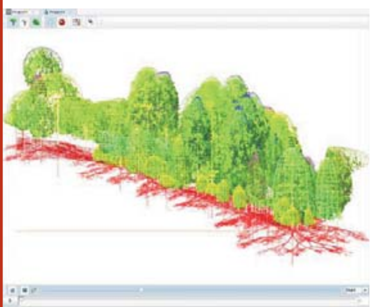
RaLMA process in Landslide area of Sentul, Bogor



3D-reconstruction with SExI-FS of recorded tree plot in Sentul, Bogor

Vegetation in the study area was dominated by 'home-garden' type agroforests with banana (non-woody), *Maesopsis eminii* (introduced timber species), *Pangium edule* (source of oil and spice), *Ceiba pentandra* (kapok) and *Sandoricum koetjape* (local fruit tree). The highest tree population density was found in agroforestry system near the scarps of overland landslides; weight of the aboveground tree biomass probably increased landslide risk.

The local fruit trees duku (*Lansium domesticum*), kemang (*Mangifera kemanga*), limus (*Mangifera foetida*), mindi (*Melia azedarach*) have a relatively important role in anchoring the soil (IRA higher than 2.0). A mix of tree species with deep roots and ground cover species with intense and strong fine roots will provide the highest slope stability in the area.

With a recent addition, the SExI-FS (Spatial Explicit Individual-based Forest Simulator) model is able to simulate the role of trees to reduce the risk of landslide trough the quantification of species IRB and IRA within a tree plot. The simulation may apply the plot management sensitive scenario. The simulation result on plot management sensitive shows that maintaining the plot density to the optimum size is would be better because increasing the density over the optimum size was not significantly increase the plot root binding.

The combined LEK, MEK and PEK studies can lead to a further discussion of the options for local choice of species, combining direct economic gain, local utility and landslide risk. The primary recommendation of outsiders visiting the village would be to look for another location of the village, but the options for doing so are limited. Maintenance of the tree root mat of the village-scale 'home-garden' and avoiding houses with rigid walls (replacing the traditional housing of woven bamboo mats) may mitigate local risk in the short term.

References

The Role of Trees Outside Forest in Anchoring Soil and Reducing Landslide Risk during High Rainfall Episodes. *In* the TROFCA project report on the role of tropical forests in climate change adaptation by University of Brawijaya and World Agroforestry Centre coordinated by the International Centre for Forestry Research (CIFOR) in 2008.

This flyer is produced by
the TUL-SEA Project
funded by the Federal Ministry for Economic
Cooperation and Development, Germany

Contacts:
TUL-SEA Project
WORLD AGROFORESTRY CENTRE
Southeast Asia Regional Office
Jl CIFOR, Situ Gede, Sindang Barang, Bogor 16115
PO Box 161 Bogor 16001, Indonesia
Tel: +62 251 8625415/ Fax: +62 251 8625416
E-mail: icraf-indonesia@cgiar.org
http://www.worldagroforestrycentre.org/sea

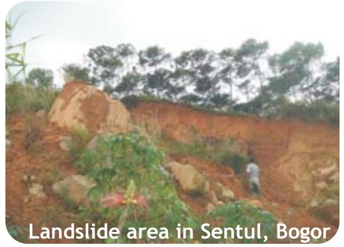
Credits:
Authors: Meine van Noordwijk and Kurniatun Hairiah
Photos: Kurniatun Hairiah, Widianto, Degi Harja and Firsta
Design & Layout: Vidya Fitrian and Diah Wulandari

RAPID LANDSLIDE MITIGATION APPRAISAL(RaLMA):

A tool for appreciating the role of trees in slope stabilization

Trees in Multi-Use Landscape in Southeast Asia (TUL-SEA)
A negotiation support toolbox for Integrated Natural Resource Management

Slope stability as ecosystem service under threat



Landslide area in Sentul, Bogor

Landslides killing hundreds of people have become an almost yearly phenomenon in SE Asia and have a high profile in the public debate. High rainfall events on wet soil on hill slopes can trigger 'failure' in planes of weakness in the soil profile which leads to movement of soil. Forest vegetation and trees can play an important role in holding a soil profile together through their root systems, and the removal of trees and subsequent decay of tree roots may be part of the explanation of specific landslides. Ironically, however, the risk of landslides after removal of trees is partially because the trees prevented landslides to happen earlier, and contributed to the build-up of soil until this is too heavy for the existing slope steepness. Landslides, or slope instability, can also be due to construction of roads and other structures that interfere with the flow paths of water through a hill-slope.

In the public debate the usual attribution of landslide damage is to ‘deforestation', but this may mean:

A. Without people living in the area no one would notice landslides, which in fact area 'natural' part of soil-vegetation processes, especially on geologically young soils in steep terrain; after people moved in to the landscape they can become 'victims' by being on the wrong place at the wrong time,

B. Increased use of a landscape by people normally implies a reduction of tree cover and increase in roads; where the slope incisions of roads lead to slope instability, the correlation with loss of tree cover is only indirect,

C. Tree roots do play a real role in providing mechanical coherence of the soil profile and the decay of tree roots are tree felling leads to gradual increase of landslide risk.

Only in case C does it make sense to expect that tree planting will, in the longer term and once the young trees have established root systems, reduce risk of landslides.

The complexity of the cause-effect relations, the destruction of evidence by the landslide and their occurrence after more-than-normal or 'extreme' rainfall episodes make it desirable to have a relatively rapid and inexpensive appraisal method that can be used to guide local natural resource managers to take precautionary measures and/or respond to early signals of slope instability. Discussions on changing rainfall patterns as part of the global 'climate change' phenomenon make it even more urgent to have such tools.

The use of forests and trees for **increased slope stability** need to deal with three important criteria:

Realistic - interventions need to be based on knowledge of the way tree roots can bind soil and anchor the rooted layer to the subsoil; they need to appraise the diversity of tree species in this regards and the way management of trees influences aboveground weight and root system properties; they also need to align with the tradeoffs between economic benefits from land use change and the consequences for slope stability;

Voluntary - the mechanisms need to respect existing property and land use rights (compare the RATA or rapid tenure claim appraisal tool) and follow principles of Free and Prior Informed Consent (FPIC); agreements require a shared understanding of the issues and options to deal with them

Conditional - economic incentives for improved management of slopes will be 'performance-based' and thus require systems of monitoring changes in slope stability in the landscape.

Objectives of Rapid Appraisal of Landslide Mitigation (RaLMA)

The RaLMA appraisal tool is designed to provide a basic understanding of the way tree roots currently and potentially contribute to slope stability, and of the way tree and (agro)forest management can enhance or maintain slope stability and protect people and sensitive ecosystems from damage.

Steps in RaLMA

As with other 'rapid appraisal tools', there are four components:

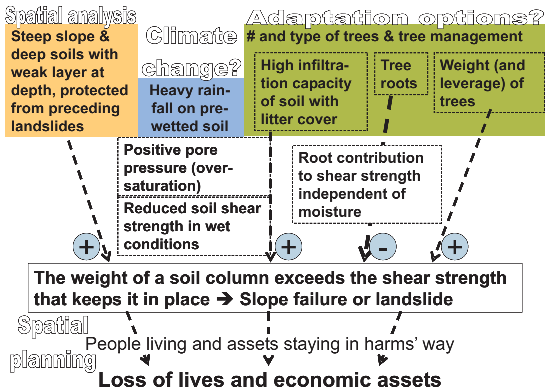
1. Spatial analysis of the landscape and recent history of land cover change
2. Exploration of 'local ecological knowledge' (LEK) of cause-effect relations, of local regulations of changes in tree cover and of preferences and aspirations as regards the presence of trees in the landscape,
3. Exploration of the 'public/policy ecological knowledge' (PEK) of cause-effect relations, of the way spatial plans do or don't take landslide risk into account and of preferences and aspirations as regards the presence of trees in the landscape,
4. Exploration of 'modelers' ecological knowledge' (MEK) of site-specific risk and of the likely time course of response to mitigating actions.

The synthesis of these various knowledge systems can inform local negotiations between stakeholders in landscape management.

For the MEK component we can assert that trees on slopes have both positive and negative effects on slope stability. Negative effects include:

- aboveground biomass adds weight and their exposure to wind exerts a lateral force,
- high porosity of the soil, supported by active soil fauna feeding on the litter layer, increases infiltration and the likelihood of positive pore pressure after heavy rainfall.

The positive effects consist of the binding of the topsoil into a root mat that either moves as a whole or stays in place, and of anchoring this rooted layer to the subsoil through vertical roots ('pinning' the topsoil to the substrate). The positive and negative effects depend on tree species, tree age and tree management; forest and agroforestry management can thus influence landslide risk in positive or negative ways (Fig. 1).



Schematic diagram of relationships of landslides with soil, climate and vegetation

How to do it?

1. Site-specific assessment of impacts of trees and tree management on landslide risk requires the following steps:
2. Identification of the area, characterization of the soils and potential planes of weakness in the soil profile, geological substrate and process of soil formation (including 'colluvial' soils derived from previous slope instability), slope and recent changes in land cover; characterization of climate and extremes in rainfall distribution.
3. Exploration of Local Ecological Knowledge on the role of trees in landslide risk.
4. Exploration of Public/ Policy Ecological Knowledge on the role of trees in landslide risk
5. Compiling parameters for Modelers Ecological Knowledge of trees and landslide risk:
   - ➔ Survey of tree species and tree population density in the landscape in relation to signs of preceding landslides,
   - ➔ Inventory of proximal tree root architecture of the major species than grow in the area to assess 'soil binding' and 'soil anchoring' Two tree root indices (Index of Root Anchoring, IRA and Index of Root Binding, IRB) can be used to evaluate tree suitability for stabilizing slope.
   - ➔ Standardized strength measurement of tree roots in relation to their lignin content,
   - ➔ Estimation of dynamic root pattern at hill slope scale using the 'spatially explicit individual tree-based forest simulator' (SExI-FS) model and the IRA and IRB parameters derived from the survey.

Case Study[1)]

Case studies in different parts of Indonesia (West Lampung, West and East Java) suggested a number of options for 'right tree in right place' management in mixed agroforestry systems to reduce landslide risk on slopes, in the context of adaptation strategies to climate change, combined with biomass carbon storage as contribution to mitigation.

Durian root vs landslide

Research was carried out from January till May 2008 in the Bukit Sentul area, Bogor District (West Java, Indonesia) in areas classified as highly at risk of landslides. Based on geological maps and recent landslide occurrence, the survey focused on the Ciherang and Cibadak sub-catchments followed by inventory of tree species and population density in the selected area. Four types of landslides occurred in Karang Tengah village i.e. overland landslides, slope failure (topple), creep and road-cut landslides; 60% of the total were overland landslides. Factors affecting landslides were identified as rainfall intensity, topography (slope >45%), and features of the soil profile: existence of bed rock or compacted soil layer as sliding plane, existence of unstable soil layer such as sandy loam layer in the sub soil with a low soil shear strength due to higher sand content.

[1)] This case study was part of the TROFCA project on the role of tropical forests in climate change adaptation, coordinated by the International Centre for Forestry Research (CIFOR)