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THE LANDSLIDE HAZARDS AND THEIR IMPACT ON ENVIRONMENT AND SOCIETY: THE EXPERIENCE OF SRI LANKA

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Abstract

Nine-tenth of the land-mass of Sri Lanka is made up of metamorphosed sedimentary rocks of Precambrian age. They are predominately granulite facies rocks and extend throughout the Central Highland, Knuckles massif and Rakwana massif. The incidence of landslides in the western flanks of these areas is due to a combination of several physical and human factors such as tophography, geological structure, excessive rainfall, man's activities and marginal effects of earthquakes in the Indian Ocean.

The occurrence of landslides has increased over the past ten years along the western flanks of Sri Lanka causing 318 deaths and the destruction of 1324 families. The intensity of damages to the houses and other properties is related to the landslide type and its magnitude. Heavy economic and rehabilitation costs are incurred in providing food, clothing, medicine and temporary shelter and in the reconstituting of infrastructures. The present problem of landslides is the result of land policies adopted by the Colonial administration and later by National Governments after Sri Lanka gained Independence. Furthermore, the intensity of environmental degradation and damage to society has increased recently, because the authorities had ignored the investigations of geological structure when undertaking different types of constructional activities, short-sighted land policies and the over exploitation of the natural forest resources in the uplands and highlands of the country.

Introduction

Landslides is a down slope gravitional movement of rock, residual soil or artificial fill failure adjoining a slope. The motion may be either that of a slide, flow or fall, acting singly or together (Simonett, 1968). Landslide may be induced either by natural agencies such as excessive rainfall and earthquakes or by human interference with slope stability. Due to extreme rainfall intensities over a short period of time, the downslope gravitational movement of rocks or earth damage the natural environment, life and property.

The incidence of landslides in Sri Lanka has increased over the past ten years in the landslide-prone areas of Kegalle, Ratnapura, Kalutara, Kandy, Matale, Nuwara Eliya and Badulla districts due to human interference such as agricultural practices, construction of reservoirs, mining of a) crystalline limestone along the steeper slopes and b) gems in valley bottoms and gentle slopes. Landslides which occurred during the heavy southwest monsoon rains between 29 May and 5 June 1989, caused 318 deaths. The intensity of damages to the houses, other properties and to the environment is related to the landslide types and its magnitude, for example slide, flow or fall of rock, debris materials or soil. Heavy economic and social service costs are incurred specially in providing food, clothing, medicine, temporary shelter, evacuation of people to safe places and reconstituting of infrastructures. Material aid for landslide victims is supplied by the Government Agencies such as the Social Services Department, Non-Governmental Organizations, different Foreign Organizations and individuals. This paper attempts to identify the factors responsible for landslides and their impact on society and the environment. Furthermore, the author aims to

recommend remedial measures to protect the landslide areas and to prevent landslide hazards.

The landslide prone areas along the western flanks and Central Hill Country of Sri Lanka has been identified and a map drawn (Fig. 2) based on tophographic sheets (1:63,360) supplemented by field investigations. Data on landslide victims and the damages to property and the environment has been collected from Divisional Secretariat Offices in each district. Discussions were held with the personnel in District Land Offices and continuous discussions were carried out with the landslide victims and others in the surrounding areas. Field investigations to examine the damage caused by landslides and to assess the impact of human interference in landslide prone areas were undertaken during the months between January and mid May in 1991.*

Study area

The study area extends along the western flanks of the Central Hill Country, the Knuckles Massif and the Rakwana Massif (Fig. 1 & 2). Physiographically the whole area ranges between 30m and 2200m altitude, and consists of uplands and highlands. The elevation of uplands varies from 270 to 1060m, and is composed of 'ridge and valley' topography and highly dissected plateau with narrow 'arenas', 'amphitheatres' and domes (Vitanage, 1972). The average slope varies from 10° to 35° along the upland ridges, but well-developed steep scarps are commonly found in

* Field investigations were carried out under the Research Project RG/89/E/03 sponsored by the Natural Resources, Energy and Science Authority of Sri Lanka.

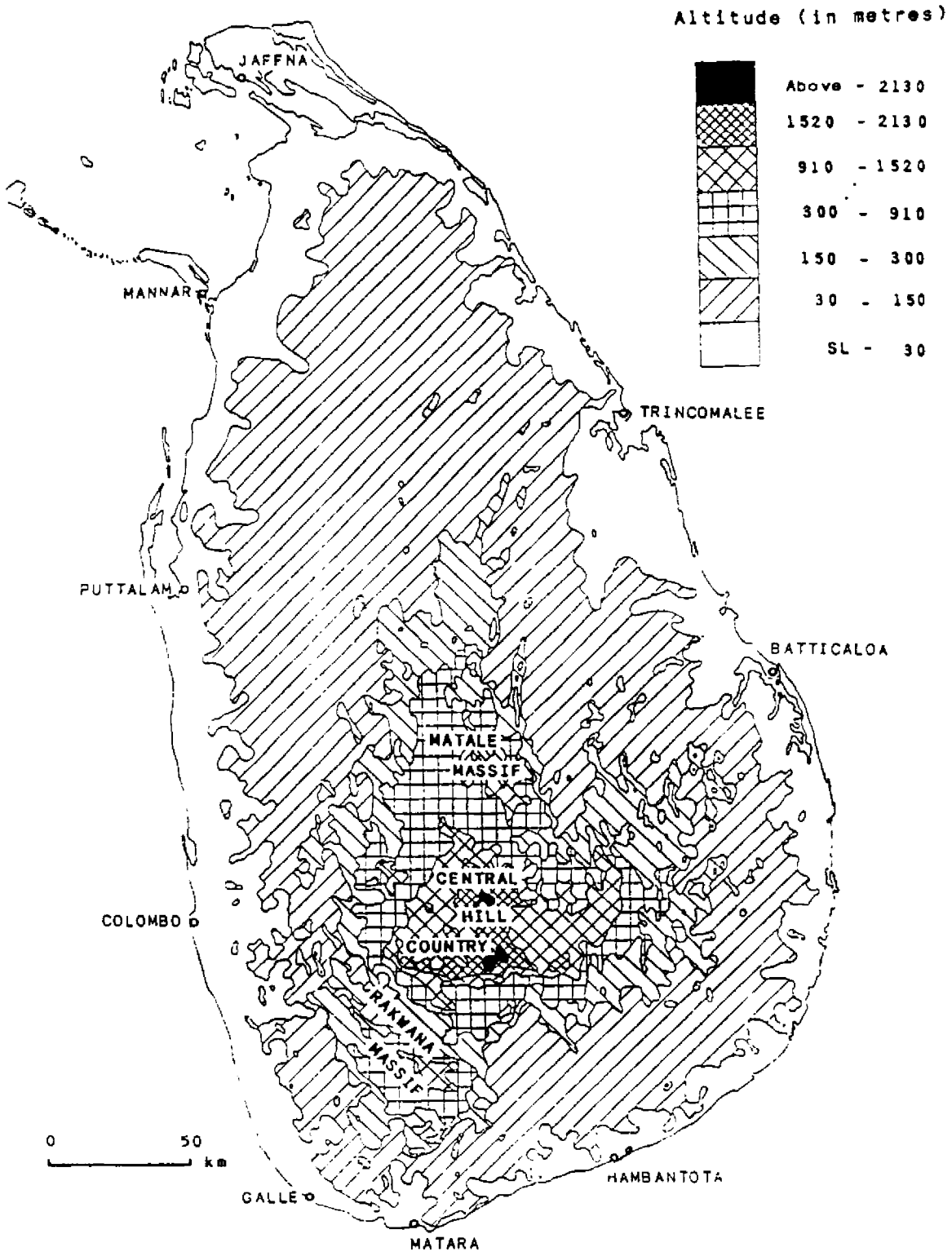

Fig. 1. Generalized physiographic map of Sri Lanka.

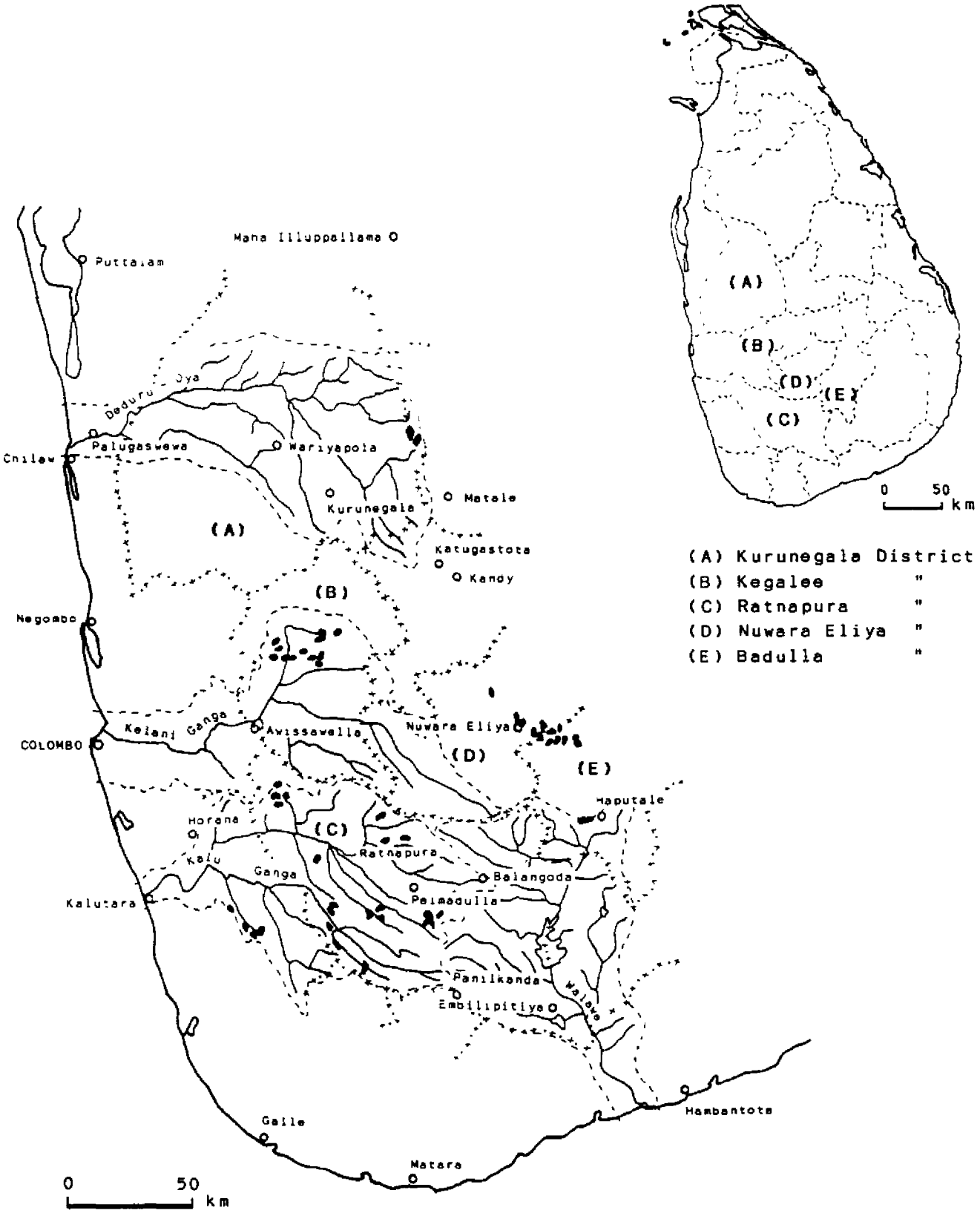

Fig. 2. Landslide prone areas along the western flanks and the Central Hill Country of Sri Lanka.

Matale, Kandy, Kegalle and Ratnapura areas. The central part of Sri Lanka is characterized by a series of well-defined high plains and plateaus rimmed by mountain peaks and ridges with elevations between 910m to 2420m. In many places steep escarpments and deep valleys have appeared, the Knuckles massif (2035m) and the Rakwana massif (1490m) are detached highlands separated from the main Central Hill Country proper by deeply eroded intermontain valleys.

The deep valleys of the Knuckles massif and northwestern part of the Central Hill Country have been carved out by the head streams of the Deduru Oya (river), while the whole Rakwana Massif and the southwestern Central Hill Country have been eroded by the head streams of the Kalu Ganga and the Walawe Ganga. Likewise, the head streams of the Maha Oya and the Mahaweli Ganga flow carving out highly eroded narrow and deep vallyes. The rainfall stations in each river basin show two maximum seasons (Table 1) during the southwest monsoon (May-September) and convectional-cyclonic-depression (October-November).

Result and discussion

Landslide prone areas along the western flanks and the Central Hill Country are shown in Fig. 2. It is evident that slope movements have been concentrated in the Kegalle and Ratnapura districts. The incidence of landslides which had increased in 1983/84, 1986 and 1989 caused 318 deaths and the loss of property and livelihood of 1324 families (Table 2).

Excessive rains between 29 May and 5 June 1989 caused damage to 40 villages in Kegalle and 56 villages in Ratnapura districts. During this

Table 1. Monthly mean rainfall in each selected river basins in 1989

River Basin	Rainfall Station	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Kurunegala	112.7	2.6	34.2	325.2	122.7	361.3	186.2	36.1	110.2	385.6	381.6	6.0	2064.4
	Matale	277.5	0.0	50.1	105.8	97.9	189.8	329.1	89.6	147.4	335.0	597.3	15.6	2235.1
	Mahaillppllama	72.6	2.9	108.5	106.8	36.7	22.3	163.8	*	28.3	28.3	364.2	27.1	961.5
Deduru	Wariyapola	74.8	0.0	8.0	90.0	62.1	114.6	216.6	*	70.7	281.5	332.9	*	1251.2
Oya	Palugaswewa	19.3	0.0	21.3	144.3	12.2	91.4	248.0	*	34.8	229.9	205.0	23.6	1029.8
	Dodangaslanda	146.5	1.8	50.8	100.8	36.6	122.9	199.4	87.6	101.3	349.5	418.3	16.8	1632.1
	Puttalama	25.7	0.0	19.6	237.0	71.1	43.5	12.7	0.0	16.0	213.1	339.3	100.6	1178.6
	Kandy	110.6	14.3	40.3	77.5	179.2	240.3	207.4	146.8	187.8	262.2	342.0	39.1	1847.5
	NuwaraEliya	134.9	22.9	58.9	70.3	273.4	201.8	530.6	144.5	217.1	270.2	228.0	95.8	2248.4
Kelani	Katugastota	102.4	15.9	62.7	121.7	77.2	225.5	255.3	149.2	150.0	273.6	391.1	23.8	1848.4
Ganga	Ambanpitiya	54.2	0.0	91.6.	175.7	259.6	354.7	295.0	90.5	137.8	196.6	155.7	*	1467.1
	Awissawella	110.0	0.0	99.6	372.3	361.4	355.2	423.1	79.6	310.3	439.3	403.0	116.1	3070.3
	Colombo	35.1	6.0	146.3	332.9	399.1	217.2	138.2	49.1	174.5	45.4	284.7	31.5	1860.0
	Ratnapura	47.5	7.8	123.3	257.1	405.9	632.2	610.9	282.7	448.7	500.4	320.0	97.4	3733.9
	Balangoda	25.4	0.0	158.2	310.7	185.0	162.3	283.0	77.0	49.1	320.0	396.4	72.1	1968.2
Kalu	Pelmadulla	75.0	21.3	7.3	122.1	107.9	303.4	260.6	10.1	81.2	280.0	273.0	5.2	1547.1
Ganga	Panilkanda	61.5	28.0	172.3	240.5	256.2	316.2	504.9	211.0	*	*	*	*	1770.5
	Horana	89.7	2.5	51.6	349.8	554.2	446.8	301.6	131.7	458.0	360.0	412.4	115.4	3253.7
	Kalutara	19.1	26.7	44.2	484.1	426.9	259.3	264.4	71.5	288.6	369.8	387.0	147.1	2788.7
	Haputale	102.5	51.0	81.0	250.5	272.0	55.0	212.0	103.5	176.0	264.0	196.0	119.0	1882.5
Walawe	Ambilipitiya	51.7	7.7	53.0	126.7	102.1	59.6	228.0	27.1	74.5	105.9	120.4	48.3	1005.5
Ganga	St. Lenard	*	*	80.0	165.0	396.0	185.0	432.0	260.0	40.0	511.0	293.0	124.0	2686.0
	Hambantota	135.7	48.0	40.8	28.9	63.4	24.0	146.8	96.5	25.0	69.3	123.1	24.4	825.9

* Data Not Available

Source: Reports of the Colombo Observatory, Sri Lanka.

Table 2. Number of destitute families affected by Landslides between 1983 and 1990 in Sri Lanka

District	Destitute Families	Number of Deaths
Kegalle	346	280
Kandy	40	-
Matale	275	14
Kurunegala	25	3
Badulla	562	5
Ratnapura	76	16
Total	1324	318

Source: Field investigations and unpublished data from District Land Offices.

Photo 2. Rock flows at Berennewa in Kegalle District.

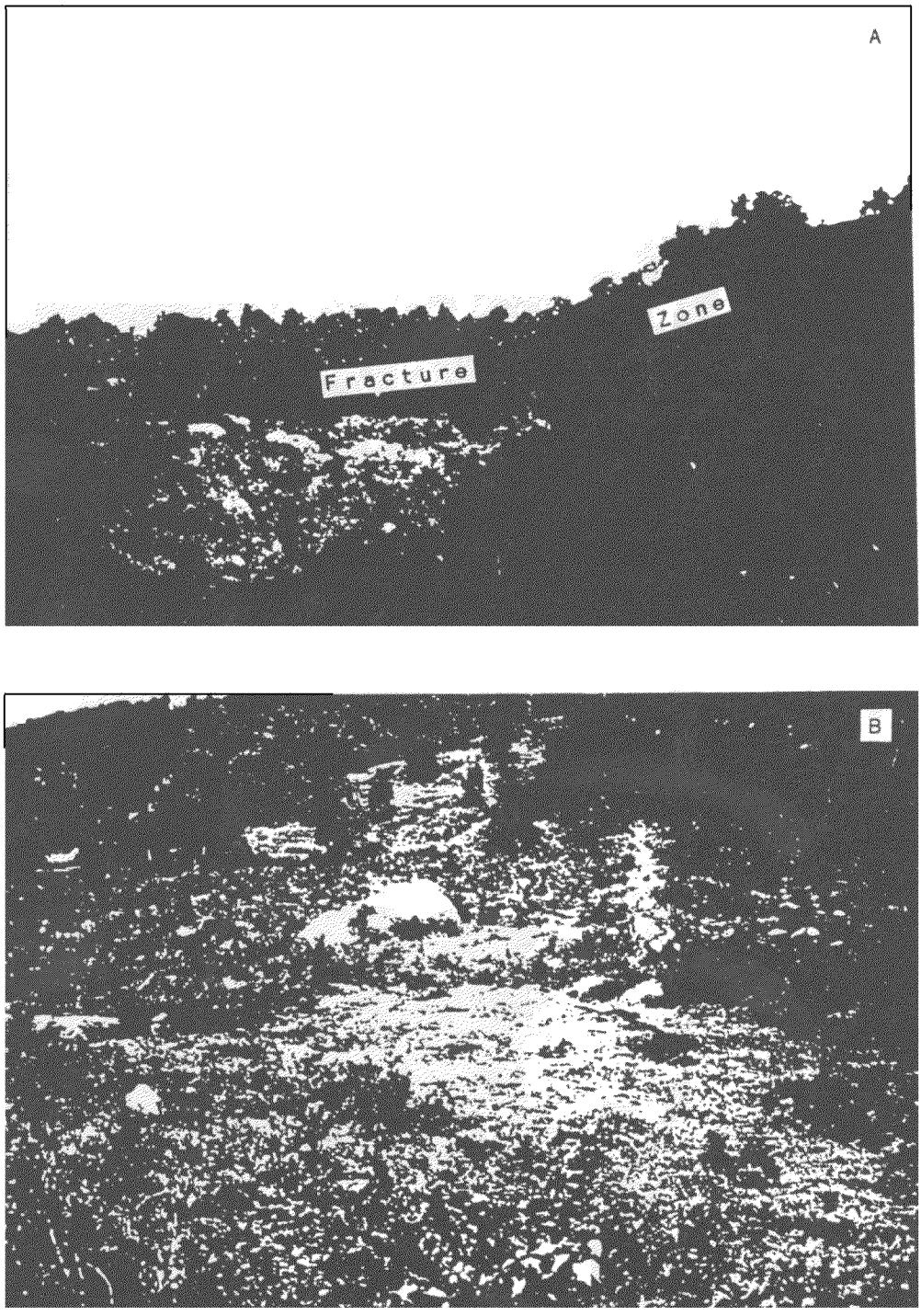

Photo 3. Earth and rock flow at Bambaragala (Kegalle District). Six houses were buried and twenty four deaths had occurred as a result of this earth movement. Fracture zone indicates that the next movement will be accelerated by excessive rainfall.

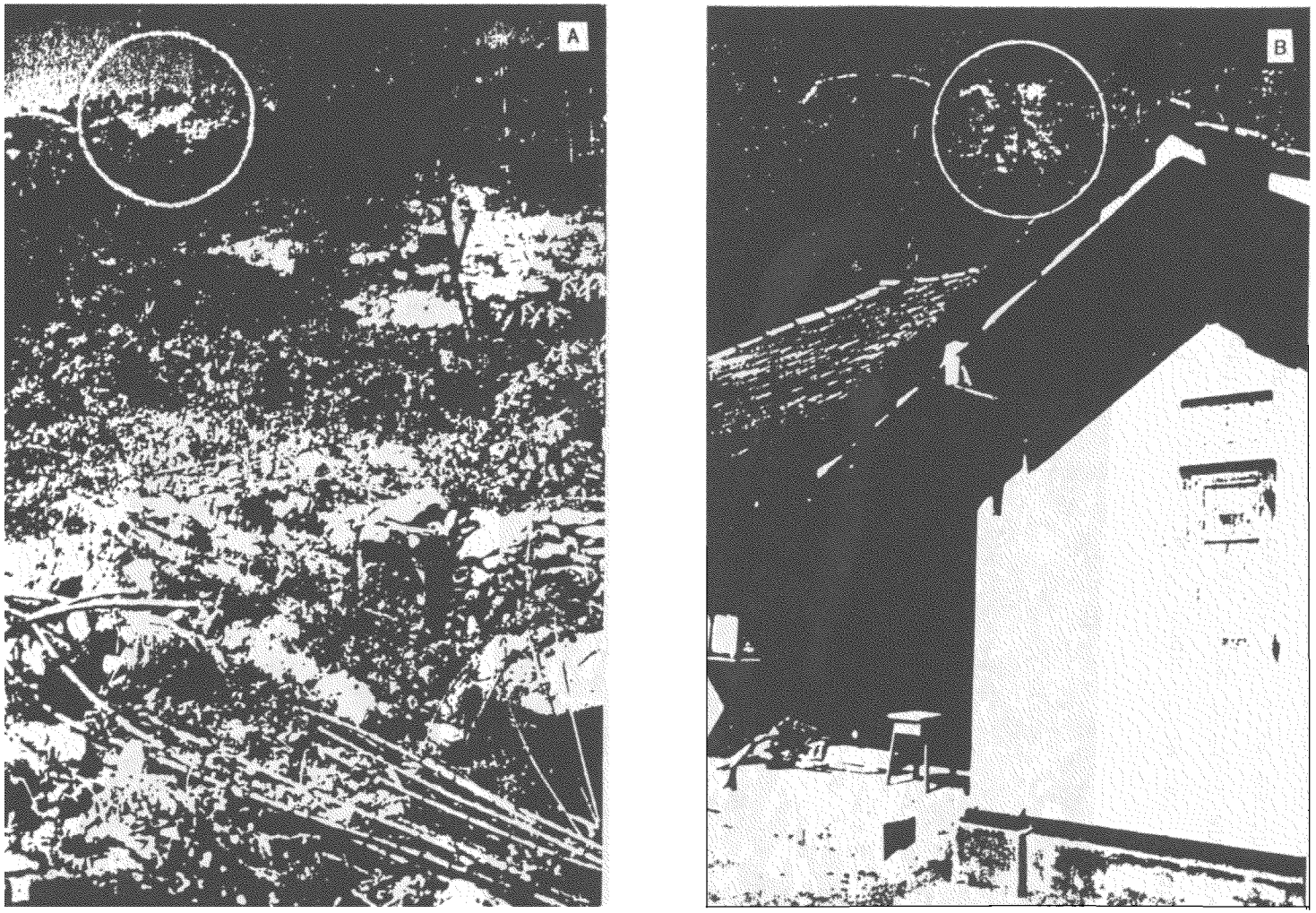

Photo 4. (A) The debris flow at Atalugankanda (Kegalle District). Encircled area shows that earth and rock have flowed from top of the ridge. (B) Future falls will threaten the houses at the foot of the ridge.

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 Bambaragala (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 disreict). 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 litho-marge 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, debri slides and earth flow. Similar actions frequently occur around newly constructed reservoirs such as Victoria, Kotmale, Rantambe, 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 landlides 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: reforestration and reafforestration; 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 considration.

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 catastropic 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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