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Landslide occurrences in the Philippines: Contributing factors and implications to local governance[1]

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Aerial shot taken few days after the landslide events (Photo courtesy of PHIVOLCS)

The case of Leyte and Southern Leyte

Leyte and Southern Leyte are two provinces in the Philippines with the most catastrophic landslide history. The worst of which occurred in Ormoc City, Leyte in November 1991 and in Panaon Island, Southern Leyte on 19 December 2003. These events, triggered by heavy and continuous rain, claimed the lives of more than 5,000 landslide and flashflood victims in Ormoc City and 200 people in Southern Leyte.

On 17 February 2006, a massive landslide also occurred in Barangay Guinsaugon, St. Bernard, Southern Leyte where more than 1,000 people were buried alive. On 2 January 2011, another landslide hit the town of St. Bernard claiming the lives of at least five people.

Landslides result in serious negative impacts to the community, society, and the environment.

In Leyte, landslides caused heavy damage to infrastructures, blockage of roads, destroyed bridges, cut-off water and power supply and communications systems, crushed and washed-out houses, and loss of lives. This geo-hazard also brought major landscape changes that influenced the biophysical characteristics of the land, thus, affecting its ecosystem services. A barangay in Southern Leyte had become a "no man's land" after the massive landslide in 2003 due to the heavy accumulation of earth materials impairing most landscape functions, particularly, the production and supply of potable water in the area.

Landslide research in the Philippines

The extensive damages and serious negative impacts caused by landslides underscore the need for landslide research in landslide-prone areas. However, in the Philippines, only few studies are conducted to address landslide problems.

One major problem faced by land-use planners and decisionmakers is the acquisition of accurate and timely information on the magnitude of land deterioration particularly in mountainous areas like Leyte and Southern Leyte. According to local officials, deforestation is the major reason for landslide occurrences. Although this is accepted, scientists identified other factors that contribute to landslide occurrence.

The lack of baseline information on landslides as a geologic phenomenon should be addressed. Research outputs on landslide studies could be used as basis in decision making for land use planners and policy makers.

Contributing factors to landslide occurence

A study using geospatial technologies such as, Geographic Information System (GIS), Global Positioning System (GPS), and remote sensing (RS) technologies was conducted to characterize the biophysical attributes of Southern Leyte and Panaon Island and identify the major factors influencing landslide occurrences.

Data on the provinces' rock formations and fault lines, seismic occurrences,

slope, digital elevation model, soil series, vegetation and land use, and rainfall characteristics were mapped.

Geologic formation. Results show that the area has a geologic formation associated with the presence of the active Leyte segment of the Philippine fault. This fault structure plays an important role in studying land movements in Leyte and Southern Leyte provinces.

Seismicity. Frequent seismicity or earthquake occurrence is also an important characteristic of Southern Leyte. From January 2000 to December 2010, at least 128 shallow and small to moderate earthquakes occurred in Southern Leyte, along the Leyte-Segment of the Philippine Fault Zone with Mercalli scale (M_s) 2.1 to 5.7 magnitude.

Two moderate magnitude earthquakes occurred on the day of the Guinsaugon landslide. Immediately after the second earthquake, the rockslide-debris avalanche occurred.

Elevation. Geomorphologic characterization of the province revealed that highest elevation was 1,000m above sea level (asl) with steep to very steep slopes (greater than 30° angle). These conditions contribute to landslide occurrence.

The Guinsaugon landslide showed that an elevation of at least 700m asl have a run-out distance (distance travelled by the landslide materials) of about 4 km.

Soil classification and vegetation. The area's soil series is generally classified as rough mountainous and rough stony (mountain soils). These soils are strictly and strongly recommended to have permanent vegetative (trees) cover and under no condition should be cultivated. However, vegetation in the mountains of Southern Leyte drastically changed over the years, becoming far from what is recommended and should be maintained. Cultivated crops, coconut, and abaca now dominate the area. Evidence from vegetation analysis confirmed that Southern Leyte including the landslide areas were used for growing crops.

Moisture. Visual observation during the field survey revealed the abundance of ferns, abaca (*Musa textilis*), pagoha (*Musa balbisiana*), and banana (*Musa sapientum*). The presence of these types of vegetation signifies the abundance of moisture in the area as these plants grow well in moist environment. Springs which also indicate instability were also found to be common in the area.

Rainfall. Records from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) showed an unusually high rainfall amount of 853mm in December 2003 and 979mm in February 2006. These are the same time when catastrophic landslides occurred in Southern Leyte.

Landslide points. Landslide inventory mapping revealed a total of 53 landslide points in Southern Leyte as of December 2010. The highest number of landslide occurrences were observed in Panaon Island, particularly in San Francisco, Liloan, and San Ricardo with 13, 12, and 6 landslide points, respectively. These were the places strongly hit by the December 2003 landslide. Landslides were also observed in Pintuyan, Sogod, Silago, Hinunangan, Tomas Oppus, and Libagon.

Households within the danger zone

Policy Recommendations

To enhance land stability, tree planting should be encouraged in the mountains of Southern Leyte and tree cutting should be completely banned. Danger zones should be established, banning human settlement at the footslopes of the mountainous terrain within the zone. If there are residents, they should be advised to leave the area for their own safety.

The local government should also constantly monitor and assess identified areas with landslide history. A four-year observation revealed that landslides tend to recur in previous landslide areas.

Moreover, considering the climate change phenomenon, it is a must that each municipality establish their own rain gauge stations to monitor the amount of rainfall which can indicate the possibility of landslide occurrence.

Lastly, landslide research in Leyte, and the rest of the Philippines should be intensified. Continuous and concerted effort of all stakeholders is necessary. These research efforts should ultimately lead to the establishment of an early warning system to prevent catastrophic consequences of landslides.

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