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Root reinforcement and its contribution to slope stability in the Western Ghats of Kerala, India

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The Western Ghats of Kerala, India is prone to shallow landslides and consequent debris flows. An earlier study (Kuriakose et al., DOI:10.1002/esp.1794) with limited data had already demonstrated the possible effects of vegetation on slope hydrology and stability. Spatially distributed root cohesion is one of the most important data necessary to assess the effects of anthropogenic disturbances on the probability of shallow landslide initiation, results of which are reported in sessions GM6.1 and HS13.13/NH3.16. Thus it is necessary to the know the upper limits of reinforcement that the roots are able to provide and its spatial and vertical distribution in such an anthropogenically intervened terrain.

Root tensile strength and root pull out tests were conducted on nine species of plants that are commonly found in the region. They are 1) Rubber (Hevea Brasiliensis), 2) Coconut Palm (Cocos nucifera), 3) Jackfruit trees (Artocarpus heterophyllus), 4) Teak (Tectona grandis), 5) Mango trees (Mangifera indica), 6) Lemon grass (Cymbopogon citratus), 7) Gambooge (Garcinia gummi-gutta), 8) Coffee (Coffea Arabica) and 9) Tea (Camellia sinensis). About 1500 samples were collected of which only 380 could be tested (in the laboratory) due to breakage of roots during the tests. In the successful tests roots failed in tension. Roots having diameters between 2 mm and 12 mm were tested. Each sample tested had a length of 15 cm. Root pull out tests were conducted in the field.

Root tensile strength vs root diameter, root pull out strength vs diameter, root diameter vs root depth and root count vs root depth relationships were derived. Root cohesion was computed for nine most dominant plants in the region using the perpendicular root model of Wu et al. (1979) modified by Schimidt et al. (2001). A soil depth map was derived using regression kriging as suggested by Kuriakose et al., (doi:10.1016/j.catena.2009.05.005) and used along with the land use map of 2008 to distribute the computed root tensile strength both vertically and spatially. Root cohesion varies significantly with the type of land use and the depth of soil. The computation showed that a maximum root reinforcement of 40 kPa was available in the first 30 cm of soil while exponentially decreased with depth to just about 3 kPa at 3 m depth. Mixed crops land use unit had the maximum root cohesion while fallow land, degraded forest and young rubber plantation had the lowest root reinforcement. These are the upper limits of root reinforcement that the vegetation can provide. When the soil is saturated, the bond between soil and roots reduces and thus the applicable root reinforcement is limited by the root pullout strength. Root reinforcement estimated from pullout strength vs diameter relationships was significantly lower than those estimated from tensile strength vs diameter relationships.