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Safer Cities 26

Case studies on mitigating disasters in Asia and the Pacific

Using Risk Assessments to Reduce Landslide Risk

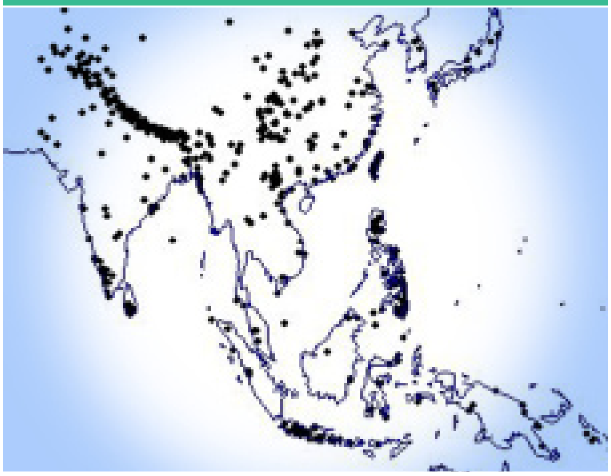
Despite the increasing level of understanding of landslides and the recent technical progress towards mitigation and landslide forecasting, human activities are still affected by landslide disasters. Landslide triggers increase with high seismic activity and excessive rainfall, both of which weaken the slope stability. The rapid growth of population leading to increased urbanization, deforestation, and unplanned land-use development contribute to enhancing the vulnerability of areas already prone to landslides. Demonstration projects in Baguio City, Philippines, Patong City, Phuket, Thailand, and Kaluthara District, Sri Lanka present how risk assessment and subsequent mitigation and preparedness activities contributed to reducing landslide risk according to local needs and resources.

Tackling the issue of landslide risk

A landslide is a movement of a mass of rock, debris or earth down a slope. It can cause extensive damage to infrastructure such as roads, bridges, human dwellings, agricultural lands, and forests, resulting in economic loss. The unplanned and rapid urbanization process in main cities in Asia contributes to increase landslide risk as the built area expands from the congested plains to the open slopes. When compared to other parts of the world, this region has a high number of hotspots and is the most affected by landslides in terms of landslide frequency, mortality, damage and losses.

In the Philippines, for example, landslide occurrences claimed hundreds of lives and caused significant property damage in an urban residential area called Cherry Hills in Antipolo City (1999). Landslides are also occurring in rural areas such as Panaon Island-Surigao (2003), Aurora-Quezon (2004), and Saint-Bernard in Leyte (2006).

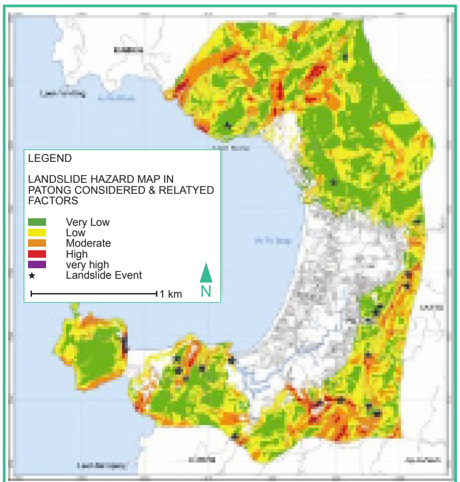
Map of landslide events in Asia. **Figure 1**



Each black dot indicates one single fatal landslide event in Asia for the period 2006-2008. Image credit: UN, 2009

Global distribution of landslides per trigger mechanism (SAARC, 2007) **Table 1**

Sl No	Activity	No. of landslides	No. of fatalities	% of fatalities
1	Intense rainfall	319	2,690	89.2
2	Construction activites	25	101	3..3
3	Mining and quarrying	17	53	1.8
4	Riverbank processes	5	23	0.8
5	Earthquake	5	20	0.7
6	Snowfall	2	9	0.3
7	Volcanic Eruption	1	8	3.7
8	Unknown	20	113	3.7
9	Total	394	3,017	100



Landslide hazard zonation map of Patong.
Image credit: RECLAIM

Abstract
This case study discusses risk assessment and the subsequent methodologies and approaches for landslide risk reduction. The Baguio City landslide risk mitigation project in the Philippines focused on strengthening community capacity and enhancing local commitment. The project for Kaluthara District in Sri Lanka developed a landslide early warning system through a school-based network of rainfall monitoring stations. Finally, the project for Patong City in Phuket, Thailand relied more on instrumentation and technical risk assessment as the basis for structural mitigation measures.

What's inside

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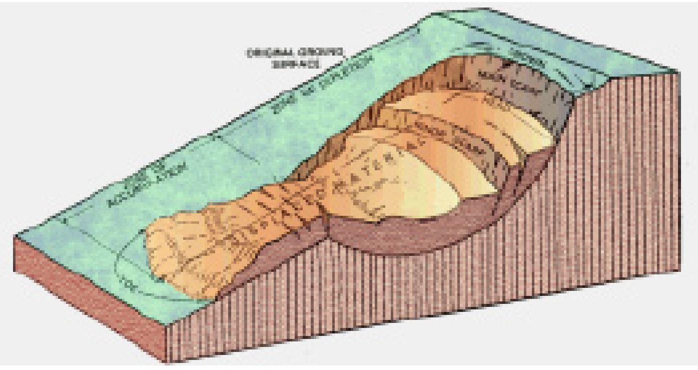
Mechanics of Landslides

The term ‘landslide” includes a wide range of ground movement such as rock falls, deep failure of slopes, shallow debris flows, and avalanches in mountains. Landslide can occur on land, at the coast, and offshore (submarine landslides). While gravity triggers ground movement, other factors – geological, mechanical, morphological and human – tend to affect slope stability:

- Geological factors focus on the slope’s composition, structure, physical properties, and the processes by which slopes are formed, moved and changed.
- Morphological factors concentrate on the erosion process. Erosion of the toe of a slope by rivers or ocean waves can contribute to reduce the stability of the slope due to its related removal of solids such as sediments, soil, rock and other particles. The loss or removal of vertical vegetative structure reduces the capacity for water absorption, and in turn increases water runoff.
- Landslides can have mechanical causes, such as groundwater changes, vibrations created by earthquakes, intense rainfall, and surface runoff; each contributes to destabilize the slope due to the modification of the initial equilibrium of the slope formation, as well as change the original composition of the earth materials.
- Finally, human factors also play a great role in increasing landslide risk mainly through land use change, water management, mining, loading, and deforestation. The main contributory factor is the excavation of slopes without providing retaining structures, leaving a deep cut.

The first step towards landslide risk management is landslide hazard mapping. Several factors need to be considered to assess the geological structure: slope stability, bedding and slope angle, lineament zone, and rock type. Other factors to be considered in hazard assessment are: land forms, slope, land use and land-cover, and surface drainage. (For details, see the list of references and suggested reading at the end.) Once these factors are evaluated, models can be created to identify the specific location and degree of landslide hazard in the area, and verified using records of past landslides. Hazard maps can be generated using each factor, and by integrating factors.

Basic characteristics of landslides **Figure 2**



Monitoring Landslide Risk at the Municipal level

In general, city officials tend to neglect landslide risk for several reasons. First, they might not be aware of the increasing danger of landslides in urban areas. Second, they might have other priorities. Third, they may lack financial and technical resources to develop mitigation programs within their cities. Finally, local governments may not have the capacity to respond and address landslide risk. Some criteria to assess a city’s capacity for landslide risk management are:

- City officials’ awareness of landslide risk, the landslide mechanism, and vulnerability factors
- Willingness to tackle landslide risk by enacting local legislation
- Institutionalization of an office within local government to concentrate on natural risks within the city and its surroundings
- Existence of or on-going process of landslide hazard/vulnerability/risk mapping
- Availability of a landslide monitoring system
- Incorporating landslide risk and efficient mitigation measures into the school curriculum
- Information and awareness-raising activities

A city can make decisions and policies to institutionalize the reduction of landslide impacts through such measures as an early warning system, slope monitoring, and information and educational campaigns. These case studies aim therefore at providing ideas and information resources for local authorities and communities who wish to manage and mitigate the landslide risk. In Baguio City, Philippines, the project gave special attention to community-based landslide mitigation. Resident capacity building and empowerment are sustainable means to ensure the tenure, continuation and further dissemination of the project. The involvement of schools in developing the landslide early warning system for Kaluthara has enabled technical agencies to advise, monitor and rapidly forecast landslide risks in more highly-prone areas than before. Assessing landslide risk became an important target in Patong City after the tsunami that had indirectly placed more demand on land. The project helped support actions to stabilize the slopes and manage the flow of water so as to lower the risk of landslides.

Participatory Landslide Risk Assessment in Baguio City, Benguet, Philippines

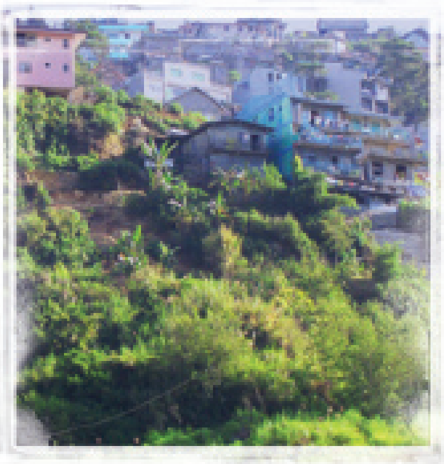
Geographical Parameters and Social Dynamics in Baguio City

Baguio City is a major city outside of Metropolitan Manila. The city, located 1,500 meters above sea-level in mountainous region of Northern Philippines, is part of the Cordillera Administrative Region in the island of Luzon. Baguio also relies on commercial inputs from surrounding provinces products such as agricultural and mining products.

The city is built on uneven terrain and the expansion of the urban area contributes to reduce the capacity of soil absorption during rainfall; the asphalt tends to accelerate the water run-off. The subsurface of the site is mostly constituted of stiff clayey silts and light clays underlain by limestone; the geomorphology of the area tends thus to be brittle and friable (crumbles easily). Moreover, up to 75% of the relief is constituted of loose soil slopes. All these parameters interact to make the slope terrain prone to natural landslide hazards. The climate is relatively cool at an average temperature of 17 degrees, ten degrees below the national average temperature; encouraging the expansion of pine trees population. This attracts both migrants and tourists, and thus the city is facing a very high urban growth. According to the 2007 Census, Baguio City has a population of 301,926 and a population growth rate of 2.5% in 2007. The rapid urbanization process at the rate of 4.39%

creates pressure on land, pushing the inhabitants to settle within hazard-prone areas (Akers and Akers, 2005). Tourism is a major economic input for the city, but it is contributing to landslide risk because it adds to the demand for land, and thus to deforestation. The expansion of the urban built area reduces the capacity of the slope for water absorption during rainfall, while the asphalt tends to accelerate water run-off.

The climate of Baguio City consists of two very distinct seasons, the rainy season from November to April and the dry season from May to October. Average annual precipitation is almost 4,000 millimeters, the highest amount of rainfall in the country (Saldivar-Sali, 2004). The city averages five typhoons annually and holds the world record for most precipitation received in a 24-hour period (46 inches on July 14-15 1911).



Buildings at risk in Baguio City.
Image credit: RECLAIM

The land movement that already occurs on a yearly basis tends to increase after high precipitation. Two processes are contributing to increase landslide risk over life and property. First, the excavation related to residential construction magnifies the water absorption and thus the slope instability. Second, only 20% of the previous total forest surface is remaining. The deforestation consistent with further construction tends to increase the water runoff; the probability of rock slides tends thus to increase. These dynamics tend to change local environmental patterns and enhance the risk of landslide hazards.

Towards Landslide Risk Mitigation

The Landslide Mitigation Demonstration Project puts together with the Baguio City officials, the Asian Disaster Preparedness Center (ADPC), University of the Philippines, and the Norwegian Geotechnical Institute (NGI). The stakeholders implemented in specific domains compile their knowledge and skills to foster a comprehensive landslide risk mitigation process.

The Landslide Mitigation Demonstration Project, under the Regional Capacity Enhancement for Landslide Impact Mitigation in Baguio, Philippines limited the study area to five out of 129 barangays[1] in Baguio City to increase the feasibility of assessing and monitoring landslide risk, and include more stakeholders and beneficiaries into the project. The five selected barangays are all adjacent to each other and Barangay San Luis is at the center. The pilot site is located at the boundary of Barangay San Luis and the Baguio Pines Garden Subdivision, and encompasses no more than 8,000 meters square.

Combining Technical and Local Knowledge to Assess Landslide Risk

Baguio City is located in an area with relatively extreme topographic relief, underlain by variable bedrock geology, and without significant differences in rainfall from one zone to another. The region is dissected by young and vigorous eroding river systems that have produced large elevation differences. At high slope angles, the velocity of runoff is increased, as is the rate of erosion. Furthermore, Baguio region has undergone intense tectonic activity since recent geologic times. The 1990 Luzon earthquake produced many slope failures, each of them representing a potential risk for landslide to occur (Saldivar-Sali, 2004).[2]

The rock on both sides of the fault plane may have become shattered during the tectonic rupturing process; the increased percolation of rainwater into the cracks is thus exacerbating the water pressure behind the slopes, further weakening the ground. The materials, involved in landslides, experience occasional soil creep when saturated by heavy rainfall. The materials flow to the creek below the slope and initiate progressive slope failures.

Observable evidence of land movements and historical landslide events has been collected among the residents through local consultation meetings. A technical survey was conducted, and concluded that the land movement patterns are related to the poor drainage system.

Strengthening the Barangay's Capacities: Enhancing Community Awareness of Landslide Disasters

The main objective of the capacity building process is to create ownership over solutions that the communities can implement by themselves. To promote cooperation between the local government and the barangay residents, round table talks were organized, putting together officials of the municipal government, management of the subdivision, and residents of the barangays. Several activities have been developed to increase awareness of the communities concerning three specific components, namely hazard, risk and prevention. A five-step methodology on landslide risk mapping was established and should be followed by a participatory risk mapping exercise. The steps are:

1. Identify community boundaries
2. Define and establish landmarks and roads
3. Delineate high-risk areas and report to authorities for action
4. Determine low-risk areas
5. Identify safe areas for evacuation

Community participation was required to ensure the implementation of landslide mitigation process, as the construction of structural mitigation measures on their land needs their cooperation. Incorporating indigenous alternative measures is crucial for monitoring and mitigating landslides. It will promote sustainability and increase the possibility of replication by other communities because the recipients can claim ownership over their own disaster risk reduction.

The community risk mapping process.
Image credit: RECLAIM

The landslide risk mapping was done mostly by the communities for them to own and manage the risk mitigation steps from the beginning. Meanwhile, the last three steps were verified by experts in landslide studies, to ensure the comprehensiveness and readiness of the landslide risk mapping.

Consultation with the residents of San Luis Barangay.
Image credit: RECLAIM

Mitigating and dealing with landslide disaster risks substantially rely on the improvement of the policy framework conditions for landslide recognition and adaptation measures at national, provincial and local level to provide the necessary inputs for adequate management and planning.

Institutional improvements have been undertaken in the Philippines aftermath of the devastating landslide event in St. Bernard Municipality. The Sangguniang Panlungsod (City Council) made resolutions, approved by the City Mayor to settle some of the issues of the evacuees. The City Disaster Coordinating Council (CDCC) structure was activated by Presidential Decree 1655 to raise the capacity at the city level. The project aimed at convening a wide range of stakeholders, each of them playing a part in disaster risk reduction at the local level.

Establishing a School-based Landslide Early Warning System in Kaluthara District, Sri Lanka

From May 11-19 of 2003, a tropical storm caused 247 deaths, the displacement of 200,000 persons and heavy damage to the infrastructure, economy and livelihood in southwest Sri Lanka. The main cause of the deaths in the central and southern parts of the country were landslides triggered by heavy rainfall. The level of rainfall has been directly correlated in studies to the possibility of a landslide event in the region. However, since the colonial period, the rainfall monitoring system in Sri Lanka is used mainly for agricultural purposes, and the locations of rain gauge stations do not correspond to the areas with landslide risks.

The predominant factor influencing the climate of the country is the occurrence of monsoon winds that bring rain-laden clouds from the Indian Ocean during the first monsoon (May to October), and from the Bay of Bengal during the second monsoon (December to March). The Kaluthara District is part of the wet zone that receives rain from both monsoon periods. The average rainfall amount ranges from 3,302mm to 5,080mm, and flood is a recurring problem in the zone. The district's topography is flat near the coastal areas and rises gradually inwards, often interrupted by high outcrops, to the foothills of the central mountains. The combination of uneven relief with heavy annual rainfall implies a high probability of landslide. In addition, this is the District is found in the most densely populated province of Sri Lanka. A project in Kaluthara District was subsequently undertaken by the National Building Research Organization (NBRO) for installing rain gauge stations as part of a landslide early warning system, wherein the warnings would be based upon rainfall data.

School workshop.
Image credit: RECLAIM

Schools as the Focal Point for Landslide Risk Mitigation

An original method to maximize the available resources for landslide mitigation was adopted by Kaluthara District, focusing on schools as center and catalyst of change for landslide risk reduction. Ten schools were identified according to various criteria, such as the level of hazard according to the already available landslide hazard zonation map, the availability of facilities like computers and technical knowledge within the school, the number of students, and the category of school.

A disaster management cell was established in each school to structure the rainfall data collection, and enable an efficient transfer of knowledge on landslide risk management. To strengthen the disaster management cell, workshops were organized to raise awareness and train the cell members on how to use a landslide probability chart. The chart was used to establish the linkage between the amount of rain and the probability for a landslide to occur in a certain area. The chart was divided five categories according to the level of landslide risk a rainfall event can trigger, based upon previous local observations. Rain gauges were distributed to the schools, and the Meteorological Department has helped in the installation and training of students and teachers on rain data collection.

Rain gauge used by the schools from Vidya Shilpa company.
Image credit: RECLAIM

The landslide risk management project was meant to be a win-win project. First, through the landslide Early Warning System implementation, NBRO can continue to monitor and forecast possible landslide occurrence. Second, engaging schools in the process of landslide risk management enables a good transfer of knowledge and ensures, in turn, the durability of the project. This demonstration project can also be a guide on how establishing permanent rain gauge stations through non-technical organizations such as schools expands the project to other areas, and extends disaster risk mitigation to other kinds of disaster risk.

Geologic map of Patong City **Figure 6**

Image credit: Sombat Yumuang (GISTHAI)

Landslide Risk in Patong City, Thailand

Patong City is situated on the west coast of Phuket island, an island that is formed by granite and mudstone rocks that have a high potential of sliding. The city is in an embayment surrounded by a high-altitude mountainous range. The city has a limited plain area for development but at the mean time, it faces pressure for further developmend beyond the urban area. Furthermore, most of Patong City is prone to inundation due to rainfall, even for moderate rainfall situations. The flat aspect of the streets, the limited capacity of the river channel and the limited capacity of the local drainage to cope with the amount of water when the main channel is filled reduce the capacity for water absorption within the city.

For the last decades, Patong has known an exponential urbanization process that disturbed the natural patterns of the area. The progressive disappearance of wetlands in the interior lowland, which was serving as natural regulation of the river flow, is due to urban expansion and its correlated man-made modifications on the local natural drainage patterns. Channels have been widened and deepened, diverted from its natural banks; and a number of bridge and culverts control the flow. The loading capacity of the main channel has been reduced over years, thus leading to the occurrence of repeated flooding events. The increased water run-off coupled with the topography of Patong City and the urbanization process contributes to weaken the slope stability and thus enhances the Landslide Risk in the area. Furthermore, after the 2004 Indian Ocean tsunami incident, land developers build upon the upper level of the mountain slopes in an attempt to reduce tsunami risk. Unfortunately, the changing of landforms and destruction of the land cover is disturbing the slope stability and so landslide disaster risk is now greater.

Studies under the RECLAIM Thailand project was carried out as team work between the municipality, the Department of Mineral Resources (DMR), the Geotechnical Engineering Research and Development Center of Kasetsart University (GERD), and the Asian Disaster Preparedness Center (ADPC), with Norwegian Geotechnical Institute (NGI) as the lead partner. A comprehensive mapping process has been carried out throughout the project to comprehend and assess the overall components of landslide risk in Patong City.

Understanding Landslide Risk through Mapping

Several technical parameters have been identified to evaluate and comprehend Landslide Risk in Patong area. A series of mapping activities were undertaken to map out the topography, hydrology, and land-use patterns in the area.

The stability of the slope in Patong City was assessed on various degrees of slopes, both natural and cut. The risk of landslide is higher in the case of a cut slope than for a natural slope due to the removal of the supporting mass at the lower leg of the slope. Within Patong City, the landslide risk mapping has been focusing on two target areas, namely Kalim and Na Nai village.

Kalim with a population of 889 inhabitants is situated on the lower and toe slope on the northern hillside, with very active land development. Landslide events have increased, leading to recent and more frequent flooding and debris flow. Na Nai village with a population of 2,656 people has the shape of a long strip. The city has to cope with high tourist arrivals that lead to rapid and mostly unplanned land development and related transit under the tourism economic sector, and that increased the erosion process of its slopes.

In urban areas, the run-off is more substantial because asphalt and buildings are more impermeable than soil. During long prevailing rainfall, the retention of the soil decreases due to its saturation. The location and structure of the sub-basins in the area influence the timing and the path of rainwater to discharge into the sea. Erosion and formation of water pockets are usually the main consequences linked to the transport of rainwater to the sea.

The flood mapping identified areas likely to be flooded. To better understand how water circulates in the area, hydrologic models were developed based upon 10-, 50- and 100-year return periods, extreme precipitation patterns and run-off patterns on 12 predefined sub-basins in the area. The hydrologic modeling, the river hydraulic modeling and the flood mapping enable the building of scenarios and to forecast potential impacts. The different areas at risk and the impacts a flood event can trigger in the different zones according to its intensity and its return period can then be known. The models are continuously updated and reviewed according to further experience through work with the model and field observations.

Landslide risk mapping combined the analysis of the results of the landslide hazard mapping and the vulnerability factors in Patong. Demographic data and building use and ownership information were extracted from the Patong taxation map. Landslide risk mapping of Patong highlighted the number of people exposed to possible landslide events, as well as the potential loss of properties in case of a specific natural hazard occur.

Mitigating and Monitoring Landslide Risk in Patong City, Phuket, Thailand

It is feasible to observe and predict landslide hazard. Land management has made over the past decades great improvements concerning cost-effective techniques to prevent landslides.

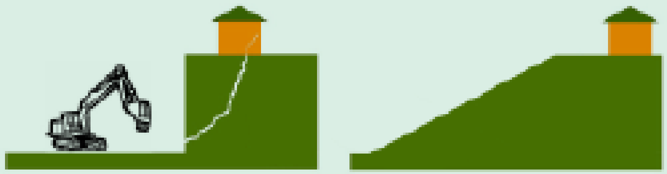
Through the overall mapping activities, the areas within the city, with specific flooding exposure and landslide risk, are identified and assessed. Understanding the scope of the potential impacts over years within a city is crucial to mitigate the landslide risk. Scenarios are then built and appropriate measures can be advocated towards decision-makers and community for them to undertake the right steps to prevent disastrous impacts on the population and the urban infrastructures. The recommendations were made according to the conclusions that the risk mapping provided. These were delivered to the decision-makers at the city-level and at the relevant disaster risk mitigation agencies.

Several steps were proposed to impede further slope failure and reduce landslide risk:

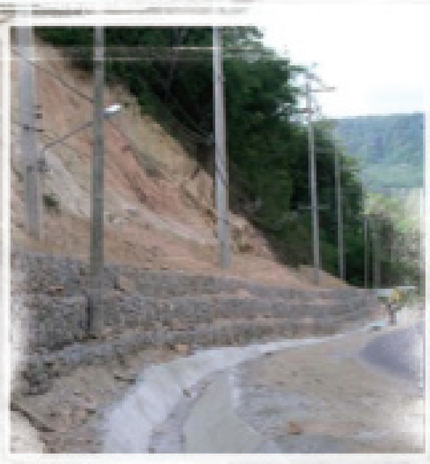
- Housing should be constructed outside of a failure zone, and away from a cut slope, according to the land authority. Furthermore, the soil excavation and filling should be endorsed by civil engineer.
- The denser the land cover in the slopes, the more the surface is protected from erosion and water infiltration. Plastic sheeting can also be used but it can only temporarily prevent surface infiltration. A clay cover can be used as permanent protection.
- Vegetation and gabion, cages of rocks, can reduce erosion by water, and should improve slope drainage, thus strengthening slope stability. In addition, synthetic fabrics such as geo-textile can be used to reinforce the soil.
- Comprehensive surface drainage in the slope prevents erosion and surface failure to be deepened by use water ditch.
- Engineering structures, including Mechanically Stabilized Earth (MSE) walls, can be used to reduce earth movement in certain areas. Retaining walls, soil nails for soil slope protection, and rock bolts/anchors for rock slope protection are some of the means for the slope to become more resistant to slipping.

Relocation of the community is usually complex; it is recommended to have the community assess and continuously observe terrain stability and, update the landslide risk mapping accordingly using the community observations. The main objective was to mitigate landslide risk in the project site, therefore land management activities were undertaken by the community to stabilize the soil.

Simple illustration of a safe vs. unsafe way to cut a slope **Figure 3**



a. Unsafe cut slope b. Safe cut slope



Gabions, cages filled with rocks, sand or soil, help to stabilize the slope from erosion.
Image credit: RECLAIM

Channel construction to improve the water circulation within the area and reduce the erosion process in Patong City.
Image credit: RECLAIM

Vetiver grass, specie of coarse perennial grass, has been planted to consolidate the slope. This sort of grass is ideal in mountainous zone as it can grow vertically and rapidly even on steep slope; can develop roots from three to five meters deep; can penetrate hard rocky soil. Furthermore, on top of their capacity to reduce the erosion process, their stiff stems diminish the rainfall run-off, thus reducing the risk of devastative downstream transfer, including the possibility of rock avalanches.

The correlation between rainwater and slope weakening prompted the technical experts to install rain gauge stations as a way to provide an Early Warning System. The data provided by the ten rain gauge stations combined with the Antecedence Precipitation Index (API) mapping enables to predict the probability of landslide location and occurrence. The current system has been reinforced by the installation of two wireless rain gauges for landslide warning in August 2007. The technical data are gathered and compiled together such as creating a comprehensive monitoring system to prevent disastrous impacts of landslide events and to give the necessary inputs to planners and decision makers to undertake the necessary mitigation steps.

The continuous urbanization process has modified the outflow from the area; the peak discharge has thus increased. To prevent residential zones within the flood plain to be flooded, channels have been constructed to expand the capacity of the river. In some places, backflow gates are installed between the main channel and the pipes, preventing inflow from the main channel.

Under RECLAIM Thailand, a capacity building workshop for Patong municipal officials, other officials in Phuket provincial government, villagers and land developers. The technical inputs were used to provide a solid and relevant basis to present and explain landslide mechanism to the local people in charge of disaster management, emergency relief, and recovery process. The technical studies were a great support for convincing them on the effective steps needed for landslide risk mitigation.

City authorities were advised to take steps to alleviate flooding: (1) avoid creating new barriers and keep all existing waterways open; (2) grey water treatment and disposal should be part of river planning to avoid contamination of flood water and the possible health-related problems; and (3) strengthen the flood monitoring program to provide precipitation and associated flooding data for effective flood management. Each head of village and municipal official in Patong are responsible for the record of rainfall intensity of their respective rainfall stations established under RECLAIM Thailand.

The risk maps can be the basis for planning roads and other infrastructure. If bridges and culverts are not adapted to long term flood return periods, they can be easily destroyed and worsen the flood situation. Identified flood-prone areas can be elevated, and the capacity of its channels and culverts improved to mitigate flood impacts and in turn reduce the associated landslide risk.

Asian Program for Regional Capacity Enhancement for Landslide Impact Mitigation

Funded by the Government of Norway, RECLAIM highlighted the need for gradual change in attitude towards proactive approaches of preventive measures to reduce losses concerning landslide events. It aimed to provide a platform for discussion and sharing experiences in landslide risk reduction between decision-makers, planners, professionals and residents. Landslide mitigation demonstration projects were implemented in the Philippines, Thailand and Sri Lanka; land use planning, environmental management and forecasting were major components of the demonstration projects. This program was implemented by ADPC with technical inputs from the Norwegian Geotechnical Institute.

Regional training courses on landslide mitigation were conducted in Thailand and the Philippines, to bring together the RECLAIM institutional partners to share the problems encountered and approaches they adopted as mitigation and preparedness measures. RECLAIM has 19 partners in seven Asian countries.

"The Asian Program for Regional Capacity Enhancement for Landslide Impact Mitigation (RECLAIM) aims for raising awareness of those who are directly concerned with the risk and works at giving the necessary and cost e ective tools to mitigate landslide risk an losses."

H E Ms Merete Fjeld Bra est
Ambassador of Norway to Thailand

Participants of the 2008 RECLAIM Regional Training Course examine the landslide site in Cherry Hills Subdivision, Antipolo City, Rizal, Philippines. Image credit: RECLAIM

Conclusion

Landslide disasters happen frequently in Asia. These three different case studies demonstrate how to reduce the impact in landslide hazard prone areas. The mapping process is the first step for landslide risk analysis, to establish zones in terms of degree of risk, and locate the landslide hotspots within the area. Monitoring the land movements and the rainfall patterns is then crucial; in each study area, scientific agencies have focused on the local communities' participation and using their traditional practices as part of their involvement in the landslide risk mitigation process.

The governance system is one of the substantial foundations for fostering an efficient policy framework for the different stakeholders to adopt and implement together a coherent strategy of landslide risk adaptation. In all cities, local authorities have started to engage themselves, following up and implementing policies to build a comprehensive landslide risk mitigation framework, to reduce the exposure and the related vulnerabilities of the population. School-based landslide monitoring project helps ensuring the durability and the expansion of landslide risk reduction among other stakeholders and also other geographical areas by involving students considered as catalysts of change.

The active engagement of the population, local officials, and technical experts tend to strengthen the knowledge dissemination channels on landslide risk mitigation and encourage further awareness raising among all the different stakeholders on the landslide risk situation. Subsequently the disaster risk adaptation mechanisms can then be expanded quicker and more easily to other type of risks.

Lessons Learned

- ✓ Scientific knowledge and practices need to be understood and used proactively by local communities. Their capacities to mitigate landslide risk are thus strengthened, ensuring sustainable risk reduction activities while the sense of ownership is created.
- ✓ Land use planning, as an important landslide push factor in case of unplanned land development, needs to consider landslide hazard in the decision making process, in consultation with civil engineering and local communities.
- ✓ Monitoring and analysis of natural parameters such as rainfall patterns and water absorption, land movements and slope evolution is critical to landslide risk mitigation.
- ✓ Traditional knowledge can validate evidence of past landslide events, and helps to further understand the landslide perception among the local communities. Traditional technologies are also useful in designing landslide Early Warning System.
- ✓ Community-level capacity building, awareness creation, effective information dissemination and advocacy are effective tools in reducing the vulnerability to landslide impacts and strengthening disaster risk management process at local level. Community level disaster risk management institutions are thus essential to be incorporated in the decision making process.

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Endnotes
1 A barangay is the smallest political and administrative unit, connecting city government to its communities.
2 Artessa Saldivar-Sali, with Herbert Einstein, developed the landslide risk assessment system for Baguio City, Philippines. The tool can be used to determine zoning and strengthen mitigation measures for regions with similar topography, geology and climate i.e. mountainous tropical regions frequently hit by typhoons.

About the Project
The Asian Program for Regional Capacity Enhancement for Landslide Impact Mitigation (RECLAIM) is implemented by ADPC with Norwegian Geo-technical Institute (NGI). The program participates at reducing landslide disaster vulnerability of human settlements, infrastructure, and critical facilities in the targeted countries of Bhutan, India, Indonesia, Nepal, Philippines, Sri Lanka, and Thailand. The program aimed to provide target countries with a cadre of specialists and decision makers with up-to-date knowledge on landslide disaster mitigation practices and to integrate this knowledge in routine development work initiated by national and local governments.

Project Partners
Norwegian Geotechnical Institute > Established in 1953, and with a present staff of 200 employees at its headquarter in Oslo, the Norwegian Geo-technical Institute is a well-known international center for research and consulting within geo-technical and geo-environmental engineering. It is organized as a private independent foundation. Through its International Centre for Geohazards, NGI has served clients in most part of the world in the field of natural hazard mitigation.

Department of Mineral Resources > The Department of Mineral Resources serves Thailand as an geological fact-finding agency that predominantly studies and researches mineral deposits and fundamental geology. Application of the mentioned activities include colleting, monitoring, analyzing, and providing geological understanding about natural resources condition, issues, and problems.

Kasetsart University, Thailand > Kasetsart University was established on 2 February 1943 with the original aim to promote subjects related to agricultural sciences. The curricula expanded to cover science, arts, the humanities, social science, education, architecture and engineering. The University's Geotechnical Engineering Research and Development Center has been performing landslide engineering research for the last decade.

National Building Research Organisation > The National Building Research Organisation is an integrated multidisciplinary institution carrying out research and development work in the diverse areas of geotechnical engineering, building materials, environmental, project management, human settlements planning and landslide disaster mitigation.

University of the Philippines Diliman > Established in 1908, the University of Philippines is comprised of seven constituent universities located in 12 campuses throughout the Philippine archipelago. UP's constituent universities nurture the intellectual and cultural growth of the Filipino through 246 undergraduate and 362 graduate programs in which more than 50,000 students are currently enrolled. UP Diliman is the flagship university of the UP System. It is the administrative seat of the system as well as an autonomous university in its own right. UP Diliman is not only the home of diverse colleges, offering 94 graduate and undergraduate courses, it also runs several centers of research, many of which have been declared by the Commission on Higher Education as National Centers of Excellence

Other Safer Cities Case Studies
Safer Cities 5: *Community-based Disaster Risk Reduction in Central Sri Lanka*
Safer Cities 12: *Demonstration Housing Construction for Landslide and Flood Prone Areas: A case study from Ratnapura, Sri Lanka*

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Designer: Lowil Fred Espada

Safer Cities is a series of case studies that illustrate how people, communities, cities, governments and businesses have been able to make cities safer before disasters strike. The series presents strategies and approaches to urban disaster mitigation derived from analyses of real-life experiences, good practices and lessons learned in Asia and the Pacific. This user-friendly resource is designed to provide decision-makers, planners, city and community leaders and trainers with an array of proven ideas, tools, policy options and strategies for urban disaster mitigation. The key principles emphasized throughout Safer Cities are broad-based participation, partnerships, sustainability and replication of success stories.

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PROMISE

During the implementation of the Asian Urban Disaster Mitigation Program (AUDMP), ADPC recognized the importance of interventions in urban areas and accordingly identified Urban Disaster Risk Management as one of its core thematic areas of work, experiences from which have also guided the selection of the target secondary cities. ADPC has developed 'Strategy 2020 for Urban Disaster Risk Mitigation in Asia' which aims to reach 200 cities by the year 2020.

The need to minimize the destructive impacts of these hydro-meteorological events on the vulnerable communities, particularly the urban communities and the economic infrastructure through enhanced preparedness and Mitigation is therefore the main trust of the present intervention in implementation of the Program for Hydro-Meteorological Disaster Mitigation in Secondary Cities in Asia (PROMISE).

ADPC considers PROMISE program as an opportunity to associate with many communities living in Asian cities vulnerable to hydro-meteorological hazards with the aim of reducing the impacts of such events and demonstrate innovative applications for community preparedness and mitigation.

This case study documents the efforts under a specific program objective to increase stakeholder involvement and further enhancement of strategies, tools and methodologies related to community preparedness and mitigation of hydro-meteorological disasters in urban communities.

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The Asian Disaster Preparedness Center (ADPC) is a regional resource center dedicated to safer communities and sustainable development through disaster risk reduction in Asia and the Pacific. Established in 1986 in Bangkok, Thailand, ADPC is recognized as an important focal point for promoting disaster awareness and developing capabilities to foster institutionalized disaster management and mitigation policies.

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