



REPORT

**Mid-Term Progress Review Meeting
of Regional Technical Cooperation Project for Asia and the Pacific Region
(RCA)
“Sustainable Land Use and Management Strategies for Controlling Soil Erosion
and Improving Soil and Water Quality” RAS/5/043**

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Participants to the Mid-Term Progress Review Meeting of IAEA Regional Technical Cooperation Project RAS/5/043

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1. THE REGIONAL TECHNICAL COOPERATION PROJECT FOR ASIA AND THE PACIFIC REGION (RCA) “SUSTAINABLE LAND USE AND MANAGEMENT STRATEGIES FOR CONTROLLING SOIL EROSION AND IMPROVING SOIL AND WATER QUALITY” RAS/5/043

1.1. Background information

Severe soil erosion and sedimentation problems occur in the Asia and the Pacific region due to improper land use and poor farming practices. Soil erosion reduces land productivity, challenges agricultural sustainability, and degrades soil and environmental functions. Effective soil conservation can substantially contribute to reduce/mitigate these problems. In this context, novel techniques for controlling soil and water quality problems caused by soil erosion are very important in designing effective soil conservation measures. These techniques need to be developed and tested under a variety of agro-environmental conditions through measurement of soil erosion, sedimentation and associated pesticide contamination. Under past IAEA regional TC project RAS5039 participating research groups in the region have established basic capacities to conduct such investigations using the ^{137}Cs technique, and have recognized the advantages of the combined use of ^{137}Cs with other radionuclides such as ^{210}Pb and ^7Be , and the importance of investigation of the relationship between soil redistribution and soil and water quality. To address these issues of soil and water quality in connection to soil redistribution measured with the combined application of fallout radionuclides (FRNs) a regional technical cooperation project RAS/5/043 was launched in 2005.

1.2. Objective of RAS/5/043

The overall objective of RAS/5/043 is to develop and evaluate sustainable land and water management strategies using fallout radionuclides (FRN) to measure soil erosion, in order to improve soil and water quality in the East Asia and the Pacific region.

Specific objectives are:

- To measure soil erosion and deposition over several spatial and time scales by the combined use of cesium-137, lead-210 and beryllium-7;
- To establish soil redistribution-soil quality relationships under different land management practices using the above results;
- To develop guidelines to assess soil quality based on radionuclides, as by 1) and 2);
- To apply/disseminate management practices developed as a result of the soil redistribution-soil quality relationship for effectively improving soil and water quality as well as increasing organic carbon storage in soil.

1.3. Outcomes of RAS/5/043

The expected outcomes of RAS/5/043 are:

- development and testing of standardized methodologies and guidelines on the use of FRNs for the assessment of soil erosion and its relationship to soil quality, and for improving the selection of effective land and water management measures adapted to different land use and management systems;
- soil and water resource management practices developed and disseminated through national extension services, demonstration activities and training of farmers, technical brochures, regional/local extension workshops, videotapes and other electronic means.

1.4. National commitments and strategy of project implementation

Participating countries nominated their national co-ordinators, appointed national project teams and adopted national work plans for implementation of the project. They have also contributed by providing the necessary facilities, funding the operating costs of the projects, and hosting the project events (such as regional project coordination meeting and training courses). The IAEA assistance to the participating countries is provided especially through regional project coordination meetings and expert missions. The progress in the implementation of the national work plans is monitored through six monthly Progress Reports submitted by the national project coordinators.

1.5. Overview of regional events in RAS/5/043

First Regional Co-ordination Meeting

The 1st Regional Co-ordination Meeting (RCM) was held in Manila, Philippines from 17 to 19th March 2005. The meeting was organized in connection with the Final Co-ordination Meeting of the former regional project RAS/5/039 held in Manila, 14-16th March 2005. The main purpose of the 1st RCM was to present and discuss the proposed national work plans. During the meeting, the following activities were carried out:

The Technical Officer presented the objectives and the expected outcomes and impacts of the project.

The representatives from the participating countries characterized the status of soil erosion in their respective country and presented the proposed work plan and the national team involved in the project.

The Technical Officer made a presentation on the linkages between soil degradation-soil erosion-surface water pollution and soil quality issues.

Ms P. Jones gave a lecture on the use of ¹³⁷Cs for erosion studies.

Mr R. Loughran gave a lecture on the use of ⁷Be to investigate erosion/deposition processes on a short-time scale.

The participants revised and updated their national work plans, taking in consideration the information obtained at the meeting.

The meeting resulted in two major conclusions:

Although RAS/5/043 is a continuation of the project RAS/5/039 part II, it was felt by all the participating countries that continuing support is still needed to strengthen national capacities required for regional networking and application of FRNs in soil erosion studies. Assistance should be provided as training of personnel, scientific visits, expert missions, procurement of minor equipment and subcontracts.

Three countries that were not involved in RAS/5/039 part II joined this new project. Of these, Thailand already has some expertise and the required infrastructure for the use of fallout radionuclides in soil erosion/deposition studies. However, this is a new field of activity for Myanmar and Mongolia. Additional technical assistance is needed for these two countries.

Regional Training Workshop

A regional training workshop on “Sustainable Land Use and Management Strategies for Controlling Soil Erosion and Improving Soil and Water Quality” was organised in Beijing, China, from 9 to 20th May 2005. The major output of the training was increased knowledge on soil erosion and deposition processes, their characteristic features, equipment and methods for their measurement with focus on the application of nuclear techniques. The main recommendation from the workshop was that more attention should be paid to further training on FRN sampling, gamma spectrometry and FRN data interpretation.

2. MID-TERM PROGRESS REVIEW MEETING

2.1. Meeting organization

The 2nd Regional Co-ordination Meeting was planned to be held after the first two years of the project. During the last quarter of 2006, but it was finally scheduled from 22 to 25 January 2007. It was hosted by the Chinese Academy of Agricultural Sciences (CAAS) in Beijing and Prof. Yong Li from CAAS was the Local Organizer. Representatives from Australia, China, Indonesia, Malaysia, Mongolia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand and Vietnam attended the meeting (Annex 1). Dr. Emil Fulajtar, Technical Officer (TO) of TC project RAS/5/043, was the Meeting Secretary. Dr. Claude Bernard from the Ministry of Agriculture, Fisheries and Food of Quebec, Canada, former TO of RAS/5/043, was invited as an expert.

2.2. Meeting objectives

The main objectives of the meeting were:

- To make the mid-term evaluation of the progress achieved on the project;
- To confirm or modify, if necessary, the national and regional work plan for second half of the project.

2.3. Work done

The meeting was formally opened by Dr. Maoxiong Long, Director of the Office of IAEA Affairs, DIC/CAEA and by Prof. Dr. Xurong Mei, the Director General, IEDA, CAAS.

Prof. Zhang delivered a key-note lecture on “Strategies for Controlling Agro-Pollution at a Multi-Dimension Scale”. The purpose of this lecture was to inform the project participants on the Chinese position towards the problem of agro-pollutions which are directly related to surface water runoff and soil erosion. This problem is one of the highest priorities for agricultural research in China and elsewhere in the region. China would like to encourage research activities in this field and would welcome the involvement of IAEA in such research. Considering the significant contribution of nuclear technology to sustainable land and water management, by controlling land degradation and soil erosion, China would like to suggest the organization of a new regional TCP on agro-pollution.

After the key-note lecture the TO made an overview of the programme (Annex 2) and objectives of the meeting and the presentations of the country reports followed. Each participant presented the objectives of his/her study and the results achieved during the first biennium (2005-6).

On Tuesday afternoon the TO presented a technical paper on “Targeting the FRN techniques to specific issues of erosion/sedimentation and soil conservation research” and the invited expert, Claude Bernard, gave a presentation on “New developments in models for conversion of FRN data to soil redistribution rates”.

The project evaluation sessions took place on Wednesday and Thursday. Country work plans were discussed in working groups. The findings of the working groups were presented in a plenary session, as were the overall evaluation of the results and modifications of work plans. Conclusions and recommendations were then formulated and adopted. Individual problems were discussed during consultations.

2.4. Country reports

CHINA

Problem to be addressed

The problem of soil erosion and associated land and water degradation, represent a major obstacle to sustainable development and environmental protection in the country. Irrational land use and poor farming practices cause a reduction of the plant cover and this accelerates soil erosion. New initiatives in regional land use planning and designing are needed to encourage appropriate land use and soil conservation practices with emphasis on sustainable crop production and environmental protection.

This IAEA regional project will address soil quality-soil redistribution relationships and their impacts on water quality and soil carbon storage by the combined use of ^{137}Cs , ^{210}Pb and ^7Be , and will promote collaboration of China with other IAEA member states from the Asia-Pacific Region.

Soil erosion rates and geographical distribution of soil erosion in China

China is one of the countries suffering most from serious soil and water losses in the world. The latest remote-sensing survey showed that soil erosion occurs on some 3.67 million km^2 , accounting for 38.2% of the country's total territory. Wind erosion affects an area of 1.91 million km^2 and water erosion 1.65 million km^2 . Severe soil erosion, dominated by gullies, is widely distributed in large areas of northern and western China, especially in the Chinese Loess Plateau and the Upper Yangtze River Basin. These two regions are the most severely affected by soil erosion and sedimentation in the world. The total annual soil loss was estimated at 5 Gt, which accounts for 7% of the total world soil loss (75 Gt). The largest soil losses can be attributed to the basins of the Yangtze River (2.4 Gt) and the Yellow River (1.6 Gt).

Status of soil conservation policy in China

In recent years the Chinese State Council approved and implemented "National Planning of Ecological Improvement" and "National Guidelines for Ecological and Environmental Protection", which outlined the master plan for soil and water conservation and ecological improvement for the early 21st century, and incorporated soil and water conservation into the strategies of sustainable development. Controlling water erosion by planting grasses and forests on steep hills and gully slopes and other soil conservation strategies has been considered key issues of the China West Development Strategies proposed by the Chinese government and World Bank Projects in the hilly areas of West China.

The implementation of conservation policy is negatively influenced by the lack of data on the efficiency of selected conservation measures. Little or no monitoring of the effectiveness of soil conservation measures on enhancing soil fertility or soil quality in erosion-prone areas has been done at field, hillslope, and watershed scales. The existing designs of soil conservation strategies are based mainly on empirical knowledge and information related to erosion data using small runoff plots. Few monitoring and experimental erosion data over large scales are available. Based on runoff plot information, however, land use planners and policy makers have difficulties in making quantitative and objective assessments and in selecting appropriate remediation strategies due to a lack of understanding of the diversity of landscapes, soils, vegetation cover, etc on sediment production, and conservation structure impacts throughout different spatial and time scales.

Objectives of the study

The objectives of the study are the use of fallout ^{137}Cs , ^{210}Pb , ^7Be for:

- Assessment of soil erosion and deposition at different spatial and temporal scales;
- Evaluation of soil quality-soil erosion relationship under different land use and management systems;

- Quantification of the fate of eroded soil organic carbon (SOC).

Expected outputs

- Procedures for the assessment of soil erosion rates and the impact of soil erosion on soil quality based on FRNs; Guidebook on establishing soil quality-soil redistribution relationships using FRNs.

Study sites: Fengning Site, Yan'an Site, Xichang Site

Location of the site: Inner Mongolia (northern China), Loess Plateau, SW-China.

Geographical, soil and agro-ecological data:

Area (km²): 100

Altitude: 800-1800 m

Slope inclination (%): 5-70

Slope length: 80-500 m

Parent material: loess

Soil type: Purple soil in south-western China; Calcicusteps in the Loess Plateau; Phaeozems (black soil) in Northern China.

Soil texture (% clay, silt, sand): 26% clay, 45% silt, and 29% sand in south-western China; 16% clay, 50% silt, and 34% sand in the Loess Plateau; 27% clay, 42% silt, and 30% sand in the Inner Mongolia.

Organic matter content (%): 0.5-4

pH: 5-8

Climate (agro-ecological type): semi-arid zone in the Loess Plateau, subtropical zone in SW-China, and temperate zone in Northern China

Mean annual temperature (°C): 12-14°C in the Loess Plateau, 17°C in the purple soil region, and 0-7°C in NE-China.

Mean temperature of warmest month (°C): 27°C in the Loess Plateau, 40°C in the purple soil region of SW-China, and 20°C in Northern China.

Mean temperature of coldest month (°C): -3°C in the Loess Plateau, 10°C in the purple soil region of SW-China, and -20°C in Northern China.

Mean annual precipitation (mm): 350-1000

Season with high intensity rainfall: June to August

Land use: terraced field and sloping farmland, forestland, pasture.

Key crops: pearl millet, potato, corn, and soybean.

Site specific characterizations:

1. Fengning Study Site:

Natural conditions: rainfall 350 mm y⁻¹, sandy soil, soil degradation resulted from both water and wind erosion located 400 km north of Beijing.

Study focuses: impacts of conservation tillage practices (NT, CT) on soil erosion/sedimentation, soil quality parameters.

Measurements of indicators: ¹³⁷Cs, ²¹⁰Pb, and ⁷Be, SOC, aggregates, bulk density, available N and P.

2. Yan'an Study Site:

Natural conditions: rainfall 450 mm y⁻¹, loess soil, soil degradation resulted from water erosion located 900 km SW of Beijing.

Study focuses: linkage of sediment delivery from hill slopes with different land uses (terraces, cultivated land) to nutrients and SOC in reservoir.

Measurements of indicators: ^{137}Cs and ^{210}Pb , SOC, aggregates, bulk density, available N and P, sediment budget.

3. Xichang Study Site:

Natural conditions: rainfall 1000 mm y^{-1} , purple soil, soil degradation resulted from water erosion located 2500 km SW of Beijing.

Study focuses: land use impacts on soil erosion and soil quality under different land uses (grazing, cultivation, and re-vegetation).

Measurements of indicators: ^{137}Cs , and ^{210}Pb , SOC, available N and P, land use history and topographic investigation.

Experimental design:

Number of study sites: 3

Sampling design: multiple transects

Approximate number of samples already taken:

Total: more than 2000

Depth incremental profiles: more than 40

Bulk cores: 1600

Approximate number of samples planned to take in future:

Total: 500

Depth incremental profiles: 10

Bulk cores: 400

FRN used already: ^{137}Cs , $^{210}\text{Pb}_{\text{ex}}$, ^7Be

Conversion models used already: mass balance model (MBM) and tillage erosion prediction model (TEP)

Results:

Soil erosion rates: Since the 1950s the estimated soil losses for the three locations ranged from 50 to 250 t year^{-1} .

Impact of soil erosion on soil quality:

1) *For the Yan'an study site in the Loess Plateau:* A single linear regression model was developed for predicting variability of soil quality parameters induced by soil redistribution. The ^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$ showed significant linear correlations with C_{org} with R^2 of 0.81 and 0.86 ($P < 0.01$), respectively, on the control plot, and with R^2 of 0.90 and 0.86 ($P < 0.01$), respectively, on the treatment plot. The data obtained from ^{137}Cs measurements indicated that the mean value of sediment production declined by 49% for the terraced hillslopes and by 80% for the vegetated hillslopes compared with the cultivated hillslopes. An increase in grassland and forestland by 42%, and a corresponding decrease in farmland by 46%, reduced sediment production by 31% in the catchment.

2) *For the Fengning study site:* The data from ^7Be measurements suggested that no tillage with high residues reduced soil erosion by 44% and no tillage with low residues reduced soil erosion rates by 33% under wheat and barley.

INDONESIA

Problem to be addressed

The erosion threat in Indonesia has been rising due to the conversion of agricultural lowland areas into residential and commercial development. Agricultural activities have been pushed toward less suitable hilly upland areas, where the potential for land degradation is higher, primarily due to soil erosion. A quantitative estimation of erosion rates and land degradation status is needed as background information for implementing sustainable land management practices. This study is

expected to reveal the cause-effect relationship between soil and water quality induced by soil erosion and the impact of soil conservation measures.

Soil erosion rates and geographical distribution of soil erosion in Indonesia

The predominant erosion process in Indonesia is commonly water erosion. It is related to the high annual amount and intensity of rainfall, improper land use and poor farming practices, especially in the western part of Indonesia. However erosion occurs also in the eastern part of Indonesia, which has a dry-arid climate. Most of the erosion occurs in the upland areas. According to the forestry department currently there are 61 catchments where soil erosion is critical and 16 of them are located in Java due to the dense population and intensive agriculture. Soil erosion rates estimated using the USLE range from 15 to 480 t ha⁻¹ y⁻¹.

Status of soil conservation policy in Indonesia

Small farmers in the upland areas are economically poor, with no land ownership and lack of capital. Therefore, low-cost soil conservation technologies are needed to protect upland farming systems.

Objectives of the study

The major objectives of the study are:

- To estimate erosion rates;
- To estimate soil redistribution on each transect;
- To establish erosion rate- soil quality parameter relationships;
- To extrapolate transect data into the representative area;
- To classify and map the distribution of degraded land.

Expected outputs

The main output will be information on the spatial patterns and rates of soil redistribution and its relation to characteristic of land use, mainly on the erosion rate-soil quality parameters relationship. The result should help decision makers to develop comprehensive soil conserving policies and to assist agricultural specialists to develop sustainable land use strategies.

Study site: WIDAS Sub-catchment

Location of the site: Nganjuk District, Province of East Java

Geographical, soil and agro-ecological data:

Area: 25,000 ha

Altitude: 100 to 1000 m

Slope inclination: 8 to 42 %

Slope length: 60 to 300 m

Parent material: Volcanic rocks

Soil type: Reddish brown Andosol, Reddish brown Latosol, Association of brown Latosol and grey Regosol

Soil texture (% clay, silt, sand): 27-63, 12-32, 7-34 %

Organic matter content (%): 0.7 to 2.44 %

pH: 5.2 to 6.5

Climate (agro-ecological type): humid tropical

Mean annual temperature (°C): 34

Mean temperature of warmest month (°C): 38

Mean temperature of coldest month (°C): 22

Mean annual precipitation (mm): 2485

Season with high intensity rainfall: November to February

Land use: production forest, social forest, multiple crops

Key crops: Pinus, Hardwoods, horticulture

Experimental design:

Number of the study sites: 2

Sampling design: individual slope transects

Approximate number of samples already taken:

Total: 140 samples

Depth incremental profiles: 2 cm from 0 to 20 cm, 10 cm from 20 to 30 cm

Bulk cores: 114

Approximate number of samples planned to take in future:

Total: 90

Depth incremental profiles: 10

Bulk cores: 80

FRN used already: ^{137}Cs , ^{210}Pb (most of samples)

FRN intended for use: ^{137}Cs , ^{210}Pb

Conversion models used already: MBM1, MBM2 for $^{210}\text{Pb}_{\text{ex}}$

Conversion models intended for use: MBM3

Results

Measurements of soil erosion rates by ^{137}Cs method:

Reference inventory: The reference ^{137}Cs inventory was determined as 273 Bq m^{-2} .

Soil erosion rates: the measured rates fluctuate from 67 to $257 \text{ t ha}^{-1} \text{ y}^{-1}$. Erosion loss during the period 1963 – 2006 ranged from 37 to 96 cm depth of soil.

The relationship of soil erosion rates and selected soil parameters was examined. Soil organic matter showed good relationship (R^2 value = 0.63), but there was no significant relationship for P stocks.

Measurements of soil erosion rates by ^{210}Pb method:

Reference inventory: 2746 Bq m^{-2}

Soil redistribution rates: the estimated erosion rates fluctuated from 7 to $285 \text{ t ha}^{-1} \text{ y}^{-1}$ and accumulation rates from 1 to $37 \text{ t ha}^{-1} \text{ y}^{-1}$. Erosion loss during the period 1963 – 2006 ranged from 37 to 96 cm depth of soil.

MALAYSIA

Problem to be addressed

Soil erosion and associated sedimentation are major agricultural and environmental problems in Malaysia. Soil erosion causes not only on-site degradation of a non-renewable natural resource but also off-site problems such as downstream sediment deposition in fields, floodplains and water bodies. During the last decades erosion has been accelerated by deforestation, overgrazing and poor farming practices. There is an urgent need to assemble quantitative data on the extent, magnitude and actual rates of erosion and sedimentation as well as on their economic and environmental consequences. This project addresses this problem. The investigations undertaken are based on the use of the ^{137}Cs method for soil redistribution studies. In addition, the use of ^{210}Pb and ^7Be will be tested. Besides the fallout radionuclide methods, the soil and water quality will also be examined by conventional methods in order to investigate their relation to the soil erosion rate.

Soil erosion rates and geographical distribution of soil erosion in Malaysia

Problems of soil erosion are very much in evidence in Malaysia. Several factors contribute towards soil erosion such as abundant high erosivity rains, soil erodibility, steep slope in mountainous areas

and intensive cropping with insufficient plant cover. It is estimated that there are about 18.9 million hectares of potentially degradable land in the country, making up 57% of total land surface.

Few studies using conventional methods have been conducted in Malaysia and the estimated soil erosion rates range from 4 to 60 t ha⁻¹ y⁻¹, but these values are not representative of the whole country. An Erosion Risk Map showing an estimation of the total soil loss for the land without conservation practices (worst case scenario) at various terrain classes was elaborated. Sloping lands that are considered critical and susceptible to erosion have been mapped using measurements in erosion plots and the modified USLE.

Status of soil conservation policy in Malaysia

The soil conservation policy is based on the Development Plan for Agriculture on Sloping Land. Several institutions and agencies are involved in the planning and implementation of the soil conservation programmes. They provide for various crops and several slope categories a) guidelines for land clearing, b) guidelines for construction of soil conservation structures, c) guidelines for agronomic practices to combat erosion. They organize meetings with farmers and visits to demonstration plots showing the various soil conservation structures and agronomic practices (mulching, contouring, terracing, construction of run-off storage ponds and silt traps).

Objectives of the study

To use isotope technique (¹³⁷Cs, ²¹⁰Pb and ⁷Be) for estimating soil redistribution.

To compare patterns of soil redistribution from controlled (stable) and uncontrolled (tilled) areas using isotope techniques.

To assess the impacts of soil redistribution on soil quality and water quality.

To develop techniques for controlling soil erosion (e.g. mulching) in cultivated land.

To disseminate the findings to technical managers, end-users and university students.

Expected outputs

- Information on soil redistribution rates from stable and cultivated (tilled) areas
- Techniques for controlling soil erosion from cultivated land
- Information on relationships or correlations between soil redistribution and soil/water quality.

The project should provide the information needed by agencies active in implementation of soil conservation policy among the land users in Malaysia. It should contribute also to increase public awareness of soil erosion problems and the importance of soil conservation.

Study site: Sendayan Agriculture Commodity Centre, Negeri Sembilan.

Location of the site: about 20 km south of Kuala Lumpur, 101° 54'N 2° 29'E

Geographical, soil and agro-ecological data

Area: 40 ha

Altitude: 30-40 m

Slope inclination (%): 9

Slope length (range): 80-120 m

Parent material: shales

Soil type (US Soil Taxonomy): Oxisols

Soil texture (% clay, silt, sand): 18.1, 10.3, 71.6

Organic matter content (%): 0.94

Climate (agro-ecological type): A_f (Koppen) Humid tropics

Mean annual temperature (°C): 31

Mean temperature of warmest month (°C): 38

Mean temperature of coldest month (°C): 22

Mean annual precipitation (mm): 2200 mm

Season with high intensity rainfall: March, April (South-west monsoon) and September to December (North-East monsoon)

Land use: complex land use

Key crops: fruits, vegetables

Experimental design

Number of the study sites: 1 and 2 plot areas (control and eroded)

Sampling design: Individual slope transects

Approximate number of samples already taken:

Total: 38

Depth incremental profiles: 1

Bulk cores: 37

Approximate number of samples planned to take in future:

Total: 42

Depth incremental profiles: 2

Bulk cores: 40

FRN used already: ^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$

FRN intended for use: ^7Be

Conversion models used already: proportional model (PM) and MBM1

Conversion models intended for use: MBM2 and Profile Model (PrM)

Results

Reference inventories: The estimated reference inventories are 288 Bq m⁻² for ^{137}Cs and 7104 Bq m⁻² for ^{210}Pb .

Soil erosion and sedimentation rates: the soil erosion rates calculated by the ^{137}Cs method and the MBM1 conversion model range from 1.5 to 9.5 (mean of 4.4) t ha⁻¹ y⁻¹ for plot 1 (control, stable) and from 3.4 to 29.0 (mean of 13.7) t ha⁻¹ y⁻¹ for plot 2 (eroded, tilled). The sediment chronology was studied using the ^{210}Pb method. The sedimentation rates were relatively constant during the period 1988 – 2003 ranging from 1 to 2 mm y⁻¹. The only exception was year 1993 when a considerably higher rate (almost 5 mm y⁻¹) occurred.

The data obtained are an important contribution to better understanding soil erosion in Malaysia. However the information on soil erosion rates gained by the ^{137}Cs method is still very limited and data with the ^{210}Pb and ^7Be methods are not available at all.

MONGOLIA

Problem to be addressed

Mongolia is a country experiencing severe soil erosion and desertification problems due to improper land use, inadequate agricultural practices, overgrazing and climate change (extreme events). Land degradation induced by anthropogenic factors is common to all ecological zones of Mongolia. There are several specific human activities that have led to serious and widespread soil erosion and land degradation.

Since the 1990s, abandoned cropland has drastically increased due to the transition from a centrally planned economy to a market economy. The reduction of the cropland has been also accelerated by advancing desertification. These vulnerable areas are almost exclusively used as rangelands, supporting 34.8 million heads of livestock (2006) and numerous populations of wild animals. As in other developing countries, the Mongolian economy is dependent on its natural resources and

animal raw materials. The purpose of this project is to evaluate the status of soil erosion problems in Mongolia and to contribute to development of effective soil conservation strategies.

Soil erosion rates and geographical distribution of soil erosion in Mongolia

Soil scientists from the Institute of Geography of the Academy of Sciences and the Plant Science and Agricultural Institute investigated the erosion status of arable and pasture land since 1960 when the extensive cultivation of virgin land was introduced. The conventional methods used for this purpose were adopted from Russia. A soil degradation assessment system was developed, according to which the country was divided into 5 classes of degradation. At present, 46.5% of the arable land is degraded: 12.9% - strongly, 28.2% - medium and 58.9 % slightly degraded and some 90% of the Mongolian territory can be regarded as vulnerable to desertification. It is estimated that over the past 30 years about 35–50 tons of soil have been lost from each hectare of cultivated land. The national map of the degradation of ecosystems was elaborated. It shows that the most degraded area is the central agricultural region.

Status of soil conservation policy

The government encourages the farmers to introduce minimum tillage and intensify animal husbandry. In 2006 the government provided to the cereal growers with Round-up herbicide (enough for 30.03 thousand ha), and modern minimum tillage machines (36 tractors and 26 harvesting combines) at a 50% discounted rate. In 2006 the area under minimum tillage has increased to 32.3 thousand ha.

Objectives of the study

- To evaluate the application of FRN techniques to elaborate soil redistribution in the fields;
- To evaluate different types of soil cultivation practices for erosion control.

Expected outputs

- Improved knowledge on soil erosion rates;
- Understanding soil redistribution-soil quality relationships under different land management practices;
- Map of soil erosion/deposition spatial distribution.

Study site: Erdenesant Sum

Location of the site: Tuv Aimag region, 230 km from Ulaan Baatar

Geographical, soil and agro-ecological data

Area: 110 ha

Altitude: 1180 m above sea level

Slope inclination: from 2% to 14%

Slope length: 2-4 km

Parent material: granitic rocks

Soil: dark Kastanozem soil

Soil texture (% clay, silt, sand): 49.9-60.1% sand, 36% silt and 6.3-13.6% clay at the abandoned land (site-1) and 27.9-42.5% sand, 48.3-64.4% silt and 6.3-9.2% clay at the pasture land (site-2).

Organic matter content (%): 1.5% (site-1) and 2.3% (site-2)

pH: 6.6-7.1

Climate (agro-ecological type): continental.

Mean annual temperature (°C): from +30°C to -30°C

Mean temperature of warmest month (°C): from 45°C to 50°C

Mean temperature of coldest month (°C): from -45°C to -50°C

Mean annual precipitation (mm): 200-300 mm

Season with high intensity rainfall: July to September

Land use: cultivated field under cereals (500 000 ha), and pasture land

Key crops: wheat, potato and vegetables

Experimental design

Number of the study sites: 2 sites: abandoned land (site-1) and pasture land (site-2).

Sampling design: regular grid

Approximate number of samples already taken:

Total: 35

Depth incremental profiles: Increment depth of 5 cm till 30 cm using scraper. Additional 2 profiles were sampled by 5 cm intervals sampling 20 m interval using the same methods.

Approximate number of samples planned to take in future:

Total: 2000

Depth incremental profiles: 2cm depth intervals

FRN used already: ^{137}Cs

FRN intended for use: ^{210}Pb

Conversion models used already: none

Conversion models intended for use: Proportional model for the arable land and migration model for the pasture land

Results

Reference ^{137}Cs inventory: 2267 +/- 109 Bq m⁻².

Up to now the results include the selection of study sites, collection of background geographical and pedological data from the literature as well as by field survey and ^{137}Cs sampling. The ^{137}Cs reference inventory was determined and the map of the ^{137}Cs distribution of the sampled site was prepared. The ^{137}Cs distribution shows clear evidence of eroded areas and deposition sites. The soil erosion and deposition rates are not yet calculated. This is planned to be done in future using the conversion models.

MYANMAR

Problem to be addressed

In Myanmar, a considerable area of land is eroded by wind and water. The erosion is caused especially by high intensity rainfall and is accelerated by incorrect cultivation practices. In hilly regions, besides shifting cultivation, a lack of proper agronomic practices, forest burning, fuel extraction, timber extraction, road making and mining contribute to the depletion the natural forest cover and accelerate water erosion.

This project will enhance the knowledge on soil erosion processes in Myanmar through the use of radionuclide techniques, and it will contribute to the development of a soil conservation programme in Myanmar.

Soil erosion rates and geographical distribution of soil erosion in Myanmar

Water erosion is the most extensive and pronounced land degradation, as 72% of the whole country is estimated to be affected. Wind erosion is affecting some 11% of the total country. The most affected is the Central Myanmar Dry Zone where low and unequally distributed rainfall is responsible for sparse vegetation. During the dry season wind erosion is active and during the rainy season strong water erosion is caused by high intensity rains.

Status of soil conservation policy in Myanmar

Traditional soil conservation structures such as terraces, dams, furrows and trenches are subsidized by the government. Up to now only about 7600 ha of land is under such measures. The Myanmar Government would like to encourage soil conservation by building national capacities in erosion research and by increasing knowledge/awareness on soil erosion processes. In this respect Myanmar's participation in RAS/5/043 is an important and timely event.

Objectives of the study

- The overall objective is to improve soil and water quality through appropriate land use and management.
- The specific objectives are:
- To reduce soil erosion and to improve soil quality in various agricultural practices using ¹³⁷Cs techniques;
- To establish soil redistribution-soil quality relationships under different land management;
- To establish the spatial data base for soil information;
- To upgrade the laboratory facilities and sampling equipment for FRN techniques.

Expected outputs

- A proposal for a national IAEA TC project
- Information system for erosion and conservation in the study area;
- Quantitative data on soil erosion and sedimentation in the study area;
- Guidelines for sustainable land management in the study area;
- Appropriate laboratory for new FRN technique in agricultural research.

Study site

The study site was not yet selected.

Results

Up to now the results include the collection of background data on agro-ecological conditions, land use, land management, land degradation (particularly soil erosion), and the national soil conservation policy in Myanmar.

PAKISTAN

Problem to be addressed

Pakistan is a developing country and its economy is largely based on agriculture. The country is situated in arid and semiarid zones and suffers from a general shortage of water. Unfortunately, it is also affected by extreme river floods during the monsoon period. More than 60% of the population is engaged in agriculture or agribusiness. Out of a total area of 79.61 Mha, 23.0 Mha is cultivated. About 25 % of the cultivated area is rain-fed. Soils represent the single-most important natural resource on which human existence and prosperity depend. Although the country's soil resources are vast, good quality soils that form prime agricultural land are limited. The present use of land is not in accordance with its potential. Soil erosion by water is the most severe problem in rain-fed areas, which have undulating topography, mostly loess parent material and concentrated monsoon rainfall. Thus these areas are highly susceptible to water erosion that causes irreparable physical (resource) and chemical (nutrients losses) degradation, resulting in aggravated productivity decline and environmental pollution. Water erosion occurs in various forms, depending on type and gradient of sloping-land, the soil material, the amount and intensity of rainfall, etc. The second major problem related to soil erosion is increased sediment loads in the rivers and streams, which are responsible

for siltation of conveyance systems and reservoirs. The third problem associated with soil erosion is the potential contamination of surface water and groundwater with agrochemicals.

The decline in soil fertility is threatening food security in Pakistan at both the national and rural household levels. Present levels of soil degradation, especially the decline in soil fertility, is attributed primarily to a combination of soil erosion and nutrient mining, as a consequence of poor land management practices. Thus development of innovative, practically feasible and appropriate technologies for monitoring of soil erosion and fertility degradation and formulation of corrective measures are urgently needed in the interest of food security, poverty alleviation as well as resource base sustainability and environmental protection.

The information on soil degradation caused by soil erosion in Pakistan is usually discussed only in qualitative terms and there is a serious deficiency of quantitative information. It is, therefore, necessary that a comprehensive quantitative analysis of the erosion, transport of soil material, reservoir sediment, and the origin of sediment is performed. In this way sedimentation remediation strategies can be planned more efficiently. Moreover, erosion and sedimentation control practices implemented in watersheds could be evaluated and compared. These problems are addressed under RAS/5/043.

Soil erosion rates and geographical distribution of soil erosion in Pakistan

The most commonly observed forms of water erosion are sheet, rill, gully and riverbank erosion. The National Agricultural Research Council (NARC), Small Dams organization, Provincial Agricultural Departments and the Soil and Water Conservation Research Institute are working on estimating soil losses as well as some management practices to tackle the problem. A comprehensive soil erosion map of the whole country is not available. But some regional maps were made by NARC. The area of land affected by soil erosion has been estimated at 8 millions ha. The Potohar region is the most affected area in the country because of topography, lack of vegetation cover, climate etc. Almost no quantitative data on soil erosion rates are available. Limited data gained by conventional methods showed erosion rates of 3-4.5 t ha⁻¹ y⁻¹, but much higher erosion rates are common as estimated by field observation.

Status of soil conservation policy in Pakistan

A well defined conservation policy is lacking. However different organizations (NARC, Small Dams organization, Provincial Agricultural Departments and the Soil and Water Conservation Research Institute) are working on different management practices like crop rotation, land levelling, tillage practices, ploughing depths, soil cover in grazing lands, terracing in hilly areas etc. However, only conventional agriculture is practiced by farmers.

Objectives of the study

The general objectives of the project are to develop the technical know-how about the application of ¹³⁷Cs, ²¹⁰Pb and ⁷Be for measuring soil erosion and sedimentation, promotion of these techniques in the end-user departments, sustainable management of land by controlling soil erosion and improving land and water quality. The specific objectives of the project are:

- To measure soil erosion and deposition over several spatial and time scales by the combined use of ¹³⁷Cs, ²¹⁰Pb and ⁷Be;
- To establish soil redistribution-soil quality relationships under different land management practices by application of the above techniques;
- To measure sediments and agrochemicals (nutrients, pesticides, etc.) in water runoff to assess contamination of water;
- To utilize these techniques to assess the effectiveness of specific land use and management measures in reducing soil erosion, improving soil quality, and enhancing soil carbon storage.

Expected outputs

- Information on soil loss from fields;
- Data on rates of siltation in a dam;
- Information on major sediment source areas in a watershed;
- Information on the effect of land use change on siltation rates in a dam.

Study site: Sandaymar dam and its catchment and Fateh Jang site

Location of the site: Pothwar, District Rawalpindi

Geographical, soil and agro-ecological data

Area: 9 km²

Altitude: 500-600 m

Slope inclination: 2-13 %

Slope length: 200-840 m

Parent material: clay, shales, sand

Soil type: loess

Soil texture (% clay, silt, sand): loam

Organic matter content (%): not measured

pH: not measured

Climate (agro-ecological type): semiarid subtropics.

Mean annual temperature (°C): 31

Mean temperature of warmest month (°C): 39

Mean temperature of coldest month (°C): 03

Mean annual precipitation (mm): usually 750-1000, rainfall varies from 100 mm to more than 2000 mm.

Season with high intensity rainfall: July–September (monsoon season)

Land use: arable land

Key crops: wheat, maize

Experimental design

Number of the study sites: 2

Sampling design: multiple transects, regular grids, sediment depth profiles from the dam, sediment samples from channels (scraper, bulk cores)

Approximate number of samples already taken:

Total: 500

Depth incremental profiles: 8

Bulk cores: 400

Approximate number of samples planned to take in future:

Total: 500

Depth incremental profiles: 5-10

Bulk cores: 500

FRN used already: ⁷Be and ¹³⁷Cs

FRN intended for use: ²¹⁰Pb (Depends on help by expert)

Conversion models used already: PM, MBM 1

Conversion models intended for use: MBM 2, 3

Results

Reference ¹³⁷Cs inventory: The inventory is 1175 Bq m⁻² for Sandaymar site and 3226 Bq m⁻² for Fateh Jang site.

Soil erosion and sedimentation rates: The measured soil redistribution rate is ranging from -24 to 39 t ha⁻¹ y⁻¹ at the first site and from -22 to 33 t ha⁻¹ y⁻¹ at the second site (negative values representing erosion and positive deposition).

The sediment chronology was studied in the dam reservoir with the ¹³⁷Cs method. The ¹³⁷Cs contamination reached to the depth of 1200 mm. Based on the time period from ¹³⁷Cs fallout in 1963 the estimated sedimentation rate would be 28 mm y⁻¹.

Reference ⁷Be inventory: An attempt was made to determine the ⁷Be reference inventory. Two profiles were sampled. The ⁷Be depth distribution was atypical for a reference site. The ⁷Be contamination increased with depth reaching its maximum at a depth of 10-30 cm. More investigation for ⁷Be distribution should be done.

PHILIPPINES

Problem to be addressed

Soil erosion continues to be a major threat to agricultural productivity and sustainability in the Philippines. Associated sedimentation brought about by soil movement also poses risks of degradation of water resources by way of increased sediment loads in rivers, sedimentation of conveyance systems and reservoirs, increased costs of water treatment, etc. The Philippines participated in the TC project RAS/5/039 where the ¹³⁷Cs method was first employed for estimating soil redistribution rates at the field level. The results showed that nuclear technologies may provide important information on soil erosion rates needed for soil conservation policy formulation. The Philippines have continued soil erosion research activities based on nuclear techniques and they are participating in TC project RAS/5/043 in order to strengthen their erosion research capability, especially for using conversion models and for testing the ⁷Be and ²¹⁰Pb methods.

Soil erosion rates and geographical distribution of soil erosion in the Philippines

Soil erosion research in the country is being conducted by different research organizations, predominantly those under the Department of Agriculture, Department of Environment and Natural Resources, and the Department of Technology. According to the Bureau of Soils and Water Management (BSWM), 60% of the land is very susceptible to erosion and 40% is not susceptible or moderately susceptible to erosion. Approximately 11 Mha (35%) of land are strongly eroded. The mean soil erosion rate is estimated at 10 m³ ha⁻¹ year⁻¹. The usual methods for measuring soil erosion are small erosion plots. The measured rates range from 20 to 100 t ha⁻¹ year⁻¹. Erosion plots were installed under RAS/5/039 involving several land uses in the watershed.

Status of soil conservation policy in the Philippines

Knowledge/awareness on soil erosion, its negative impacts and the necessity of soil conservation was introduced to the farmers, but the response is very limited. Very few farmers show any interest to adopt new technology, especially in the uplands. A vigorous campaign for information dissemination is needed. Contour tillage and terracing are the main soil conservation measures used.

Objectives of the study

- To measure the spatial patterns and rates of soil redistribution under different land use and management practices using FRNs;
- To measure selected soil parameters and to relate them to data on soil redistribution obtained by FRN-methods.

Expected outputs

- Data on soil erosion rates;
- Information on the impact of soil erosion on soil quality;

- Information on the impact of land use on soil erosion rates.

Study site: Frabanga (Irabange) watershed

Location of the site: Bohol, Central Visayas

Geographical, soil and agro-ecological data

Area: 570 km²

Altitude: 120-140 m

Slope inclination: 3 – 50 %

Slope length (range): 10-120 m

Parent material: shale, sandstone, coralline limestone

Soil type: strongly weathered tropical soil (Oxisol)

Soil texture (% clay, silt, sand): clay 18-70%, silt 5-36%, sand 6-65%

Organic matter content (%): 1-1.5%

pH: acid soil

Climate (agro-ecological type): tropical monsoon climate

Mean annual temperature (°C): 32

Mean temperature of warmest month (°C): 35

Mean temperature of coldest month (°C): 25

Mean annual precipitation (mm): 2000 mm

Season with high intensity rainfall: May - September

Land use: arable land, paddy fields for rice cultivation, perennial crops (palm plantations), forest

Key crops: cassava, rice, corn, coconut

Experimental design:

Number of the study sites: 2

Sampling design: regular grid

Approximate number of samples already taken:

Total: 300

Reference site:

Depth incremental profiles: 50

Bulk cores: 100

Study sites:

Depth incremental profiles: 50

Bulk cores: 100

Approximate number of samples planned to take in future:

Total: 174-194

Reference site:

Depth incremental profiles: 24

Bulk cores: 20

Study sites:

Depth incremental profiles: 50

Bulk cores: 80-100

FRN used already: ¹³⁷Cs, ²¹⁰Pb

FRN intended for use: ¹³⁷Cs

Conversion models used already: PM

Conversion models intended for use: MBM

Results

Reference inventories: The ¹³⁷Cs reference inventory is 420 Bq m⁻² and the ²¹⁰Pb reference inventory is 3,300 Bq m⁻².

Soil erosion and sedimentation rates: The soil redistribution rates calculated by ^{137}Cs and the proportional model range from -60 to 100 t ha⁻¹ y⁻¹ at first site and from -30 to 130 t ha⁻¹ y⁻¹ at second site (negative values representing erosion and positive deposition). The use of the ^{210}Pb method is in the initial stage, and so far only the reference value was calculated.

Relation of ^{137}Cs distribution to selected soil characteristics: In order to evaluate the relationship of soil redistribution to soil quality the relationships of ^{137}Cs to selected soil characteristics were investigated. Most relationships were not significant. Correlations were found only for soil Fe ($R^2 = 0.40$), Mn ($R^2 = 0.11$) and Zn ($R^2 = 0.21$). There was no significant correlation with soil organic matter.

SRI LANKA

Problem to be addressed

Soil erosion in Sri Lanka is often caused by high intensity rainfall during the monsoon rainy season. Intensive soil erosion affects large parts of the country as the cultivated land occupies some mountainous areas. Rice, tea and vegetables are cultivated on steep slopes which in many cases are not properly managed. The improvement of land management and the selection of the appropriate land use to minimize soil erosion losses can be achieved only through the development of scientific knowledge. Nuclear technology was identified as an important tool for assessment of soil erosion. Implementation of soil erosion studies using nuclear methods is done in close cooperation with IAEA under this project.

Soil erosion rates and geographical distribution of soil erosion in Sri Lanka

Central, south-western, and some areas in the southern regions of the country have severe erosion hazard. In these regions, the areas that are in the wet and intermediate climatic zones are particularly susceptible to erosion. Inappropriate land use/management has led to land degradation due to erosion in such areas. The rates are in the range 8-52 t ha⁻¹ y⁻¹.

Status of soil conservation policy in Sri Lanka

The Soil Conservation Act states that cultivation should not be practiced on slopes steeper than 60% and at altitudes higher than 4500 ft. The Act does not encompass land use and land management.

Objectives of the study

- To measure soil erosion and soil deposition over several spatial and time scales by combined use of ^{137}Cs , ^{210}Pb , and ^7Be ;
- To establish soil redistribution-soil quality relationships under different land management practices by application of the above technique;
- To enhance the capacities of Sri Lanka for improving soil and water quality.

Expected outputs

- Information on the relationship of erosion to land use;
- Recommendations on land use and land use management;
- Increased awareness of erosion problems and awareness of the contribution of nuclear technology to assessing soil erosion.

Study site: Uma Oya

Location of the site: Central Province

Geographical, soil and agro-ecological data:

Area: 90 km²

Altitude: 500-2500 m

Slope inclination: 20-80 %

Slope length (range): 50m – 1000m

Parent material: basic rock

Soil type: Dystric Cambisols, Plinthic and Haplic Acrisols

Soil texture (% clay, silt, sand): 40% clay, 20% silt, 40% sand

Organic matter content (%): 5-8%

pH: 5-6

Climate (agro-ecological type): upcountry wet and upcountry intermediate climatic zone

Mean annual temperature (°C): 20

Mean temperature of warmest month (°C): 25

Mean temperature of coldest month (°C): 10

Mean annual precipitation (mm): 2500 mm

Season with high intensity rainfall: October-January

Land use: cultivated land, bush and grassland, forest

Key crops: tea, vegetables, rice, primary forest, secondary forest

Experimental design:

Number of the study sites: 5

Sampling design: regular grid

Approximate number of samples already taken

Total: 30

Depth incremental profiles: 5

Bulk cores: 25

Approximate number of samples planned to take in future

Total: 23

Depth incremental profiles: 3

Bulk cores: 20

FRN used already: ¹³⁷Cs

FRN intended for use: ²¹⁰Pb, ⁷Be

Conversion models used already: PM

Conversion models intended for use: MBM 1 and 2

Results

The **soil erosion rates** were determined by the ¹³⁷Cs method for 5 sites with different land use.

At each site also the **quality of runoff water** was analyzed.

Site 1. Steep slope with vegetable and rice cultivation

Land use history of the site: tea plantation (100 y), shrub and grass (30 y), rice-vegetable rotation (last 5 y).

Soil loss (Proportional model): 48 t ha⁻¹ y⁻¹

Runoff water quality:

- total suspended solids: 0.8 - 2.7 g l⁻¹
- total phosphates: 1.0 - 4.0 mg l⁻¹
- total nitrates: 3.0 - 19.0 mg l⁻¹

Site 2. Terraced slope with vegetable cultivation

Land use history of the site: tea plantation (100 y), vegetable cultivation (last 50 y)

Soil loss (Proportional model): 22 t ha⁻¹ y⁻¹

Runoff water quality:

- total suspended solids: 0.1 - 0.5 g l⁻¹
- total phosphates: 1.0 - 2.0 mg l⁻¹

- total nitrates: 6.0 - 14.0 mg l⁻¹

Site 3. Eroded tea plantation

Land use history of the site: tea plantation for 150 y

Soil loss (Proportional model): 52 t ha⁻¹ y⁻¹

Runoff water quality:

- total suspended solids: 0.4 - 1.0 g l⁻¹
- total phosphates: 1.0 - 2.0 mg l⁻¹
- total nitrates: 4.0 - 7.0 mg l⁻¹

Site 4. Well managed tea plantation

Land use history of the site: tea plantation for 150 y

Soil loss (Proportional model): 32 t ha⁻¹ y⁻¹

Runoff water quality:

- total suspended solids: 0.2 - 0.3 g l⁻¹
- total phosphates: 1.0 - 3.0 mg l⁻¹
- total nitrates: 6.0 - 9.0 mg l⁻¹

Site 5. Secondary forest

Land use history of the site: primary forest (until 50 years ago), secondary forest (last 50 y)

Soil loss (Proportional model): 29 t ha⁻¹ y⁻¹

Runoff water quality:

- total suspended solids: 0.1 - 0.2 g l⁻¹
- total phosphates: 1.0 - 2.0 mg l⁻¹
- total nitrates: 2.0 - 3.0 mg l⁻¹

The data show that the erosion rates reach as much as 50 tons per ha per year. The highest rates are reached on very steep slopes that are non-appropriate for cultivation (Site 1), and also on less steep slopes if the land management is not appropriate (Site 3). Proper land management and soil conservation measures, such as terraces can reduce the erosion rates by 60% (Sites 4 and 2). The results from Site 5 show that erosion is active not only on agricultural land but in secondary forests where it can reach similar rates as on well managed cultivated land.

The research work has attracted the attention of the plantation sector and some regional administrations who are interested in scientific land use planning. A project with the objective to identify the eroded lands in the tea plantations and to recommend appropriate land use for such areas has been proposed by the Southern Regional Administration.

THAILAND

Problem to be addressed

Sloping lands and uplands are widespread in Thailand and cover most of the Northern part of the country. In such regions, inappropriate land use and lack of soil and water conservation practices has led to widespread soil erosion and land degradation. However, as the different processes and factors contributing to the actual degradations are still unknown, it is difficult to propose relevant and adapted solutions to the different problems. In this context the Land Development Department has the responsibility for conducting research on soil erosion, using the most up-to-date techniques and for promoting farming systems and soil and water conservation techniques accessible to farmers for a sustainable agriculture in Thailand. Advanced nuclear technology for erosion assessment will be adopted in collaboration with IAEA through participation in RAS/5/043.

Soil erosion rates and geographical distribution of soil erosion in Thailand

Most of the studies were carried out in erosion plots (total runoff and sediment collection). Different soil conservation practices were tested. Plot size was 5 x 30 m, and usually 3-4 treatments were tested in 3-4 repetitions, so that the total area of such an experimental site was up to 0.4 ha. The data from erosion plots indicate that in the highlands on fields under conventional farming practices the erosion rates range from 2 to 4 t ha⁻¹ y⁻¹. Where conservation measures are applied the soil erosion rates are reduced to 0 - 2 t ha⁻¹ y⁻¹.

Apart from plot measurements, erosion modelling (USLE) and GIS were applied. The territory of the highlands was divided into 5 classes. The majority (52%) belongs to 1st class with soil erosion rates ranging from 0 to 2 t ha⁻¹ y⁻¹, 13 % is in class 2 (2-5 t ha⁻¹ y⁻¹), 8 % in class 3 (5-15 t ha⁻¹ y⁻¹), 3 % in class 4 (15-20 t ha⁻¹ y⁻¹) and 24% in class 5 with soil erosion rate higher than 20 t ha⁻¹ y⁻¹.

Status of soil conservation policy in Thailand

The government supports the Land Development Department to promote soil conservation. The information from the soil erosion plots was disseminated among the farmers. Usually hill side ditches, terraces, and strips of vetiver grass were promoted.

Objectives of the study

The main objective of the study is to assess the soil redistribution pattern and soil quality as influenced by erosion.

Expected outcomes

- Information on:
 - Soil erosion and deposition rates;
 - Effects of soil erosion on soil quality,
- Spatial patterns of erosion and deposition and their territorial extension will be available for policy makers and land users as background information for assessment of impact of soil erosion on agricultural land and production and for planning soil conservation strategy.

Study sites: 1st Site: Khon Kean Site
2nd Site: Uttaradit Site

Khon Kean Site

Location: Phra Yuhn watershed, Phra Yuhn district, Khon Kean province, northeast of Thailand.
Location around 48258718 E and 1806262 N

Geographical, soil and agro-ecological data

Acreage: 70 ha

Altitude:

Slope inclination: 2 – 5 degrees

Slope length:

Parent material: fine arcose red-coloured sandstone

Soil type: polygenic soil covered by eolian fine sandy soil

Soil texture (% clay, silt, sand): sandy (2% clay, 9% silt, 89% sand)

Organic matter content (%): 0.17-0.57%

pH: 5.7

Climate (agro-ecological type): tropical

Mean annual temperature (°C): 29

Mean temperature of warmest month (°C): 37

Mean temperature of coldest month (°C): 22

Mean annual precipitation (mm): 1000 mm

Is there distinct season with high intensity rainfall? If yes, when? August

Land use: cultivated land

Key crops: pararubber, lucy grass, rice.

Experimental design:

Sampling design: individual transects

Approximate number of samples already taken:

Total: 50

Reference site: 8

Depth incremental profiles: 6 cores (5 cm depth increments down to 30 cm depth)

Bulk cores: 0

Study sites:

Depth incremental profiles: 6 cores (5 cm depth increments down to 30 cm depth)

Bulk cores: 30 (0-30 cm)

Approximate number of samples planned to take in future: 30

Total: subject of discussion with expert

FRN used already: ^{137}Cs ,

FRN intended for use: ^{137}Cs , may be ^{210}Pb

Conversion models used already: none

Conversion models intended for use: MBM

Uttaradit Site

Location: Lee watershed, Thapla district, Uttaradit province, northeast of Thailand. Location around 47200633816 E and 1974317 N

Geographical, soil and agro-ecological data

Acreage: 20 ha

Altitude: 200-400 m. MSL

Slope inclination: 40 degrees

Slope length:

Parent material:

Soil type: Silty clay, Clay loam, and Clay

Soil texture (% clay, silt, sand): sandy (34-48% clay, 31-44% silt, 7-32% sand)

Organic matter content (%): 1.5-4.5%

pH: 5.5-6

Climate (agro-ecological type): tropical

Mean annual temperature ($^{\circ}\text{C}$): 28

Mean temperature of warmest month ($^{\circ}\text{C}$): 36

Mean temperature of coldest month ($^{\circ}\text{C}$): 18

Mean annual precipitation (mm): 1200 mm

Is there distinct season with high intensity rainfall? If yes, when? August

Land use: forest

Key crops: banana.

Experimental design:

Number of the study sites: 3 catchment areas

Sampling design: individual transects in each catchment area

Approximate number of samples already taken:

Total: 48

Reference site: 12

Depth incremental profiles: 6 cores (5 cm depth increments down to 30 cm depth)

Bulk cores: 6.

Study sites: 36

Depth incremental profiles: 6 cores (5 cm depth increments down to 30 cm depth)

Bulk cores: 30 (0-30 cm)

Approximate number of samples planned to take in future:

Total: subject of discussion with expert

FRN used already: ^{137}Cs ,

FRN intended for use: ^{137}Cs , may be ^{210}Pb

Conversion models used already: none

Conversion models intended for use: MBM

Results

Up to now the results include:

Background data on agro-ecological conditions, land use, land management, land degradation (particularly soil erosion), and soil conservation policy in Thailand;

Soil analyses;

Data on ^{137}Cs depth distribution in soil profiles sampled at the reference site. The ^{137}Cs depth distribution is irregular (random) and it does not show a depth distribution typical of a reference site.

VIETNAM

Problem to be addressed

Over the last two years, the National Institute of Soils and Fertilisers (NISF - Ministry of Agriculture and Rural Development) and the Vietnam Atomic Energy Commission (VAEC - Ministry of Science and Technology) have been involved in the use of environmental isotopes (^{137}Cs and ^{210}Pb) for studying the influence of soil management practices on soil erosion and redistribution in sloping areas in northern Vietnam. The results obtained encouraged NISF to integrate nuclear techniques into its current program on “Sloping Land Management for Sustainable Agriculture and Environmental Protection”. VAEC will continue to co-operate with NISF by providing technical support. In order to build on the experience with nuclear technology for soil erosion research, NISF is participating in RAS/5/043.

Soil erosion rates and geographical distribution of soil erosion in Vietnam

Soil erosion research in Vietnam is benefiting from the attention being paid to it by the government and through its participation in IAEA CRP D1.50.08. Data on soil erosion rates in Vietnam were gained by both conventional and nuclear techniques. Data obtained from erosion plots in Buon Yong catchment (located 25 km to the North of Buon Ma Thuot city in Dak Lak province (average elevation 550 m) showed erosion rates fluctuating from 25 to 45 t ha⁻¹ y⁻¹. The soil erosion rates measured by ^{137}Cs at a study site near Dalat (central Vietnam) reached 4 – 28 t ha⁻¹ y⁻¹. According to recent information the usual soil erosion rates on sloping sub-mountainous and mountainous areas is approximately 30 to 40 t ha⁻¹ y⁻¹ and 11 million ha (33%) of land are severely affected by erosion.

Status of soil conservation policy in Vietnam

The soil conservation policy in Vietnam focuses on several measures. In mountainous areas, which are not suitable for agriculture reforestation is encouraged. On agricultural land agro-forestry, intercropping, hedgerows and conservation agriculture with legumes are promoted. The recent status of implementation of soil conservation measures is quite good.

Objectives of the study

The objectives are to:

- Search for appropriate cultivation methods to minimize surface water runoff and soil and nutrient losses on sloping lands;
- Identify appropriate cropping patterns for improving soil productivity and increasing crop yields;
- Apply these techniques on large scale sloping lands;
- Take advantages of the unique capability of ^{137}Cs and ^{210}Pb techniques in studying soil and nutrient redistribution;
- Explore the suitability of the ^7Be technique for assessing event-based soil redistribution patterns.

Expected outputs

Improved knowledge on soil erosion processes, data on soil and nutrient redistribution in the landscape and their impact on soil quality and water pollution. The final outcome will be improved soil quality and reduced water pollution in streams, rivers and water reservoirs.

Study site: Ea Kao catchment

Location of the site: Buon Ma Thuot city in Dak Lak province of Vietnam

Geographical, soil and agro-ecological data

Area: 50 ha

Altitude: 450 m

Slope inclination: 20-60%

Slope length: 200 m

Parent material: basalts

Soil type: Rhodic Ferrallsols

Soil texture (% clay, silt, sand): sandy clay

Organic matter content (%): 2.5 3.5 **pH:** 4.0-4.5

Climate (agro-ecological type): tropical monsoon

Mean annual temperature ($^{\circ}\text{C}$): 23

Mean temperature of warmest month ($^{\circ}\text{C}$): 32

Mean temperature of coldest month ($^{\circ}\text{C}$): 12

Mean annual precipitation (mm): 1750

Season with high intensity rainfall: May to October

Land use: cultivated land

Key crops: coffee

Experimental design:

Number of the study sites: 1

Sampling design: individual transects, multiple transects and regular grid

Approximate number of samples already taken:

Total: more than 300 samples.

Depth incremental profiles: 30

Bulk cores: 50

Approximate number of samples planned to take in future

Total: 350

Depth incremental profiles: 30

Bulk cores: 70

FRN used already: ^{137}Cs

FRN intended for use: ^{137}Cs

Conversion models used already: PM

Conversion models intended for use: PM, MBM

Results

Reference inventory: Measured activity at the reference site is 331 Bq kg^{-1}

Soil loss: The use of the ^{137}Cs method was combined with the use of an hydrological method. The samples for sediment discharge determination were collected at 5 weirs. The runoff, suspended sediments, bed load sediments and ^{137}Cs concentration in sediments were recorded. The soil erosion rates were determined in two ways 1) from measured runoff, suspended and bed load sediments and 2) by the ^{137}Cs method. The soil erosion rates calculated from sediment loss ranged from 0.4 to $9 \text{ t ha}^{-1}\text{y}^{-1}$ with an average of $4.8 \text{ t ha}^{-1}\text{y}^{-1}$. The correlation with the results obtained by the ^{137}Cs method was very good ($R=0.99$). The values obtained by the ^{137}Cs method are usually smaller as compared to data obtained by sediment measurements. The difference is between 7 and 26%.

2.5. Application of Frn methods

After the presentation of the country reports a round table discussion focused on methodological aspects. Each participant evaluated his experience and skills achieved in the use of FRN methods, specified the problems confronted and presented plans about further steps for implementing the nuclear technology. The problems were analysed and the recommendations were formulated to address specific issues in the future.

China

All three radionuclides are successfully used and a lot of experience with FRN methods was gained at CAAS. This experience can be shared with other project participants, and China as the Lead Coordinating Country of RAS/5/043 can provide expert services and methodological advice. In the future attention should be paid especially to the further development of the ^{210}Pb -method and its application to the studies on gully development and soil quality parameters..

Indonesia

Soil sampling and ^{137}Cs and ^{210}Pb analyses were carried out and the mass balance model was used to calculate soil losses. The major problem is the low ^{137}Cs inventories, which are sometimes below the detection level of the gamma detector. These low inventories result in great variability and this makes the reference site sampling especially difficult. Also, the ^{137}Cs depth distribution in the sampled profiles is not typical for a reference site. More reference site sampling is recommended. The implementation of the ^{210}Pb -method would also contribute towards solving the problem with the low ^{137}Cs inventories.

Very low values of ^7Be were measured in the samples collected. This problem could be caused by sampling thickness, i.e. samples being too thick (1 cm). The sample thickness should be reduced to 2 mm.

Malaysia

The soil sampling and ^{137}Cs and ^{210}Pb analyses were carried out and the proportional and mass balance models were applied. Good experience with the ^{137}Cs method was obtained and there are no problems with this method. In future the mass balance model and the profile model will be adopted. Attention should be paid now to improving the knowledge on the ^{210}Pb -method and especially ^7Be analyses. The short half life of ^7Be is causing logistic problems because the time to arrange the analysis (sample preparation and counting) is too short.

Mongolia

Mongolia did not participate in RAS/5/039 and FRN methods are new. However there is available a good team conducting soil erosion research. This will help to build up the capabilities for the application of FRN methods quickly. Reference sampling already began and the first ^{137}Cs analyses were made. There is a need to more about the principles and procedures of FRN methods and to gain experience with field sampling design.

Myanmar

There is a lack of knowledge on FRN methods because Myanmar did not participate in RAS/5/039. A national team for soil erosion studies should be established and national capabilities to use FRNs build up under a national IAEA TC project. The systematic study of the basic principles of FRN-methods is needed.

Pakistan

Soil sampling, ^{137}Cs and ^7Be analyses were carried out and the proportional and mass balance models were used to calculate soil loss. Experience with the ^{210}Pb method is lacking. The application of the ^7Be method should be improved.

Philippines

Soil sampling and ^{137}Cs and ^{210}Pb analyses were carried out and the proportional model was used to calculate soil loss. The mass balance models will be adopted. In the future the interpretation and representation of the results will be improved.

Sri Lanka

Soil sampling and ^{137}Cs analyses were carried out and the proportional model was used to calculate soil loss. In future the interpretation of the results will be improved and the mass balance models will be adopted. Recently the application of the ^{210}Pb and ^7Be methods is being explored.

Thailand

Thailand did not participate in RAS/5/039. The experience with FRN methods is being built and should be further developed. The study sites were selected, background information was collected and the reference sampling was done. The reference values obtained are not typical for a reference site. The reference sampling should be improved (sampling should be repeated). Further attention should be paid to learn the selection and use of the conversion models and approaches for data interpretation.

Vietnam

The basic experience with the ^{137}Cs method is already in place. Vietnam participates also in CRP D1.50.08 "Assess the effectiveness of soil conservation measures for sustainable watershed management using fallout radionuclides". However, so far only the proportional model is used. The mass balance model should be adopted. The use of ^7Be and ^{210}Pb is not planned.

Overall status of FRN methods implementation

The results of the meeting showed that most countries have already established the basic national capacities for implementation of FRN methods. They have also gained some experience with the use of ^{137}Cs method. However, some problems with selection of reference sites persist, and more experience is needed for planning the field sampling design. The problem of low ^{137}Cs -inventories occurs in Indonesia. More experience is also needed with the use of models and data interpretation. Mass balance models are used by 4 countries (China, Indonesia, Malaysia and Pakistan). Another 3 countries (Philippines, Sri Lanka, and Vietnam) use proportional models. A proficiency test for

^{137}Cs should be organized by the IAEA to ensure that the results produced by the participating countries are based on reliable analytical data and are mutually comparable.

The ^{210}Pb -method is used by 4 countries (China, Indonesia, Malaysia, Philippines) and another 3 countries (Mongolia, Pakistan, Sri Lanka) are planning to use it. There is a need for better understanding the basic principles and application of the ^{210}Pb -method, in particular the analytical techniques. Whenever possible, an inter-laboratory comparison exercise for total ^{210}Pb should be organized.

The ^7Be -method is used by 2 countries (China, Pakistan) and another 2 countries (Malaysia, Sri Lanka) are planning to use it. There are problems related to the sampling (sampling thickness) and counting of the sample's activities (short half-life of ^7Be).

There are 3 countries (Mongolia, Myanmar and Thailand) which did not participate in RAS/5/039 and the national capacities for FRN methods are not built and experience in implementation of FRN methods is lacking. In Thailand and Mongolia the first initiatives to use ^{137}Cs already began. In Mongolia it is related to a new national technical cooperation project, while Thailand started to develop the FRN using its national funding. In Myanmar the implementation of FRN methods did not start yet. However there is a strong interest to adopt FRN methods. It would be useful to encourage these activities by launching a national TCP on erosion research.

The FRN capacities built in China are at an advanced technical level and experienced staff is available. In the future China will be able to provide expert services to other countries in the region. China proposed to organize the proficiency test for total ^{210}Pb measurements. The test could be organized by CAAS in Beijing. The project participants should send samples to check the accuracy of their measurements.

2.6. Regional and National Work plan Review

The progress made in implementing the activities carried out under RAF/5/043 was evaluated with respect to previous work plans. The work plans for the 2007-8 bienniums were reviewed and updated. The requests of project participants for IAEA support were discussed. As the project is entering into the second half (final stage), special attention was paid to the strategies for generation and dissemination of results.

China

The research activities were carried out according to the work plan. In the work plan for the period 2007-8 the requests for a subcontract for the participating countries to measure ^{210}Pb , and expert services were proposed.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for second half of project (Q1 2007)
- Collection and measurement of soil samples for ^{137}Cs inventory from the reference site (Q3 2007)
- Detailed field surveys (topography, land use history, soil conservation measures, etc.), design of sampling map in the catchments (Q3 – Q4 2007)
- Intensive collection of soil samples from different land use sites for ^{137}Cs , ^{210}Pb , and ^7Be and soil quality parameters (Q3 2007 – Q2 2008)
- Monitoring gully erosion rates (Q1 2007 – Q2 2008)
- Analysis of soil and sediment samples for ^{137}Cs , ^{210}Pb , and ^7Be and soil quality parameters (Q1 2007 – Q2 2008)

- Data processing and analysis (Q1 2007 – Q2 2008)
- Soil erosion and soil quality modelling (Q1 2007 – Q2 2008)
- Dissemination of results (Q1 2007 – Q4 2008)
- Final report (Q4 2008)
- Final evaluation meeting (Q4 2008)

Requests for IAEA support:

- Expert mission: to help with the application of FRNs to gully development studies and modelling (Proposed expert: G. Hancock, Australia)
- Subcontract to CAAS to cover the expenses of the measurements of ^{210}Pb for the participating countries (3000 Euros for 120 soil samples).

Dissemination strategy:

The following activities have been made for the dissemination of results:

- Lectures to China Atomic Energy Authority, Ministry of Agriculture of China, Graduate College of CAAS
- Invited presentation in a National Meeting of Soil Erosion and Water Conservation
- Dissemination of data to local governments and soil conservation committees
- Publications in national and international scientific journals
- Publications:
 - Li Y., Zhang QW, Reicosky DC, Bai LY, Lindstrom MJ, Li L. 2006. Using ^{137}Cs and $^{210}\text{Pb}_{\text{ex}}$ for quantifying soil organic carbon redistribution affected by intensive tillage on steep slopes. *Soil & Tillage Research*, 86: 176–184.
 - Li Y., G. Ruysschaert, J. Poesen, Zhang Q.W., L.Y. Bai, L. Li. 2006. Soil losses due to potato and sugar beet harvesting in NE China. *Earth Surface Processes and Landforms*, 31, 1003–1016.
 - Li Y., Zhang Q.W., D.C. Reicosky, M. J. Lindstrom, L.Y. Bai, and L. Li. Changes in soil organic carbon induced by tillage and water erosion on a steep cultivated hillslope in the Chinese Loess Plateau from 1898-1954 and 1954-1998. 2007. *Journal of Geophysical Research*, 112
 - Li Y., Zhang QW, et al. 2006. Physical mechanisms of plant roots affecting weathering and leaching of loess soil. *Science in China*, 49 (9):1002-1008.
- Another dissemination activity will be the production of a guidebook:
- Guidebook on establishing soil quality-soil redistribution relationship using FRNs.

Indonesia

The activities were carried out according to the work plan. However the results of the ^7Be measurements should be verified. Also, more sampling for ^{137}Cs at the reference site is planned in order to improve the accuracy of the ^{137}Cs reference inventory. Therefore the sampling for ^7Be and ^{137}Cs should be extended in the work plan. As a result other activities related to sampling should be postponed.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for second half of project (Q1 2007)
- Soil sampling for ^7Be determination (Q1 – Q4 2007)
- Continuing sampling for ^{137}Cs reference inventory (Q1 – Q2 2007)
- Analysis of soil quality parameters (Q1 – Q3 2007)
- Determination of soil erosion and deposition rates using conversion models and interpretation of data obtained (Q1 – Q3 2007)
- Formulation of recommendations based on the study results (Q3 2007 – Q3 2008)

- Dissemination and transfer of information to agricultural authorities at national and regional levels (Q2 - Q4 2008)
- Final report (Q3 - Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Expert mission (August): Reference sampling for ^{137}Cs at the reference site, investigation of the variability of ^{137}Cs at the reference site, reference site selection for the 2nd study site (Proposed expert: Yong Li).
- Dumpy level

Dissemination strategy:

- To publish a paper in an agriculture-soil research journal and to give seminars
- Distribute some brochures or leaflets to the university and other institutions
- Incorporate FRN methods in soil erosion studies into the university lecturing program as an optional subject

Malaysia

The only activity which was delayed is the determination of ^7Be . There is a need for more ^{137}Cs sampling at the reference site to improve the accuracy of the ^{137}Cs reference inventory. In the work plan for the next period major changes are not needed, but the delays of the above mentioned activities should be addressed.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for second half of the project (Q1 2007)
- Soil sampling for ^7Be , ^{137}Cs and ^{210}Pb (Q1 - Q4 2007)
- Sample analyses for ^7Be (Q1 - Q4 2007)
- Sampling and analysing of water samples (Q3-Q4 2007, Q1 2008)
- Data analysis and interpretation (Q3 2007 – Q2 2008)
- Final report preparation (Q3 2008)
- Dissemination of project achievements (Q3 - Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Dumpy level
- Inter-laboratory comparison of FRN and organic carbon in soil samples (~10 soil samples)

Dissemination strategy:

Publishing in journals and newsletters, printing of leaflets and organizing seminars and lectures. Communication to the farmers will be carried out by agricultural extension authorities.

Mongolia

The activities were carried out according to the work plan. The original work plan for 2007-8 needs only one change. The requested subcontract for 2008 should be cancelled.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Collection of soil samples (Q2 2007 – Q3 2008)
- ^{137}Cs and soil quality analysis of soil samples (Q2 2007 – Q4 2008)

- Establishment of laboratory and field equipment received under new TCP (Q4 2007)
- Data processing and interpretation (Q2 2007 – Q4 2008)
- Development of a soil erosion map (Q2 – Q3 2008)
- Assessment of soil quality-soil erosion relationships under various land uses, crop rotations and management. (Q1 – Q2 2008)
- Developing of standardized methodology for erosion assessment (Q1 – Q4 2008)
- Organization of seminars, workshops, conferences and field days for land users (Q1 2007 – Q4 2008)
- Final report (Q3 - Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Expert mission for 2 weeks (May 2007): study site selection and sampling design, reference site selection and reference sampling (proposed expert: Yong Li).
- Scientific visit for 1 week to China (November 2007): Conversion models, interpretation of results (proposed visitor: B. Burmaa, the National Coordinator, RAS5043).

Dissemination strategy:

- Standardized methodology and guidelines will be prepared for scientists and students
- Scientific seminars and conferences can be organized for researchers and students to become familiar with the FRN methodologies
- National workshops and seminars for farmers can be organized to increase their awareness of the importance of proper land management practices.

Myanmar

Several initial activities were carried out, especially the collection of background information on land use and management and soil erosion status in the country. The work plan was proposed and the study site selection was initiated. Although not finalized, it was decided that it will be located in the Central Dry Zone, which is the area with high erosion risk in Myanmar. The implementation of the FRN technology did not start because Myanmar did not participate in the earlier project RAS/5/039 and therefore the national capacities in FRN methods were not established.

Work plan 2007-8:

The best approach to overcome the problem of national capacities for FRN methods would be to arrange a national TCP on this topic. A similar solution was arranged for Mongolia, which also did not participate in RAS/5/039. The first step should be the evaluation of the status of national erosion research capacities in Myanmar by an expert mission. The expert will help the Myanmar researchers to prepare the national TCP proposal, and to prepare the work plan for the second biennium of RAS/5/043. This work plan should be in accordance with the activities proposed under the national TCP.

Requests for IAEA support:

- Expert mission: to evaluate the national capacities available for erosion research and to help with preparation of the national TCP proposal (Proposed expert: Yong Li).
- Fellowship: Training to learn basic principles of FRN-methods.

Dissemination strategy:

Dissemination activities will be planned at a later stage.

Pakistan

All activities were carried out according to the work plan except for the agrochemical analyses. Agrochemicals (fertilizer nutrients and pesticides) were not analysed because they are used in very small quantities and mostly animal manures are applied. The agrochemical analyses should be removed from the work plan for 2007-8. Another activity, which may need to be changed is the determination of ^{210}Pb planned for Q1 2007 – Q3 2008. This activity will be carried out only if the expert will provide the know-how on the ^{210}Pb -method.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Collection of soil samples from the selected sites having different land use and soil conservation practices for radionuclides (^{137}Cs , ^7Be , ^{210}Pb) and agrochemical analyses (Q1 2007 – Q3 2008)
- Monitoring of runoff discharge (Q1 2007 – Q2 2008)
- Collection of water and sediment samples from runoff (Q1 2007 – Q2 2008)
- Analysis of soil, sediment and water samples for ^{137}Cs , ^{210}Pb , ^7Be (Q1 2007 – Q3 2008)
- Assessing the impact of land management practices on soil erosion (Q2 2007 – Q4 2008)
- National workshop for dissemination of information on integration of nuclear and conventional techniques in soil and water management (Q4 2007)
- Final report (Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Fellowship to China: Fellowship was planned in 2005 but it was not organised. Training programme should include general training on FRN methods (sampling strategy, sample analysis with special emphasis on ^{210}Pb , but mainly conversion models and data interpretation)
- Expert mission: to help with ^7Be -method (sampling, sample analysis, data interpretation) and with ^{210}Pb analysis (proposed expert: Yong Li, September 2007).

Dissemination strategy:

- The practical results would be translated into the local language for distribution to the farmers
- The brochures are already prepared and distributed to different organizations such as the National Agriculture Research Institute and Small Dam Organization, etc.
- A national seminar will be held in 2007 for researchers and scientists already involved in related matters from different departments like the National Agriculture Research Institute, Small Dam Organization and the Soil Conservation Department, etc.

Philippines

The activities carried out fulfilled the work plan for the biennium 2005-6 except for water quality analyses. No changes are required regarding the work plan for 2007-8 except for the water quality analyses that were postponed to the 1st half of 2007.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Determination of soil and water quality parameters (Q1-Q2 2007)
- Radionuclide analyses (^{137}Cs , ^{210}Pb) (Q1 2007 – Q1 2008)

- Data processing and interpretation (Q2 2007 – Q2 2008)
- Development of soil conservation measures (Q1 2007 – Q1 2008)
- Extension services and dissemination activities (Q1-Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Expert mission to help with implementation of conversion models and data interpretation (proposed expert: D. Walling)

Dissemination strategy:

The farmers were involved in the project at an early stage. They participated in the selection of the study area and the objectives of the research were formulated (pre-activities). The future dissemination will be done through seminars for scientists, students, policy makers and farmers. Technical demonstrations at model farms are planned. The selected soil conservation measures to reduce soil erosion will be demonstrated to farmers through Farm Days.

Sri Lanka

All activities were carried out according to the work plan except for the measurement of ^{137}Cs , which was postponed because the new gamma detector was fully commissioned only in December 2006. Counting started in January 2007. The time schedule of ^{137}Cs analysis was adjusted and the analysis of ^{210}Pb and ^7Be was included in the work plan.

Workplan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Collecting information on land use, soils, water (Q1 2007 – Q1 2008)
- Soil sampling for ^{137}Cs , ^{210}Pb and ^7Be and for soil quality parameters (Q1 2007 – Q1 2008)
- Processing and FRN analyses of soil samples (Q1 2007 – Q3 2008)
- Soil and water quality analysis (Q1 2007 – Q3 2008)
- Data interpretation (Q1 2007 – Q4 2008)
- Model testing and preliminary conclusions (Q2 2007 – Q2 2008)
- Formulation of conclusions and recommendations (Q1 – Q4 2008)
- Preparation of final report, manuals, guidelines and maps (Q2 – Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Subcontract to cover expenses of field work.

Dissemination strategy:

Technical reports to agricultural authorities, meetings with national and regional agricultural administration.

Thailand

Most of the activities planned for 2005-6 started but they were delayed. The FRN techniques are new and more skills and experience are needed for their proper application. The reference sampling should be repeated. Consequently most of the activities following the sampling need to be postponed or extended. The scientific visit to study field strategies, laboratory techniques, and soil conservation practices should be cancelled.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Soil sampling and laboratory analysis of ^{137}Cs (extended to Q1 - Q4 2007)
- Data analysis, model validation and interpretation of data (postponed to Q3 2007 - Q4 2008)
- Testing of improved soil and water management practices for erosion control (extended to Q1 - Q4 2007)
- Assessment of soil erosion at the experimental field (extended to Q1 - Q4 2007)
- Collection of soil and water samples from runoff and laboratory analysis (Q2 – Q3 2007)
- Data processing and interpretation and preparation of the final report (postponed to Q2 – Q3 2008)
- Dissemination of results (Q3 - Q4 2008)
- Final meeting (Q4 2008)

Requests for IAEA support:

- Expert mission I (March-May 2007): sampling site selection and sampling design (Proposed expert: Y. Li)
- Expert mission II (March-May 2008): to help with implementation of conversion models and with data interpretation
- Fellowship: training on conversion models and data interpretation
- Equipment: Dumpy level and hand core sampler

Dissemination strategy:

In general the dissemination activities are planned for the 2nd half of 2008. Specific activities will be planned later on, taking into account the results of the project.

Vietnam

All activities were carried out according to the work plan. No changes in the work plan are needed for the period 2007-8.

Work plan 2007-8:

- Mid-term review meeting to assess progress and set objectives for the second half of the project (Q1 2007)
- Soil sampling for ^{137}Cs (Q1 – Q3 2008)
- Sample analyses for ^{137}Cs (Q1 – Q3 2008)
- Measurements of sediment discharge (Q1 – Q3 2008)
- Data analysis and interpretation (Q3 2007 – Q4 2008)
- Final report preparation (Q3 – Q4 2008)
- Dissemination of results (Q3 - Q4 2008)
- Final meeting (Q4 2008)

Request for IAEA support:

- Fellowship: general training on FRN methods
- Budget for sampling and analysing soil samples

Dissemination strategy:

The conclusions and recommendations of the project will be simplified in a pamphlet that will be distributed to the farmers.

The regional work plan

The regional work plan for RAS/5/043 was reviewed. Despite delays in some activities in several countries, no changes in the regional work plan are needed because the relevant experimental work activities such as sampling, analysis and data interpretation and the soil redistribution-soil/water quality relationship were planned to continue until Q3 2008. Formulation of guidelines on soil and water management should start in Q3-Q4 2007 and will be continued by dissemination during 2008. The only change made was to postpone the final review meeting from Q3 to Q4 2008.

The regional work plan for 2007-8:

- Mid-term review meeting (Q1 2007)
- Data collection for the study site (Q1 2007 – Q3 2008)
- Soil analysis (Q1 2007 – Q3 2008)
- Data analysis and modelling (Q1 2007 – Q3 2008)
- Establishment of linkages with other government agencies and end-users (Q1 2007 – Q4 2008)
- Formulation of recommendation on land management and soil conservation measures (Q3 - Q4 2008)
- Publication of experimental results (Q1 2007 – Q4 2008)
- Final report (Q4 2008)
- Final review meeting (Q4 2008)

Evaluation of the requests for assistance from IAEA

The requests made by the project participants involve 8 expert missions, 2 scientific visits, 5 fellowships, 2 subcontracts and 5 requests for procurement of equipment.

The TO informed the participants that expert missions will be the main IAEA inputs for project implementation during the second half of the project.

As the capacities for FRN methods were built already under RAS/5/039 the participants of RAS/5/043 are expected to use these capacities to develop technologies to reduce soil erosion and improve soil and water quality. Further purchases of equipment and training of staff through fellowships are not planned. Also, the award of subcontracts for financing expenses of the experimental work (especially field work expenses and small consumables) carried under the project would not be possible. It is expected that such expenses should be covered from national resources.

The requests for IAEA assistance were evaluated as follows:

All 8 expert missions (China, Indonesia, Mongolia, Myanmar, Pakistan, Philippines and 2 missions to Thailand) and 1 scientific visit (Mongolia) are fully justified. They are essential to complete successfully the planned experimental activities and to achieve the goals of the project.

The requested equipment is also recommended for procurement, if financial resources are available. The dumpy levels would contribute significantly to overcome the problems with reference sampling and planning the study site sampling design.

The requests for fellowship training, though beneficial, cannot be funded from the budget of RAS/5/043. These expenses were not foreseen as the training of the staff was supposed to be completed under RAS/5/039. The award of subcontracts is also not recommended.

In case of those countries which did not participate in RAS/5/039, the budget available under the regional TC project RAS/5/043 is not sufficient to build full national capacities for the application of FRN in soil erosion studies. This support should be obtained either through national TCPs or national funding.

3. CONCLUSIONS AND RECOMMENDATIONS

The experimental work and related activities carried under TCP RAS/5/043 during the biennium 2005-6 are progressing well in accordance with the work plan. Some activities have been delayed/postponed in individual countries due to methodological problems/limitations but the activities planned in the regional work plan were completed.

The results obtained so far meet the expectations of specific objective 1. Overall, good progress in implementing the nuclear technology has been achieved. Most participating countries have already gained experience with the use of ^{137}Cs -method. Additional experimental work should be made using other FRNs. Specific problems/limitations with the application of these methods in the countries were identified.

A proficiency test for ^{137}Cs should be organized by the IAEA to ensure that the results produced by the participating countries are based on reliable analytical data and are mutually comparable. Whenever possible, an inter-laboratory comparison for total ^{210}Pb should be organized.

National capacities for the application of FRN methods are not well established in three countries (Mongolia, Myanmar and Thailand), which did not participate in the past regional TC project RAS/5/039. As it is not possible to build these capacities under TC project RAS/5/043, it is recommended that these countries should attempt to build their FRN capacities through national TCP or by national funding.

The FRN capacities of a very good technical level have been established in China and staff with skills and experience is available. China is encouraged to provide expert services for other countries.

During the second half of the project, experimental work should focus on activities to achieve the specific objectives 2 and 3 of the project, namely: 2) To establish soil redistribution-soil quality relationships under different land management practices using the above results; and 3) To develop guidelines to assess soil quality based on radionuclides, as by 1) and 2);

With regard to the objective 4) to apply/disseminate management practices developed as a result of the soil redistribution-soil quality relationship for effectively improving soil and water quality as well as increasing organic carbon storage in soil, several means of disseminating the project results and management practices developed were proposed according to the local conditions in the participating countries.

The assistance from the IAEA for successful implementation of the project should be provided through fielding 8 expert missions (China, Indonesia, Mongolia, Myanmar, Pakistan, Philippines and 2 missions to Thailand) and 1 scientific visit (Mongolia). Besides that, 4 requests for procurement of equipment (dumpy levels for Malaysia and Indonesia and dumpy level and hand core sampler for Thailand) are also recommended, subject to budget availability.

China proposed to prepare a new RAS project "Controlling Agro-pollution of Soil and Water Resources".

4. ACKNOWLEDGEMENT

The Soil Science Research Institute of the Chinese Academy of Agricultural Sciences should be commended for its very kind hospitality and the excellent arrangements in organizing the meeting. Particular thanks go to Prof. Yong Li and his colleagues for their continued efforts to organise and host the meeting.

Annex 1

RAS5043/9001/01
Mid-Term Progress Review Meeting
22-25 January 2007, Beijing, China

List of Participants

| | | |
|----------|------------------|---|
| 1 | IAEA | <p>Mr Emil Fulajtar International Atomic Energy Agency Department of Nuclear Sciences and Applications Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture Soil and Water Management and Crop Nutrition Section Q-1 08/09 Wagramerstrasse 5 P.O. Box 100 1400 Vienna Austria</p> <p>Tel.: 0043 1 2600 21645 Email: E.Fulajtar@iaea.org</p> |
| 2 | Canada | <p>Mr Claude Bernard Direction de l'innovation scientifique et technologique Ministère de l'agriculture, de la pêche et de l'alimentation (MAPAQ) 200 Chemin Ste. Foy Québec, Québec G1R 4X6 Canada</p> <p>Tel.: 001 418 3802100 3288 Fax: 001 418 3802162 Email: claud.bernard@mapaq.gouv.qc.ca</p> |
| 3 | Australia | <p>Ms Paula Jones Cotton Catchment Communities Cooperative Research Centre Australian Cotton Research Institute Commonwealth Scientific and Industrial Research Organisation (CSIRO) Locked Bag 1001 Narrabri, NSW Australia</p> <p>Tel.: 0061 2 67992440 Fax: 0061 2 67931171 Email: paula.jones@csiro.au</p> |
| 4 | China | <p>Dr Yong Li Institute of Agricultural Environment and Sustainable Development Chinese Academy of Agricultural Sciences (CAAS) 12 Zhongguancun South Street Beijing 100081 China</p> |

| | | |
|----------|------------------|--|
| | | <p>Tel.: 0086 10 62137112 Fax: 0086 10 62137112 EMail: yongli32@hotmail.com</p> |
| 5 | Indonesia | <p>Mr Barokah Aliyanta Centre for Application of Isotopes and Radiation Technology (PATIR) National Nuclear Energy Agency (BATAN) Jl. Cinere, Pasar Jumat Jakarta, Selatan 12070 Indonesia</p> <p>Tel.: 0062 21 7690709 Fax: 0062 21 7691607 EMail: his45@bit.net.id</p> |
| 6 | Malaysia | <p>Mr Zainudin Othman Malaysian Nuclear Agency (Nuclear Malaysia Ministry of Science, Technology and Innovation (MOSTI)Bangi 43000 Kajang, Selangor Malaysia</p> <p>Tel.: 0060 3 89282972 Fax: 0060 3 89250907 EMail: zainudin@nuclearmalaysia.gov.my</p> |
| 7 | Mongolia | <p>Ms Burmaa Badral Ministry of Food and Agriculture Government Building 9 Enkhtaivan avenue 16a Ulaanbaatar 210349 Mongolia</p> <p>Tel.: 00976 11 262835 Fax: 00976 11 453121 EMail: b_burmaa2001@yahoo.com</p> |
| 8 | Myanmar | <p>Ms Lei Lei Oo Department of Atomic Energy Myanmar Scientific and Technological Research Department (MSTRD) Ministry of Science and Technology 6, Kaba Aye Pagoda Road Yankin Township Yangon Myanmar</p> <p>Tel.: 00 95 1 664 233 Fax: 00 95 1 650 685 EMail: dae.myatom@mptmail.net.mm</p> |
| 9 | Pakistan | <p>Mr Jamil Tariq Ahmed Radiation and Isotope Applications Division (RIAD) PINSTECH Pakistan Atomic Energy Commission (PAEC)</p> |

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| | | <p>P.O. Box 1482, Nilore Islamabad Pakistan</p> <p>Tel.: 0092 51 9290261 Fax: 0092 51 9290275 EMail: manzoor@pinstech.org.pk</p> |
| 10 | Philippines | <p>Ms Adelina Bulos Philippine Nuclear Research Institute (PNRI) Commonwealth Avenue, Diliman P.O. Box 213 Quezon City 1101 Philippines</p> <p>Tel.: 0063 2 9296011 Fax: 0063 2 9201646 EMail: admb_79@yahoo.com; ambulos@pnri.dost.gov.ph</p> |
| 11 | Sri Lanka | <p>Mr Tissa Senerath Bandara Weerasekera Land Use Division Ministry of Lands and Minor Agricultural Exports Buddhaloka Mawatha Jawatte Road 26 Colombo 7 Sri Lanka</p> <p>Tel.: 0094 11 2583474 Fax: 0094 11 2583474 EMail: weerasek@slt.lk</p> |
| 12 | Thailand | <p>Ms Darunee Chaiyarojana Office of Science for LD. Department of Land Development Ministry of Agriculture and Cooperatives (MOAC) Phaholyothin Rd., Jartujak Bangkok 10900 Thailand</p> <p>Tel.: 00662 5614382 Fax: 00662 5613167 EMail: daruneechai@yahoo.com, daruneechai@gmail.com</p> |
| 13 | Vietnam | <p>Mr Tu Trinh Cong Tay Nguyen Soil Research Station Hoa Thang-Buon Ma Thuot Dak Lak Vietnam</p> <p>Tel.: 0084 50 862341 Fax: 0084 50 862107 EMail: tctu@dng.vnn.vn</p> |

Annex 2

RAS5043/9001/01
Mid-Term Progress Review Meeting
Regional Technical Cooperation Project for Asia and the Pacific
“Sustainable Land Use and Management Strategies for Controlling Soil Erosion and
Improving Soil and Water Quality” RAS/5/043

22-25 January 2007, Beijing, China

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| AGENDA |
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Monday, 22 January

08:45 – 09:00 **Registration**

09:00 – 09:10 Welcome and Opening Remarks
Dr. Maoxiong Long, Director of Office of IAEA Affairs, DIC/CAEA
Prof. Dr. Xurong Mei, Director General, IEDA, CAAS

Session I: **Introduction session**
Chairperson: Paula Jones

09:10 – 09:15 Introduction of participants

09:15 – 9:30 Objectives of the meeting
Emil Fulajtar, TO (IAEA)

09:30 – 10:00 Keynote address: Strategies for Controlling Agro-pollution at Multi-Dimension Scale
Vice President of CAAS, Prof. Dr. Lijian Zhang

10:00 – 10:30 Coffee/Tea break

Session II: **Reports by country**
Chairperson: Yong Li

10:30 – 11:15 Zainudin Othman - Malaysia

11:15 – 12:00 Lei Lei Oo – Myanmar

12:00 – 12:30 Group Photo

12:30 – 14:30 Lunch

Session III: Reports by country (*continued*)
Chairperson: Tissa Weerasekera

14:30 – 15:15 Burmaa Badral – Mongolia

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| 15:15 – 16:00 | Yong Li – China |
| 16:00 – 16:30 | <i>Coffee/Tea break</i> |
| 16:30 – 17:15 | Tu Trinh Cong – Vietnam |
| 17:15 – 18:00 | Jamil Ahmed Tariq – Pakistan |

Tuesday, 23 January

Session IV: Reports by country (*continued*)
Chairperson: Tu Trinh Cong

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| 09:00 – 09:45 | Tissa S. B. Weerasekera - Sri Lanka |
| 09:45 – 10:30 | Narong Chinabut – Thailand |
| 10:30 – 11:00 | <i>Coffee/Tea break</i> |
| 11:00 – 11:45 | Adelina Bulos - Philippines |
| 11:45 – 12:30 | Barokah Aliyanta - Indonesia |
| 12:30 – 14:30 | Lunch |

Reports by country (*continued*)
Chairperson: Tu Trinh Cong

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| 14:30 – 15:15 | Paula Jones – Australia |
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Session V: Technical presentations
Chairperson: Adelina Bulos

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| 15:15 – 16:00 | Technical presentation I Emil Fulajtar – IAEA: Targeting the FRN techniques to specific issues of erosion/sedimentation and soil conservation research |
| 16:00 – 16:30 | <i>Coffee/Tea break</i> |
| 16:30 – 17:15 | Technical presentation II Claude Bernard - Canada: New developments in models for conversion of FRN data to soil redistribution rates |
| 17:15 – 18:00 | Discussion on methodological aspects of nuclear techniques used for erosion research: problems and recommendations |

Wednesday, 24 January

Session VI: Discussion of the results and work plans in working groups

Chairpersons: Emil Fulajtar, Claude Bernard

- 09:00 – 10:30 Discussion on results obtained, problems and obstacles faced and evaluation of the results with respect to individual work plans of particular countries (discussion in 3 working groups; WG Leaders: E. Fulajtar, C. Bernard and P. Jones)
- 10:30 – 11:00 *Coffee break*
- 11:00 – 12:30 Discussion on the work plan for period 2007-2008 (continuation of discussion in 3 working groups; WG Leaders: E. Fulajtar, C. Bernard and P. Jones)
- 12:30 – 14:30 Lunch

Session VII: Evaluation of the progress of research activities with respect to work plans

Chairperson: Claude Bernard

- 14:30 – 16:00 Presentation of findings on the work progress obtained from working group discussion; brief evaluation of achievements of participating countries with respect to their national work plans (per country)
- 16:00 – 16:30 *Coffee/Tea break*
- 16:30 – 17:00 Evaluation of overall progress of TCP
- 17:00 – 18:00 Individual consultations

Thursday, 25 January

Session VIII: Review and updating of work plans

Chairperson: Paula Jones

- 09:00 – 10:30 Presentation of findings on the future working plans obtained from working group discussion; Presentation of updated national work plan by countries (per country)
- 10:30 – 11:00 *Coffee/Tea break*
- 11:00 – 12:30 Updating overall work plan of the TCP; preparation of plan for publishing and dissemination strategy
- 12:30 – 14:30 Lunch

Session IX: Formulating and adopting conclusions

Chairperson: Emil Fulajtar

- 14:30 – 15:30 Formulating and adopting conclusions

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| 15:30 – 15:40 | Closing of the meeting |
| <i>15:40 – 16:00</i> | <i>Coffee break</i> |
| 16:00 – 18:00 | Individual consultations |