

period, 280 deaths had been reported and 346 families (nearly 2100 persons) were destitute in Kegalle district only. The intensity of damage to the houses and other properties is related to the landslide types and the magnitude such as bedrock related materials (rock fall, rock block slide and rock slide), debris movement (debris fall, debris slide and debris flow) and earth movement (earth fall, earth slide and earth flow) where they occur. Bedrock related materials (debris and boulder) have been moved at Hettikanda (Himidunkanda) in Ratnapura district (Photo 1) and Berannewa in Kegalle district (Photo 2). As a consequence, 24 deaths occurred and paddy fields were covered by a rock block slide with earth flow at Bamba-ragala (Kegalle district) during the same period (Photo 3). Debris and earth movements have occurred at Ataluganlanda (Photo 4), Punugala, Minimaruwa, Gatemulla, Warawela, Malmaduwa, Makura (Kegalle district), Wewalagama and Dodamghaela (Kurunegala district). The slope movements in several places appeared as a combination of two or more types.

Natural hazards, for example flood, landslide and drought have incurred heavy economic and social service costs to provide food, clothing, medicine and temporary shelter. Material aid for victims are supplied by Government Agencies especially by the Social Services Department, Non-Governmental Organizations (Red Cross Society, Lions Club etc.), different Foreign Organizations and individuals. In many locations, where landslides had occurred in the Kegalle district, it was impossible to reach hazardous places either to protect lives or to provide food, medicine and other necessities due to the destruction of transportation routes made by rock slide, debris and earth flows as well by subsidence. Most of these areas

are rural and densely populated. Furthermore, they are concentrated in valley bottoms and surrounded by tea or rubber estates.

Evacuation of people from hazardous areas is another problem faced by the State due to lack of suitable land for resettlement. The Sri Lanka State Plantation Corporation (SLSPC) and Janata Estate Development Board (JEDB) have released marginal lands for resettlement. The destitute families are faced with problems such as insufficiency of land (20 or 40 perch for a family), infertility of the land, inadequacy of material or financial aid to build a shelter, lack of drinking water and transportation facilities.

The island of Sri Lanka which is situated in the Australia-Indian Plate is considered as stable. This landmass is made up of metamorphosed sedimentary rocks of Precambrian age (2000 m.y., Rb/Sr) and is similar to other Gondwana masses of the Indian Ocean (Crawford and Oliver, 1969). Several researchers have indicated the occurrence of high seismicity conditions for example, magnitudes of 7 or larger earthquakes, between Sri Lanka and Cocos Islands, Sri Lanka and Carisberd Ridge and along the Carisberg Ridge in the Indian Ocean (Stover, 1966; Banghar and Sykes, 1969; Sykes, 1970) which have had an impact movement of the landmass of Sri Lanka. Vitanage (1990) had reported that 53 earthquakes had occurred in Sri Lanka during the period between 1823 and 1976. This indicates that deeply weathered parent materials of high slopes can be shaken and moved downwards during periods of excessive rainfall.

Metamorphosed sedimentary rocks in the Central Hill Country of Sri Lanka contain a high proportion of feldspar and they are sometimes well jointed. These rocks weather into a reddish brown clayey material known as lithomarge which are embedded boulders of varying size (Cooray, 1967). When this weathered material is saturated with rain water, the iron-rich clayey material acts as a kind of lubricant causing the mass of earth and rock to move rapidly down the slope under the force of gravity. If there is no vegetation cover to bind and hold this material together it takes the form of rock slide, debris slides and earth flow. Similar actions frequently occur around newly constructed reservoirs such as Victoria, Kotmale, Rantamb, Randenigala etc. and tunnel areas in the Hill Country. Infiltration of water along the joints or natural tunnels of crystalline limestone areas have increased the landslide problem in the hilly lands. Besides, the parent rocks of the area blasted by dynamite or other heavy explosives for construction of new roads e.g., Kandy-Mahiyangana road has shaken the highly weathered surfaces of steep areas. Such surfaces are prone to downward movement during heavy rains.

The land policies in Sri Lanka adopted by the Colonial Government and later by National Governments since Independence can be cited as the major reason for the present problem of landslides (Madduma Bandara, 1988). Before the advent of plantation agriculture, most part of the hilly slopes remained under a canopy of tropical montane forests. Under the Land Ordinance of 1840, the Colonial administration forcibly acquired the lands used by the peasants, for plantation agriculture. Before this, the human habitation was largely concentrated in the valley bottoms where the staple food, rice, had been grown with water tapped from natural streams, and

occasionally, the hilly slopes had been used for chena (shifting) cultivation. The absence of human habitation on steep slopes of the head streams often minimized the damage to life and kept the balance of nature during the pre-colonial times. After the beginning of plantation agriculture by the British, the tropical mountain forests were cleared and set on fire. Tea and rubber plantations were introduced to those areas, and this broke the structural bond between natural vegetation cover and earth materials. Since then, the occurrence of landslides has increased in proportion to the rate of clearance of forest cover in the hilly areas. Legislations for controlling and management of those forest lands as well as soil, water, air and land were passed during the Colonial Government and later by the National Governments, but they have not been enforced (Karunanayake and Katupotha, 1990).

The population in the villages of the Hill Country has increased gradually and land deficiency has become a national problem. The imbalance in man/land ratio, due to the pressure of population on land has caused the dense forests and reservations in the steeper slopes to be utilized for chena cultivation (for subsidiary food crops), tobacco and plantation crops such as rubber, tea and potato by small-holders and land-less people. As a result, the natural forest cover was reduced further. Besides, the patches of Patanas (grassland) along the steep slopes and peaks have been set on fire to clear the land for chena cultivation, to collect medicinal herbs and bees honey, for cattle grazing and at other times Patanas have been set on fire for no apparent reason. All this resulted in an increase of landslide and soil erosion due to the drying up of springs, soil and breaking

up of the relationship between parent rock and weathered materials of the upper surface. It has contributed to the destabilization of slopes leading to landslides in prone areas.

Over exploitation of forest reservations and other Government lands in intermediate and upper slopes due to illicit felling of timber, cultivation, construction of houses, reservoirs and tunnels have destroyed the strong bond between parent rock and soil in these areas. This has resulted in the heavy run-off of rainfall, floods, soil erosion and landslides. Similarly, tunneling and pumping out of water from gem mines have led to subsidence of land and slope instability. Furthermore, inefficient and uncontrolled drainage under plantations, uprooting of tea and rubber plantation of upper slopes evidently increased the number of landslides (Karunanayake and Katupotha, 1990). Those features are most common on dip slopes in poorly consolidated weathered material lying as a thick cover above solid, unweathered rock, or in steep talus or scree slopes lying at the foot of escarpments and cliffs in the Kegalle, Ratnapura and Kalutara districts.

The intensity of environmental degradation by landslides have increased due to the unplanned investigations of geological structure, increased constructional activities, short-sighted land policies of the Government and over exploitation of natural forest resources. Therefore, several options are needed urgently to protect hazard prone areas and to remove the evacuees from high risk areas. In order to counter the threat posed by landslides, a District Steering Committee and Divisional Committee have been formed in the Sabaragamuwa Province (Kegalle and Ratnapura districts)

to coordinate action on landslide. For this purpose, technical advice and information is supplied by the Geological Survey Department and National Building Research Organization. Karunanayake and Katupotha (1990) recommended following conservation measures either singly or in combination: reforestation and reafforestation; preventing haphazard forest clearance; monitoring of 'suspect' areas; grading of steep slopes; providing contour drains; terracing and non utilization of landslide affected slopes either for human settlement or agriculture. Karunanayake and Katupotha (1990) pointed out that the adoption of long-term strategies for hazard management is constrained by several factors, such as a) basic drawback is the absence of a landslide preparedness plan within the context of an overall district natural disaster preparedness strategy; b) technical advice on the conservation of landslide prone areas is inadequate and given the paucity of funds, the implementation of conservation measures is made extremely difficult; and c) lack of inter-agency (district administration, JEDB, line departments and NGO's) coordination is another limiting factor.

For resettlement of evacuees following options have to be considered: (1) resettle the evacuees in the areas around their homeland where suitable land is available. This is very important, because many evacuees are unwilling to leave their traditional homelands and relatives. Land for homes and agricultural settlements for this purpose can be obtained from SLSPC, JEDB and acquired private lands in the neighbouring areas. Sometimes the evacuees could be absorbed into surrounding estates as employees; (2) relocating them in downstream areas of the Mahaweli Development Project and absorbing them into present agriculture. Therefore, it is necessary to provide reasonable quantity of land, for example, about 1.5 or 2.0 ha. for

a family to grow seasonal crops (chillies, onion and leguminous crops), annual crops (sugar cane) and animal husbandry. Moreover, the imbalances in the man/land ratio due to the increasing of population, the poverty of the people, vocational and educational background of the younger generation should also be taken into consideration.

Conclusion

The incidence of landslides in Sri Lanka has shown a two or three year cyclic occurrence over the past ten years. About 1324 families were rendered destitute and the lives of 318 persons were sacrificed by this catastrophic event. Under the Land Ordinance of 1840, the Colonial administration expanded plantation agriculture in the uplands and highlands which created a situation favourable to present problem of landslide. This increased gradually due to unplanned investigation of the geological structure, short-sighted land policies, village expansion programmes and over exploitation of the natural forest resources in the area.

There is no National Action Plan for landslide hazard mitigation in Sri Lanka. Although, the Government, non-Governmental Agencies and individuals supply different types of material and financial assistance to provide food, medicine, temporary shelter for the victims and to reconstruct the infrastructure of the damaged areas when hazards occur. Furthermore, the Government encourages resettlement and relocation but due to lack of suitable lands for agricultural settlements, insufficient quantity and their infertility, unwillingness of the evacuees to leave their traditional homeland and relatives still remain unsolved problems. Therefore, it is necessary to consider rural poverty, vocational and educational background

for resettlement and relocation of the evacuees from hazardous areas. Besides, detailed geological investigation of all intermediate and high slope areas should be undertaken for evacuation of people to protect and conserve the prone areas from future hazards.

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