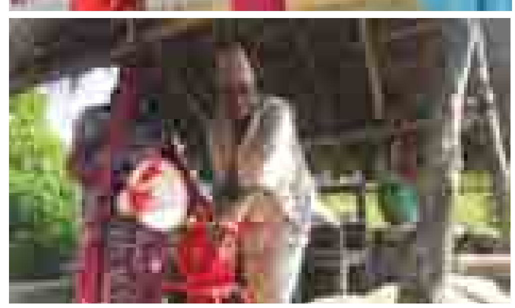
Estimating Landslide Probability

A community based approach for rainfall monitoring



Content And Material Developed By:
Anup Phaiju
Yuwan Malakar
Alisha Ghimire
Keshab Kumar Pokhrel
Anil Nepal
Ramesh Shrestha

Photo Contribution:
Mercy Corps Nepal and Practical Action

Reviewers:
Gehendra Gurung

Design And Printing:
Mind Share Communications Pvt. Ltd.

Organisational Introduction

ECHO

The European Commission's Humanitarian Aid and Civil Protection department (ECHO) was created in 1992. In its 20 year existence it has provided €14 billion of humanitarian assistance to victims of conflict and disasters in 140 countries around the globe. In 1996 ECHO launched a specific programme, DIPECHO (Disaster Preparedness ECHO) dedicated to disaster preparedness. This programme has been operating in South Asia since 2001.

Mercy Corps

Mercy Corps is an international, non-governmental humanitarian relief and development agency that exists to alleviate suffering, poverty and oppression by helping to build secure, productive and just communities. Mercy Corps works amid disasters, conflicts, chronic poverty and instability to support people, communities and organizations that can bring about positive change. Since 1979, Mercy Corps has helped people turn the crises they confront into the opportunities they deserve. Driven by local needs, Mercy Corps programmes provide communities in the world's toughest places with the tools and support they need to transform their own lives. Mercy Corps worldwide team in 41 countries is improving the lives of 19 million people.

Mercy Corps works in Nepal to strengthen, protect and expand access to productive livelihoods for the poor. Mercy Corps began operations in Nepal in 2005, and since then has implemented projects in the sectors of agriculture, microfinance, youth engagement, and disaster risk reduction/ climate change adaptation.

MC-N focuses on the sectors of: Economic and Food Security; Climate, Natural Resource and Disaster Risk Management; and, Youth Engagement. Inclusion of women and disadvantaged groups are important cross-cutting themes. In the Economic and Food Security sector, key intervention sub-sectors include agriculture, food security, and financial services; for the Climate, Natural Resource and Disaster Risk Management sector, these sub-sectors include climate change adaptation, natural resource conflict management, and disaster risk reduction; and, for the Youth Engagement sector, these sub-sectors include youth civic and economic engagement, and migration.

In Disaster Risk Reduction (DRR) and Climate Change, MC-N works to mitigate vulnerability in the long term through organizing Disaster Preparedness Committees, building community capacity to prepare for and respond to disaster, building VDC capacity to support community level DRR activities, supporting early warning system, small scale mitigation works, school-based DRR and response capacity. In the event of an emergency and where local response capacity is overwhelmed, Mercy Corps also supports disaster relief services as resources permit. Disaster risk reduction is also closely linked to climate change adaptation.

Through the support of the DIPECHO Action Plans for South Asia, Mercy Corps has been working in Disaster Risk Reduction (DRR) in Nepal since 2007, concentrating specifically on the Far Western Region districts of Kailali and Kanchanpur. The current programme "Strengthening Capacity of Communities for Disaster Risk Reduction through Early Warning in Nepal (SCORE)" is being carried out in conjunction with Mercy Corps' local partner, Nepal Red Cross Society and has continued ground breaking work in Community Based Flood Early Warning System (CBEWS) development and the use of low cost bio-engineering approaches for flood protection. The project has also piloted measures to mitigate damage from landslide in hilly areas. The project's goal is to reach over 23,000 community beneficiaries and 6,000 schools students in Kailali and Kanchanpur by the end of 2012.

Practical Action

The renowned economist Dr. E.F. Schumacher established Practical Action in 1966 to prove that his philosophy of 'Small is Beautiful' could bring real and sustainable improvements to poor people's lives. With its Head Office in the UK, Practical Action works through its country and regional offices in Bangladesh, Kenya, Nepal, Peru, Sri Lanka, Sudan and Zimbabwe.

Practical Action is committed to reduce poverty. It supports the efforts of poor women and men to improve their livelihoods by providing appropriate technology options, associated information, knowledge and skills, and the capacity to organise and use all these to get more control over their lives and livelihoods. The people centred unique and innovative approach of Practical Action incorporates local knowledge and skills, which ensure their wider adoption and replication respecting sustainability, basic human rights, and strategic partnership.

In its current strategy period 2012–17, Practical Action has regarded "Technology Justice", "Innovation" and "Scale up" as its guiding principle and prioritised working areas mainly into four sectors and two cross cutting sectors realising its comparative advantages in these sectors. The sectors are: Access to energy; Agriculture, markets and food security; Urban waste, water and sanitation; and Disaster risk reduction with Climate change and Making markets work for the poor as cross cutting sectors.

Practical Action has been working on Community Based Early Warning Systems (CBEWS) in Nepal since 2002 through DIPECHO I, III, IV, V and VI projects co-funded by European Commission's Humanitarian Aid & Civil Protection department (DG ECHO) which provides early warning information on flood together with other preparedness capacities to the most vulnerable communities including women, children, and people with disabilities. Under DIPECHO I and III, the Early Warning System (EWS) was based on "Watch and Warn" system, which is based on river monitoring locally and warning vulnerable communities. DIPECHO IV built information linkage between upstream river monitoring stations and downstream vulnerable communities. EWS based on upstream and downstream linkage provides sufficient lead time for communities to better prepare and respond to imminent deluge. In DIPECHO V and VI, Practical Action promoted accessing real time river level information from hydrological and meteorological stations. Technologies were also scaled up from manual to automatic river monitoring systems allowing access to information round the clock. Practical Action extended technical supports on establishing CBEWS in other geographical areas, national and regional, in collaboration with other partners. National EWS strategy has also been drafted by the Government of Nepal based on the learning through these projects.

Practical Action has prioritized CBEWS as a crucial mechanism to aware the people on disaster and its risk, their vulnerabilities and capabilities, and to establish a well-functioning warning service by putting people at the centre of the system to make the warning easier and reliable while disseminating and communicating the warning signal. Moreover, the focus has also been given to increasing the response capacity of the community.

Acknowledgement

This case study is an outcome of a piloting initiative implemented under a project entitled, "Strengthening Capacity of Communities for Disaster Risk Reduction through Early Warning in Nepal (SCORE-Nepal)" co-funded by DG ECHO.

We appreciate the support provided by Department of Soil Conversation and Watershed Management (DSCWM) for carrying out technical study for identifying suitable approach for establishing landslide early warning system. We would also like to thank the SCORE project implementation team for their successful attempt to establish community-led rainfall monitoring system for landslide probability. The manuscript of this publication is collaborative efforts of Anup Phaiju, Yuwan Malakar, Alisha Ghimire, Keshab Kumar Pokhrel, Anil Nepal and Ramesh Shrestha. Both the organisation would like to express sincere gratitude for all their efforts in understanding landslide context and introducing comparatively new initiative.

Practical Action and Mercy Corps acknowledges the eminent support of the European Commission Humanitarian Aid and Civil Protection department for providing us opportunity to pilot landslide monitoring for establishing community based early warning system. Both the organisations are grateful to communities of Tanahun and Kailali Districts for collaborating efforts to scrutinize landslide early warning possibilities. Without their enthusiasm, motivation and willingness to consider new approaches, very little would have been achieved. The assiduous role of NRCS Tanahun and Kailali, local partners for implementing project interventions, in executing this particular initiative is admirable.

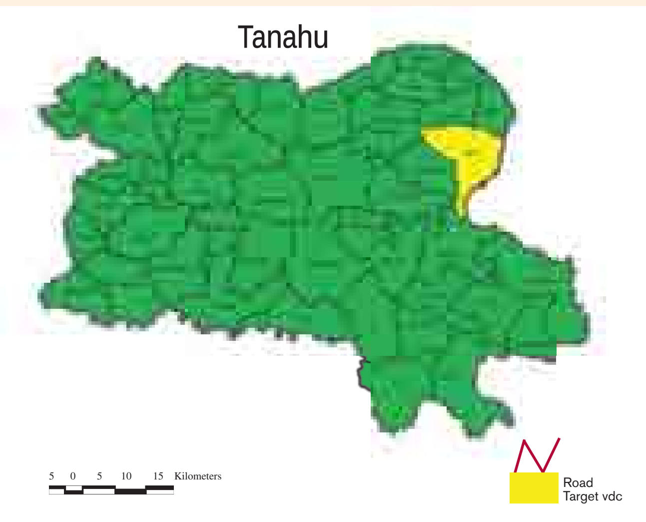
Contents

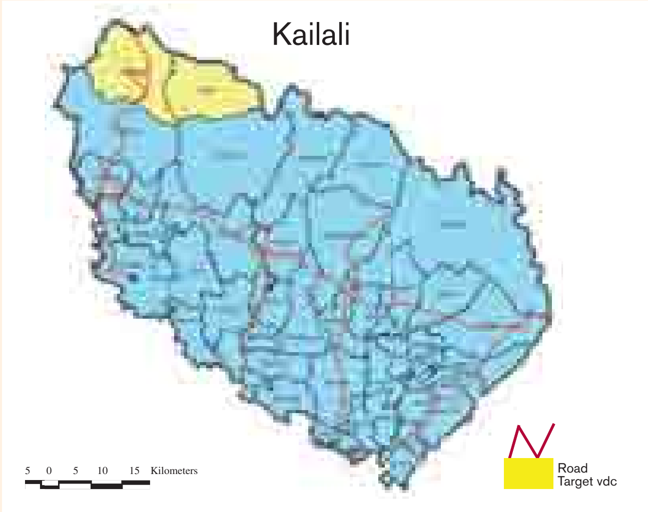
Introduction

Nepal possesses rugged and fragile topography with high relief, variable climatic conditions, and complex geological features. It has vast climatic and ecological diversity within short north-south span. Nearly 83 per cent of the total area is occupied with mountains and hilly regions. Nepal is prone to number of hazards because of the kind of topography it has. Landslide is one of the major hazards, which claims loss of human life and properties.

According to official statistics by Ministry of Home Affairs (MOHA), more than 100 people die annually due to landslides in Nepal. The loss due to landslides and related problems in the Himalayan region alone constitutes about 30% of the world's total landslide-related damage value. Along the Himalayan chain of 2400 km, landslides (includes shallow, deep seated and debris flows) occur extensively and in particular within Nepal. Due to the continuous deterioration in environmental conditions, and loss to the life and properties, landslides hazards are becoming serious issues in Mid hill region of Nepal. Landslides are one of the major hazards causing environmental deterioration and loss of life and properties. Efforts for landslide preventing and controlling measures are less effective because of complex properties associated with landslide occurrence.

Landslide is a geomorphological phenomenon. Nonetheless, it jeopardizes social and economic settlings of human livelihood. Experts argue that





disasters are major barriers for poverty alleviation and sustainable development because it severely undermines the results of development. Though mitigating landslide risk in the context of Nepal is an uphill task but its impacts on human lives can be minimized with small effort.

Early warning system (EWS) is crucial component in reducing disaster risks. The system helps early detection of emerging danger and enables response action in advance that helps downplaying human deaths, injuries, and loss of property. In the context of Nepal, landslide early warning system is essential that provides comprehensive approach to reduce disaster risks.

Practical Action and Mercy Corps jointly piloted community based landslide early warning system in Bhanu VDC of Tanahun District and Sahajpur and Nigali VDCs of Kailali District. These VDCs are landslide prone and have encountered with several landslide events in the past. There were cases of displacement, human injuries, and loss of cultivable lands.

Relationship of Rainfall with Landslide

The mean rainfall in Nepal ranges from 1500-2500 mm whereas approximately 80 per cent of rain occurs during monsoon (June-September). Most of the landslides occur during the monsoon. Heavy and concentrated rainfall during monsoon period causes landslides in Nepal. The small-scale rainfall-triggered landslides in Nepal are generally shallow (about 0.5 to 2.5 m thick) and are triggered by changes in physical properties of slope materials during rainfall. In the project locations, most of the landslides are shallow in type. For the Nepalese terrain, the factors like fluctuation of rainfall pattern in a very short distance has an influencing role in causing landslides.

Empirical thresholds have been used to establish the relation between rainfall and landslides in various parts of the world. The most commonly investigated rainfall parameters in relation with landslide initiation include cumulative rainfall, antecedent rainfall, rainfall intensity, and rainfall duration. Since the majority of slope failures are triggered by extreme rainfall, attempts have been made to define rainfall thresholds employing various combinations of these parameters.

Nonetheless, rainfall is not only the triggering factor but multiple combinations of factors can lead the landslide to happen.

A study conducted by Department of Soil Conservation and Watershed Management, Government of Nepal in Kailali and Tanahu districts suggests that the rainfall threshold might be one of the significant tools to alert the local people against possible landslide in the context of Nepal.

"In 30 August 2008, we had several landslides in this area. 5 families took temporary shelter in the nearby school for 5 days. Landslides swept away 5.7 hectare of land in more than 20 sites, made cracks in houses, and killed livestock. I immediately ran outside to inspect our house and went inside with my family."

- Lok Bahadur Bhujel, Bhanu-3, Ramgha

Landslide Risk and Vulnerabilities

Nigali and Sahajpur VDCs of Kailali district are situated in Siwalik region. This region is made up of geologically very young unconsolidated and easily disintegrable sedimentary rocks. Thick beds of conglomerates, mudstones, and sandstones make this region vulnerable to landslides. In Sahajpur, most of the part of VDC is formed of boulders and sediment deposits brought by the Himalayan Rivers. Rocks in the VDCs are fragile and easily erodible. Participatory landslide vulnerability ranking shows that there are 13 and 12 major landslides distributed around Sahajpur and Nigali VDCs respectively. These landslides have affected 245 and 256 households respectively in Sahajpur and Nigali VDCs.

The major recent landslides occurred at different places of Kailali from September 19th to 21st 2008.

Tanahun district is situated in lesser Himalayan region. Most part of the Bhanu VDC is occupied by hills with jungles and cultivated land. There are several river valleys in between these hills. The geology of VDC consists of weak rocks that can be broken down with bare hands. Percolation capacity of soil is very high. Rainfall infiltrates easily and soil saturates in a short duration of rainfall. The landslides occurred in the year 2008 were the most recent one on people's memory. The recent landslides from people's memory is in the year 2008 when most of the slides occurred in forested land and agriculture slopes. No human death was recorded nevertheless more than 5.7 hectares of land was damaged. There are 174 households who are vulnerable to landslides.

Defining Rainfall Thresholds

Landslides can occur in several circumstances and has numerous factors involved. Some of them are slope, gradient, profile, vegetation, soil type, and bed rock orientation. The slope gradient combined with curvatures can influence directly to the mobility of slope material, runoff and movement of water. The landslides mainly occur in the wet monsoon seasons i.e. in June-July, so it can be assumed that rainfall amount has played important role for sliding of a slope.

Rainfall is one of the triggering factors, which is very dynamic in nature compared to other factors. Rainfall and landslides build up a simple correlation that states 'landslide can trigger when there is either high intensity rainfall in short duration or low intensity rain in long duration'. This correlation was applied to define rainfall based threshold for detecting landslide probability. An assessment in Tanahun showed that there were low intensity rainfall since five days (from August 25 to 29 2008) and on sixth day (August 30, 2008) the rainfall recorded 229 mm in few hours that caused the landslides.

"Rainfall is major factor in triggering landslide. There was low intensity rainfall since five days before landslide occurred. Suddenly huge rain occurred for 3 hours (from 6 am to 9 am) on 30 August 2012. Then, the landslides occurred in between 8:30 am to 9:00 am."

- Kamala Ranabhat, Bhanu-4, Dandagaun

The study suggests that shallow landslides (0.5 to 2.5 m thick) trigger when physical properties of slope materials changes during short duration high intensity rainfall. Relatively large-scale and deep-sheeted landslides, on the other hand, are affected by long term variation in rainfall. The rainfall based thresholds are empirical and cannot exactly predict landslides. However, the thresholds can be used to generate 'conditional probability' of landslides.

Correlation of rainfall and landslide events will help in identifying empirical rainfall based thresholds. Historical landslide events can be identified from historical timeline exercise. Rainfall data can be collected from the nearest rainfall station. In case of unavailability of rainfall station close to the landslide affected community, rainfall data can be reckoned by analysing data of stations from surrounding area.

Similarly, the key informants from Kailali informed that there was continuous rainfall from 19th to 21st September 2008 in Kailali and during this period, there were number of landslides at Nigali and other places of Kailali.

"We were not aware of how much rain occurred on that day but we knew that rain played crucial role. After we visited rainfall station and reviewed rainfall data of the day, we found that what we assumed was right. 229 mm of rainfall over 24 hour on 30 August 2012 and 141 mm of accumulated rainfall since 5 days were recorded in nearby rainfall station. There was accumulated rainfall of 141 mm since 5 days. The high intensity rainfall occurred in the morning triggered landslides."

- Amar Bahadur Ranabhat
Bhanu-4, Dandagaun

Table 1: Rainfall recorded at Synoptic station at Attariya, Kailali during 17th-24th September, 2008:

Date	Rainfall in mm
17/09/2008	0
18/09/2008	0
19/09/2008	11.8
20/09/2008	229
21/09/2008	180.2
22/09/2008	0.4
23/09/2008	0
24/09/2008	0

The rainfall data recorded at the synoptic station also shows that there was significant rainfall in and around Attariya during September 19th to 21st 2008.

Community-led Rainfall Monitoring

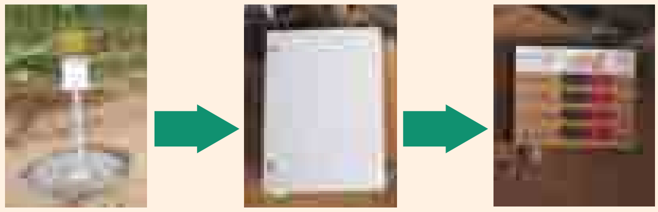
Both short duration-high intensity and long duration-low intensity rainfall need to be monitored for identifying landslide probability. For this purpose, two types of rainfall monitoring devices were installed. They are: a) automatic; and b) manual.

Manual system consists of standard 8 inch (200 mm diameter) rain gauge. This system is used for recording 24-hour rainfall. Rainfall data is recorded every day at 3:00 GMT (08:45 am Nepal time).

Automatic system consists of three components. They are tipping bucket, data logger, and display unit. Tipping bucket measures rainfall and sends data to data logger in an interval of 1 minute (that can be modified according to the requirement).

"I've never heard that this kind of technology existed to measure rainfall. Now, I am well oriented to keep record. I know the rainfall thresholds and how to inform communities. I have to inform communities when the display screen shows 30 mm and/or 50 mm of rainfall in 1 hour, 160 mm of rainfall in past 12 hours, and 200 mm of rainfall in past 24 hours. I am given with telephone numbers of communication focal persons and a hand-operated siren to disseminate the rainfall information."

- Gauge Reader, Bhanu-3, Ramgha



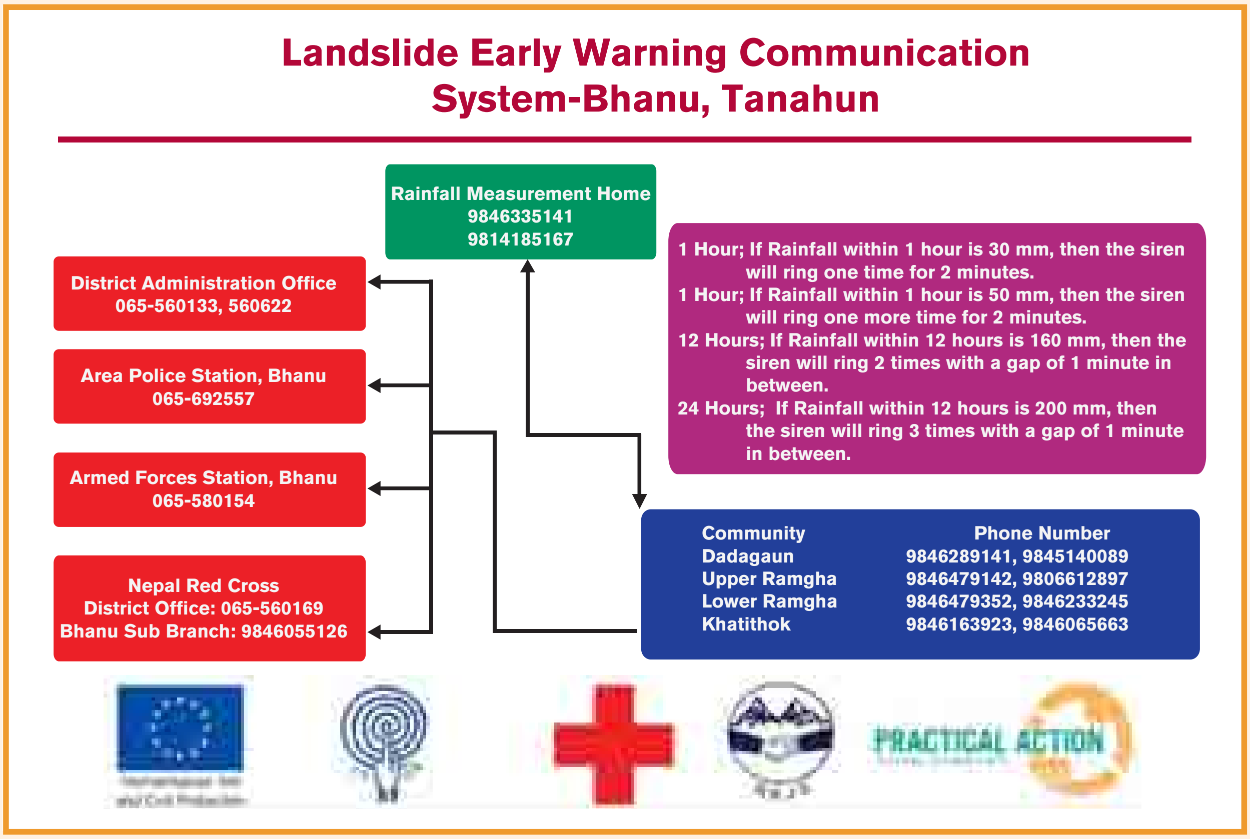
Then data logger displays it in display unit. The display unit shows rainfall of three periods: rainfall occurred in one hour; accumulated rainfall over 12 hours; accumulated rainfall over 24 hours; and accumulated rainfall over 36 hours. The objective behind defining these periods is to monitor both short and long duration rainfall.

These systems generate information on rainfall. Manual system provides daily rainfall data, which can be used to validate the data generated by automatic system as well. A family is nominated by the communities where both the systems are installed. The person – gauge reader – is given responsibility to record the data from manual system as well. In Bhanu, these systems are established at one location. Similar system is installed at one location in Nigali as well. There are mechanisms developed to disseminate the rainfall information to communities.

"I had only seen manual rain gauges and did not know the importance of measuring rainfall. When Mercy Corps and NRCS shared the idea of installing tipping bucket in Nigali, we were less interested because we were targeting additional mitigation measures like gabion boxes, side drains, coconut nets etc. for our community. But when I attended different trainings and meetings, I realized the importance and necessity of regular rainfall monitoring during monsoon. I now inform my community by using the siren (of hand mike) and hand mike when the rainfall is 30 mm and more per hour. Similarly, I get telephone calls from different people about the real time rainfall amount during rainfall and the people plan their works accordingly. "

Hikmat Singh Bhat, Chairperson of Shivshankar CDMC and gauge reader, Bhaktapur, Nigali-1

Communication Mechanism



There are – at least two – communication focal persons nominated from each community. The gauge reader will inform communication focal persons when the rainfall reaches or crosses identified threshold. Two focal persons were nominated because the gauge reader will inform second focal person if first focal person's phone in out of the network. The communication focal persons are equipped with communication equipment like hand-operated sirens and mega phones. There are specific tune agreed to inform rainfall thresholds to communities. For instance, the siren tune established to inform rainfall thresholds in Tanahun is shown in the table 2 below. According to the table, if the siren rings 2 times with 1 minute gap, community shall understand that the rainfall is 160 mm over 12 hours.

The system only generates information to rainfall. Communities are well oriented on what to do when siren rings. As ringing of siren is not a prediction of landslide occurrence, people are suggested to evacuate by adequately analysing their local surrounding. Families will not have to evacuate if they feel their houses are in comparatively stable slope. Communities have identified landslide prone houses during social and vulnerability mapping. Those who are identified as most vulnerable houses are suggested to evacuate when siren rings irrespective of time periods.

There are communication channels also prepared and placed in strategic locations. These channels contain emergency telephone number of community focal persons and concerned agencies like security forces, District Administration Office, District Development Committees, and Nepal Red Cross Society. (See communication channel of Tanahun).

Table 2: Siren communication mechanism

Hour	Rainfall	Siren tune
1 hour	30 mm/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

Response Mechanism

The communities in Tanahun and Kailali have constructed evacuation routes that lead to shelter/safe place during emergencies. Similarly, there are early warning , first aid and search and rescue task forces formed which are supported with necessary trainings, equipment and materials to perform their roles effectively.

Search and rescue task forces formed in the vulnerable communities are trained to operate light search and rescue. There are designated first aiders within the search and rescue task forces, who also received training on first aid. These task forces have been supported with necessary materials and equipment to perform light search and rescue.

"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

Mitigation Measures

Along with the formation of Community disaster management committees and different task forces, different mitigation measures have been adapted in the project implemented areas.

Gabion boxes, side drains, plantation of about 2700 plants of different species most of which having additional economic value too like Broom grass, Bamboo and Gooseberry, Bamboo fencing and coconut netting in the unstable slopes are some of the measures implemented to reduce the incidences of landslides in weak slopes of the communities.

"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

Challenges

This is completely new initiative and has not been verified through real time experiences. The system is an output of scientific and community knowledge collaboration between and interface of scientific and community knowledge. This system is established in 2012 monsoon. The rainfall did not exceed identified rainfall thresholds. Since, this system is based on rainfall thresholds it does not cover landslides triggered by earthquake. The factors like vegetation and gradient are vital for landslide to occur. These factors may change over time due to shift in livelihood options of the inhabitants. In such case the rainfall-based thresholds might differ. Therefore, the system needs careful examination and verification time and again.

Conclusion

This system provides a substantial base to identify landslide probability based on rainfall and landslide relation. Nepal, where 80 per cent of rainfall occurs in four months, receives most of landslides event in monsoon. Rainfall is a crucial landslide triggering factor in case of Nepal. It is very important to build thresholds based on rainfall for landslides.

In conclusion, this is an innovative initiative in the field of landslide early warning system. However, further study and testing is required to exactly predict landslide in real time and ultimately enhance its applicability. The involvement of community is a prerequisite. It ensures their ownership and improves their understanding over the system.

For more Information

Mercy Corps Nepal
P.O.Box 24374
Sanepa Chowk, Lalitpur, Nepal
Tel: +977 1 555 5532
Fax: + 977 1 555 4370
Website: www.mercycorps.org

Practical Action Nepal Office
PO Box 15135,
Narayan Gopal Sadak, Maharajgunj
House no. 2677
Kathmandu, Nepal
Tel: +977 1 4720 803, 4720 804 and 4720 761
Fax: +977 1 4720 402
Website: www.practicalaction.org