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Environmental hazards: How much are we responsible?

Landslides are frequently responsible for considerable loss to life and property, and the severity of the landslide problem worsens with increased urban development and changes in land use. Any area composed of very weak or fractured material resiting on a steep slope can and will likely experience landslides. The term landslide includes a wide range of downward ground movement of soil and rock debris from a high elevation owing to the force of gravity along a hill slope. Although gravity acting on an over steeped slope is the primary reason for a landslide, there are other contributing factors such as erosion by rivers, glaciers or ocean waves that create over-steepened slopes. Earthquakes that create pressure and make weak slopes fail, have also been known to trigger landslides. Volcanic eruptions which produce loose ash deposits, debris flows, excess weight from the accumulation of rain or snow, stockpiling of rock or ore from waste piles, or from man-made structures, may also contribute to making weak slopes fail. Slope material that become saturated with water may also develop a debris flow or mud flow resulting in a slurry of rock and mud, which may pick up trees, houses and cars in its wake, thus blocking bridges and tributaries, causing flooding along its path.

Landslide mitigation works are conducted in order to stop or reduce the landslide movement so that the resulting damages can be minimized. With a clear understanding of the causes and mechanics of landslides, landslide control works can be implemented. These landslide control works can broadly be classified into two categories: control work and restraint work. Control work involves modifications of the natural conditions of landslides such as topography, geology, water drainage, and other conditions that indirectly control portions of the entire landslide movement. Restraint work relies on constructing reinforcing structures.

Scientists continue to produce landslide susceptibility maps for many areas that help monitor the stability of slopes, stream flow, and note changes in the sediment load carried by rivers and streams which would help minimize the damages caused by landslides. Although the physical causes of many landslides cannot entirely be removed, geological investigations, good engineering practices and effective enforcement of land use management regulations can reduce landslide hazards.

Recurrences of natural disasters due to landslides have been reported in Sri Lanka. With a view to introducing scientific practices to delineate the degree of this hazard, N.M.S.I. Arambepola from the National Building Research Organization has carried out a research on risk assessment and environmental protection in landslide prone areas, the first of its kind in Sri Lanka. As an outcome of the study, a landslide hazard zonation map has been prepared with sufficient details to enable risk assessments together with guidelines on landslide risk assessment and environmental protection. This research was funded by the NSF.

At a recently held NSF/SLAAS Forum, Dr. S.A. Kulathilaka, Senior Lecturer, Dept. of Civil Engineering, University of Moratuwa made a presentation that focused on his findings in the determination of the stability of slopes. He also shared his experiences at the 3rd International Conference on Landslides, Slope Stability and the Safety of Infrastructure at the workshop on "Landslide Causes and Landslide Remediation" held in July 2002. In his presentation, he noted that the stability of slopes is conventionally evaluated by computing a factor of safety. The methods of slices are the most widely used technique in analyzing slopes of different complexity. These methods of slices possess different levels of accuracy owing to the assumptions made during their derivations. The value of the factor of safety obtained will be meaningful only if an appropriate method of analysis is used, together with a failure surface of appropriate shape, compatible with the prevailing geological conditions.

Dr. Kulathilaka mentioned that two probabilistic models have been developed and are being applied for the deterministic and probabilistic analysis of two hypothetical slopes containing different geological features. He stated that the first slope consists of several soil layers of similar sheath strength parameters and that the potential failure surface is circular. The second slope has a thin and weak horizontal layer and thus the potential critical failure surface is non circular. According to the results, the deterministic analysis had indicated that the most critical failure surface and the corresponding factor of safety depend on the model used. The probabilistic analysis illustrates that the computed probability of failure depends on the deterministic model incorporated in the analysis. It also depends to a certain extent on the approach adopted in the implementation. Dr. Kulathilaka emphasized that according to these findings, it could be concluded that in the valuation of the probability of failure, it is essential to develop a probabilistic model based on an appropriate deterministic model.

A special meeting was also organized by the Media Resource Centre of SLAAS to discuss the landslides and floods that occurred recently. According to Prof. K. Dahanayake, Professor of Geology, University of Peradeniya, landslides are triggered mainly by high rainfall in Sri Lanka. Furthermore, he said that killer landslides may occur on geologically weak, unstable hill slopes underlain by clayey rocks during periods of continuous rains characterized by intents precipitation (rainfall) of more than about 75 to 100 mm during a few hours. Some of these landslides are newly formed due to reactivation of ancient landslides which had previously remained stable for a long period of time.

The reactivation of these landslides occurs due to disturbances caused by man, nature or by both. If one considers the recent spate of landslides in the hill slopes of different districts of Sri Lanka, most of them had been reactivated owing mainly to man's need to construct homes and networks of roads. He mentioned that on Saturday 17th May 2003, the rainfall at Elapatha, Ratnapura had been 345 mm during perhaps a period of 12 hours. At Elapatha, like in the case of many a killer landslide, the sudden movement arising out of the disturbance of an old landslide occurred at a very high speed over 2 minutes. There had been 175 houses built on small parcels of land (about 10 or more perches) and about 40 of those dwellings were levelled to the ground accounting for more than 60 human casualties. According to Prof. Dahanayake, the survivors had reported that one of the signs of the impending landslide was that there had been considerable movement of the area before the landslide occurred, but they had been unaware of its significance. Prof. Dahanayake further stressed that had the inmates of these houses been educated about warning signs such as cracking of walls, slits on mountainous areas, rolling of rocks, changes in the trees on the slopes etc, they might have been able to save their lives. However, it was emphasized that the exact dates and time of such a disaster cannot accurately be predicted. The Government is now taking measures to relocate families living in landslide prone areas.

Taking part in the discussion, G.H.P. Dharmaratne, Deputy Director of the Meteorology Department and G.B. Samarasinghe, Director, Weather Forecasting Division noted that weather forecasting can play a major role in minimizing the damage caused by such disasters.

However, they noted that quantitative rainfall forecasting is an extremely difficult task for meteorologists in the tropical countries and is still in the research and development stages but is being used as a guide in forecasting. Describing the recent disaster, he said that intense rainfall had taken place in areas where many rivers and streams originate. As a result, the collection points of those water paths had inundated. This he pointed out was what happened to major rivers like Nilwala, Walawe, Kalu, Ging, Bentota, and other tributaries.

This had resulted in many areas in the districts of Ratnapura, Kalutara, Galle, Matara, and Hambantota being flooded. Dharmaratne stated that there are two types of floods: river floods and flash floods. Ratnapura was affected by a culmination of both, while the other districts were mainly affected due to river floods. Due to the intensity of rainfall and other man-made factors, many of the slope areas already identified as vulnerable in the above districts and nearby, gave way to landslides.

At the Science Forum organized by the NSF and SLAAS, Prof. J.D.A.N. Jayakody, Dept. of Soil Science, Faculty of Agriculture, University of Peradeniya delivered a lecture on soil fertility and nutrient contamination of water in a hilly catena of Sri Lanka under intensive cropping.

He had presented his research findings at the 17th World Congress of Soil Science meeting held from 14 - 21 August 2002 in Bangkok. He stated that the central highlands of Sri Lanka are famous for intensive cultivation of vegetables where framers usually use fertizliers and manure exceeding the accepted recommendations. Hence, the residual amounts of Phosphorus (P) and Potassium (K) in soil are adequate for the next crop. Such overdoses promote constraints relating to soil degradation, environmental pollution, cost of production, and yield quality. Prof. Jayakody had carried out an assessment of soil fertility and water pollution of a catena (in Pattipola, Nuwara Eliya) intensively exploited for vegetables, with the objective of educating the community on the proper use of fertilizer/manure.

Prof. Jayakody's research demonstrates that soil fertility is improved under intensive cultivation with an increase in the easily approachable root zone. He emphasized that a reduction of P and K applications in the form of fertilizers is feasible as a result of accumulation. He further recommended that applications have to be reduced to protect water from nitrate pollution. According to the findings, it is worth considering the nutrient quantities in irrigation water in arriving at fertilizer recommendations. The necessity of liming and applying poultry manure is also confirmed for the improvement of fertility conditions. However, the loosening of the soil by land preparation aggravates soil erosion. Hence, erosion control measures are of prime importance. According to Prof. Jayakody, farmers need to be advised of the need to reduce their doses of fertilizer. The need to conduct soil tests prior to the application of fertilizers was also stressed.