Soil Erosion Management in Catchments: Identifying Best Bet Options with Farmers' Participation

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Abstract: Sustaining upland agriculture and food security is very much constrained by continuing land degradation brought by soil erosion in the sloping lands of Asia. With the primary purpose of developing and promoting sustainable and socially acceptable community-based land management systems through a participatory and interdisciplinary approach, the Management of Soil Erosion Consortium (MSEC) started a project in 1998 with funding from the Asian Development Bank (ADB) and supervised by the International Water Management Institute (IWMI).

Representative catchments were selected by using carefully defined criteria and methodological guidelines (IBSRAM, 1997). The baseline information were established through biophysical and socio-economic characterization of the sites. Up to five smaller sub-catchments of various land uses were further delineated and instrumented soil erosion and hydrological studies. Monitoring of the socieoeconomic parameters was likewise undertaken. The best bet options were identified in consultation with the farmers.

Observations showed the significant influence of land use and catchment size on soil erosion. Smaller and more intensively cultivated catchments yielded relatively higher soil loss Variants of the contour hedgerow farming in combination with soil fertility management, use of improved varieties and livestock integration were the primary interventions identified. Consultation with the farmers helped very much in the identification of the land management options that were introduced. While farmers are aware of soil erosion and its effects, their more active involvement increased their appreciation of looking at a longer time horizon. As they are aware of the declining productivity of their land, they were also interested in improving the fertility of their land. Because their immediate concern are the benefits in the short term, other sources of livelihood must also be explored.

Keywords: land management, farmer participation, soil erosion management, catchments and sub-catchments, best bet options

1 Introduction

Sustaining upland agriculture and food security is very much constrained by continuing land degradation brought by soil erosion in the sloping lands of Asia. Farming has become environmentally unsustainable causing deleterious effects on-site and off-site. Studies on soil erosion and soil and water conservation have been undertaken, but results have not yielded land and water management options that are adopted in a sustainable manner, particularly in being able to provide reasonable returns without further degrading the resource base. With the primary purpose of developing and promoting sustainable and socially acceptable community-based land management options through a participatory and interdisciplinary approach, the project of the Management of Soil Erosion Consortium (MSEC) was started in 1998 with funding support from the Asian Development Bank (ADB). Under the supervision of the International Water Management Institute (IWMI), the project evaluated the biophysical processes, socioeconomic dynamics and land management options introduced in selected catchments in Asia. This paper presents the results of such evaluation, highlighting the effect of land management on soil erosion and the identified options to address soil erosion problems, particularly in Indonesia, Philippines, and Vietnam.

2 Approach and methodology

MSEC uses a new approach to the organization and implementation of soil erosion management research. The approach provides a mechanism that engages scientists and research institutions in a coordinated and participatory mode at the catchment scale. The concerned NARES, IARCs, ARIs, NGOs, and farmers are consulted in the research planning and implementation. The NARES play the central role in the consortium, particularly in the conduct of participatory research, but with a broad responsibility for underpinning applied and strategic research as well (Figure 1). IWMI serves as the consortium secretariat and facilitator. Project and institutional linkages are likewise established to strengthen partnerships at the country level.

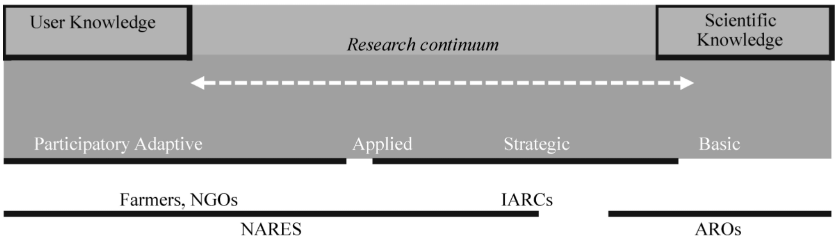

Fig. 1 The research continuum showing the role of different groups in the implementation of MSEC MSEC research (Craswell and Maglinao, 2001)

The catchment sites were selected using methodological guidelines developed based on carefully defined biophysical, socio-economic, and logistical criteria (IBSRAM, 1997). Different tools and techniques for conducting biophysical and socio-economic surveys were employed to establish the baseline information about the sites. Within the catchments, up to five sub-catchments were further delineated and instrumented for more detailed soil erosion and hydrological studies (Maglinao *et al.*, 2001). Monitoring of the socioeconomic parameters and the agricultural practices of the farmers was likewise undertaken.

The best bet land management options were identified in consultation with the farmers. The information generated from the monitoring of the biophysical and socioeconomic data were explained to the farmers during the discussion. The identified options were implemented by the farmers with the technical assistance from the researchers. Regular monitoring of the effect of the introduced options is underway.

3 Results and discussion

3.1 Catchment profiles

The experimental catchments range from 91 ha in the Philippines to 139 ha in Indonesia (Table 1). The catchments have slopes ranging from 8% to 75% with Indonesia and Philippines having wider ranges. The Vietnamese catchment has a narrower range limit and more towards the steeper slopes. The average annual rainfall ranges from 1,500 mm in Vietnam to 2,500 mm in Indonesia and Philippines. In the Indonesian and Vietnamese catchments, water flows in the creeks throughout the year, while water flows only during the rainy season in the catchment in the Philippines. The catchment in Indonesia is largely grown to annual upland crops, perennials (rambutan) and lowland rice. Natural grass and forests still exist in the catchments in Vietnam and the Philippines.

Table 1 Profile description of the MSEC catchments in participating countries

General Description	Catchment name Babon	Mapawa	Dong Cao
Basic information			
Country	Indonesia	Philippines	Vietnam
Province	Semarang	Bukidnon	Hoa Binh
Latitude	07°20′ S	08°02′ 50″ N	20°57′ 40″ N
Longitude	110°E	125°56′ 35″ E	105°29′ 10″ E
Elevation (m)	390—510	1,080—1,505	125—700
Catchment size (ha)	139	91	96
Biophysical attributes			
Slope (%)	15—75	8—35	40—60
Geology and landform	Basaltic lava	Basalt, pyroclastics	Schist
Rainfall (mm)	2,500	2,537	1,500
Soils	Inceptisol	Ultisol, Inceptisol	Ultisol
Vegetation and land use	Rice, maize, rambutan	Forest plantation, open grassland, maize, potato, vegetables	Cassava, rice, maize, taro, peanut
Hydrology	Permanent flow (water flows year round)	Intermittent flow (water flows only during rainy season)	Permanent flow (water flows year round)
Socioeconomic attributes			
Population			
- household (HH)	405	70	38
- persons	1,812	155	196
Ethnic group		Talaandig	Kinh (40%); Muong
Land tenure	Owners, shareholders	Mostly owners, with some shareholders	Land use right
Income (100%)	46%		57%
- on farm	18%		39%
- crop	36%		4%
- animal	Rambutan, lowland rice; upland crops		Cassava, rice, maize, peanut
- off farm			Two-crops in one year
Dominant crops	Two crops in one year	Vegetables, maize	MARD, NISF, VASI; ICRISAT
Agricultural Practices	CSAR, CIRAD, BPTP; AIAT	Two crops in one year	
Relevant institutions		PCARRD, DA, DENR, CMU, SANREM, ICRAF, SEARCA,	

The farmers cultivating in the catchments in Indonesia and Vietnam live outside the catchments, while in the Philippines, a number of them are settled within the area. There are more farmer households in Indonesia than in Philippines and Vietnam. Land use rights are provided to the Vietnamese farmers to farm the land, while in the Philippines and Indonesia, the farmers are either owners or shareholders. In all three areas, some research and development institutions have been collaborating with the project. The catchments in general represent a resource management domain with biophysical and socio-economic characteristics common in the marginal sloping uplands.

The sub-catchments range from a small of 0.9 ha in Indonesia and Philippines to as large as 38.5 ha in Indonesia (Table 2). Those in Indonesia are primarily cropped either with upland annual crops or perennials, primarily rambutan. In the Philippines, the sub-catchments represent a combination of the area cultivated to maize, vegetables or potato and grasslands with a small settlement area in one of the sub-catchments. In Vietnam, the sub-catchments are cropped with either monoculture or intercropped cassava, but with areas of natural grass still present.

Table 2 Land management, catchment size and soil erosion in the different sub-catchments in the catchments in Indonesia, Philippines and Vietnam

Microcatchment (weir)	Area (ha)	Land use	Soil loss (tons ha^{-1})
Indonesia	15%—75% slope		
MC-1I	1.1	50% annual upland crops, coffee and nutmeg on the upper slopes	20.0
MC-2I	0.9	Rambutan and some bare plots	1.7
MC-3I	20.0	Rambutan	1.9
Philippines	8%—35% slope		
MC-1P	24.9	20% cultivated, 80% Falcata, grassland	0.1
MC-2P	17.9	40% cultivated, 60% grassland/firest	0.7
MC-3P	8.0	10% settlement, 15% cultivated, 17%, 75% natural grass	1.0
MC-4P	0.9	40% cultivated, 60% grassland	53.9
Vietnam	40%—60% slope		
MC-1V	4.8	67% monoculture cassava, 33% natural grass	4.4
MC-2V	9.4	24% cassava intercrop, 59% cassava manaculture, 17% natural grass	3.9
MC-3V	5.2	Cassava intercrop	2.9
MC-4V	12.4	26% cassava intercrop, 74% natural grass	1.6

Note: Period of observation: Indonesia – March 2000 to February 2001
Philippines – April 2000 to March 2001
Vietnam – January to August 2001

3.2 Soil erosion and land use

The existing land management practices showed their effects on the degree of soil erosion in the different sub-catchments within each of the three catchments. In general, the areas more intensively cultivated to upland crops produce more soil loss than those grown to perennials or left under grass cover (Table 2). This confirms the initial observations from the same catchments a year before (Maglinao *et al.*, 2001). In Indonesia, sediment yield was highest in sub-catchment MC-1I which is dominated by upland annual crops yielding a soil loss of 20 tons/ha in one year of observation. This is presumably because of minimal soil surface litter and little canopy cover of the catchment (Agus *et al.*, 2001). On the other hand, the other sub-catchments (MC-2I and MC-3I) planted to perennials (primarily rambutan), lost relatively less amount of soil during the same period, only less than 2 ton/ha and yielding considerable amount of sediment only during the middle part of the rainy season (January).

In the Philippines, observations conducted from April 2000 to March 2001 showed that the smallest sub-catchment (MC-4P) and which has a higher percentage of cultivated area gave the highest soil loss of 54 ton/ha. The lowest soil loss was in sub-catchment MC-1P which has a lower percentage of cultivated area and a larger area covered with grasses. Sub-catchment MC-3P which has the lowest percentage of cultivated area but with some settlement within yielded a higher soil loss. This observation may be attributed to erosion from the foot trails and road network (Duque *et al.*, 2001). Using a simulation model, Ziegler *et al*. (1999) showed that roads generate runoff sooner during an event, and have greater discharge values than other surfaces. Sediment transport was also greater and footpaths emerged as important areas of accelerated runoff generation on agricultural fields that otherwise require large amount of rainfall to produce runoff.

In Vietnam, the data collected from January to August 2001 showed that among the sub-catchments, MC-1V (predominantly cassava monoculture with some natural grass) had the largest soil loss of about 4.4 t/ha. The least was from MC-4V (predominantly natural grass and cassava intercropping) at 1.6 t/ha. The larger soil loss from MC-1V (primarily cassava monoculture) than from MC-3V (all cassava intercropping) shows the effect of cassava intercropping system. At its peak growth, cassava provides only about 47%—56% soil cover and mixed cropping or intercropping can increase this protection (Toan *et al.*, 2001). The effect of natural grass in the sub-catchments was also manifested. Natural grass enhances infiltration, reduces runoff and runoff velocity, and consequently reduces soil loss.

Factorial analysis of runoff and sediment yield done by Phommassack *et al*., (2001) also showed the effect of land use on soil erosion. They concluded that the areal percentage of the catchment cultivated with annual crops is the best predictor of sediment yield. No relationship between catchment size and sediment yield could be established presumably because of the overriding influence of land use.

3.3 Soil erosion and catchment size

In the Philippines, the smallest sub-catchment (MC-4P) which incidentally has a large proportion of cultivated area yielded the highest soil loss both in total amount and in tons per hectare. In Indonesia, most of the sediments measured from the trap in the smaller sub-catchments (MC-1I and MC-2I) were of the larger sized aggregates or particles (bed load) while for the larger sub-catchment (MC-1I), the finer sediment (suspended load) dominated. This reflects that during the erosion process, relatively small portion of soil aggregates was dispersed, especially for the MC-2I sub-catchment with no tillage and with ideal cover (Agus *et al.*, 2001). This also reflects that the source of most sediment reaching the sediment trap was relatively close to the trap and the larger the catchment, the less the bed load contribution to sediment yield. These results however were not confirmed by Phommassack *et al*., (2001) who pointed out that the effect of catchment size on erosion could have been overridden by the effect of land use. Caution should therefore be taken in making direct extrapolation of soil loss data from plot scale to small catchments and from small catchments to bigger catchments.

3.4 Best bet land management options

In most instances, the land management options identified and introduced in the catchments were variants of the contour hedgerow farming in combination with soil fertility management and animal production. In the Philippines, the use of natural vegetative strips (NVS) being promoted by ICRAF was identified by the farmers. This is done by using naturally-growing grasses and some agro-forestry crops as hedgerows. Some of the project farmers have already made use of this technique and it appears that adoption is affected by the tenure system of the farmers. About half of the landowners have adopted some conservation measures but none from the tenants (Duque *et al.*, 2001). For those who are interested but have not yet adopted, the major reason is the cost of establishment. In addition to the immediate economic benefits that the farmers expect from the technology, these factors were also cited by the ASIALAND network project which made an analysis of the factors that affect farmers’ adoption of soil conservation technologies (Sajjapongse, 1998; Nilo, 2001).

In Indonesia, the option identified is a combination of fodder grass planted on alternate terraces of land currently used for annual upland crops and cattle fattening. In terms of seriousness of erosion, this area needs priority attention. The fodder grass is expected to reduce erosion and serve as feed for the livestock. The identification of the option was based on lessons learned from elsewhere in Indonesia that farmers' adoption and improvement of a conservation measure is determined by the economic contribution of the measure to the household economy. Farmers are attracted to a practice only if it promises economic benefit and this consideration must be put forward in the participatory technology selection.

Vetiver grass and *T. candida* are the hedgerows in the alley cropping system introduced in Vietnam. The technology intervention has just been started and so the effect of the intervention on crop growth and yield cannot still be evaluated. Possibly as a result of the demonstration site on alley cropping near the site, the farmers believe that the system will reduce runoff and soil loss, add organic matter and improve soil fertility by adding the hedgerow trimmings.

It was observed that presentation and discussion of the results of monitoring in the catchments with the farmers helped very much in the evaluation of the most appropriate land management options for a particular area. While the farmers are aware of soil erosion and its negative effect, actual observations and the alarming figures presented increased their appreciation of looking at a longer time horizon. As they are aware of the declining productivity of their land, they were also interested in improving the fertility of their land. Because their immediate concern are the benefits in the short term, other sources of livelihood must also be explored. In the Philippines, planting tiger grass and bamboo along the creek banks is seen to provide additional income as tiger grass is used for soft broom production and the bamboos as props for the banana plantation.

4 Summary and conclusion

Monitoring of soil erosion in three catchments in Indonesia, Philippines and Vietnam showed that it is affected by land use and catchment size. More intensively cultivated areas produced more erosion than those planted to perennials or left idle with grasses. On a per hectare basis, calculated soil loss is higher in smaller sub-catchments probably because of the short distance traveled by the moving sediments and less deposition occurring along the way. In general, the land management options identified with the farmers are variants of the hedgerow cropping technology. While the farmers expressed interest to apply these technologies, they mentioned of some constraints like inadequate labor for establishment.

Further analysis has to be done to consider other factors like soil properties and slope to more clearly understand the role of appropriate land use in erosion management for upland development. This is to be able to effectively plan a development agenda for a particular area especially in scaling up technology interventions. The role of the farmers in deciding the options that will be introduced is crucial.

These observations will be useful in identifying erosion "hot spots" where application of soil conservation measures should be prioritized. It will also be important in the development and application of the methodology for extrapolation or scaling up of potential interventions for sustainable upland development. As the interventions introduced in the catchment will surely affect other sectors downstream, recognition of their concerns becomes necessary.

It is still too early to make any conclusion on the approach that is employed by MSEC in soil erosion management. However, it has in itself added a new dimension to soil erosion management, with the potential to enhance the adoption and sustainability of introduced options. With stronger and continuing partnerships among stakeholders, particularly the farmers, it is believed to bear its fruits in the longer term. MSEC will continue to employ this approach and the promising outputs will further be validated at different scales of application and expanded to a much wider area for greater impact.

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