Date of Submission	30th March, 2018

IPL Project (IPL 199) Annual Report 2017
1 January 2016 to 31 December 2017

1. **Project Title:**

   The Effect of Root Systems in Natural Slope Erosion Protection in the Hill Country of Sri Lanka

2. **Main Project Fields** - Capacity Building; - **Collating and Disseminating Information/ Knowledge**

3. **Name of Project leader** : Mr. PVIP Perera; B.Sc. (Env.Mgt.), M.Sc. (F.A.R. Mgt.), MIEPSL

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   Core members of the Project

   Ms. N.N. Katuwala, BSc (Computational Chemistry) Chemist, CRD, CECB

   Ms H.M.J.M.K. Herath (BSc (Geology Special) Engineering Geologist; CRD, CECB

   Eng. A .A .Virajh Dias B.Sc. (Civil Eng); CEng; AGM, NRM&LS, CECB

   Ms B Pavani, Research Assistant,

4. **Objectives**:

   To Study the existing natural slope protections in over 30 sites in the hill country of Sri Lanka to document the observed details and patterns of vegetation which support slope protection and the roles played by different species in such scenarios. It is understood that not one, but a collection of species contribute to this end through the setting and functions of each type of vegetation and their positioning. Thus results of the study can be directly used for practical application in critical slopes.

5. **Background Justification**:

   Natural slope instability is one of the major scientific concerns in the world today with landslides and slope erosion being encountered in different ecosystems. Sri Lanka's hill country too encounters many earth slips during heavy rainfall events, especially in and around tea estates where the natural cover has been disturbed. Landslide events too have occurred in these areas resulting in loss of life and much economic and social harm. Much attention has been focused on predicting landslides and disaster mitigation, however a remedy to the problem seems distant. The use of natural systems already in place if reciprocated in these disturbed areas could be a solution or a major contributing factor to such a remedy and in that light this study would bridge the existing knowledge gap of natural solutions.

6. **Study Area**: In the hill country of Sri Lanka where similar slope angles exists with different vegetation cover in comparison with tea grown areas.

7. **Project Duration**: 5 years (July 2015 t0 June 2020)

8. **Report**

Progress in the project: - Introductory Remarks

Landslide risk and the selection of stabilization measures mainly depend on bedrock characteristics, hillside hydrology, slope gradient, length and curvature, and soil depth and type. Vegetation cover also plays an important role. Deep-rooted trees and shrubs can reduce the occurrence of shallow rapidly moving landslides by strengthening soil layers and improving drainage. Therefore, in recent years, the extent to which mountain slope stability and studies on stabilize slopes with native speices has become of interest. At the present stage, there was not much data on slope stability with native species. Famers and communities in hill counry are used to select some native species and planted on contours along slopes, allow reservations areas and used to grow their agricultural plantation without much issues from the erosional potential of slopes and found to be performing well. Theferore, initial face of the study a number of sites where slope failures were recorded have been visited and documented. The type of vegetation in each location is being studied and being compared to locations with critical slopes where natural protection was evident.

9. Planned Future Activities or Statement of Completion of the Project

July 2015 - December, 2016:	Identification of sampling locations and initial field work – Completed
January 2016 – December 2018:	Study of various natural slope protections in forest covered areas of the hill country having critical slope angles. Comparison of the type of vegetation in such scenarios and collecting data of any slope failures that have occurred in the recent past in such forested areas.
January 2018 – December 2018:	Visiting over 30 such sites will be conducted to gather data and conducting appropriate field testing, data collection and analysis to identify patterns and type of vegetation present at different elevations and rainfall levels – on going
January, 2019- June 2020:	Further field studies on identified patterns for in-depth analysis. In depth analysis and evaluation to formulate results and conclusions

10. Beneficiaries of Project for Science, Education and/or Society

The beneficiaries of this project would be the tea estate workers and other people residing in landslide prone areas in the hill country of Sri Lanka. The natural protection that can be provided would be environmentally friendly and cost effective while also being a long term solution.

11. Results (resent Outputs):

Dominant trees in mountain rain forests in Sri Lanka is given below.

Dipterocarpus, Rhododendron, Shorea, Calophyllum, Syzygium, Strobilanthes, Stemonoporus, Myristica, Cullenia, Aglaia, Litsea

Lower Montane Notophyllous Dipterocarp Rain Forests

This forest type is common in the wet zone, especially on the southern encampment of the wilderness at an elevation between 900 to 1525 M. The main species are Doona gardneri, Doona zeylanica, Stemonoporus cordifolius, Stemonoporusj latisepalum, Stemonoporus acuminatus, Cryptocarya wightiana, Syzygium aqueum, Myristica dactyloides, Meliosma simplicifolia, Mappia ovata, Acronychia pedunculata, Hortonia floribunda, Wormia triquetra, Memecylon gardneri, Euonymus walkeri, Chloranthus glaber, Chassalia ambigua, Lindsaea sp.

Lower Montane Notophyllous Evergreen Mixed Rain Forests

This forest type is common at an elevation ranging between 900 M to 1370 M. The main species are Eleaeocarpus glandulifer, Myristica dactyloides, Semecarpus nigro-viridis, Cryptocarya wightiana, Palaquium hinmolpedde, Aglaia congylos, Calophyllum acidus, Fahrenheltia spp, Pygeum zeylanicum, Bhesa montana, Gordonia ceylanica, Nothopegia beddomei, Hortonia floribunda Elaeagnus latifolia, Asparagus falcatus, Freycinetia walkeri, Fagraea ceilanica, Pothos remotiflorus Rauvolfia densiflora, Agrostichachys coriacea, Strobilanthes spp. Hedyotis spp. Scutellaria, Pogostemon, Impatiens spp.

Upper Montane Microphyllous Evergreen Dipterocarp Rain Forests

Such forests are widespread in the southern escampment above 1525 M. The main species are Stemonoporus rigidus, Stemonoporus cordifolius, Stemonoporus gardneri, Garcinia echinocarpa, Alphonsea coriacea, Gordonia spp., Palaquium rubiginosum, Syzygium spp., Mastixia sp., Cinnamomum ovalifolium, Semecarpus spp., Agrostistachys coriacea, Strobilanthes spp. Indocalamus, Hedyotis, Psychotria, Lasianthus Leucocodon reticulatum, Kendrickia walkeri Impatiens spp., Sonerila spp., Hymenophyllaceae, Orchidaceae, Bryophyta and Hepatophyta.

Upper Montane Microphyllous Evergreen Mixed Rain Forests

These forests are common at elevations above 1370 M. The main species are Calophyllum walkeri, Palaquium rubiginosum, Calophyllum trapezifolium, Cinnamomum ovalifolium, Garcinia echinocarpa, Neolitsea fuscata, Michelia anilagirica, Syzygium rotundifolium, Gordonia speciosa, Gordonia ceylanica, Actinodaphne speciosa, Symplocos spp. Glochidion montanum, Microtropis ramiflora, Eugenia cyclophyllu, Actinodaphne speciosa, Symplocos spp. Glochidion montanum, Microtropis ramiflora, Eugenia cyclophyllum, Disporum leschenaultianum, Exacum walkeri, Lichenes, Hepatophyta, Bryophyta, Orchidaceae.

Fig 1: Observation of native species; Typical forest reserves in steep slopes with no record of landslides

Fig 2: Typical soil profile with native grass adjoin to a perennial stream

Fig 3: Native grass / tree combination of structure adjoin to a perennial stream

Major findings / records

1. With respect to vegetation removal of reserved areas in agricultural zones in mountainous slopes have shown that clearance of reforested or native forests on sloping land increases landslide risk by reducing rooting strength for up to two to three decades (common in rubber plantation areas)
2. In most cases microbial and nutrient biomass takes time to redevelop and different species may be more suited to new conditions than those previously present
3. Changes in climate are expected to cause increase in extreme rainfall events are likely to directly increase the frequency of landslides in sloping areas while cyclone winds may induce landslides by toppling trees, exposing bare soil and increasing saturation failures.
4. Studying of the patterns of soil protection trees/species roots are important aspect but in practically difficult task. Therefore, observation on cutting slopes and identification of roots structure is an important task.

12. Publications (Journal Papers and conference Papers)

1. H M Janaki, M K Herath, S S I Kodagoda and A A Virajh Dias; Shallow Modes of Slope Failure in Road Earth Cuttings in Sri Lanka; World Landslide Forum 3; Beijing, China, 2014.
2. "Empirical Relationships of Elastic Modules and Uniaxial Strength of Intact Metamorphic Rocks of Sri Lanka"; Proceeding of the International Conference of Geotechnical Engineering(ICGE) 10th – 11th August 2015 in Colombo, Sri Lanka; PP 515 -518; Authors were E M T M Ekanayake , H M J M K Herath and A A Virajh Dias; ISBN 978-955-1411-01-5.

13. References

1. Soil Bioengineering for Upland Slope Protection and Erosion Reduction; Part 650 Engineering Field Handbook; U.S. Department of Agriculture, Washington, DC 20250.
2. Leiser, A.T., 1998, 'Biotechnology for Slope Protection and Erosion Control' paper presented to Peaks to Prairies: A Conference on Watershed Stewardship, Rapid City, South Dakota, 27-30 September, first viewed 30 January 2015.
3. The Vetiver Network International, Available from <http://www.vetiver.org/g/slope_protection.htm>. [First Accessed:10th January 2015].
4. Forests and landslides The role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia; by Keith Forbes and Jeremy Broadhead; Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok 2011