Using fallout radionuclides and CSSI techniques to assess soil erosion and sedimentation under different land uses in the central highlands and the preparation of GIS maps for the implementation of the Soil Conservation Act of Sri Lanka

This Best Practice was submitted by Ms Champa Dissanayake, Mr Chandrapala Anhettigama Gamaralalage, Ms Maheshika Darshani Kalpage, Mr Mr K. M. A. Kendaragama and Ms Thilaka Nanda Attanayake as part of the Best Practices Cycle 2016

Description

Sri Lanka is prone to soil erosion due to steep slopes and high intensity rainfall, and climate change has aggravated this process. Several soil and water conservation programmes have been implemented to tackle this, however, conventional erosion assessment techniques are time consuming and costly to operate in large scale. The IAEA has recently introduced the fallout radionuclide (FRN) technique to assess soil erosion and sedimentation in catchment scale and the identification of sources of sediments using the compound specific stable isotope (CSSI) technique. Officers of the Sri Lanka Atomic Energy Board (SLAEB) and Natural Resources Management Centre received training on FRN and CSSI through the IAEA, and based on this training, soil erosion and sedimentation studies were conducted in catchments in central highlands using FRN and CSSI. The results were compared with those of conventional erosion study methods, and based on the results, the Council for Agriculture Research Policy provided funds to continue the study in two other watersheds. Research is now being carried out.

Categories:

1. Country Programme Framework (CPF)/ Regional Profile Process.
3. Logical Framework Methodology
4. Coordination arrangements
5. Regional and Interregional Cooperation: RCA
6. Partnership: Technical
7. Project results: Educational impact and impact on decision and policy makers

Problem/issue

Land degradation, especially soil erosion and associated sedimentation of hydropower reservoirs, is an environmental problem in Sri Lanka, causing streams that provide water to the 103 rivers, originating from central highland, to dry up, declining soil fertility and reduced hydro-electricity production. To tackle this, the Government of Sri Lanka enacted the Soil Conservation Act in 1951. Various mechanical, vegetative and agronomic soil conservation measures were introduced and promoted to minimize soil erosion and siltation of reservoirs. However, the prioritization of areas and land uses with more emphasis on soil conservation is needed, to allocate the limited funds available for soil conservation more effectively. One of the major obstacles for this was the unavailability of a complete database of soil erosion rates under different land uses in catchment scale, which would allow the issue of appropriate recommendations. The Department of Agriculture initiated soil erosion

studies using standard runoff plots, and erosion prediction using Universal Soil Loss Equation (USLE) in different locations of the country. However, this did not allow for a good understanding of the soil redistribution within the catchment. On the other hand, there was a huge disparity of results generated from USLE and runoff plot studies.

How & who

The IAEA introduced the use of FRN for the assessment of catchment scale soil erosion and sedimentation. The CSSI technique was introduced to identify the sources of sediments. Researchers from the Department of Agriculture and the SLAEB participated in training programmes on soil erosion assessment using FRN and CSSI techniques. Based on the training, two soil erosion studies under different land uses in the sub catchments of Kothmale and Randenigala hydropower reservoirs using FRN and CSSI were initiated.

The results of the RAS5055 project were widely discussed in working group meetings involving Government, non-government and private sector organizations. The project identified the best method for assessment of soil erosion and sedimentation at catchment scale. Based on the results of RAS5055, the government of Sri Lanka provided financial support to the Natural Resources Management Centre through Sri Lanka Council for Agricultural Research Policy Institute, to continue the assessment of soil erosion using the nuclear technique in other agro-ecological regions of Sri Lanka.

At present, the FRN technique has been established and applied widely at the field level to mitigate land degradation due to soil erosion and improve land productivity.

Approach

The techniques used were FRN (using137Cs and 210Pb), combined with the CSSI technique, to assess the soil erosion status of the catchment, to identify and apportion soil sources from land uses and to integrate FRN with CSSI in establishing a comprehensive soil redistribution study. The combination of FRN and the CSSI fingerprinting technique can provide a better insight of the processes and origin of soils in a catchment. Findings are used to introduce standardized tools to support better land management decisions on an area-wide basis.

Study watersheds were selected based on the relative importance of the watersheds to the national economy and environment of the country. Samples were collected from marginal tea lands, well managed tea lands, grasslands and homesteads in Kothmale sub catchment, and then analysed using Gamma detectors. The data was then converted to erosion and deposition rates using conversion models. Sources of sediments were determined using the CSSI method.

How effective

The research projects conducted in three watersheds under the IAEA projects RAS5055 and SRL5038 are the main successful projects conducted on soil erosion and sedimentation studies using FRN in Sri Lanka. Up to now, the scientists in Sri Lanka used conventional erosion plot methods and GIS-based methods to assess soil erosion in limited areas.

The studies in the well grown tea lands, home garden and grassland land use systems in the Kothmale sub catchment revealed better soil conservation in well managed tea lands compared to marginal tea lands. According to the CSSI signatures of suspended sediments, soils from marginal tea lands dominated the sediment load by 80%, compared to the value of 20% from other land uses.

Soil organic matter content was also analysed in order to find the relationship between soil erosion, soil organic matter content and soil nutrient availability. The highest soil erosion occurred at the upperslope positions, where there was a minimum soil organic matter content.

The Hanguranketha area of Randenigala Reservoir catchment had a high soil erosion rate. The present estimation of soil erosion using the FRN technique revealed a great reduction of soil erosion in crop rotation by shifting cultivated lands after the introduction of mechanical and vegetative soil conservation measures in 2000, which indicates the success of the soil conservation programme on soil erosion mitigation.

The results of soil erosion and sedimentation studies conducted using this technique, impressed the decision makers of the Government, which provided funds to continue the study in two other watersheds in the central highlands of Sri Lanka (Project No. NARP15/DOA/NRMC/01). This technique was included in the training schedules of the Natural Resources Management Centre and SLAEB, and training programmes for University staff, students, government officers and farmers were conducted. The outcome of the research conducted in the mid-country wet zone was published in Annals of the Department of Agriculture in 2014. There have been many requests from the Government and private sector organizations to conduct soil erosion and sedimentation studies in different agro-ecological regions, using the FRN technique.

There was a self-evaluation process within the project at the national level. A pre-project planning and evaluation mission was held with the participation of an IAEA expert. The counterparts of the project and stakeholders identified the limitations of the conventional erosion plot method. Generally, the USLE with GIS is considered as a quick method to assess soil erosion at a large scale. However, due to a large variation in land use, topography and soils in Sri Lanka, the USLE method was identified as less accurate and precise. The FRN technique provided precise information about soil erosion and sedimentation at an area wide scale with greater confidence and accuracy, and allowed the identification of land uses that are highly vulnerable to soil erosion and sedimentation.

Lessons learned

The majority of eroded soils are deposited in low lying areas. There is a positive correlation among soil erosion/deposition, organic carbon and available phosphorus in the soil. The conventional runoff plot method of soil erosion study can be replaced by the fallout radionuclide method. However, the use of FRN and CSSI methods has additional advantages such as:

- Soil erosion assessment can be done over a large area since one-time sampling is sufficient;
- Both erosion and sedimentation can be assessed;
- Comparison of land uses based on soil erosion and sedimentation is possible using the CSSI technique;
- With the FRN method, soil erosion or deposition is measured as point estimate, by practising sampling as a grid method. It is possible to measure soil erosion/deposition in a wider catchment or region by extrapolation of the results, and the eroded and deposited area can be mapped digitally using the GIS technique.

Key success factors

- Need of the country to successfully assess the scale of soil erosion in catchment areas;
- Provision of training, funds and follow up actions by the IAEA;

- Commitment of both the Department of Agriculture and SLAEB;
- Constructive criticism of scientists and officers from various sectors.

Beneficiaries

Decision makers benefitted by understanding the land uses, which cause more soil erosion. This understanding can be used to make policy decisions to promote environmentally friendly cultivation practices and optimum crop selection. Additionally, Government and non- government organizations involved in soil conservation programmes and land owners benefitted.

Quality criteria: Relevance; Ownership; Sustainability; Efficiency; Effectiveness.

This Best Practice is directly relevant to the RAS5055 technical cooperation project. It is also relevant to the government's main environmental programme 'Green Lanka', which is intended to prevent land degradation in Sri Lanka. There is a comparative advantage in using nuclear techniques in this project, compared to the conventional methods used. There is also a well-defined gap in the availability of sufficient soil erosion data, which affects the implementation of land degradation prevention programmes, sustainable food production and the national economy.

Ownership: Under RAS5055, the IAEA provided financial support for training in FRNs, while other project expenses were covered by the counterpart institute. After completion of the project, a realistic budget was prepared to continue the soil erosion assessment in another four agro-ecological regions with funds from the Sri Lankan Government.

Special conditions

The demand to conduct erosion studies using this technique is encouraging. However, limited analytical facilities available in the country could limit the number of studies conducted.

During the project, the SLAEB had only one high purity germanium detector (HPGe detector), which was received under the IAEA technical cooperation project SRL5038, based on a shield p-extended type HPGe detector (model: Gx3020-Canberra). The HPGe Detector is calibrated for energy and efficiency over the proton energy range 20–3,000 KeV using mathematical efficiency calibration option of LABSOCS software (model 5574C Canberra) for the measurement geometry and sample matrix. Quality control and quality assurance of the analytical measurement is being carried out using the IAEA reference material IAEA RM soil-6.

Between 2015-2016, the SLAEB installed one additional Ultra low background HPGe detector to strengthen the analytical capabilities.

The laboratory was accredited by the Sri Lanka Accreditation Board (SLAB) for radioactivity measurement (TL 012-01) under the requirement of ISO/IEC 17025 since 2006.

SLAEB has recently decided to procure more advanced equipment, including GC-EA-IRMS, through the IAEA technical cooperation projects SRL5045 and SRL7005. The IAEA procurement process is in progress and the equipment will be installed in 2018.