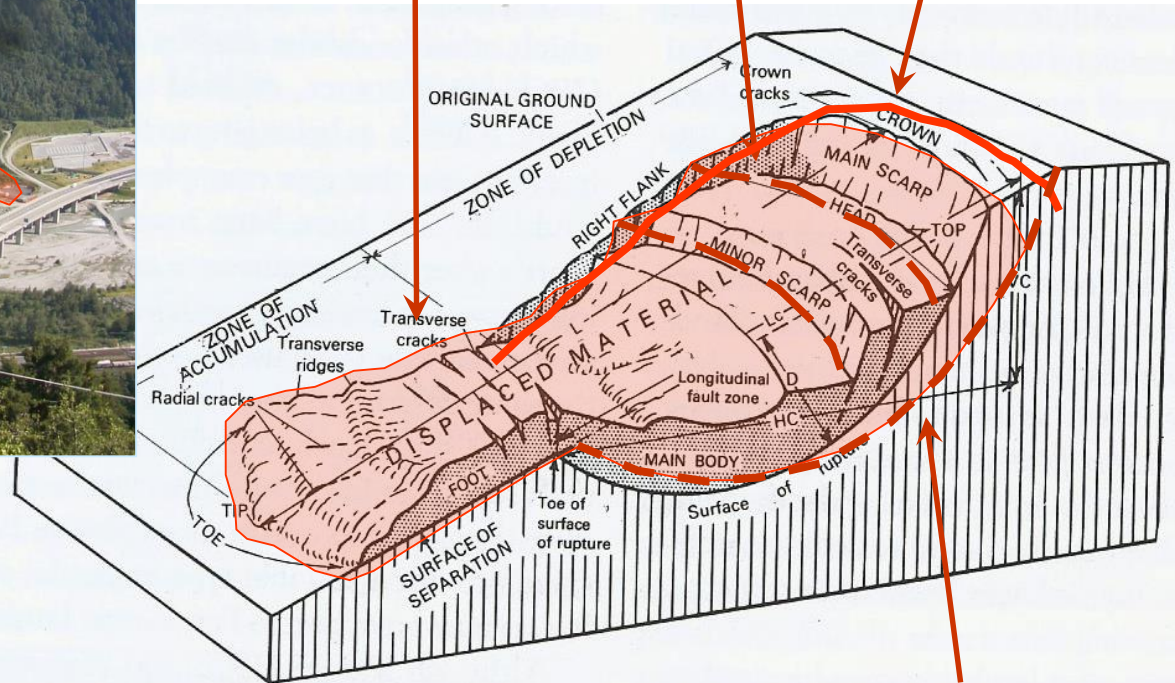
- Landslides are one of the most damaging and significant but underestimated natural disasters.
- Emphasis is generally given to high magnitude, low frequency events (Lavell, 1994 and Wisner, 2001 as cited by Oven, 2009).
- Small and medium sized landslides, which are localized and affect small numbers of people, cumulatively account for similar or greater levels of economic losses than less frequent large-scale events (ibid).



Main Scarp

Secondary Scarps

Accumulation



Surface of rupture

Factors that may trigger landslide

- Regional movement (geological movements)
- Increase of lateral pressures (hydraulic pressures, roots, swelling of clay)
- Increase of load (weight of rain, Vegetation)
- Removal of lateral and underlying support (erosion, previous slides, road cut)
- Transitory stresses (earthquakes, vibrations of trucks)

Disaster Risk Management Cycle



Now, let's enter into the topic

- Previous presentations must have covered about the Nepal's steep terrain and the suitable cropping and land use pattern for the slopes.
- I will focus on some of the lessons learnt on landslide Early Warning System, particularly the landslide monitoring and communication system...
- Based on the experience of piloting Landslide EWS by Mercy Corps and Practical Action in the past 5 years
- Experience of three time scales have been summarized:
 - 2011-2013
 - 2014-2015
 - 2015-2016
- These initiatives were parts of DIPECHO VI and VII projects funded by European Commission Humanitarian Aid and Civil Protection and project supported by MAC foundation
- I will also try to share some of the low cost measures for landslide mitigation and risk reduction.

First of all...what is EWS?

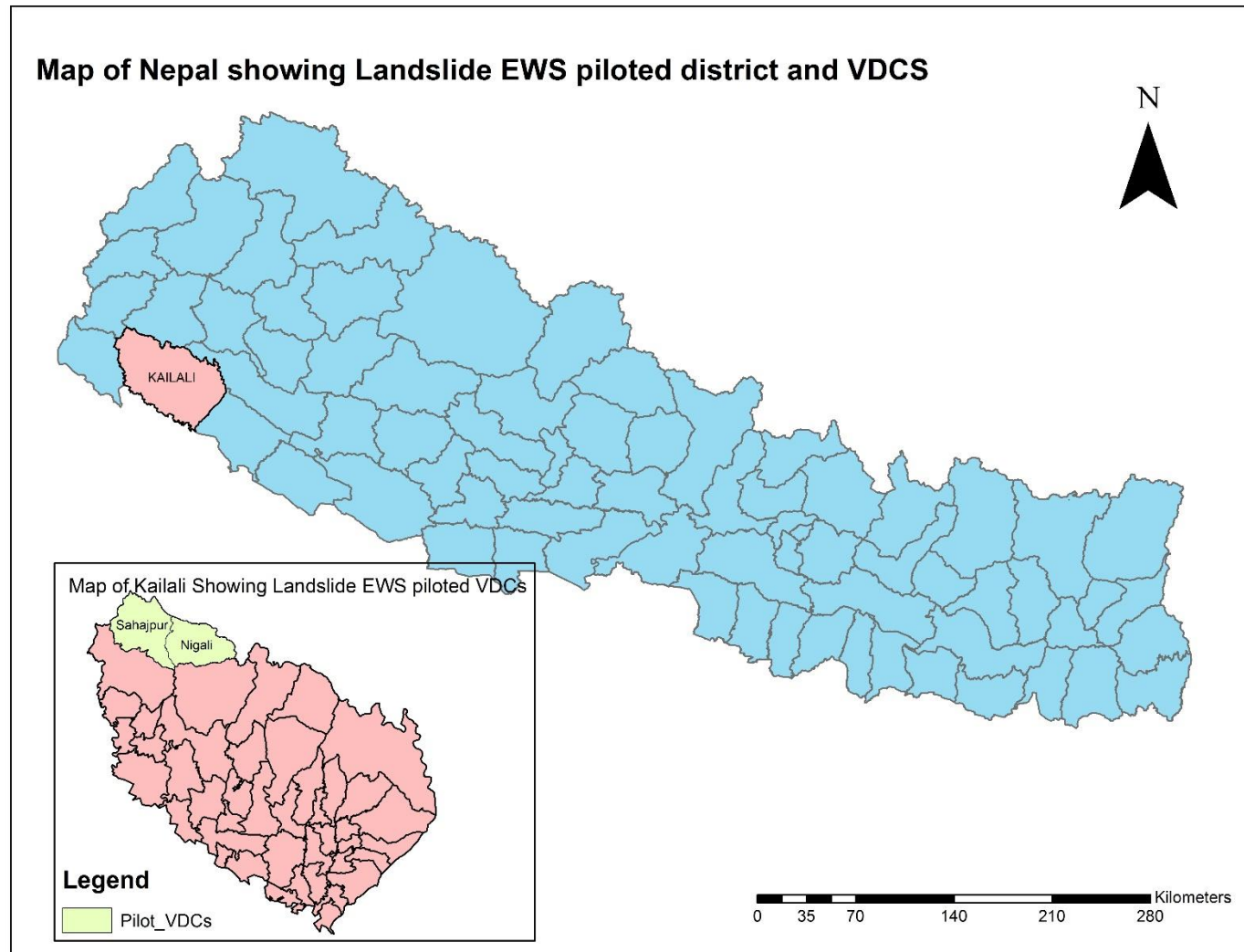
- UNISDR (2009) definition of Early Warning System
 - “The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.”
- Community based EWS comprises of four key elements:
 - Risk Knowledge;
 - Monitoring and observation services
 - communication or dissemination of alerts and warnings; and
 - Response capabilities

Why landslide EWS?

- Save life and property.
- Density of landslide is high.
- Cost of mitigation is high.
- Mitigation measures require time and till the mitigation measures are adopted, EWS is crucial in saving lives and property.
- Experience in Flood EWS had shown functional EWS is efficient and effective.

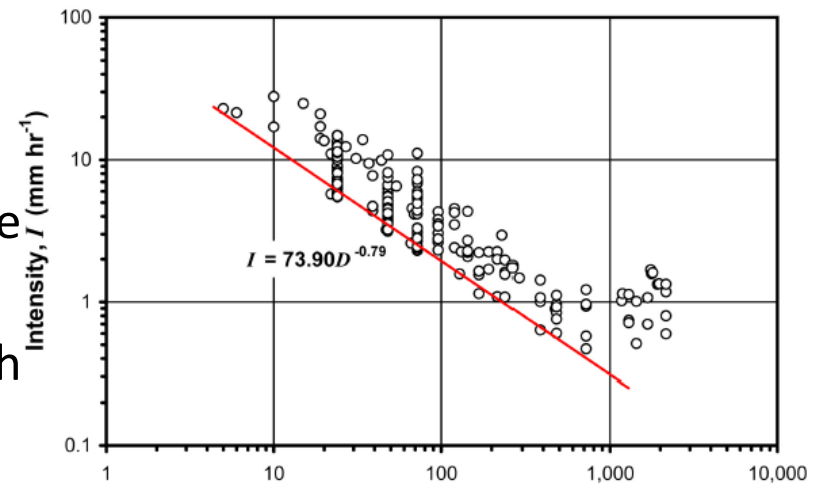
Period: 2011-2013

- Initiated rainfall based pilot in Kailali District (Sahajpur and Nigali VDCs) of Nepal



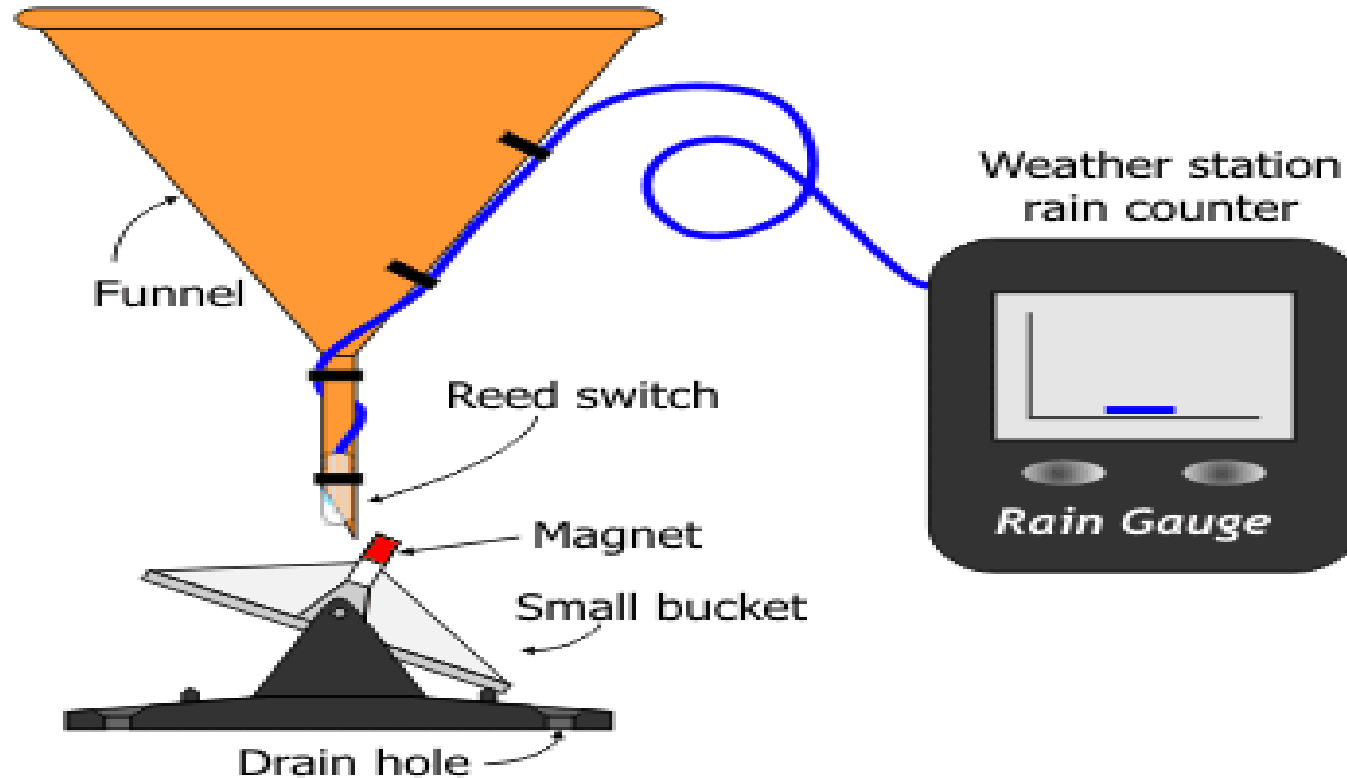
Key highlights...

- Pilot hypothesized rainfall as the major cause of landslide
- Referred the threshold relationship approach developed by Dahal and Hasegawa (2008):
 - $I = 73.90D^{-0.79}$
 - Where I =rainfall intensity in mm/h and D =duration in hours.
- Using the participatory VCA tools, the past landslide locations were identified in the pilot VDCs
- Dates of occurrence of historical landslides were identified.
- The rainfall data of the closest station were obtained from the DHM and correlation between the landslide occurrence and rainfall were determined to determine the empirical rainfall threshold for landslide occurrence.
- Automatic rain gauges and display boards



How does a tipping bucket work?





Threshold determination

- *Integration of science and community perception was done*

Hour	Rainfall	Siren tune
1 hour	30/50 mm	Ringing siren for 2 minute 1 time
12 hour	160 mm	Ringing siren for 1 minutes 2 times with 1 minute gap
24 hour	200 mm	Ringing siren for 1 minutes 3 times with 1 minute gap

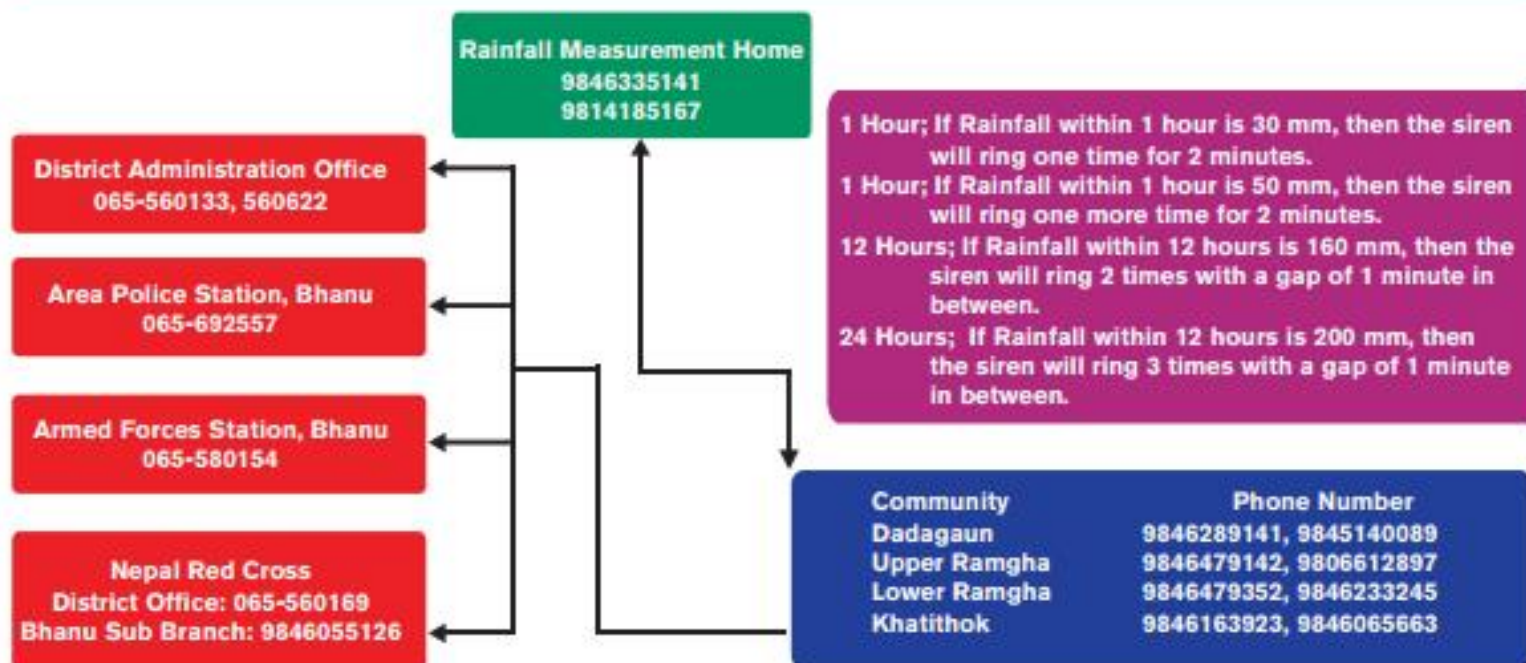
- *Communication channels and mechanisms were developed*
- *Community Response teams (EWS, FA and Search & Rescue) were formed and trained*

For more details:

<http://nepal.mercycorps.org/pdf/publication/estimating-landslide-probability.pdf>

Sample Communication channel

Landslide Early Warning Communication System-Bhanu, Tanahun



Period: 2014-2015

Adding monitoring of strain component in landslide EWS

- The rainfall threshold approach could not predict landslide – rather gives conditional probability for landslide.
- Landslides are very complex phenomenon and are associated with different factors (not only rainfall)
- Hence, Mercy Corps partnered with Institute of Engineering to incorporate strain based monitoring system in the community based EWS.
- Moving pegs were used to monitor the land movement in Massey landslide of Sahajpur VDC.
- Moving pegs method was chosen since it is low cost and easily used by the communities.



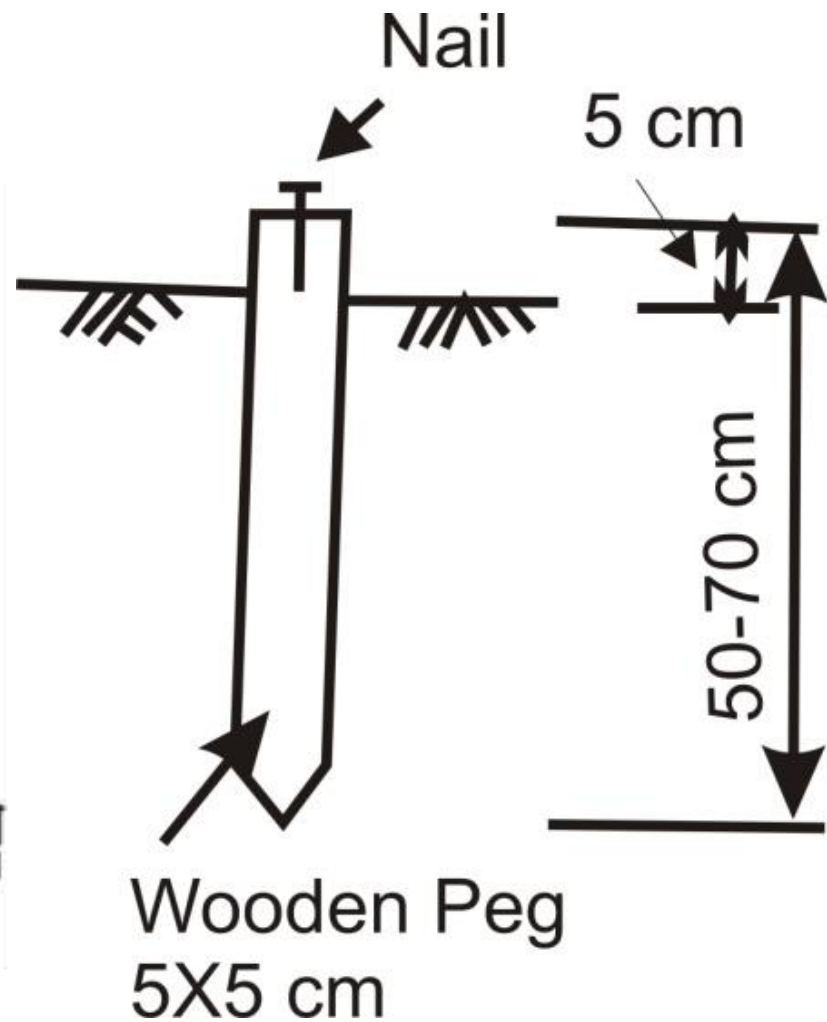
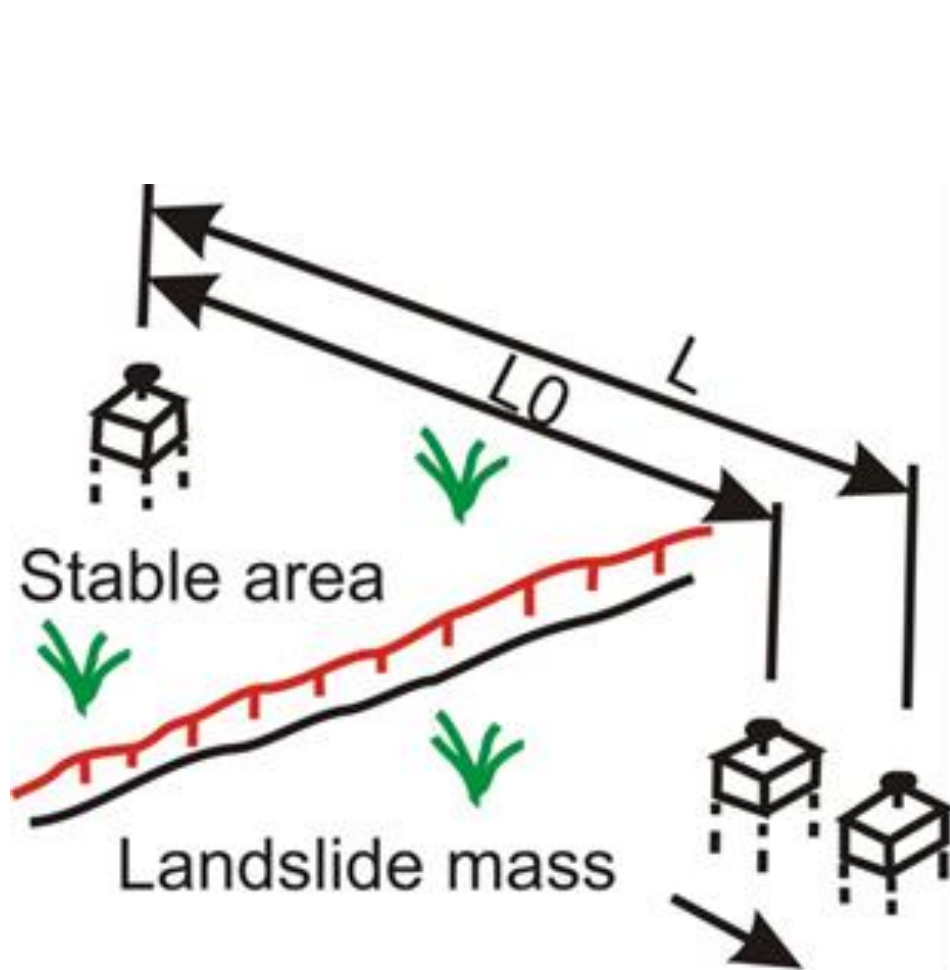
Moving pegs method being done in Massey

- Wooden posts were longitudinally installed in two series at the interval of 10 meters from crown to the toe along the slope of Massey landslide, the end of which were connected to the reference point on the stable area.
- The wooden posts were put at intervals 10 meters of distance within the total length of 120 m in two lines.
- [http://nepal.mercycorps.org/pdf/publication/Landslide EWS Report Piling Monitoring System.pdf](http://nepal.mercycorps.org/pdf/publication/Landslide_EWS_Report_Piling_Monitoring_System.pdf)

- 8 houses near the toe were at high risk where as more than 15 were at medium risk
- Members of EWS Task Force which is a subcommittee under Community Disaster Management Committee was delegated to take regular measurements of distance between two pegs so as to find out temporal displacement of the slope.
- However, no significant movement of the slope occurred after installation of moving peg.
- Data of movement of pegs were collected from August 2014.







Period 2016-

Analyzing the effectiveness of moving peg method

- After 19 months of moving pegs installation and monitoring of the pegs' movements, a research on effectiveness of moving peg method was conducted
- The daily rainfall patterns recorded by the nearby stations were analyzed during the period of monitoring of the movement of slopes.
- The maximum rainfall (144.8 mm) of a closest station (Sandepani: St. ID 208)) was measured in 14 August 2014 and other stations are also measured large amount of rainfall.
- However the slope did not move.
- Hence, it was concluded by the expert that the threshold for that area is more than 140 mm/24 hr.
- However, the displacement and movement of the landslide does not depend only in rainfall but also depends on rock type, slope, weathering and vegetation etc.
- The experts from IOE suggested to use the threshold provided by Dahal and Hasegawa for the upcoming few years.
- It was concluded that the moving peg method is very cost-effective and easy to handle by community.
- For more details :
http://reliefweb.int/sites/reliefweb.int/files/resources/52996_codesigningdrrsolutionsebook.pdf (Page number 31)

Use of information of slope movement

- Based on the recommendation from landslide expert, change in land use pattern was suggested
 - For example: Changing paddy field to plant alternative species that require less water, dewatering/trenching, improving drainage to run off

Some other possible signals of landslides.....

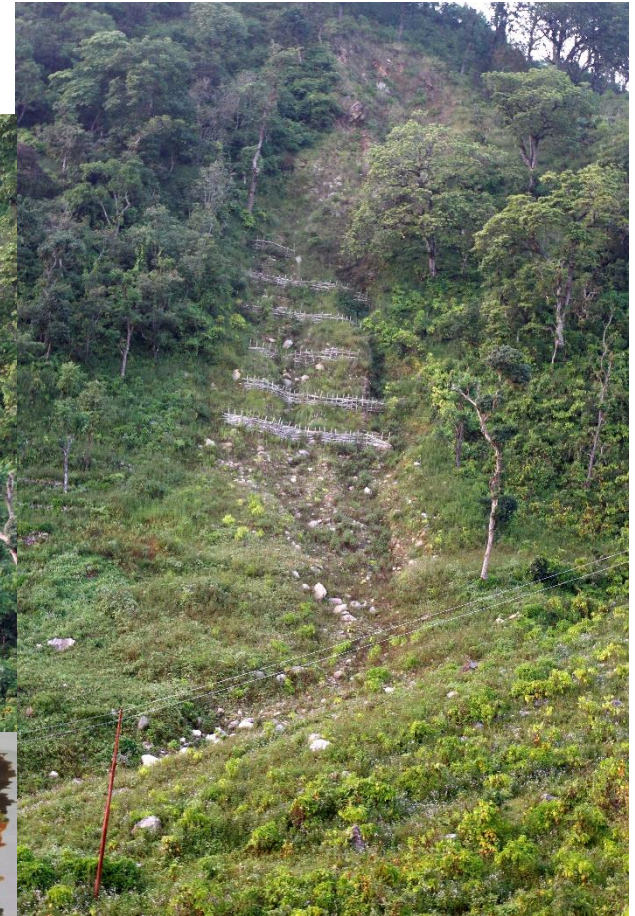
- Tilting/bending of trees
- Weakening of rocks
- Cracks on walls, slopes, field
- Bending of telephone towers, retaining walls
- Doors, windows getting tight
- Small rocks falling from the slopes
- Water sources getting muddy



Some other low cost landslide risk reduction measures



Low cost bio-engineering using local resources such as bamboo and coconut/jute nets...



Consultation with geologists should be done to finalize the schemes together with engineers, sectoral experts and community people

Fodder and dairy nexus activity: Incentivizing Disaster Risk Reduction

- Comparison between the control and treatment households showed that treatment households were 3.4 times as likely to have structural mitigation protecting their land as the comparison group. They were also 3.1 times as likely to use bio-engineering, such as fodder plantations, and 3.7 times as likely to use advanced planting techniques to protect their fields.
- Beneficiary households produced an extra 544 NPR worth of milk each month, relative to the comparison group.
- The message is people will engage in conserving nature and disaster risk reduction if they see value in it; particularly the economic benefits.
- Volunteer engagement of people/communities diminishes with time



<http://nepal.mercycorps.org/pdf/publication/estimating-landslide-probability.pdf>

"The mock drill conducted in Masse has increased the awareness level of villagers. Similarly the confidence level of different task force members as well as villagers has also increased after the Mock drill. The villagers actively participated in mock drills and performed the roles of different disaster affected people. The EWS task force demonstrated the mechanism of blowing siren and use of hand mikes during emergencies and the villagers were taught to respond accordingly. Similarly, the search and rescue task force demonstrated their skills to rescue affected and the first aid task force members showed their skill of first aid. Now, our community will not wait for external support for response during and after disaster."

*Prem Rana, Chairperson,
Samajekata CDMC, Masse, Sahajpur-6*

"There are numerous unstable slopes in Bayela. We were tired of reporting different agencies about our problem. Then a day, Mercy Corps-Nepal and NRCS Kailali helped us prepare social map showing the vulnerable households, safe routes and sheltering places during emergencies. Similarly, they also provided support in attempting to stabilize some unstable slopes in our community. We learned quite simple and easily understandable and adaptable technology in our community Bioengineering. Initially, we doubted the efficiency of bio-engineering and asked for civil structures only but time has proved us wrong. Its quite amazing to see how the bamboo fences and coconut nets catch the falling debris. It also feels great that unstable slope in our community has started to get green after implementation of bio-engineering. Today, we realize the gabion boxes could have failed gradually as the metal wires used start rusting."

*Dan Bahadur Mahara, Chairperson,
Melkatteshore CDMC, Bayela,
Sahajpur VDC-4&7*

Sloping Agricultural Land Technology (SALT)



व्यवस्थित जलाधार, विपद जोखिम न्यूनीकरण तथा समुन्नतिको आधार

जलाधार व्यवस्थापनका केही उपायहरूः

खाली ठाउँमा वृक्षरोपण, भिर पाखाको ढालेघाँस रोपण,
खहरे तथा पहिरो नियन्त्रण, गह्वा सुधार, कूलो सुधार, गोरेटो सुधार,
भूस्खलन भएका स्थानमा जथाभावी घर निर्माण, खेतीपाती र चरिचरण नगर्ने



- Also somewhere known as contour hedgerow intercropping (agroforestry) technology (CHIAT)
- The technology was developed in the Philippines
- It is a system in which dense hedgerows of fast growing perennial nitrogen-fixing tree or shrub species are planted along contour lines thus creating a living barrier that traps sediments and gradually transforms the sloping land to terraced land.
- The nitrogen-fixing hedgerows lining the terrace help improve soil fertility through nitrogen fixation.
- For more details:
<https://www.youtube.com/watch?v=y9D-gWk4S5U>
[http://lib.icimod.org/record/21492/files/Sloping%20Agricultural%20Land%20Technology%20\(SALT\).pdf](http://lib.icimod.org/record/21492/files/Sloping%20Agricultural%20Land%20Technology%20(SALT).pdf)

Some other useful sites for more information

- www.vetiver.org
- <https://www.youtube.com/watch?v=UAmai36XJDk>
- https://www.youtube.com/watch?v=AK_qTm2pUsw

*Thank
you*

