Geohazards Risk Assessments

Landslides in Honduras triggered by rainfalls in 2008

October/November 2009

Consolidated Report by Åsa Granath and Markus Lundkvist

The Joint UNEP/OCHA Environment Unit
in cooperation with the Swedish Rescue Services Agency (SRSA)*

Comisión Permanente de Contingencias (COPECO)
United Nations – Honduras

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** On 31st December 2008 the Swedish Rescue Services Agency (SRSA) ceased operations due to a merger with the Swedish Emergency Management Agency and the Swedish National Board for Psychological Defence. On 1 January 2009 a new authority, replacing these three, commenced operations, namely, the Swedish Civil Contingencies Agency (MSB).*

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Cover photo: Åsa Granath; Hills east from Catacamas, in the department of Olancho. Deforested areas affected by landslides-erosion around 20 October 2008.

TABLE OF CONTENTS

SUMMARY

Following heavy rains in September and October 2008, which resulted in flooding and landslides, the Honduras Government declared a state of emergency and formally requested humanitarian assistance. A UN Disaster Assessment and Coordination (UNDAC) team was deployed from 22 October to 9 November. To assist the UNDAC team, the Joint UNEP/OCHA Environment Unit (JEU) prepared an overview of potential secondary environmental risks using the Hazard Identification Tool (HIT). This was done to highlight infrastructure and industrial facilities in the affected area that could potentially cause additional secondary environmental risks to human health and life, as well as cause damage to the environment.

The possibility of further landslides was identified by the UNDAC team as an urgent secondary risk that required additional international technical assistance. At the request of national authorities, the JEU deployed a team of geologists to assist the Honduras Authorities in undertaking a rapid Geological Risk Assessment. The team was deployed through the Swedish Rescue Services Agency, and worked closely with UNDP and the national authorities. The mission was financed by the Swedish International Development Cooperation Agency.

The geohazards experts assessed landslide risk at nine separate locations and made recommendations for further consideration. The affected sites displayed different types of landslides such as falls, slides, flows or a combination of these. Fortunately, the findings indicate there are limited impacts and there are no immediate recovery needs. However, on three sites in the Department of Olancho, houses, infrastructure, and agricultural land were found to be in need of reconstruction.

One of the main conclusions is that long term risks for reactivation of existing landslides, as well as initiation of new landslides, need to be addressed. The probability or likelihood of movements triggering landslides is difficult to predict as they are strongly dependent upon precipitation and seismic activity. Therefore, ensuring appropriate land use is likely the best measure to reduce landslide risks.

The recommendations for the visited sites focus primarily on monitoring and prevention. Monitoring at most sites is needed to identify any changes in the assessed risk level and trigger appropriate actions by the authorities. Site-specific recommendations have also been made to prevent landslides from destroying critical infrastructure like housing and drinking water supply. The individual site assessments reports provide more detailed information and recommendations.

Lastly, there is an overall need to improve the availability of data, working procedures and organization at the national and regional levels. In particular, there is a need to:

- Update topographical maps;
- Produce geological and hydrogeological maps;
- Collect and extend the use of remote sensing data;
- Collect precipitation and seismic data;

- Establish and maintain a national database on landslide occurrence and damage;
- Develop systems and routines for monitoring, inspecting and assessing landslide and landslide risks;
- Review and possibly develop legislation and routines regarding land-use planning, in particular by considering land utilization that directly or indirectly influences landslide risk;
- Identify, assess and implement various and suitable approaches to prevent deforestation and promote reforestation;
- Develop contingency plans as a risk reduction tool in landslide-prone areas;
- Extend participation in international networks on landslide risk issues.

The assessments did not address allocating specific responsibilities pursuant to the recommendations. This should be undertaken by national and regional authorities.

The **Joint UNEP/OCHA Environment Unit,** integrated into the Emergency Services Branch of the Office for the Coordination of Humanitarian Affairs**,** is the United Nations mechanism to mobilize and coordinate the international response to environmental emergencies.

The Joint Environment Unit works with affected countries to identify and mitigate acute negative impacts stemming from emergencies, providing independent, impartial advice and practical solutions. It also works with organizations dedicated to medium and long-term rehabilitation to ensure a seamless transition to the disaster recovery process. More information is available at http://ochaonline.un.org/ochaunep.

INTRODUCTION

1.1 Context

Prolonged and intense rain fell over Honduras in September and October 2008. The heavy rains resulted in flooding and landslides, leading the national authorities to request the deployment of a United Nations Disaster Assessment and Coordination (UNDAC) team. As several landslides had occurred and the risk for further landslides was considered high, the UNDAC team together with the Comision Permanent de Contingencias (COPECO) identified a need for geohazards experts to assess the risk in selected areas. The Honduran Government forwarded a request for international assistance to the UN Resident Coordinator in Honduras, who in turn conveyed the request for assistance to the Joint UNEP/OCHA Environment Unit (JEU).

A geographer and a geologist were subsequently deployed through the Swedish Rescue Services Agency, and worked closely with UNDP and the national authorities. They visited nine sites to assess landslide risk and to suggest recommendations to be considered and evaluated. The mission was financed by the Swedish International Development Cooperation Agency.

The overall aims of the mission were to:

1. Identify and assess potential and residual risks from landslides and address acute life-threatening situations thereof;
2. Where applicable, recommend practical mitigation measures.

1.2 Honduras

Honduras is located in Central America with a population of about 7.3 million people living on an area of 112 000 km2. It neighbours Nicaragua, El Salvador and Guatemala. Honduras borders the Caribbean Sea on the north coast and the Pacific Ocean on the south through the Gulf of Fonseca. The climate varies from tropical in the lowlands to temperate in the mountains. The Honduran territory consists mainly of mountains, but there are narrow plains along the coasts, a large undeveloped lowland jungle in the northeast, and a heavily populated lowland valley in the northwest.

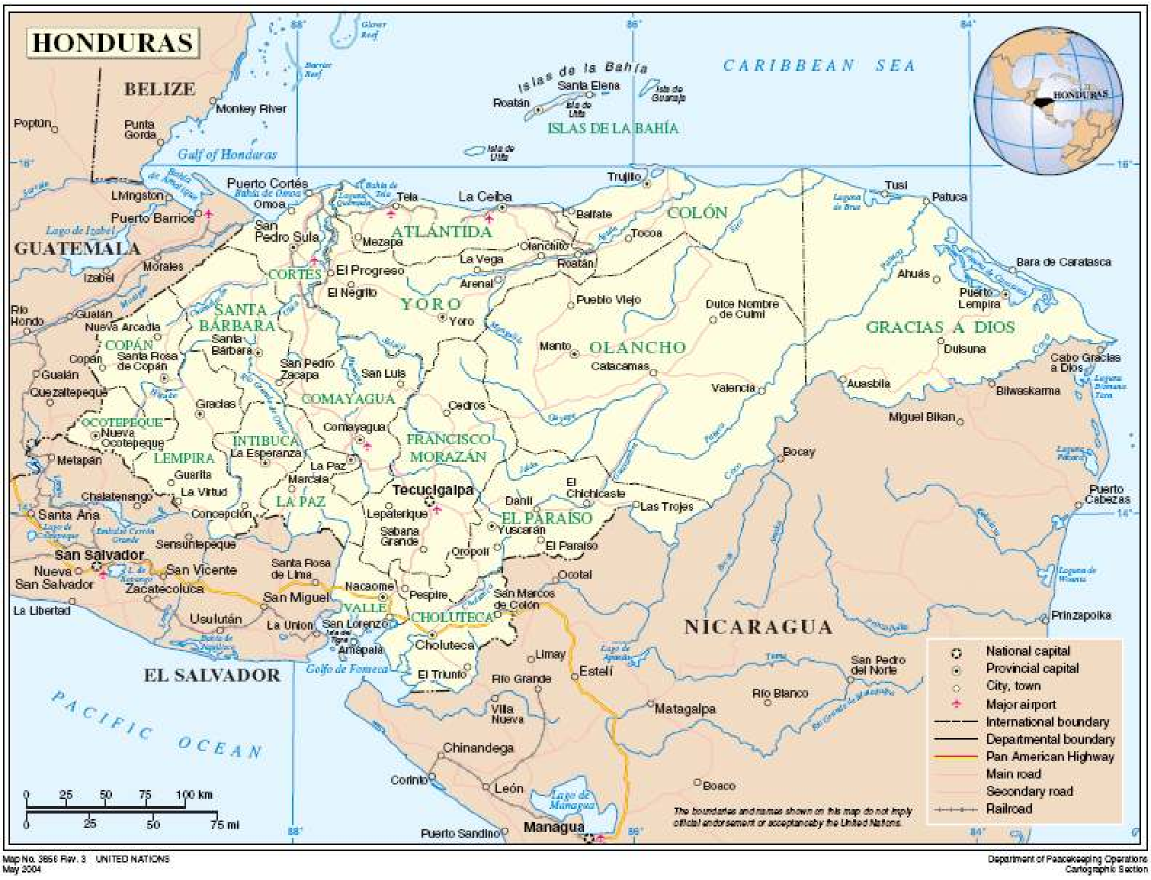

Figure 1. Map of Honduras with administrative borders.

Honduras has experienced several large natural disasters in its recent past. Large earthquakes with epicenters located in neighbouring countries have impacted Honduras while in 1974, Honduras experienced major devastation in the wake of Hurricane Fifi. Fourteen years later, in 1998, Hurricane Mitch – one of the worst hurricanes ever recorded in Central America and the Caribbean – also severely affected the country.

1.3 LANDSLIDES

“Landslides” is often used as an umbrella term for movements of rock, debris and soils of various origin, volumes and speed. The term encompasses events such as rock falls, slides, and flows, such as debris flows commonly referred to as mudflows or mudslides. Different types of landslides are presented in Table 1 (Varnes, 1978).

Honduras is a landslide-prone country. Landslides have been triggered both by large amounts of rainfall related to hurricanes and other tropical depressions, as well as seismic activity. Landslides can also be initiated by changes in groundwater levels, disturbance and change of a slope due to man-made construction activities, or any combination of these factors.

Table 1. Selection of the landslide classification by Varnes (1978).

Type of movement		Type of material		
		Bedrock	Engineering soils	
			Predominantly coarse	Predominantly fine
Falls		Rock fall	Debris fall	Earth fall
Slides	Rotational	Rock slide	Debris slide	Earth slide
	Translational			
Flows		Rock flow	Debris flow	Earth flow
Complex		Combination of two or more principal types of movement		

Failure of a slope occurs when the force that is pulling the slope downward (gravity) exceeds the strength of the earth materials that compose the slope. A slope can move slowly, millimeters per year, or move quickly and disastrously, as is the case with debris flows. Debris slides and earth slides are often referred to as landslides and have been labeled as such in this report.

2 APPROACH

2.1 SITE VISITS

For the geohazards risk assessment, nine priority sites were identified as having a pronounced landslide risk by COPECO, the UNDAC team, and non-governmental organizations. Landslides to be visited were decided by COPECO. The visits were carried out between 12 to 27 October 2008, with total time spent at each site ranging between two to three hours. Eliseo Silva, project leader at PMDN (Proyecto Mitigacion Desastres Naturales) /COPECO, and Betulio Dominguez, liaison officer at UNDP/COPECO and acting as interpreter, accompanied the visits. Information regarding the landslide activation, former landslides, land use, and impacts was provided by the affected population. The diversity of people interviewed was not necessarily representative of the make-up of the population, with a vast majority of the informants being male adults.

For each site, individual reports on risk assessment and risk reduction recommendations were produced. A map of visited sites and a table with information about the sites are presented in Figure 2 and Table 2, respectively.

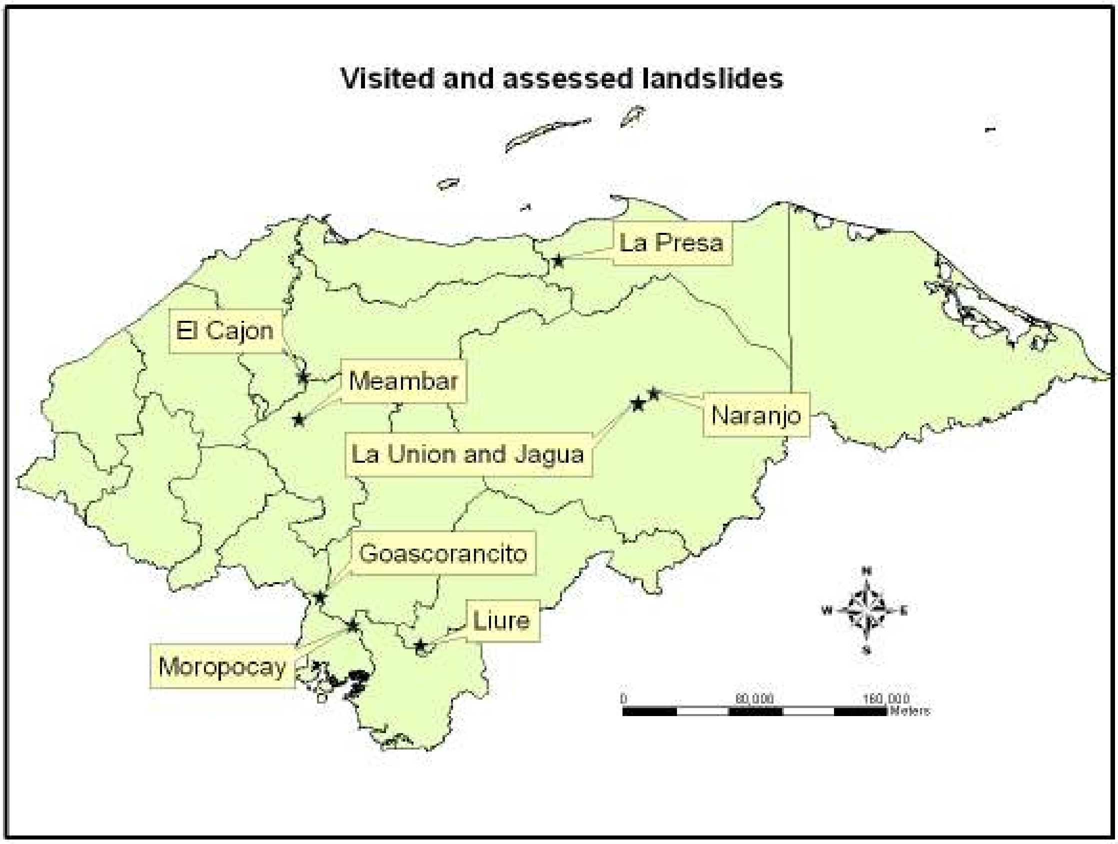

Figure 2. Visited and assessed landslides.

Table 2. Site visits – Date of landslide activation, impacts and main concerns.

Site/village Municipality Department	**(Estimated) date of land-slide activation, landslide type and impacts**	**Main concerns**
1. Liure Liure El Paraiso November 12	September 2008 Earth slide Two villages were evacuated.	Landslide impact on nearby village. If a landslide creates a dam, the dam bursts and this subsequently leads to flooding, might the downstream areas be affected? Is it safe to move back?
2. El Cajon Yoro November 18	No landslide and thus no dam-age.	Landslide damming river with subsequent dam burst and inundation of communities.
3. Matapalo Comayagua November 19	October 2008 Earth slide. Minor damage to a couple of houses. Evacuation of village.	Resettlement of evacuated people. Evaluation of proposed village relocation.
4.Goascorancito Calidad Valle November 20	In 2007 Earth slide, rock-fall, debris flow. One house was evacuated.	Might falling rocks and a landslide affect the village? Is it safe to move back to the evacuated house? Will falling rocks and a landslide affect a lar-ger area farther downhill?
5. Moropocay Valle November 21	October 2008 Debris flows, mudflows, ero-sion.	Might future landslides affect the village and its surroundings?
6. La Union Olancho November 24	21 October Debris flow, erosion. Damage to infrastructure and land.	Might future landslides affect the village and its surroundings?
7. La Jagua Olancho November 25	20 October Debris flow, erosion. One girl killed. Damage to one house and land.	Might future landslides affect the village and its surroundings?
8. El Naranjo Olancho November 25	20 October Debris flow, erosion. Damage to houses and land.	Might future landslides affect the village and its surroundings?
9. La Presa El Zapotal Colon November 27	20 October Rock fall., debris slide One woman and two children were killed. Broken water pipes, and 20.000 people lost access to drinking water supply.	Will landslides occur again around the water source/ landslide area? Preventive measures that can be taken to se-cure the water supply.

Figure 3. Mule transportation to the landslide site Goascorancito in the Department of Valle. From left, project leader Eliseo Silva, PMDN/COPECO, geohazards experts Åsa Granath and Markus Lundkvist, Swedish Rescue Services Agency.

2.2 METHODOLOGY

The assessments follow a three-step approach as described below.

Firstly, observations and descriptions of the area have been provided. In order to perform a rapid geohazards risk assessment and to suggest recommendations, a description of the area, including observations, proved to be an indispensable precondition. The findings were mainly collected from visual observations of various features and conditions indicating landslide-related parameters. Topographical maps and precipitation data were also used. Field observations were positioned by GPS measurements.

The second step consists of the actual rapid geohazards risk assessment. Probabilities for, and consequences of, recent and potential landslides have been qualitatively described based on the following questions:

- Has a landslide recently been activated?
- How far has the landslide moved during the recent rainy period?
- How fast was the movement?
- How far are the initiated landslide movements from the area where it directly or indirectly might cause harm?

- How much damage has occurred?
- Are there other signs of previous landslide activity?
- Is there any need for early recovery?
- Are there signs of landslide susceptibility?
- How have the preconditions for new landslides changed after the landslide?
- How extreme was the precipitation in the area compared to average figures?
- What is the seismic activity in the area?

It needs to be underlined that the rapid risk assessments are based on on-site judgment, as more thorough scientific investigations were not feasible due to the limited time of the visits.

The third section consists of the recommendations. Here, site-specific and general mitigation measures have been proposed. The recommendations are based on findings collected during the rapid geohazards risk assessments. It must be emphasized that due to time constraints in the field, more in-depth site investigations will be needed in order to make detailed recommendations.

The assessments did not address allocating specific responsibilities pursuant to the recommendations. This should be undertaken by national and regional authorities. In addition to the need for allocation of responsibilities, appropriate legislation, financial support and capacity building are issues that need to be addressed and, as such, are not expanded upon here.

Further reading suggestions on landslides (in general and specifically in Honduras) can be found in Appendix 2.

3 ASSESSMENT FINDINGS

3.1 LIURE

On 13 October 2008 the village Paso de Los Lopez, Department of El Paraiso, was evacuated, due to an increased risk of being affected by a landslide. The village is located downhill and near an active landslide. The village El Carrizal, situated 3 km farther downstream of the Chiquito river, was evacuated in anticipation of a landslide damming up the river with the possibility of a subsequent rupture and flooding.

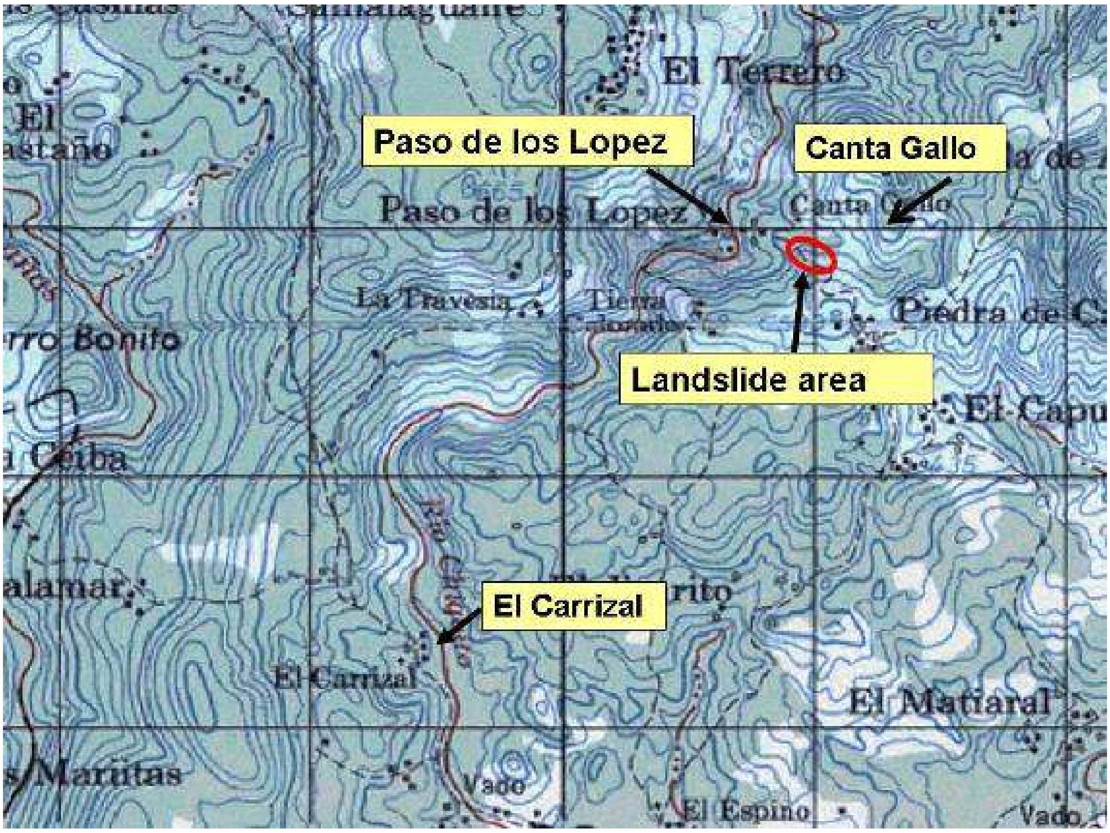

Figure 4. Liure, El Paraiso. Topographic map showing the site and evacuated villages.

The Liure landslide site clearly showed landslide processes such as subsiding soil and frequent deep and wide cracks in the ground. Prolonged rain might trigger new movements of the landslide. Seismic activity might also cause soil movements, which could take place all year round.

The village Paso de Los Lopes might be at risk of being affected by the landslide. The eastern side of Rio Chiquito is most likely to be affected. The risk can be assumed to be higher during the rainy season. Monitoring of soil movement should be performed along the landslide slope. The monitoring is a priority and should start as soon as possible. In addition, it is recommended to undertake a detailed slope stability assessment. If the measurements show slow or no soil movement, it should be safe for the inhabitants in Paso de los Lopez to move back, at least temporarily, until the next rainy season.

The inhabitants in the village El Carrizal can move back. However, a contingency plan should be conducted for El Carrizal and other settlements near Rio Chiquito and downstream from the landslide.

3.2 El Cajon

During a visit to the El Cajon Dam, Department of Yoro, the UNDAC team identified a slope for assessment as a possible disaster scenario could involve a landslide damming the Humaya River, followed by a subsequent dam rupture and significant inundation of communities living farther downstream.

Figure 5. Assessed slope south of the El Cajon Dam.

As no landslide had taken place recently, in spite of recent deforestation and heavy rains, the slope was regarded as relatively stable at the time of the assessment. Any movement on the steep deforested slope is likely counteracted (i.e., slowed down) by an apparently stable, large and densely forested area below. The probability of a landslide subsequently leading to inundation downstream was therefore regarded as small.

3.3 Matapalo

In Matapalo, Department of Comayagua, activation and extension of an old rotational landslide caused cracks in a couple of houses in late October 2008. Although 40 houses were evacuated as a precautionary measure, the extent of the damage was limited.

The sporadic landslide movements at this site are generally slow and the probability of human causalities can be regarded as low. It is suggested that inhabitants in unaffected houses can move back. However, prior to the next rainy season, when the probability of a landslide will be higher, damaged houses should be evaluated by a structural engineer to determine the possibility to return, or to abandon the houses.

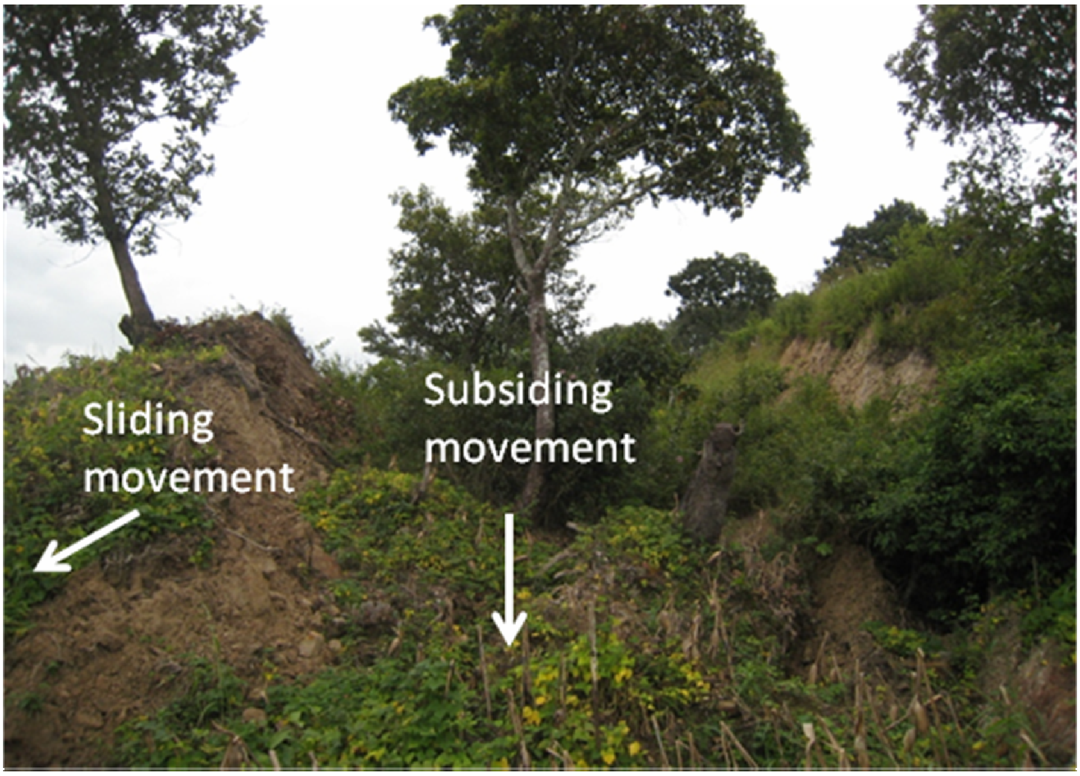

Figure 6. Recently extended fault in the landslide in Matapalo village.

In the long term, the movement is relatively deep-seated and landslide reactivation is likely to take place in the event of extreme precipitation. At this site, it may be difficult to prevent landslides from occurring by undertaking short-term measures, as the probability of significant movement annually is relatively low. It should be kept in mind that precipitation levels during both Hurricane Mitch in 1998 and the rainy season of 2008 are exceptional, and no movements seem to have taken place in the years in-between.

However, with every new landslide reactivation, the preconditions for further landslide activity might change. Future movements are more likely to cause material damage than human casualties.

The proposed area for a relocation of Matapalo village seems to possess more favourable conditions from a geohazards perspective, such as gentler slopes and a vaster area of vegetation. However, further investigations are needed to determine the suitability.

3.4 Goascorancito

A landslide in Goascorancito, Department of Valle, was activated in October 2006 by a combination of prolonged rainfall and seismic activity.

Figure 7. The activated landslide area in Goascorancito with descriptions of various landslide processes.

Below the landslide, there is a low probability of one particular house to be affected by a rockslide and/or debris flow. The situation should be further analyzed, including a detailed estimation of the landslide propagation direction and assumed paths of debris flows and rock falls.

The possibility of falling rocks and debris from the assessed landslide affecting other houses in Goascorancito is also assumed to be low. The town of Calidad, which is located approximately 5 km west of the landslide, is unlikely to be affected by falling rocks and debris flow from the studied landslide.

A more extensive study, as well as monitoring of the landslide site, are recommended. The study should comprise a geological investigation of the active landslide as well as the area above the rock outcrop. The landslide and the surrounding hills should also be monitored and inspected regularly regarding leaning trees, fissures, and rock falls.

3.5 MOROPOCAY

Prolonged and intense rainfall initiated an extensive mudflow and debris flow down the slopes near the village of Moropocay, Department of Valle, on 23 October 2008. The mudflow ended relatively near a house and covered some agricultural land. A couple of houses near the landslides were evacuated, but the inhabitants have now returned.

The slopes of Moropocay hill have previously been affected by landslide activity, related to Hurricane Fifi (1974) and Hurricane Mitch (1998). The probability of new landslides is high. The village of Moropocay, its surroundings, and the connecting road are situated in the direction of a possible landslide movement and are thus at risk of being affected. Landslides have so far coincided with prolonged and intense rainfall. Seismic activity might also be a triggering factor. Seismic activity during the rainy season and saturated soils can amplify the risk for landslides.

Figure 8. Mudflow release zone and path are illustrated in the picture. Eastern landslide in Moropocay seen from the mudflow outlet.

Geological and hydrogeological investigations are recommended to form a basis for improved land use planning.

The landslide area and the surrounding hills should also be monitored, focusing on leaning trees, fissures, erosion and rock falls. Dense vegetation below the landslide should remain in place, as that will prevent and reduce accelerated debris flow. The landslide sites should be avoided due to the risk of being hit by falling stones and debris. The risk is especially high during the rainy season.

3.6 La Union

According to the inhabitants in La Union, Department of Olancho, the landslides occurred in the surrounding hills on 21 October 2008. Intense debris flows and mudslides flooded part of the village. The flows passed nearby some houses, damaging one. Fluvial erosion also caused deep trenches in the streets and the soil. The main drinking water pipe broke, and the village lost its water supply for two weeks.

Figure 9. La Union, Olancho. Debris flow deposits cover the former football ground.

During Hurricane Mitch there were some minor landslides in the surrounding areas, but they never affected the village. Since Mitch, many of the surrounding hills have been deforested.

More extensive site investigations are recommended in La Union. The investigations should comprise a hydrological survey and an investigation into the possibility of reducing or diverting the transport of debris. The results would constitute basic data for decision making on structural risk mitigation measures such as altered drainage and the possibility to construct dams and channels to trap sediment/debris and divert overflows. Due to the current situation of heavy rainfall and subsequent risk of inundation of debris flows, it is necessary to address the need of relocating some of the people in the village to safer grounds.

In addition, a number of non-technical measures are recommended, including the development of hazard maps, enforcement of land use regulations, the development of a monitoring network (with rainfall forecasting models), and the establishment of a contingency plan and an early warning system.

3.7 La Jagua

On 20 October 2008, the small village of La Jagua, Department of Olancho, was affected by debris flows and mudflows. According to inhabitants, a total of 50 landslides were triggered in the surrounding hills, killing one girl. The village was subsequently evacuated.

Figure 10. The hills upstream from La Jagua are affected by shallow landslides.

Being situated in a narrow valley surrounded by steep landslide-prone slopes and a river that might overflow, the village of La Jagua is vulnerable to landslides and flooding. The removal of the topsoil layer, caused by erosion in some of the surrounding hills, is likely to increase this vulnerability. Loss of ground cover can also lead to flash flooding.

Based on the risk of being inundated by debris flows, coinciding with heavy rainfalls, it is recommended that the people of La Jagua village, which consists of five houses, are relocated to safer grounds. The selected area for relocation should be based on detailed site investigation of future landslide risk and risk of being inundated by future debris flows in the area.

In order to reduce further erosion of ground cover and avoid flash flooding, replanting of the areas and slopes damaged by landslides with appropriate vegetation should be considered. Reforestation efforts should also be considered as a long-term mitigation measure, as deforestation of the hills might be a landslide-promoting factor.

3.8 El Naranjo

The small village of El Naranjo, in the Department of Olanco, was on 19 and 20 October 2008 partly inundated by debris. In addition, fluvial erosion also caused severe damage to houses and the ground.

Figure 11. Debris flow affected most of El Naranjo village.

The village of El Naranjo is vulnerably situated in a narrow valley, surrounded by steep landslide-prone slopes and a river that might overflow. The landslides on 19 and 20 October 2008, which caused the removal of the topsoil layer, are likely to have increased this vulnerability.

The preliminary recommendation for El Naranjo is to relocate its inhabitants due to the potential risk of being inundated by future debris flows. The selected area for relocation should be based on a detailed site investigation of future landslide risk and the risk of being inundated by future debris flows in the area. The detailed studies in El Naranjo and the immediate surroundings studies should comprise a hydrological study and an investigation of the possibility to reduce transport of debris.

3.9 La Presa

In a landslide in La Presa, Department of Colon, on 20 October 2008, a woman and two children were killed and two water pipes damaged. The city of Sonaguera, which has 20.000 inhabitants, suffered the loss of its water supply, further exacerbating the humanitarian crisis.

The water pipes are located downstream from steep landslide-prone slopes and in the direction of a possible landslide movement of large boulders and debris, and continue to be at risk of being affected again in the future.


Figure 12. The water pipes are located in parallel along the eastern riverbank of Rio Juan Lazaro.

To prevent similar events in the future from happening, three options should be further explored. Firstly, the possibility of relocating the intake of raw water and the water pipes to a safer location should be investigated. Based on the preliminary findings, the most feasible location would be downstream and to the south of the assessed area. Detailed site investigations of water quality and hydrology are essential for the collection of primary data. Secondly the separation of the water pipes by rerouting one of the pipes in order to reduce the risk could be considered. Lastly, it should also be investigated if it is possible to better secure the pipes, by solid construction material and/or by replacing the existing pipes with more flexible material that would be less vulnerable to impacts from future landslides.

3.10 Summary of visited sites

The assessed sites displayed different types of landslides such as falls, slides, flows and a combination of those. Most performed assessments indicated impacts not requiring any recovery efforts. The sites in Department of Olancho, La Union, La Jagua, El Naranjo have houses, infrastructure or agricultural land that have reconstruction needs.

The long-term risks for reactivation of existing landslides and initiation of new landslides should be given higher priority. Probabilities of triggering movements are strongly dependent upon precipitation and seismic activity.

The recommendations for the visited sites focus primarily on monitoring and prevention, and are summarized in Table 3. Monitoring at most sites is needed to identify any changes in the assessed risk level and to trigger appropriate actions by the authorities. Site-specific recommendations have also been made to prevent landslides from destroying critical infrastructure like housing and drinking water supply. The individual site assessment reports provide more detailed information and recommendations.

Table 3. Recommendations at visited sites.

Sites Recommendations	1. Liure	2. El Cajon	3. Matapalo	4. Goascorancito	5. Moropocay	6. La Union	7. La Jagua	8. El Naranjo	9. La Presa
Monitoring actions/investigations									
Geodetic measurement		x	x						
Slope stability assessment	x		x						
Geological mapping	x		x	x	x				
Hydrogeological survey			x		x				
Hydrological survey						x	x	x	x
Inspections of houses and infrastructure			x						
Observations of biogeophysical indicators; leaning trees, fissures, lagoon formation etc.	x		x	x	x				x
Calculation of landslide volume required to dam river		x							
Prevention									
Avoid deforestation / promote reforestation	x		x	x	x	x	x	x	x
Alter drainage			x			x			
Install debris flow barriers						x		(x)	
Reduction in debris transportation						x		x	
No trespassing in landslide area	x			x	x				x
Avoid construction of houses and infrastructure	x				x				x
Conduct a contingency plan	x					x			
Relocate people, houses or infrastructure			(x)			(x)	x	x	x
Strengthening measures of houses			x						

Parentheses indicate that measures might be realized after further studies. Regarding altered drainage, it is important to acknowledge the possible change in risk of flooding or loss of fertile soil.

3.11 GENERAL RECOMMENDATIONS

During the mission, some general observations concerning the need of e.g. basic data, standard operating procedures, and organization were noticed. Data collection follows a risk-based approach. The interval for collecting and updating basic data, as well as its level of detail, should be prioritized for high-risk areas.

- Topographical maps. Most maps are from the beginning of the 1980s with a scale of 1:50.000 and need to be updated. Slope angles, vegetation patterns and location of roads and houses are important when assessing probabilities for, and consequences of, landslides. The mapping scale for areas with pronounced relief might need to be more detailed.

- Geological and hydrogeological maps. The geology of many mountainous and landslide-prone areas has not been mapped in Honduras. A few areas are covered by maps in the scale of 1:50.000. The geology indicates soil and rock properties as permeability and weathering potential, which is critical for the occurrence of landslides.

- Remote sensing data. There are old aerial photos and an update should be considered. Aerial photos are an important tool while working in remote places and establishing hydrological and geological maps. Satellite images may be acquired in order to capture various data related to landslide risk parameters such as vegetation cover and hydrology.

- Precipitation and seismic data. A denser network of meteorological stations and collection of seismic data should be considered, as datasets can support forecasts and assessments of landslides.

- Establish and maintain a national database regarding landslide occurrence and damage.

- Develop systems and routines for monitoring, inspecting and assessing landslides and landslide risks.

- Review and if possible, develop legislation and enforcement of land-use planning by considering land utilization that directly or indirectly influences landslide risk. Settlements and roads should not be located close to potential landslide areas.

- Identify various approaches to prevent deforestation and promote reforestation. Vegetation has a stabilizing function in preventing landslide release and landslide propagation.

- Contingency plans. Develop contingency plans as a risk reduction tool in landslide-prone areas.

- Extend participation in international networks on landslide risk issues.

APPENDIX 1 SITE REPORTS

Granath, Å., December 2008: Geohazards Risk Assessment. Landslide at the Canta Gallo hill, Municipality of Liure, Department of El Paraiso, Honduras. Joint UNEP/OCHA Environment Unit, Switzerland, 2009.

Granath, Å., Lundkvist, M., December 2008: Geohazards Risk Assessment. Landslide Scenario downstream from the El Cajón Dam, Department of Yoro, Honduras. Joint UNEP/OCHA Environment Unit, Switzerland, 2009.

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APPENDIX 2 FURTHER INFORMATION

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Further technical information may be obtained from the Joint UNEP/OCHA Environment Unit website at: http://ochaonline.un.org/ochaunep/

The **Joint UNEP/OCHA Environment Unit**, integrated into the Emergency Services Branch of the Office for the Coordination of Humanitarian Affairs, is the United Nations mechanism to mobilize and coordinate the international response to environmental emergencies. The Joint Environment Unit works with affected countries to identify and mitigate acute negative impacts stemming from emergencies, providing independent, impartial advice and practical solutions. It also works with organizations dedicated to medium and long-term rehabilitation to ensure a seamless transition to the disaster recovery process.

The Joint Unit's key functions include:

Monitoring
Continuous monitoring and ongoing communication with an international network of contacts.

Notification
Prompt notification and dissemination of emergency information in the event of an environmental disaster.

Information
Serving as an effective focal point for providing technical information such as maps and satellite images, scientific information and other expert assistance that can be channelled directly to requesting countries.

Brokerage
Facilitating contact between an affected country and donor countries that are ready to assist and provide needed response resources.

Assistance
Mobilize multilateral assistance from the international donor community when requested to by countries affected by environmental emergencies. OCHA Emergency Cash Grants may also be released in certain circumstances.

Assessment
Arrange for the urgent dispatch of international experts to conduct impartial and independent assessment of the environmental impacts of an emergency.