Management of Soil Erosion Consortium (MSEC): An Innovative Approach to Sustainable Land Management in Nepal

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INTRODUCTION

The kingdom of Nepal with an area of about 147,500 km^2 lies at the northern rim of South Asia. On the basis of physiography, geology, and geomorphology the country is divided into five major agro-ecological regions, commonly known as Terai, Siwalik, Middle Mountain, High Mountain, and High Himalayan regions. The middle mountain region occupying the largest land area of about 30% of the total has the highest population density per unit cultivated land. Even the marginal areas with steep and very steep slopes have been encroached for cultivation in order to feed the increasing population. Consequently the land resources have been overutilized.

Nepal is basically an agrarian country. Over two-thirds of the country's total land area is occupied by hills and mountains where the majority of the country's population live. Much of the country's land base is environmentally fragile and susceptible to erosion and degradation. Cultivation on sloping and terraced land is a common feature of the Nepalese hill agriculture. Over the centuries, Nepalese farmers have been adopting a system of land use compatible with their environment such as shifting cultivation. But such a traditional farming system has not been able to cope with the rapid growth of both human and livestock population.

Over the recent decades, degradation of land and mountain ecosystems has become increasingly widespread. The traditional farming system and cultivation on steep hill slopes have accelerated the rate of erosion and degradation. Agricultural productivity especially in the hills and mountains is declining due to the erosion of fertile surface soils every year. Therefore, there is an urgent need to develop suitable land management systems for sustainable agricultural production and environmental protection.

In Nepal, soil erosion has been identified as the major problem concerning sustainable agriculture in hill and mountain farming systems. It causes severe on- and off-site environmental, economic, and social impacts. It is, in general, realized that there is lack of (a) feedback mechanisms to alert producers to problems that may arise from their actions, and (b) strategies to deal with them within the time frame of normal on-farm decision making. These are the most critical barriers to the adoption of more sustainable practices in many countries. To overcome these problems, the Management of Soil Erosion Consortium (MSEC) Project has adopted a new research paradigm based on a participatory, interdisciplinary catchment approach. The three key elements of this approach are: the focus on on- and off-site impacts, the provision of scientifically sound information for decision-makers, and the involvement of the whole range of stakeholders from land users to policy-makers.

While the indigenous methods of hill farming in Nepal were designed to minimize erosion, population growth and strain on the land resources have led to intensification of agriculture generally at the cost of loss of nutrients and productivity in the long run. The challenge now is to introduce farming practices aimed at minimizing soil erosion and nutrient losses. Understanding the hydrological processes, the relationships between rainfall, runoff, and sediment and nutrient transport and the socioeconomic conditions of the farmers in the area is an important part of the research.

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REVIEW OF PAST WORK

The Department of Soil Conservation, HMG/N has been working on watershed management and soil conservation in the country. Since the last few years, it has studied two important watersheds in the country, Fewatal and Kulekhani. Its focus is on afforestation programmes as a part of rehabilitation of degraded land and on forestry research within the watershed.

For the last few years, the International Centre for Integrated Mountain Development (ICIMOD), an international organization devoted to the development of the Hindu Kush Himalayan region, is presently carrying out a research study on watersheds in collaboration with national agencies like the Nepal Agricultural Research Council (NARC), Department of Soil Conservation (DSC), and the Department of Hydrology and Meteorology (DHM). They work mainly in Jhiku Khola Watershed and Yarsha Khola Watershed in central Nepal.

NARC initiated a preliminary study on erosion processes and water quality at Likhu Khola Watershed from 1991–1993 in collaboration with the Royal Geographical Society and the Institute of Hydrology, UK. This study included five subcatchments selected within the watershed. It produced some preliminary and basic data on water quality, biological diversity, and erosion processes in the watershed area.

The Soil Science Division (SSD) of NARC also carried out on-farm research in farmers' fields on the management of sloping land for sustainable agriculture in the middle mountains of central Nepal in collaboration with IBSRAM from 1989–1991. The study was related to soil and crop management for sustainable agriculture on a farm scale. In collaboration with ICIMOD, it has carried out the on-farm research in farmers' fields in central Nepal since 1995. It is an adaptive research which evaluates and tests Sloping Agricultural Land Technology (SALT). The results of these studies are expected to provide useful inputs to the MSEC project in the country.

OBJECTIVES AND EXPECTED OUTPUTS

Objectives

The objectives of this project are to:

- Develop sustainable and acceptable community-based land management systems that are suitable for the entire catchment.
- Quantify and evaluate the biophysical, environmental, and socioeconomic effects of soil erosion, both on and off site.
- Generate reliable information and prepare scientifically-based guidelines for improvement of catchment management policies.
- Enhance the national capacity in research on integrated catchment management and soil erosion control.

Expected outputs

The final outputs as expected from the project are as follows:

- Better understanding of the on- and off-site effects of soil erosion.
- Improved soil erosion control technologies that are socially and institutionally acceptable to the communities in the catchment area.
- Methodology for obtaining the participation of farmers and other stakeholders in the management of catchments.
- Appropriate policies that will improve the management of catchments by the local government

and communities and will induce the farmers to adopt improved land management technologies.

- Quality catchment research and effective dissemination of its results to farmers.
- Enhanced capacity of the national institutions in integrated catchment management.

METHODOLOGY

Site selection

The criteria for site selection as recommended by the IBSRAM site selection mission were considered in the selection of the site in Nepal. The factors considered were its representativeness, replicability, accessibility, farmers' willingness to participate, availability of research facilities, size of the catchment, biophysical and socioeconomic characteristics, and peace and security situation. The process involves the following activities:

- Collection and compilation of secondary biophysical and socioeconomic information including a topographic map.
- Field visits for additional data collection on biophysical and socioeconomic information, for on-site evaluation and assessment, and for discussion with the key farmers and village heads.
- Analysis and interpretation of the data and information.
- Discussion among the members of the national team and the IBSRAM site selection mission.
- Evaluation and final selection.

Biophysical and socioeconomic characterization

After the site was finally selected, the national team, composed of a soil scientist, socioeconomist, and an hydrologist conducted another visit to the field for a rapid rural appraisal (RRA) of the area. Biophysical and socioeconomic information were gathered through discussion with the farmers and key informants like the village head.

A structured questionnaire was used to collect information from individual households. Data sets obtained through the household survey were analyzed using SPSS-PC and GIS tools. The detailed data and information needs for socioeconomic inventory and characterization are given in Table 1.

Evaluation of on-site effect of erosion

Within Masrang Khola Catchment, with an area of about 124 ha, four microcatchments were further identified and delineated on the topographical map of a scale of 1:5,000. These are identified as W2, W3, W4, and W5 with areas of about 72.6, 39.6, 11.5 and 1.6 ha, respectively.

Five weirs and sediment traps were constructed from February to May 2000 and the measuring devices (automatic water level recorders, manual rain gauges) were installed in May. Three weirs were constructed in Masrang Khola, one in one of its tributaries and one in a gully within Bari land (upland). Two Orphimedes water level recorders were installed in W1 and W2 and three Thalimedes recorders were installed in W3, W4, and W5 (Figure 1). Eight manual rain gauges were distributed at appropriate sites within the catchment. Data collection and monitoring started in June 2000.

Rainfall was measured on a daily basis through eight manual rain gauges installed at eight different locations within the catchment. The hydrological data were monitored at the weirs constructed at five different locations, one representing the catchment as a whole and others representing the microcatchments. The water discharge and water level were monitored through dataloggers, Orphimedes in W1 and W2 and Thalimedes in W3, W4, and W5. Bedload and suspended sediment were also monitored regularly. The quantity of bedload collected in the sediment traps was determined and recorded for cumulative events of rain. The water samples (1 litre for each sample) were taken regularly from each weir for the determination of suspended sediments. However, there are very few suspended sediment data collected to date. Therefore suspended sediment data are not presented here.

The data from the datalogger downloaded using a lap top computer and evaluated using HYDRAS 3 software. The water level data thus obtained is converted to discharge using a rating curve of the individual weir. Unfortunately, no discharge measurement has been taken in the catchment so far; therefore rating curves are still lacking. Analyses so far have to be based on the gauge height data. From the data collected, attempts were made to determine any kind of relationship between rainfall and runoff, runoff and erosion, and rainfall and erosion.

Table 1. Data and information needs for socioeconomic characterization.

Factors	Data information needed	Relevance/ importance	Tools and techniques
Population	Total no of HHs Population Ethnicity HH size Religion Age structure Migration pattern Education	Demographic structure Pressure on resources Availability of labour	Household survey RRA Key informants Group discussion
Settlement history	Village origin	Information flow	Key informants
Institutional environment	Social organization	Function of the institution Distance	Key informants RRA
Agricultural survey	Land holdings	Decisions for long-term	Households
information	Land distribution Land tenure Land utilization by crops Farming system	investment	Key informants Direct observation Group discussion RRA
Biophysical environment	Area and production of different crops Ethnicity Cropping patterns Crop calendar Input use	Effectiveness of information dissemination	Household survey Key informants Group discussion RRA
Food situation	Food sufficiency by ethnicity	Decision for the investment	Household survey Key informants
Credit	Source of credit	Availability of capital	Household survey Key informants
Marketing	Marketing channel Prices	Decision for long-term investment	Household survey Key informants
Source of income	Different sources	Investment potential	Household survey Key informants
Gender	Role, decision making	Technology transfer	Household survey

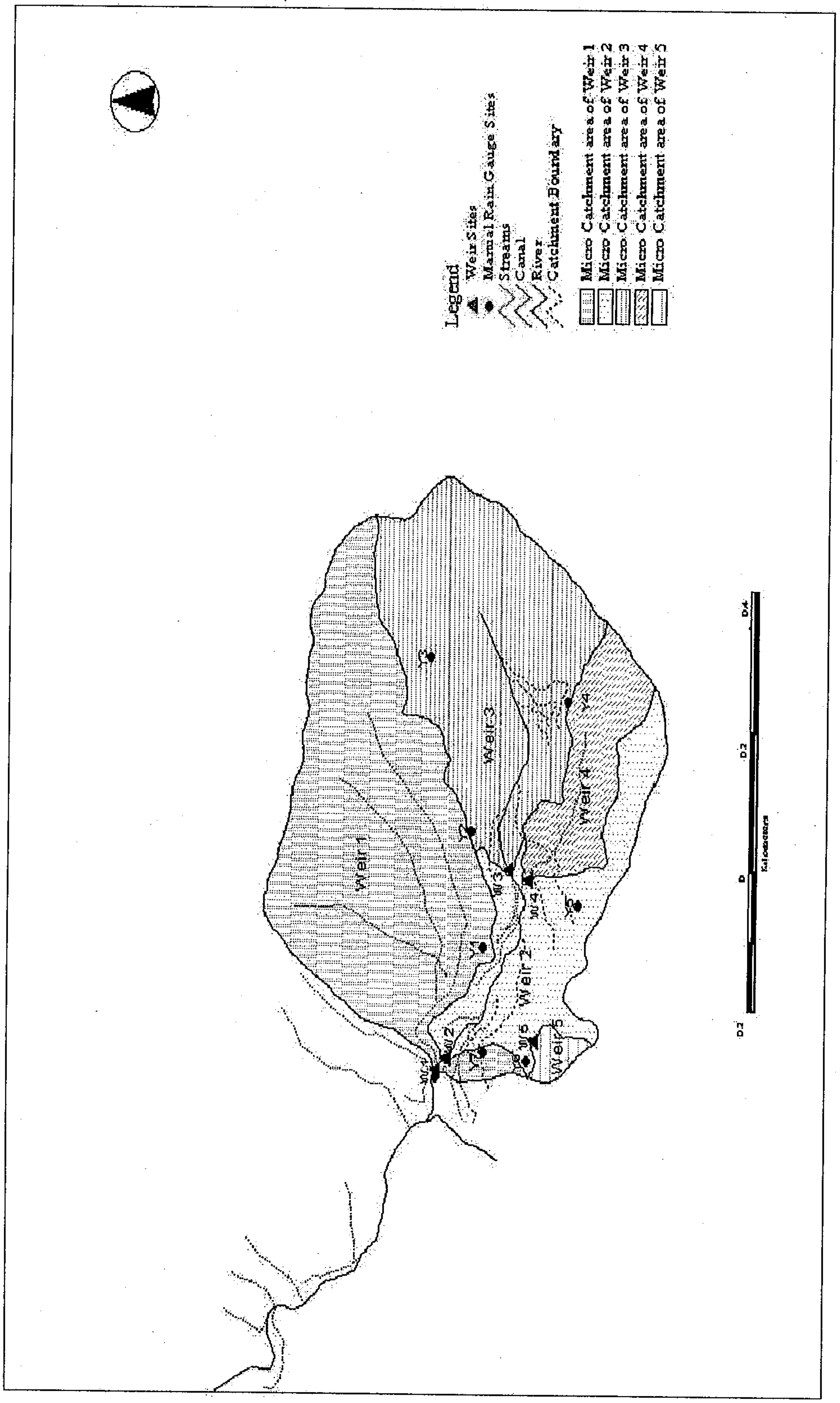

Figure 1. Masarang Khola Catchment with Microcatchment.

EVALUATION OF THE OFF-SITE EFFECTS OF SOIL EROSION

Identification of potential off-site impacts

There could be various off-site effects of soil erosion in the downstream area and some of the potential impacts envisaged are as follows:

- Effects on crop yields (mostly paddy).
- Effects on soil properties and fertility.
- Effects on stream water quality.
- Flooding and sedimentation in the agricultural land.
- Erosion due to stream bank cutting.

Survey of off-site economic activities affected by erosion

Based on the potential impacts of soil erosion in the downstream areas, an initial survey of farmers who potentially could be affected was conducted. They were asked about their experiences and observations on the effect of soil eroded from the upland areas. Their responses will then provide the basis of valuing these effects. To complement the results of surveys and interviews, periodic monitoring and analysis of quality of irrigation water, soil properties and fertility status, farm inputs, and crop yields of paddy will be conducted.

RESULTS AND DISCUSSION

Site selection

Initially Dee Khola Catchment within the Likhu Khola Watershed in Nuwakot District in central Nepal was identified as the study site for the MSEC project in Nepal. But due to some problems, later, it was agreed to look for another catchment. The national team presented their recommendation during the MSEC assembly in 1999 in the Philippines. After several visits to and assessment of the recommended sites, the national team and IBSRAM finally decided to have the project at the Masrang Khola Catchment (Figure 2).

The catchment which has an area of about 124 hectares represents the typical farming situation in the hills. The topography is moderately to very steep with 40 to 100 % slopes. It is situated at 27^0 49' N latitude and 84^0 32 30" E longitude. It is located at Chandi Bhanjyang V.D.C. Ward 9 and 8 of Chitwan district in Narayani Zone in Central Nepal. The catchment has elevation ranging from 650 to 1400 m above sea level.

BIOPHYSICAL AND SOCIOECONOMIC CHARACTERIZATION

Biophysical attributes

Climate

Climate in the area is subtropical to warm temperate. The average annual rainfall is about 2,337 mm, 85% of which falls from May to September (Table 2). The mean annual temperature is about 22^{0}C with a maximum of 35^{0}C in May and a minimum of 9^{0}C in January (Table 3).

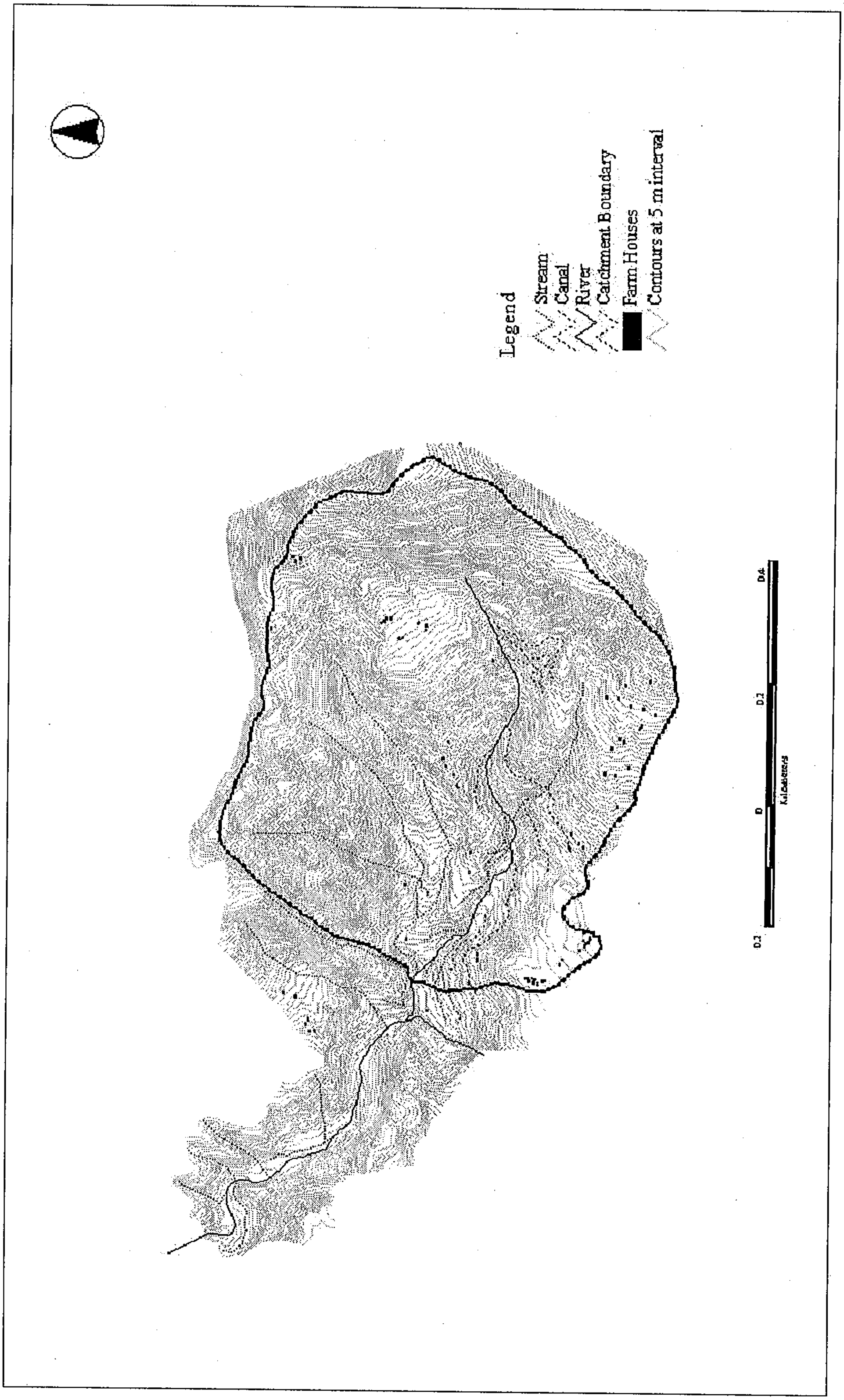

Figure 2. Masarang Khola Catchment Area.

Table 2. Precipitation (mm) recorded at the ATSCFS project site, Paireni village, Chandi Bhanjyang VDC, Chitwan.

	Year				
Month	**1996**	**1997**	**1998**	**1999**	**Mean**
January	63.0	32.0	0.0	8.0	25.8
February	40.0	0.0	15.0	1.0	14.0
March	44.0	23.0	53.0	3.0	30.8
April	99.0	110.0	74.0	22.0	76.2
May	167.0	75.0	138.0	383.0	190.8
June	401.0	267.0	274.0	374.0	329.0
July	629.0	730.0	733.0	803.0	723.7
August	425.0	431.0	742.0	692.0	572.5
September	122.0	235.0	254.0	399.0	252.5
October	115.0	35.0	64.0	79.0	73.2
November	0.0	13.0	0.0	1.0	3.5
December	0.0	178.9	1.0	1.0	45.2
Total	**2,105.0**	**2,129.9**	**2,348.0**	**2,766.0**	**2,337.2**

Table 3. Meteorological records (average of 4 years, 1996–1999), taken from the ATSCFS project site, Paireni village, Chandi Bhanjyang VDC, Chitwan.

Month	**Solar Rad. ($MJ\ m^{-2}$)**	**Max. temp. (^0C)**	**Mini temp. (^0C)**	**Mean temp. (^0C)**	**Mean Soil temp. (^0C)**
Jan.	7.3	18.9	9.4	13.3	11.6
Feb.	12.5	24.0	11.7	16.8	13.4
Mar.	16.9	29.5	15.4	21.7	17.1
Apr.	23.5	33.7	19.4	25.7	21.0
May	25.4	35.0	21.6	27.3	24.2
Jun.	21.8	34.3	23.4	27.9	25.6
Jul.	17.5	33.1	24.2	27.2	25.0
Aug.	17.5	32.7	24.0	26.9	25.1
Sep.	17.6	32.6	23.2	26.3	24.3
Oct.	14.0	29.2	19.4	22.8	21.0
Nov.	9.7	24.2	15.2	18.4	16.4
Dec.	5.5	18.8	11.1	13.8	12.4

Soils

Soils in the area are, in general, well to excessively drained, sandy loam to loam in texture, and acidic in reaction. These soils are tentatively identified as Inceptisols, Alfisols, and Entisols (Soil Taxonomy, USDA, 1975). Organic matter and NPK contents are generally moderate to high.

Land use and cropping system

The cropping system in the upland area is corn as the summer crop followed by either millet, pulses, vegetables, mustard or potato as the winter crop. In the lowland area, paddy is grown as the summer crop followed by fallow, wheat or spring corn as the winter crop.

Of the total cultivated area of 54 ha, about 80% is used for cereal crops, 7% for cash crops and 3% for fruit crops. The main source of irrigation is Masrang Khola. There are mainly two crops grown in a year. In case of 'khet' (lowland), only a single crop of paddy is grown as the summer crop and only a few farmers have recently started growing wheat as a winter crop after paddy. Some farmers have also grown spring maize on khet land before paddy. The other crops grown in 'bari' (upland) are maize, millet, buckwheat, mustard, and legumes. The overall cropping intensity is 147.

Socioeconomic characteristics

Population

The socioeconomic survey carried out from March to April 2000 showed that there are 54 households and a total population of 354 persons in the area. The main ethnic groups are the Gurung, Gharti, Chhetri/Thakuri, and Brahmans. The average family size is 6.6 members.

The people depend mainly on agriculture for their livelihood. A total of about 54 ha of land are cultivated, 62% of which is on bari lands and 26% is khet land. The average farm size is 0.66 ha, 0.25 ha for khet and 0.62 ha for bari. Among the households, the average farm size of Brahman, Chhetri/ Thakuri, Gharti, and Gurung are 0.71, 1.26, 0.94 and 0.97 ha, respectively. About one-fourth of the total land is occupied by marginal and smallfarm households which comprise half of the total farm households. Half of the land is under medium farm households and less than one- fourth is under the large holdings.

Given the limited opportunities for rural employment and low agricultural production, a few households have migrated to other adjoining villages. About 62% of the population, mostly from the Gharti and Gurung ethnic groups, travels to other districts for waged labour.

Land ownership

Land ownership in the area is classified into three groups: owned land, leased-in land, and leased-out land. About 78 and 94% of the total households own khet and bari lands, respectively. All the households have land ownership certificates according to land types. The leased-in land system is significantly high while leased-out land is comparatively low. Generally, farmers have to pay half of their produce as land rent. The rent differs according to the soil, location of land, and land types.

Agricultural production and income

The major crops grown are maize, millet, paddy, mustard, and legumes. Farmers give top priority to maize cultivation. According to them, the biophysical condition is most suitable for this crop which is utilized as human food as well as cattle feed.

The average yields of maize, millet, and paddy are estimated to be 1.2, 0.9, and 2.2 ton ha^{-1}, respectively. Local varieties as well as improved varieties are used in the area. Weeding is commonly practiced and FYM is used for the maize crop along with urea topdressing. The average seed rates used in paddy, maize, and wheat are 84, 30, 115 kg ha^{-1}, respectively. About 70% of the total households has reported that their product is only enough for less than nine months of their annual food requirements. Only 6% of the total households (Chhetri and Gurung) has surplus food production.

Farmers reported that off-farm income contributes to fulfilling their food requirements during the deficit period. The average income from the farm represents on 41% of the total. About 59% of the income comes from off-farm activities. Income from crops and livestock is almost the same.

Livestock is also an important source of farm income to support farmers' livelihoods. On average, the households own 2.5, 3.5, 2.0, 5.2, and 9.7 heads of buffaloes, cows, bullocks, goats, and poultry, respectively. The Gurung have more buffaloes, cows, bullocks, goats, and poultry than other ethnic groups. Almost all the farmers rear some cattle in the farming system and farmyard manure is the main source of plant nutrients added to the soil. Some chemical fertilizers like urea and di-ammonium phosphate are also used but mostly for the paddy crop. The majority of the farmers are not aware of soil conservation practices except for traditional methods of terracing and planting trees and grasses on their farmland. Most of the households live at the subsistence level. About 70% of the households is not able to support their family from their own farm produce

EVALUATION OF THE ON-SITE EFFECTS OF SOIL EROSION

Rainfall–runoff relationship

Figure 3 shows the relationship between rainfall and runoff as indicated by the water level at the weirs. Rainfall is in general homogeneous at daily time scales throughout the catchment. In contrast, water levels are diverse in terms of the magnitude of fluctuations, general trends, and correspondence with storm events. The water level in W2 shows generally very little fluctuation in the records except between Julian days 160 and 170. The spike during this period corresponds to a storm event with 106 mm precipitation. Storm events of similar large magnitudes occurred on days 175 and 206, although they did not cause as large fluctuations in the water level. Nevertheless the rise in water level with storm events is evident throughout the records. The water levels show a gradual increasing trend after day 170.

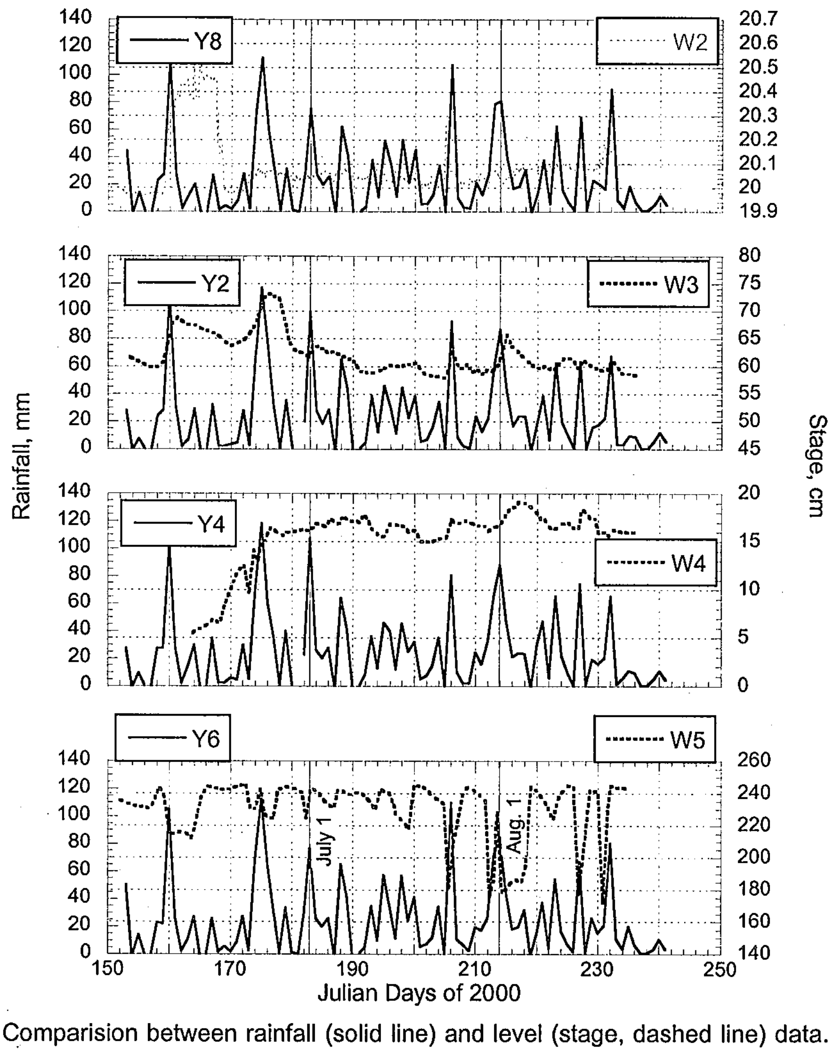

Figure 3. Comparision between rainfall (solid line) and level (stage, dashed line) data.

The water level at W3, representing a catchment area of 39.6 km^2, shows much better correspondence with storm events. Owing to the small catchment area and steeper slope the fluctuations in water level are larger, while the water level is not persistent with quick recession after the storm.

There is very little correspondence between rainfall and water level at W4, although the area represented by this weir is only 11.5 h. The mechanism behind the sharp rising trend before day 175 and relatively stable water levels thereafter is a matter for further investigation. It is noteworthy that there is no rain gauge directly within the elongated catchment represented by W4. The rainfall regime of the catchment could be different leading to the poor correlation as seen in Figure 3.

The stage at W5 fluctuates mostly around 240 cm, which drops several times by as much as 60 cm. These drops in stage occur more frequently towards the end of the record. While there are some rises in water levels corresponding to storm events, the relationship seems to be complex.

Rainfall and bedload

Rainfall amount and daily bedload at W2, W3, W4, and W5 are plotted together in Figure 4. The bedload amount increases with the area of the catchment. The bedloads at W5, W4, W3, and W2 are in progressively increasing order. Although bedloads measured after large storm event showed higher values compared to samples preceding the storm, the data do not show the relationship between the two parameters.

Erosion and land use

Table 4 compares monthly total and specific bedloads at different weirs with rainfall and land use within respective microcatchments. The microcatchments, except W5, are characterized by mixed land use. The available data show that the soil loss is significantly lower from upland cultivation area (i.e. W5). In August, however, the soil loss from the same microcatchment is many times higher, perhaps owing to harvesting and preparation of land for another crop. The cultivated area in microcatchment W2 occupies 50% of the total. The soil loss from this microcatchment is minimum in July due to the standing crop.

Table 4. Monthly soil loss from different microcatchments

Micro Catchment	Month	Total Rainfall (mm)**	Soil Loss Indicator		Land Use
			Bed Load (kg)	Specific Bed Load (kg)	
W2	June	678.3	13,992.7	192.7	Mixed
	July	840.3	6,596.9	90.9	
	August*	931.9	28,289.8	389.7	
W3	June	691.5	6,039.2	152.5	Mixed
	July	820.9	6,004.1	151.6	
	August*	588.9	11,630.2	293.7	
W4	June	704.9	1,046.8	91.0	Mixed
	July	842.9	2,018.6	175.5	
	August*	630.7	3,798.8	330.3	
W5	June	699.4	6.4	4.0	Upland Cultivated
	July	855.7	9.4	5.9	
	August*	609.0	320.0	200.0	

* Bed load for August 1 to 20 only.

** Rainfall data is taken from the rain gauge within of closest to the micro catchment.

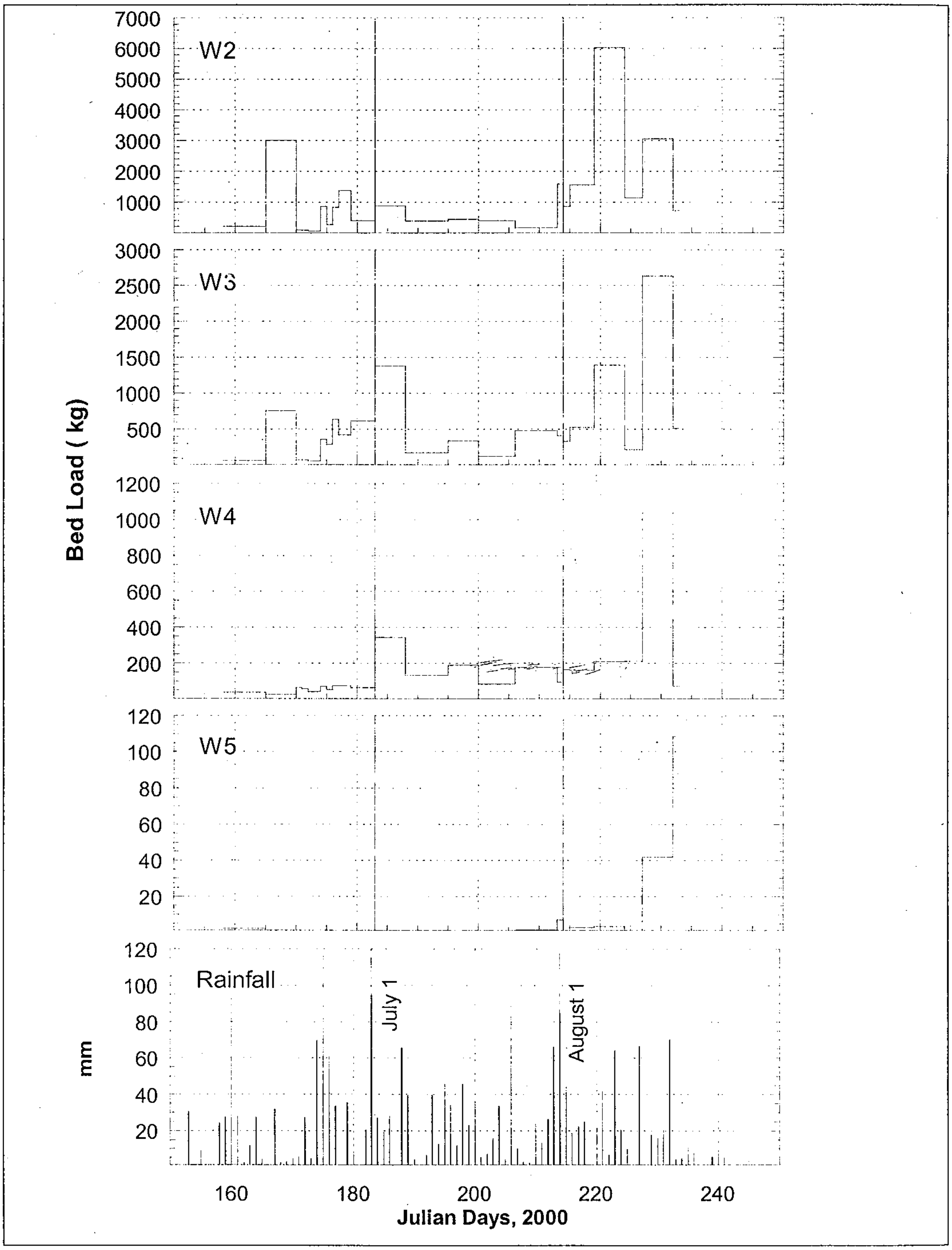

Figure 4. Average rainfall (vertical bars) and bedloads (lines) at different sites in the catchment.

EVALUATION OF THE OFF-SITE EFFECTS OF SOIL EROSION

Potential off-site effects of soil erosion

The potential off-site effects of soil erosion in the downstream area in the local context may be viewed as the possible changes in water quality, soil fertility in the downstream area, and crop yield of paddy. The quality of irrigation water that comes usually from Masrang and Soti Khola in the downstream area may be affected and this may ultimately affect the crop yields.

Deposition of sediments on the paddy fields downstream caused by erosion and flooding may result in terrace failures and changes in soil fertility also. It could have a direct effect on soil properties, which could consequently affect the yield of crops.

Initial feedback from farmers

Initial discussion with the farmers downstream of the catchment revealed the following observations that could be related to the effect of erosion and flooding from the upper catchment:

- Need to repair irrigation canals including the intake sites two or three times a year.
- Need to repair terraces damaged by flooding and streambank cutting that happens, in general, once in four or five years.
- Need to clear farmland when sands, gravel and stones are deposited due to flooding

Valuing the potential impact of erosion

The main causes of the soil erosion in the catchment area are inappropriate farming systems, collection of non-timber forest products (NTFP), streambank cutting, geological activities, and landslides. The stream water with high nutrient contents that comes usually from upstream areas may affect the crop yields, especially in the paddy field, during the raining season. This effect may be negative or positive. Consequently, the income of the downstream farmers will be increased or decreased due to an increase/decrease in the productivity of crops. The cropping pattern of the area may be adopted according to the situation of the agricultural field. For the downstream area, the productivity of the crop will definitely be increased because of plant nutrients that the paddy field gets through irrigation water. Thus, there may be more positive impact in the downstream area.

The composition of the soil may change due to sediment deposition on the cultivated land in the downstream area through irrigation water. Sand, gravel, and stones may also be deposited over cultivated land due to flooding during heavy rain. The maintenance cost will be high to clear such things and repair the terraces by human labour (opportunity cost of labour). Thus, the cost of cultivation will be high and the net profit margin will be reduced in such a situation. This is just an example of negative impact due to the deposition of sediments on the crop field.

Soil erosion and deposition of coarse sediments are the key factors of decreasing per capita income due to low productivity and high operation and maintenance cost for repairing the terraces. This type of information can be obtained by field observation as well as by discussion with key informants. All these impacts need to be quantified in economic terms such as quantities of agricultural crops damaged, percentage of yield increase or decrease due to sedimentation, volume of water disposal, increase in operation and maintenance costs, etc. There is a question of how many farmers in the downstream area are affected by these activities.

CONCLUSION AND RECOMMENDATIONS

Increases in population density in the catchment would result in more cropping and eventually in soil erosion and yield declines. Agricultural production in the catchment area has not increased satisfactorily because of sloping terrace land, erosion problems, fragmented holdings, biophysical and socioeconomic constraints, and poor infrastructure. Efforts should be made to integrate the different farming components for the promotion of agriculture by introducing suitable crop varieties and improving farming systems like legumes, mustard, off-season vegetables, milk production, goat raising and fruit farming with less degradation of natural resources. Commercialization of agriculture generates farm income and increases employment opportunities in the area since the catchment is situated close to the highway.

This report includes the hydrological data for the short period from early June to about mid-August 2000. Although limited in quantity, the data collected from Masrang Khola Catchment has shown that the project still has a lot of investigating to do. There is certainly a perspective (and necessity) for rainfall runoff modelling. For this, it is important to calibrate the weirs and convert the stage data to discharge. The sediment dynamic is an important factor and sound farming practices cannot be identified and suggested for application without knowledge of the former. It is therefore necessary to augment the project activity by analyzing samples for nutrients and suspended sediment on a regular basis. Similarly, regular bedload samplings are to be conducted in the future to model the soil erosion dynamics.

The results from such a short period are certainly not enough to draw any conclusive statement. It needs to continue for several years in order to obtain some conclusive results for sustainable land management with a sound watershed approach.

ACKNOWLEDGMENTS

The authors would like to express their sincere gratitude to Mr. D. Joshy, the Executive Director of Nepal Agricultural Research Council (NARC) for his keen interest and constant encouragement to carry out the MSEC project in Nepal. Similarly, we are grateful to Dr. S. L. Maskey, the Chief Soil Scientist of Soil Science Division, NARC, for her continuous support and help in carrying out project activities smoothly. The devotion and hard work of Mr. K. P. Dahal, Technical Officer and Site In-charge, in collecting the field data and information are equally acknowledged. The contribution made by Mr. K. B. Thapa, Technical Officer, especially in establishing the project study site is highly appreciated. The help and services rendered by the staff of the Soil Science Division including those of the Soil Laboratory are duly acknowledged. Last, but not least, we would like to express our sincere gratitude to both IBSRAM and ADB for the advice and funding without which it would have been almost impossible to implement this study.

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Appendix 1

Masrang Khola Catchment
Socioeconomic characterization

Parameters	Simple variables	Number
Demography	Total no. of households	54
	Population	356
	<15 years	148
	15–60 years	185
	>60 years	23
	Male	182
	Female	172
Ethnicity	Brahman	35
	Chhetri/Thakuri	73
	Gharti	81
	Gurung	165
	Religion (HH no.)	
	Hindu	38
	Buddhist	16
Agricultural land	Total cultivated area (ha)	53.55
	Average farm size	0.66
	Khet	0.25
	Bari	0.62
Land utilization	**In percentage**	
	Cereal crops	80
	Cash crops	7
	Fruits	3
	Forest/pasture	10

Area and productivity	**Maize**	
	Area (ha)	28.12
	Productivity (kg ha^{-1})	1176
	Paddy	
	Area (ha)	9.38
	Productivity (kg ha^{-1})	22.57
	Millet	
	Area (ha)	2.27
	Productivity (kg ha^{-1})	867
Input use	**Paddy**	**kg**
	Seed	84
	Urea	1.67
	Di-ammonium phosphate	1.0
	Farmyard manure	541
	Maize	
	Seed	30
	Farmyard manure	1438
	Wheat	
	Seed	115
	Urea	7.0
	Farmyard manure	456
Food situation		HH no
	<4 months	3
	4–6 months	18
	6–9 months	19
	9–12 months	10
	Surplus	3
Livestock		
	Buffaloes	Average livestock herd
	Cow/calves	2.5
	Bullocks	3.5
	Goats	2.0
	Poultry	9.7
	Milking	Av milk produced per month in litres
	Cows	47.4
	Buffaloes	84.0
Credit	**Source (%)**	
	Formal	70
	Informal	30
Cash income	**Sources in %**	
	Crop products	21
	Livestock products	21
	Off farm	58