INTEGRATED ENVIRONMENTAL EMERGENCY RESPONSE STAGE IN NATURAL DISASTER PREPAREDNESS - LANDSLIDES

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Keywords: Roads, Landslides, Emergency Response, Mitigation, Disaster Management, Integrated Environmental Management, Natural Disaster Preparedness

Abstract
Natural slope instability is one of the major scientific concerns in the World today. Outcomes such as disintegration of soil structure, flows, depositions, damages to dwellings, loss of human life, generation of toxicity, contamination and pollution will always threaten the environment. The speed and the manner, the responses systems evolve have a critical impact on performance in the search and rescue operations. However, today's concern and the growing demand for the development of multidisciplinary & integrated mechanism which improves ecosystem stability is the most significant concern of the development of an integrated environmental emergency response stage of natural disaster preparedness – landslides.

1. Introduction
Natural disaster observations are always interconnected to the environment and the geotechnics. Societies vulnerable to natural disaster risk, severe landslides represent situations similar to civilians war resulting a massive shock to the entire technical, organizational, economic, political, and social system. The manner in which the complex, social - ecological system responds to this shock provides valuable insight into further evolution of subsequent phases of performance, and actions to prevent recurrence.

Performance of rescue work within the first hours after a major disaster is of paramount importance. The paper pinpoints landslide disaster issue. In landslide most instants ad hoc decisions taken just after the event had marginally managed emergency crisis with out respecting the environmental disciplines.

2. Landslides Dynamics
Landslides are commonly recognized as downward and outward movements of earth mass as described in the Table 1. The combination of steep terrain, fine grained and deeply weathered bedrock and the occurrence of moderate to extreme rainfall events favors episodic soil erosion or landslides, often during major floods and heavy rainfall.

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Table 1: Geomorphologic Disaster Proven Risk Elements in Landslides

Type of Movement	**Type of Material in Fall, Flow or Deposited**		
	Bed Rock	**Debries (coarse soil particles)**	**Earth (fine Soil, soil water mixd)**
Fall	Rock fall	Debries fall	Earth fall
Topples	Rock topple	Debries topple	Earth topple
Rotational Slides	Rock slump	Debries slump	Earth slump
Translational Slides	Rock block slide Rock slide	Debries slide	Earth slide
Spreads	Rock spread	Debried spread	Earth lateral spread
Flows	Beadock flow	Debries flow Debries avalanche Block stream Soil creep	Wet sand flow Rapid earth flow Earth flow Dry earh flow(sand & fines)
Complex	Composite failures in rock including topple, fall and slump etc.	Slump and earth flow	Composite failures in soils including fall and sliding etc.

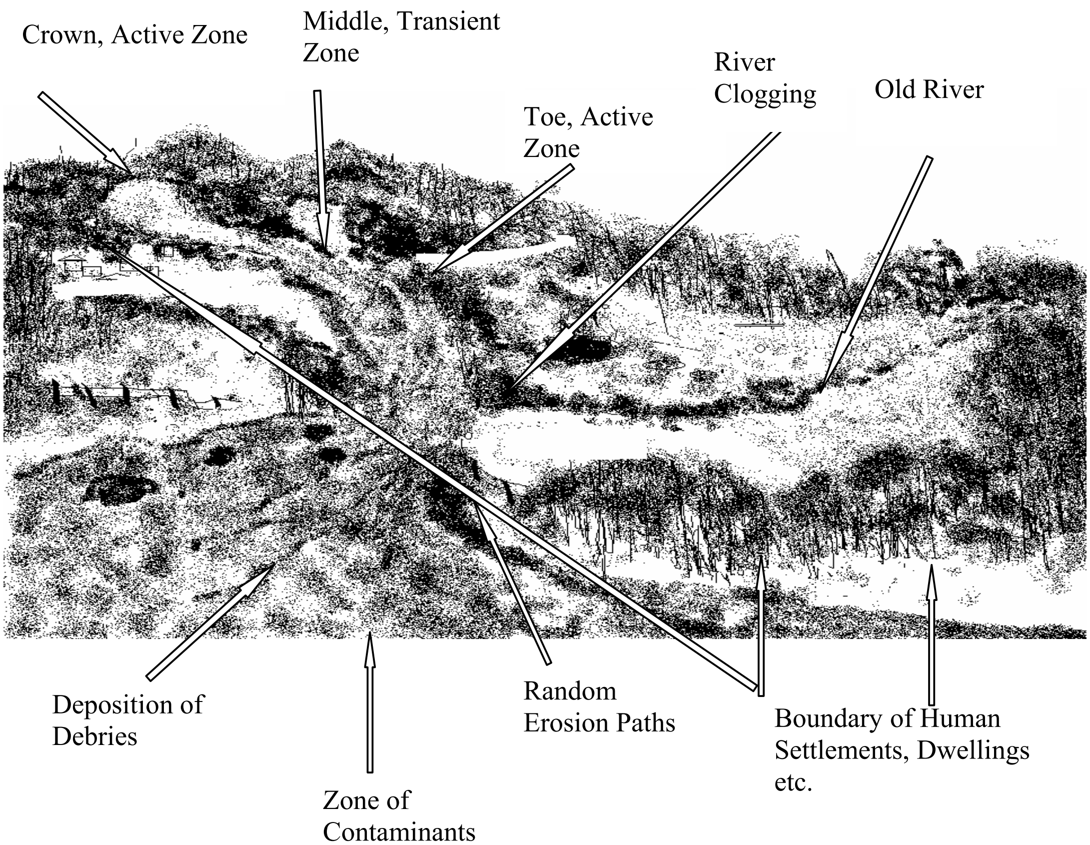
Therefore, two types of landslides, categorized according to its motion such as rapid landslides and slow moving landslides respectively can be recognized. Rapid landslides are; debris flows, debris avalanches, rock falls and rock avalanches. Furthermore in some cases, toppling can initiate a brittle catastrophic rockslide. Some continues to exhibit intermittent, relatively slow deformations with limited mobility.

Under certain complex conditions some of these landslides may suddenly develop into a catastrophic failures with extremely rapid flow slides consisting of various combination of soils and rock. These may dam large rivers in the course of a few minutes and projecting waves onto the opposite bank propergating subsequent failures as well. Typical example of such a failure was recorded at Ocdagala mountain range, Mandaramnuwara, Sri Lanka in 1986.

3. Potential Instability & Emergency Indicators

Many emergency response stages are designed to ensure careful response in small-scale emergencies. Response systems in most major disasters, such as an earthquake and landslide, are overwhelmed and tenuous. The various disaster records of landslides and earthquake reveal a startling drop in the proportion of persons who lived after being rescued from collapsed earth mass or buildings. And, usually underscore the critical issues of timeliness in emergency response. Therefore, knowledge on more accurate predication of potential instability of earth mass and the emergency indicators are quit important in natural disaster preparedness in landslides.

Fig 2: Schematic Representation of a Landslide Disaster



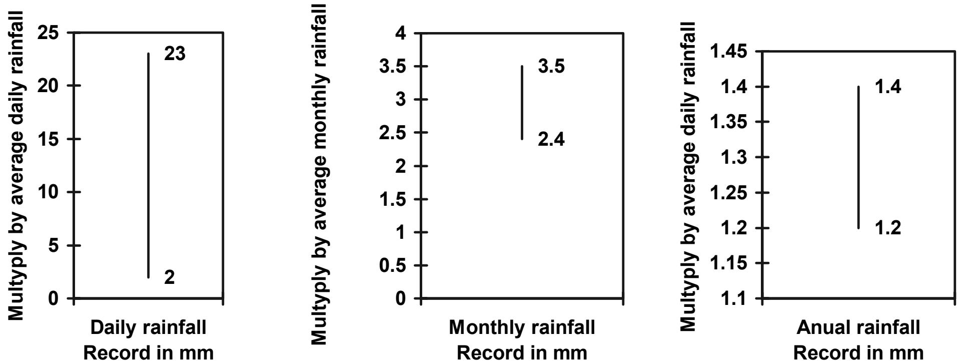
4. Preliminary Indicators- Integrated Landslide Hazard Zonal Maps

Interplaying of several factors such as geomorphology, sub surface geology, overburdened deposits, rainfall, ground water hydrology, landform and landuse pattern etc remarkably modulates landslide dynamics. The landslide history of the area may deal a key role of the evaluation of potential risk or vulnerability. Since, the advantage of collective knowledge of state of nature data, systematic and scientific integration of the above finding create an integrated landslide hazard zonal map as a preliminary emergency indicator of the landslide dynamics. These indicators can be recognized as planner's level of response indicator.

5. Hydrological Indicator - Rainfall

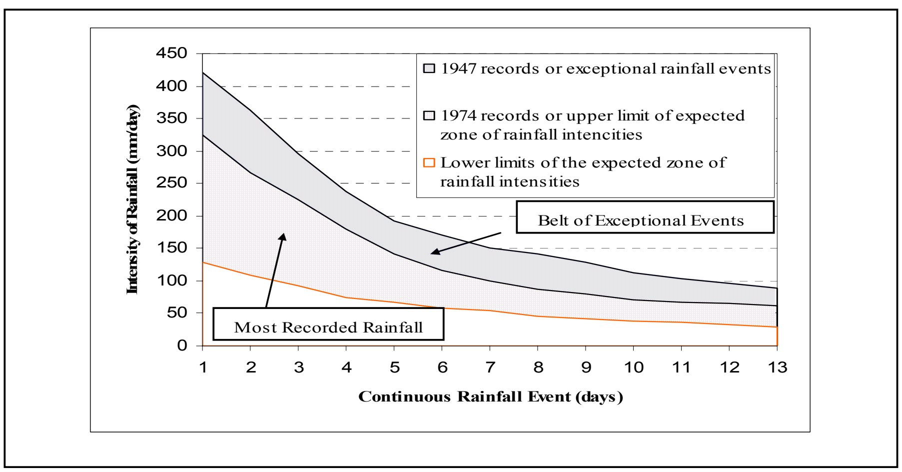
Most of the landslides investigated to date are known to be rain triggered, seismic triggered or both. Analysis of rainfall records of a very large number of Sri Lankan landslides conveys that 24-hour rainfall associated with a landslide event was generally 2 to 23 times higher than the average daily rainfall of that location, Bhandari, R K, & Dias, A A V (1996, ISL, Norway). The month in which a particular landslide event fell attracted 2.4 to 3.5 times the average monthly rainfall, and the annual rainfall in the year of a landslide event was found to be 1.2 to 1.4 times higher than the annual rainfall average.

Fig 2: Representation of hydrological indicators of early response at the event of landslide disaster records in Sri Lankan Landslides.



Studies on the past occurrence of landslides in the hill districts of Sri Lanka study yielded the conclusions that if the cumulative rainfall on three consecutive days exceeds 200mm and if the rains are found to be continue the probability of landslides occurrence should be considered high, Bhandari, R K ., Senanayake, K S., Thayalan, N (1992).

Fig 3: Intensity of Rainfall per day for continuous rainfall days at the Watawala Landslide Sri Lanka for years 1947 to 1993 (Bhandari,.Dias..et.al, 1996, Norway)



6. Geotechnical Evidences & Indicators

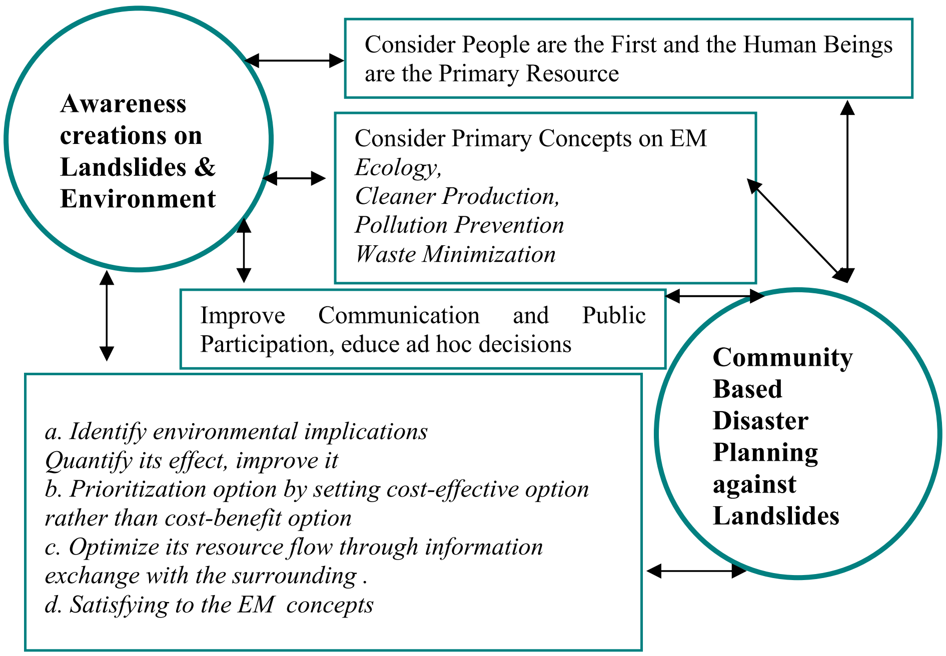
A landslide often indicates very large number of macro and micro features which if studied in detailed, would enhance our understanding of initiation, development, rotation and eventually transforming mechanism into well defined cracks oblique to the boundary shears, at its maturity. All internal deformations, compression or separation forces of sliding mass are widely recognized as activating forces. Those activating forces finally form surface indicators and the process continues in nature. Various cross bedding, deformations, cracking, leaching, shearing, subsidence, upheavals and associated events reflect a collective story of the instability.

Direct measurements have shown that when a slope tends to fail, it generate a set of stress waves of sub audible level, audible level, usually called acoustic emission that can be sensed by a suitable transducer. The experimental studies have revealed that from a stable slope, acoustic emission counts are low and usually decay with the passage of time. If the slope is steep or high, the acoustic emission count tends to rise, shooting up to a high value at failure.

7. Environmental Management Strategy

The environmental law declares "the continuous improvement of process, product or services to reduce the use of natural resources, to prevent pollution at its source, to reduce the volume and toxicity of generated waste and consequently reduce the human and the environment". Therefore, ecological stability, pollution prevention, cleaner production and waste minimization acts as the goal or objective for disaster mitigation planning measures and improves environmental performances.

Fig 4: Environmental Management Concepts which are applicable to Natural Disaster Mitigation – Landslides (TIEMS – 2002)



Integrated environmental management concept primarily declares the strongest link between the ecological stability of the community and the various engineering solutions to the known problem. This deals various crucial and environmental issues which arise during a natural disaster such as damages to soil flora and fauna, damage to oil storages, gas storages, chemical production storages, domestic and industrial wastes, drinking water, loss of soil $P_{H,,}$ accumulated debries, depositions, etc.

Table 2 : Primary Environmental Management Practices in Emergency Response Stage in Landslide Disaster Event

LANDSLIDES	Environmental Management Concepts / Practices			
	Ecological Stability	***Clener Production***	***Pollution Prevention***	***Waste Minimisation***
Aims	Promote sustainability	Waste minimisation	Reduced risk to humans and the environment	Reduction of quality or toxity of hazadius wastes
Focus	Minimise the speding of environmental threat after the event	any industrial factories, hospital wastes within the landslide vulnerable areas and focus on protection in an emergency	Chemical storages, petroleum storages, fertilizer storages within the landslide vulnerable areas and focus on protection in an emergency	Individuals, industrial etc.

8. Environmental Emergency Indices in Landslides

The environmental emergency indices in landslides recognized through combinations of physical structures and shortfalls in community preparedness for disaster management in hilly regions of a country. Those are,

Physical factors

- Above Ground Storage of Petroleum, Gases, Chemical etc.
- Below Ground Storage Wastewater, Waste disposal yards etc.
- Water Storage Reservoirs at high or lower elevations
- Large Reservoir Impounding, Tanks etc.

Shortfalls in community preparedness for disaster management

- Unplanned Community Developments in hilly regions
- Unplanned Roads and Infrastructures network in hilly regions
- Lack of early warning indicators within the hazard zones
- Lack of Awareness of Landslide and its Victims
- Lack of Community Participatory Oriented Social applications

9. Environmental Emergency Responses

The purpose of the study, environmental emergency response in landslides, is to protect public health and the environment from damage caused by accidental discharges, spills, leaks, and other releases of hazardous substances and subsequent contaminations, debries depositions etc during an landslide disaster event.

Landslides event involving a spread or spill of earth debries that may be small or large in quantity defines scale of incident.

A small incident is one that meets all of the following conditions

- Contaminant, substances / material condition and potential hazards are known.
- Contaminant, substances / material presents no actual or potential threat to human health or the environment.
- Incident results in nothing more serious than a minor pollution requiring simple mechanism for removing or further pollutions.
- No emissions of gases, fire or electric earth inning due to primary failure

A large incident is one that meets any of the following conditions

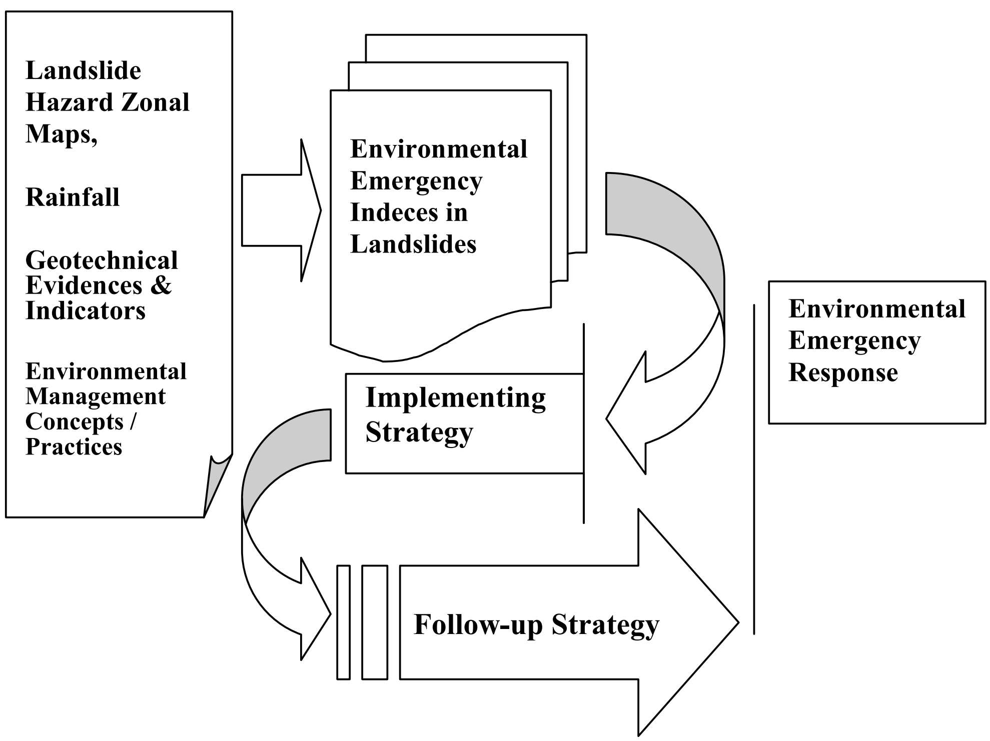
- Contaminant, substances / material unfamiliar to personnel.

- Contaminant, substances / material that cannot be identified.
- Contaminant, substances / material migrates into a storm drain or sewer.
- An incident that is regarded by personnel as unsafe to manage without the aid of the rescue operations
- Significant amounts of emissions of gases, fire, water flooding etc. due to primary failure and its increasing tendency
- Pollution environment more closer to sensitive environmental receptors such as human settlement or within it

10. Integrated Environmental Emergency Response Stage

Landslides can and do happen in the hilly regions of any country, if it meets most vulnerable conditions as above. Therefore, effective communication is essential to enable authorities to take prompt measures and to provide reliable information to the public at large in order to minimize the environmental disaster. Therefore, this study can address the consequences of landslide event, save lives, and protect the environment. Therefore, this provides dedicated space, lives, and resources towards developing a comprehensive emergency response system called integrated environmental emergency response stage as in Fig 5, shown below.

Fig 5: Integrated Environmental Emergency Response Stage



11. Response Planning & Management

These strategies delegate control over planning activities to state and local agencies or community participatory organizations (government or non government). Their overall objective is to limit potential damage to the greatest extent possible through advanced planning and appropriate environmental emergency response.

One of the more important aspects of the environmental emergency planning process is the identification of specific facilities with any potential risks for unplanned releases and their consequent impacts to the public health or environment. This process typically includes the following:

- Developing a comprehensive inventory of landslide hazardous areas, materials, events, and accessibility & communication facilities at a specified area.
- Establishing an environmental emergency response protocol, notification procedures, specific responsibilities, and training guidelines for all appropriate agencies and personnel.
- Inventorying the types and condition of process or storage equipment, tanks, containers, or transportation equipment.
- Ensuring ongoing evaluation and training of workers in proper rescuer operations, hazardous material management and handling operations.
- Identifying adequate equipment, personnel, and other resources available for timely, appropriate environmental emergency response and protection of public health.
- Creating reasonable accident scenarios used in training exercises.

12 Recommended Follow-up Procedures

The following procedures shall be followed appropriate to the level of the incident and environmental emergency.

- Regional Water Quality Control
- Identification & Listing of Hazardous Waste, Storages etc.
- Underground Tank Regulations for Oil Storing, Waste water
- Oil Pollution Prevention against Ground Instability
- Maximum Contaminate Levels of Disposal Systems
- Interim Status Standards for Owners & Operators of Hazardous Waste Treatment, Storage & Disposal Facilities
- Response to leaks or Spills and Disposition of Leaking or unfit-for-use Tank Systems
- Emergency Planning and Notification Practices
- Comprehensive Emergency Management System
- Pollution Prevention and Waste Minimization
- Radiation Protection of the Public and the Environment,
- Comprehensive Environmental Response, Compensation, and Liability
- Hazardous Materials Release Response Plans and Inventory
- Occurrence Reporting & Processing of Operations Information

13. Conclusions

Landslides and slope erosions are encountered within the ecosystem and interact with all natural and man-made stresses from grass root level until slope failure event occur damaging the resources such as soil, water, flora & fauna. The paper highlights most important and primary issues of environmental response against potential instability in hilly regions. Some of these finding are site specific. The establishment of multidisciplinary & integrated mechanism of environmental stability for a natural disaster is a tedious task for the resource planner. The planning requires careful interplay of above-mentioned indicators. However, hilly regions of a country subjected to natural process of soil degradation, which should be obeyed to some extent in the planning process or mange the system by becoming a partner in the integrated environmental emergency response in disaster preparedness – landslides.

Acknowledgments

The authors would like to thank the project team of the Pre Feasibility Study of Designing of Major Roads in Landslide Area. The views express in the paper are however those of authors only. Our grateful thanks are due to Eng. H B Jayasekara, Chairman and Eng N Rupasinghe,

Additional General Manager, Central Engineering Consultancy Bureau for the permission and encouragements. The all assistance received from the Mr. B M P A Mapa , Project Manager, Laboratory & Site Investigation Unit & the Staff is gratefully acknowledged.
The G V M Silva & Sons sponsors the presentation of this paper at the conference.

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