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

N.V. Carpina [1], C.M. Duque [2], M.T. de Guzman [3], R.O. Ilao[3], R.Q. Quita[2], B.G. Santos, L.E. Tiongco [4] and R.S. Yadao[2]

INTRODUCTION

Soil erosion in the Philippines is a major threat to sustainable production on sloping lands where mainly subsistence farmers carry out food and fibre production. Sloping lands occupy about 9.4 million ha or one-third of the country's total land area of 30 million ha. The sloping topography and the high rainfall subject the cultivated sloping lands to various degrees of erosion and other forms of land degradation. Field experiments conducted in the IBSRAM *ASIALAND* Management of Sloping Lands network sites in the Philippines showed that up-and-down slope cultivation resulted in annual erosion rates averaging about 100 t ha^{-1}, depending on the rainfall and kind of soil. It was estimated by the Bureau of Soils and Water Management that about 623 million metric tons of soil are lost annually from 28 million ha of land in the country.

The Philippines has a high population growth rate of 2.3% and the National Census and Statistics Office (NCSO) estimated about 76 million Filipinos in 2000. With increasing population and limited arable land, agricultural production activities are now being carried out on hilly and mountainous lands. Recent trends show that more and more of the sloping lands are being used for agriculture to support the needs of the burgeoning population.

The present approaches on soil conservation and management primarily hinge on the biophysical impacts of soil erosion on on-site productivity but have limited success in improving the quality of life of farmers in developing countries. In the Philippines, the major focus of soil conservation is to minimize or stop soil erosion and not to manage it to increase agricultural productivity. There have been few undertakings in the last 10 years that dealt with the social, economic, political, and institutional aspects of soil erosion. While research and development activities are slowly experiencing a paradigm shift in the study of natural resources like soil, the approaches used in organizing and using data and information on soil erosion and conservation have not yet reflected this change.

The Management of Soil Erosion Consortium (MSEC) is now employing in Asia the principles advocated by the new research paradigm for research on sustainable land management that meets the twin needs of increased productivity and resource conservation. The catchment, which is a topographically delineated land area drained by a common stream system, is used as a unit for the assessment of resource use management and planning. In particular, the new paradigm addresses the following concerns: 1) incorporation of indigenous knowledge related to land use management into resource-use evaluation systems, 2) capability to assess the implications of these indigenous practices for soil erosion and its on- and off-site effects, and 3) establishment of practical indicators of sustainability that relate to both the state or condition and process.

[1] Local Government of Lantapan, Lantapan, Bukidnon
[2] Central Mindanao University (CMU), Musuan, Bukidnon
[3] Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Banos, Laguna
[4] Department of Environment and Natural Resources – Region 10 (DENR-10), Malaybalay, Bukidnon

This paper presents the technical progress of the MSEC project in the Philippines during the past year. It describes in more detail the profile of the project site in terms of biophysical and socioeconomic attributes. It likewise presents initial results of field measurements and monitoring to evaluate the effects of soil erosion on and off site.

OBJECTIVES

The MSEC project in the Philippines aims to:

1. Enhance the transfer of sustainable and acceptable community-based land management system in the Mapawa Catchment.
2. Assess the on- and off-site impacts (biophysical, socioeconomic, environmental) of soil erosion in Lantapan and surrounding areas.
3. Generate reliable information for formulating scientifically-based guidelines for improving catchment management.
4. Enhance R&D capability on integrated catchment management and soil erosion control.
5. Enhance institutional arrangements for R&D information exchange, sharing, and dissemination.

METHODOLOGY

The methodology is anchored on the new research paradigm based on a participatory and interdisciplinary catchment scale approach. Figure 1 shows the organizational arrangement for its implementation from the national down to the local level. It follows a holistic approach to study the important biophysical and socioeconomic aspects of land management in the catchment area. Experiments conducted address on- and off-site erosion effects. It uses as much as possible the existing knowledge and models and undertakes needed field observations and trials for the different activities. The major activities carried out are catchment inventory and characterization; hydrological studies; land use changes; information systems and modelling; institutional and policy changes; and people empowerment.

SITE SELECTION

The site selection team evaluated two pre-selected sites in the Philippines from January 19–27, 1997: the Patgan Catchment in the west coast of Luzon Island and the Manupali Watershed in southwest Mindanao. The process of evaluation involved three key steps:

1. Interviews and discussion with the local chiefs of relevant agencies or research stations, their personnel, and villagers mainly based on questionnaires and the examination of available reports.
2. Field assessment and examination of existing equipment, land use systems, soil conservation practices of farmers and their willingness to participate, and the degree of the on- and off-site effects of erosion.
3. A summary discussion involving all team members to evaluate: the representativity of the catchments, the main problems and options, and potential activities to be recommended.

BIOPHYSICAL AND SOCIOECONOMIC CHARACTERIZATION

Conceptual framework

A benchmark survey and preliminary site characterization was conducted after selecting the site. The approach used is based on the model of a regional ecological-economic system (Figure 2)

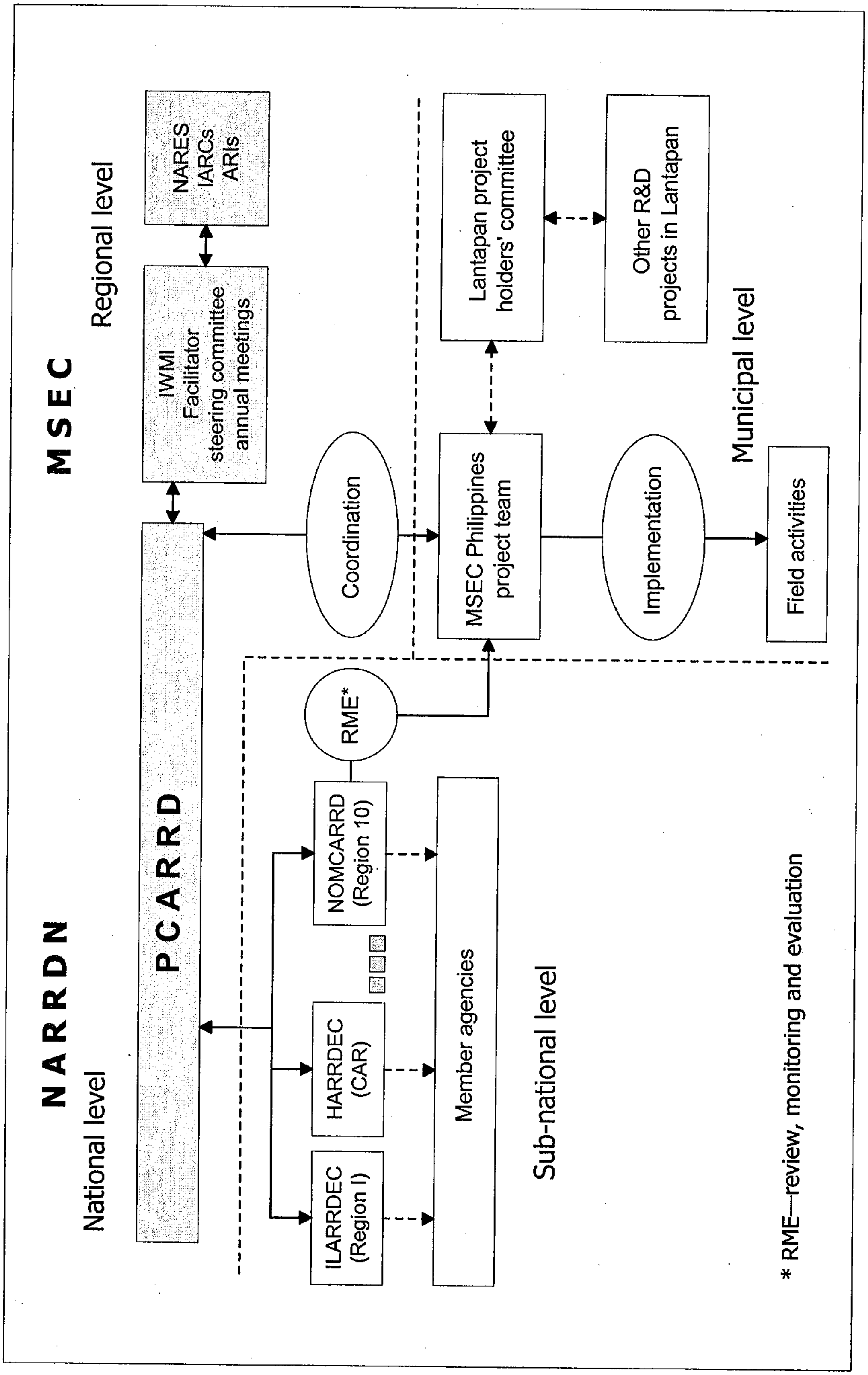

Figure 1. Organization and linkages, MSEC Philippines Project.

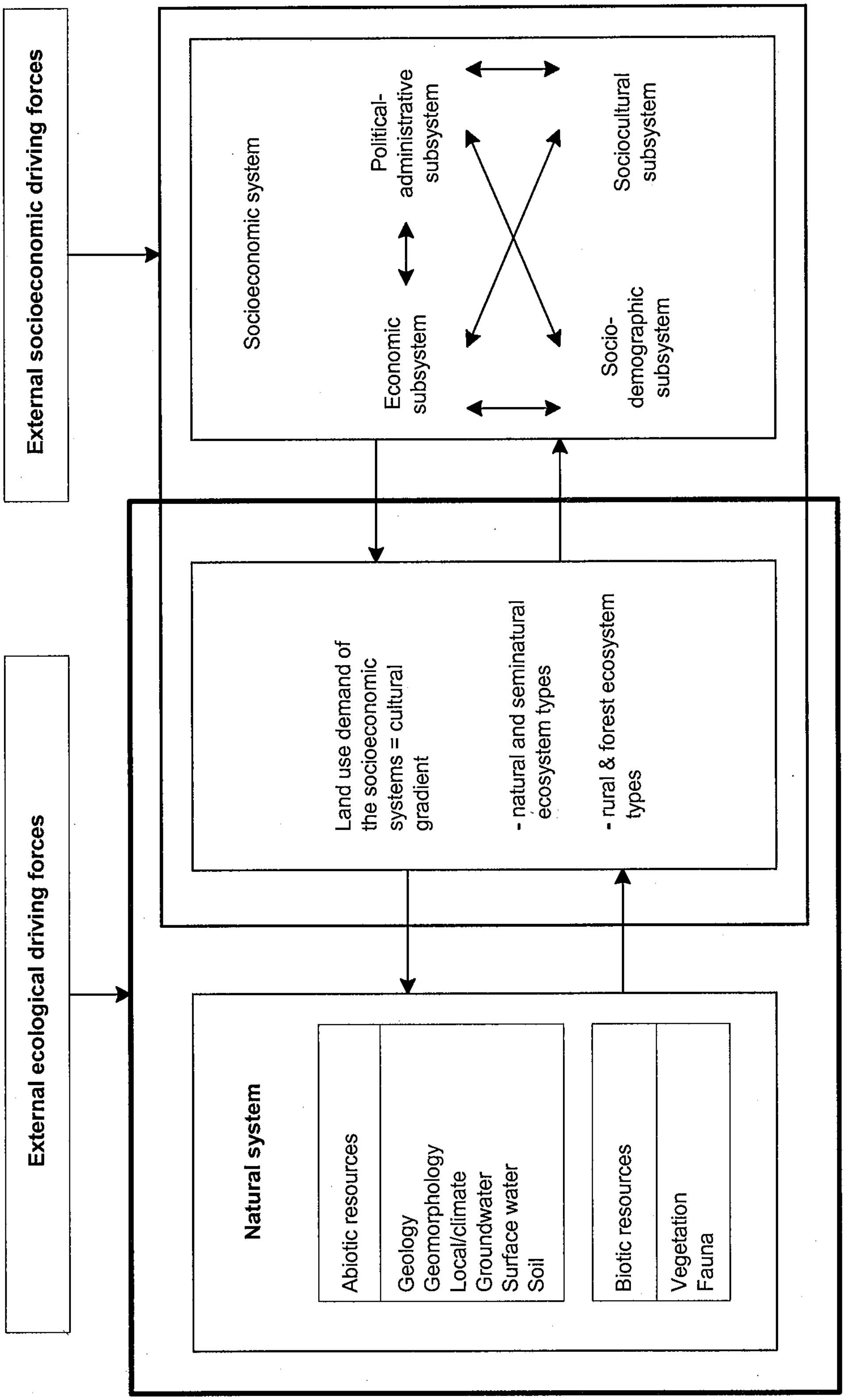

Figure 2. Ecological-socioeconomic system model (adapted from Wolfgang Haber, 1994).

originally developed by Messerli and Messerli (1979) and adapted by Haber (1994). The threefold system is comprised of the natural system (biophysical system), the socioeconomic system, and the land use system. The land use system is the result of the interaction between the biophysical and socioeconomic systems. There are also external inputs and outputs, e.g. government subsidies entering it or agricultural products flowing out. This interaction gives an indication on what important attributes are needed for characterization and explains why such attributes are needed or important to be taken. These ecological and socioeconomic systems can be transformed into environmental planning or management models and can be used for predictions and simulation. The same approach can also be adopted for monitoring purposes.

Different tools and techniques were used in the collection and analysis of the data. These include: 1) collection of secondary data/literature review; 2) reconnaissance survey; 3) soil sampling and analysis; 4) map analysis; 5) key informant interview; 6) participatory rural appraisal techniques (resource mapping, transects, trend line, time line, constraint identification, Venn diagram, crop preference and patterns, group discussions); and 7) a formal survey using a structured questionnaire. Tables 1 and 2 show the data and information needs for the biophysical and socioeconomic characterization of a watershed. Depending on the circumstances, the data collected were on a macro (national, regional, municipal) or micro (catchment, farm, household) level.

Table 1. Data and information needs for biophysical characterization.

Factors	Data/information needed	Relevance/importance	Tool/techniques
Location and area		Land use allocation	Field measurement, GIS, other map measurement techniques
Abiotic features			
Geology and physiography / landform	Parent material, rock formation, mineral resources, topography, landform/shape, altitude, slope, slope aspect	Soil classification, assessment of erosion potential suitability, selection, design and evaluation of alternative land uses and practices	Secondary data, field observation, map analysis
Climate	Rainfall, temperature, sunlight duration, wind velocity, and direction	Assessment of land suitability, erosion potential and land, productivity; prediction of future hydrologic events; impact assessment of alternative land uses and practices	Instrumentation, field measurement, records from nearest PAGASA station, literature review
Soil	Soil morphology, texture, structure, permeability, erosion condition, fertility, pH	Assessment of fertility/ productivity, land suitability, and erosion potential; selection, design and evaluation of alternative land uses and practices	Soil survey/analysis, literature review
Water resources	Hydrology, drainage pattern and density, stream order, channel gradient, stream length	Appreciation of hydrologic behaviour, assessment of land suitability, erosion potential and impacts of alternative land uses/ practices	Instrumentation/field measurement, literature review, map analysis
Biotic features:			
Vegetation	Farming systems, crops planted, species composition, type and structure of plant communities, plant and land use density, canopy and groundcover, existing land uses.	Assessment of land suitability, erosion potential and land productivity; prediction of future hydrologic events; impact assessment of alternative land uses and practices	Vegetation sampling assessment and analysis; land use assessment/mapping

Fauna/ livestock	Species/kinds, population/ distribution, management practices	Assessment of land suitability and impact on vegetation	Reconnaissance survey, key informant interview

Table 2. Data and information needs for socioeconomic characterization.

Factor	Information	Importance/relevance	Tools/technique
Population	Total population Population density Population growth rate Age/class structure Gender Migration pattern	Population pressure Scarcity of land Pressure on resources Availability of labor Property rights' regimes	Key informant interview
Settlement and land use history	Historical events Villagers' origin Reasons for settlement	Planning horizon Decision making Information flow	Literature review Key informant interview PRA
Composition of village population	Ethnicity Religion Cultural practices/ rituals related to land use	Reaction to innovation Representation	Key informant interview
Predominant occupation and typology of farming enterprises	Predominant occupation On-farm income Non-farm income Main crops produced Extent of Commercialization Farming systems Degree of mechanization Hiring of farm laborers	Investment potential Adaptability of practices Recommendation domains Adoption of labour- intensive land management technologies Opportunity cost of labour	Key informant survey Direct observation Structured survey
Access to markets	Product flow Markets for inputs Road system Proximity to markets and roads Travel costs Transportation Trading centres Farm-gate prices History of commercialization	Availability of inputs Product distribution Profitability of alternative land management and crops Potential for agricultural development	Literature review (maps, aerial photographs) Direct observation Key informant interview
Access to survey information on agricultural innovation	Sources of information (e.g. extension workers, merchants/sales representatives, other farmers, radio, tv) Frequency of visit to area (of sources of information) Farmers' perceptions of soil erosion Level of education	Effectiveness of information dissemination	Formal (structured) Key informant interview Group discussion with farmers
Credit constraints	Sources of credit Lending activities Interest rates	Availability of capital	Key informant interview
Structure and functions of local organizations	Local organizations Characteristics of local organizations	Effectiveness of project implementation Information dissemination	Key informant interview

	Linkages/collaboration among organizations	Technology transfer	
Conflicts	Conflicts Causes of conflicts Insights into off-site issues	Understanding and explaining behaviour	Key informant survey Formal survey
Land tenure arrangement and presence of land markets	Land classification Tenurial arrangement Presence of land markets Prices of eroded land and land with soil conservation Legal status (e.g. crop land, forestland) Presence of long-term investments	Decisions for long-term investments	Cadastral maps Participatory mapping Key informant interview Direct observation Formal survey
Rural development	Previous and current interventions	Probability of getting support from relevant institutions	Literature review Key informant interview
Other support services	Extension support services (government, NGOs, other groups, private sector, other groups)	Technology transfer Technical assistance	
National, regional, and local policies	Development thrusts Prices for inputs and marketed produce Price support, subsidies, taxes Credit Land rights Conservation/watershed protection Irrigation Upland agricultural development Afforestation Resource utilization	Relevance of project to national and local goals Policy formulation Planning	Literature review

EVALUATION OF THE ON-SITE EFFECTS OF SOIL EROSION

Identification and characterization of microcatchments

Three site visits were conducted from November 1998 to May 1999 to delineate the catchment and microcatchments. The Mapawa Catchment which covers 91 ha was identified and four microcatchments within were delineated. Each of the microcatchments was characterized following the tools and techniques enumerated in the earlier section.

Standard procedures for soil classification were followed. Four pits were dug strategically to describe the soil profile. Soil samples were randomly collected using a soil auger. Likewise, soil sampling on marked areas on current field crops (corn and vegetable farms) was undertaken for soil fertility and productivity monitoring.

Instrumentation and data collection

A main weir for the whole catchment and four smaller weirs for each microcatchment were constructed from July to September 1999. An automatic weather station (AWS) was installed in the lower half of the Mapawa Catchment and five rain gauges were put up in spots identified by the project team. Water level recorders were installed in each of the weirs. The exact location of the weirs, rain gauges, and AWS was determined using a GPS GARMIN III Plus.

The data collected and monitored were: 1) rainfall; 2) streamflow velocity; 3) water level; 4) volume of runoff; 5) runoff sediment load; 6) bedload; 7) chemical analysis of sediments and bedload, and organic matter content, extractable K, available P, exchangeable Ca, Mg, pH; 8) crops and cropping patterns; 9) prices of farm inputs and produce; and 10) cultivation practices. Items 1 to 6 were collected through the instruments installed in the catchment.

Evaluation of the on-site cost of soil erosion

There are two basic approaches that can be used in estimating the on-site costs of soil erosion: the ***change in productivity approach*** and the ***replacement cost approach*** In the first method, the cost of soil erosion is estimated by getting the difference in crop yields with and without erosion, multiplied by the unit price of the crop, and less the costs of production. The method requires estimation or knowledge of the relationship between soil loss and yield loss. Estimating the relationship between soil loss and yield loss may be accomplished by direct measurement on farm or through the use of prediction models. The second approach assumes that soil erosion leads to a reduction in organic matter and nutrients due to loss of soil. In turn, this process will lead to a decline in crop production unless nutrients are replaced in the soil. Therefore, a good indicator of the economic loss may be based on the cost of replacing those nutrients.

Since there are still not enough data to arrive at a good soil loss-yield loss relationship, the replacement cost approach was used to evaluate the on-site economic impacts of soil erosion at the site. The other method will be used later as the data required in the analysis are collected.

The on-site cost of soil erosion was evaluated making use of the data on bedload, sediment load, and nutrient content (organic matter, available P, extractable K, exchangeable Ca and Mg) of bedload and suspended sediment. These data were collected from the four microcatchments from April to July 2000. The cost of the nutrients lost by erosion that have to be replaced was estimated from the prices of fertilizers available locally such as urea (46-0-0), ordinary superphosphate (0-20-0), and muriate of potash (0-0-60). The transport cost was considered in the estimate.

Evaluation of the off-site effects of soil erosion

The steps used in the crude calculation of the magnitude of the off-site cost of erosion were those described by Francisco (1999). These are:

1. Identify the water body (e.g. reservoir, catchment, lake, etc) where the runoff carrying soil sediments from the study site drains.
2. Define the watershed where the project site belongs (Assess relative contribution of the sediments from the project area to the total volume of sediments observed in the water body).
3. Collect information on the sedimentation rate of the water body.
4. Gather information on the water-based economic activities of the downstream communities most vulnerable to the pollution of the water body (e.g. irrigation, hydroelectric power, domestic and industrial water uses).
5. Measure the impact of sedimentation-induced water pollution.
6. Value the off-site impact of erosion.

Identification of potential off-site impacts

The identification of potential environmental impacts is based on a careful evaluation of the activity or processes involved. During rainfall events, part of the soil lost from the upper parts of the catchment are transported by runoff down to the lower parts of the catchment, others are carried further to the water bodies downstream. The detached soil that is carried to the water bodies downstream either end up as bedload or sediment trapped in dams or reservoirs, or are further carried away to the lower water bodies as suspended solids. The sediments and suspended solids carried by runoff cause off-site impacts to water-based activities downstream.

Barbier (1996) identified possible downstream or off-site impacts of soil erosion that result from water-borne runoff and sedimentation. These impacts include: reservoir sedimentation; losses to navigation; irregular flow of irrigation; effects on agricultural, fishing, and industrial production in lowlands and coastal regions; impacts on water supply and potability; and impacts on drought or flood cycles. The soils eroded from the MSEC Philippine site end up as sediments in the reservoir of the Manupali River Irrigation System, which is located in the lower part of the Manupali Watershed.

Evaluation and analysis

Off-site costs are normally measured in terms of the net present value (NPV) of foregone benefits from any loss of downstream economic activities (loss of income due to crop production losses) or of additional operating costs, such as dredging costs for canals, reservoirs or port facilities. Methodologies employed in estimating off-site costs are specific to the off-site impacts.

The change in productivity approach was used in the evaluation of the off-site impact of soil erosion at the Philippine site. It values the operation and maintenance cost of removing sediments through dredging and replacing damaged equipment (Grohs, 1994 as cited by Enters, 2000). Regular dredging of the Manupali River Irrigation System has been done since 1995. The actual costs of dredging from 1995 to 2000 were gathered. The potential contribution of the MSEC site to the total cost of soil erosion in the system was estimated based on the relative location and characteristics of the site.

RESULTS AND DISCUSSION

Site selection

The site selection mission finally selected the Manupali Watershed as the MSEC site in the Philippines. It is where the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP), with a strong participatory and socioeconomic component is also being conducted. The specific site selected was the Mapawa Catchment.

The Mapawa Catchment, located at Sitio Mapawa, Songco, Lantapan, Bukidnon. Lantapan is about 40 km west of the provincial capital of Bukidnon, Malaybalay city, and 140 km southeast of Cagayan de Oro city, the closest trading centre and port of the provinces of Mindanao (Figure 3). It is situated at the footslope of Mount Kitanglad Natural Park. It is around 4 km from Mount Kitanglad which has been declared a protected area. Coordinates 08°26'50" north latitude and 125°56'35" east longitude may be used as reference for locating the catchment.

The steepness of the slopes and the rainfall characteristics make the soils very susceptible to erosion especially under disturbed or cultivated condition. The inventory team recommended that erosion monitoring and soil conservation management research be undertaken. Also identified as major concerns in the area are, sedimentation, water quality problems, and nutrient pollution.

Biophysical and socioeconomic characterization

Biophysical and socioeconomic characterization helps to understand the conditions in a given area and the various factors affecting the land use decision of the farmers. This allows the buildup of a knowledge base for use in the identification of problems, opportunities, and constraints within and

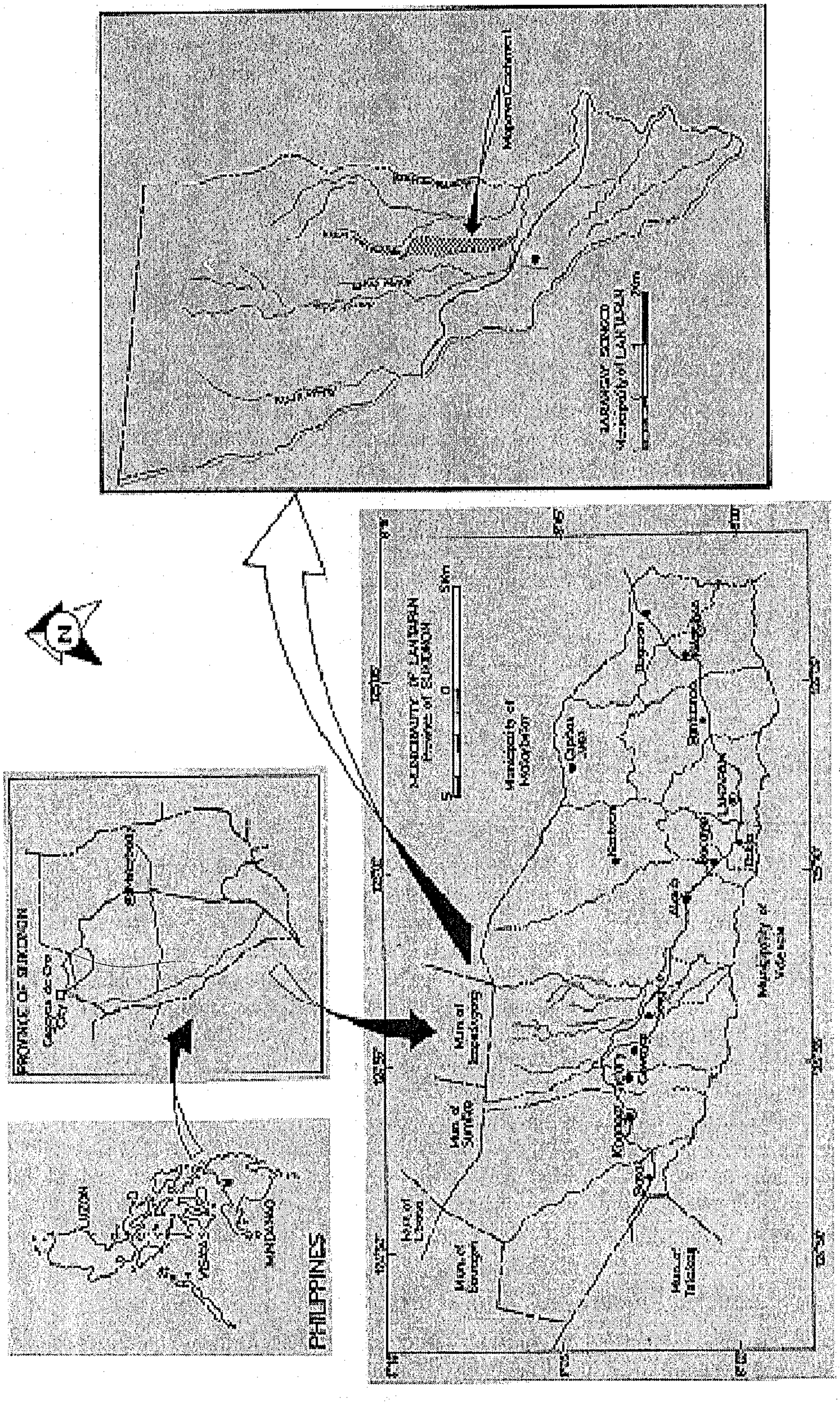

Figure 3. Location map of Lantapan, Bukidnon.

outside the watershed (PCARRD-DOST-DENR-FMB-DA-UPLB-CFNR-FDC/ENFOR, 1999). This also provides information for clarifying research priorities, extrapolating research results, and targeting relevant technologies to appropriate areas (Enters, 2000).

Geology, physiography, and landform

Mapawa Catchment is situated on the southern slopes of Mount Natotong. The footslopes comprise deeply incised basalt and pyroclastic materials which originated from the adjacent volcanic peak of Mount Kalatungan.

The study area looks like an elongated, narrow leaf with the slope gradient facing southeast. Elevation ranges from 1,080 to 1,505 m asl with an average of 1,300 m (Figure 4).

The watershed shape factor is 0.69 km with rolling to sloping terrain with slopes of 8 to 35% (Figure 5).

Climate

Mapawa Catchment is relatively wet and humid with rainfall more or less distributed throughout the year. Mean annual rainfall is 2,537 mm (Table 3), with rainfall peaks in June to September. The driest months are February to April.

The temperature ranges from a minimum of 17.5^{0}C in February and March to a maximum of 30.4^{0}C in April and May. The mean annual temperature is 23.6^{0}C.

Table 3. Climatological data of the project site (adapted from Malaybalay PAGASA Station).

Month	Rainfall (mm)	Temperature (^{0}C)		
		Maximum	Minimum	Mean
January	124.5	29.7	17.8	22.8
February	95.9	28.3	17.8	22.9
March	103.2	29.4	17.5	23.4
April	104.4	30.4	18.2	24.3
May	222.5	30.2	19.1	24.0
June	307.1	28.8	19.2	24.0
July	315.9	28.0	19.0	23.5
August	300.3	28.1	19.0	23.5
September	327.0	28.3	19.0	23.6
October	299.4	28.5	18.8	23.6
November	187.3	28.8	18.6	23.4
December	149.8	28.3	18.2	23.2
Annual	2,537.3	28.8	18.5	23.6

Source: Climatological norms (1951–1985) PAGASA, 1987.

Soils

The soils of the catchment area are deep clay, acidic, and with low cation exchange capacity and base saturation. The organic matter content of the surface soil horizon is high, except for the eroded phase. The soils of the catchment are mostly Ultisols except for the eroded phase (possibly Inceptisols).

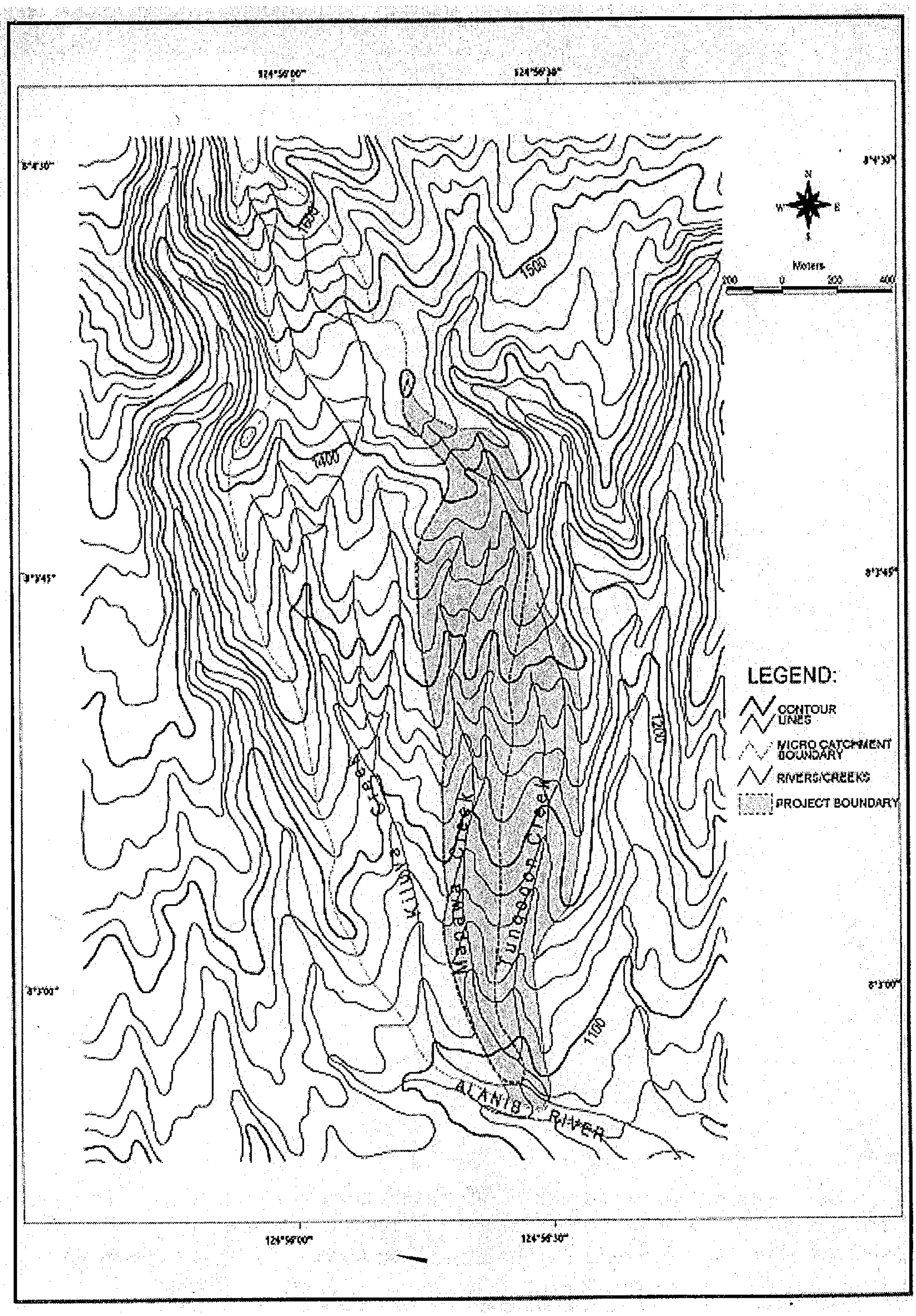

Figure 4. Topographic map of Mapawa Catchment.

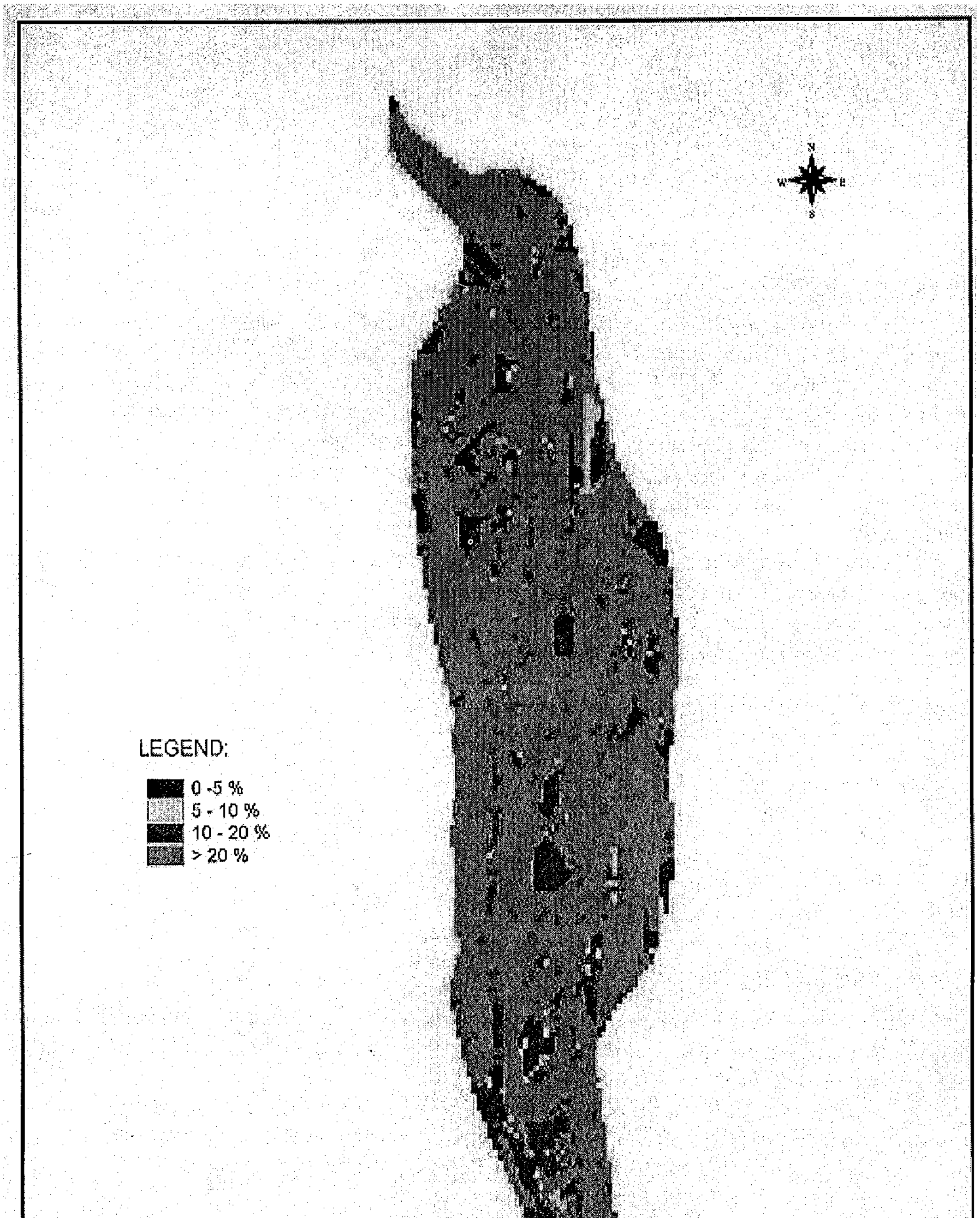

Figure 5. Slope map.

The mapped soils of the catchment area are tentatively classified locally as follows:

Soil series/type	Average slope (%)	Area (ha)
Adtuyon clay (deep)	15–35	74
Adtuyon clay, bouldery phase	8–18	29
Adtuyon clay, eroded phase	15–35	21
Creek escarpment zone	50	93

Water resources

The surface hydrology is ephemeral or intermittent (dry during summer months and with running water during rainy months). The creeks in Mapawa Catchment are tributaries of the Alanib River (Figure 6). The drainage pattern is asymmetrical in nature, which indicates that the surface materials are relatively homogenous. They develop where bedrocks do not outcrop the surface to block or deflect stream channels. The drainage density is about 6.15 km km^{-2}. Creek frequency is approximately 2.19 km^{-2}. Drainage pattern and density are excellent indicators for assessing the health of the catchment, its responses to human interventions with the suitability and impact of land uses and practices.

There are two main creeks in the catchment, namely, Tungogon and Mapawa. The creeks traverse a total length of about 5.61 km southeast and flow out to the Alanib River. Tungogon Creek divides the Tungogon microcatchment while Mapawa Creek transects the Mapawa microcatchment. Table 4 presents the morphometry of the creeks.

Table 4. Morphometry of creeks found within the study area.

Creek	Length (km)				Average slope (%)		
	Segment 1 (U_1)	Segment 2 (U_2)	Segment 3 (U_3)	Total	U1	U2	U3
Tungogon	0.800	0.375	0.985	2.160	19.17	31.61	12.69
Mapawa	0.780	1.745	0.925	3.450	20.00	16.87	12.97

Vegetation and land use

Information on the farming system; composition, type, and structure of plant communities; plant density; and canopy and groundcover in the catchment area is vital to the understanding of the role vegetation plays in the physical processes at the site.

The area is composed of forest plantations of *Eucalyptus spp.*, *A. mangium*, *A. falcataria*, and *Eucalyptus* mixed with jackfruit; open grassland with cogon and ferns; coffee, cropland (with corn, root crops, and vegetables); and shrubs and bamboo with pioneer species (Figure 7).

Population

The catchment site is within Sitio Mapawa. Mapawa is one of the seven 'sitios' (hamlet) of Barangay Songco which is one of the 14 'barangays' (villages) in the municipality of Lantapan. The catchment is currently occupied by 70 households. With an average household size of 4–6 persons, the catchment has approximately 155 people, a density of 1.7 persons ha^{-1} or 170 persons km^{-2}. In the analysis of migration patterns in the Philippines done by Cruz *et al.* (1992), population densities exceeding 117 persons km^{-2} are already considered high. As the population density in the Mapawa Catchment is more than this figure, it is considered as high and may have a significant influence on

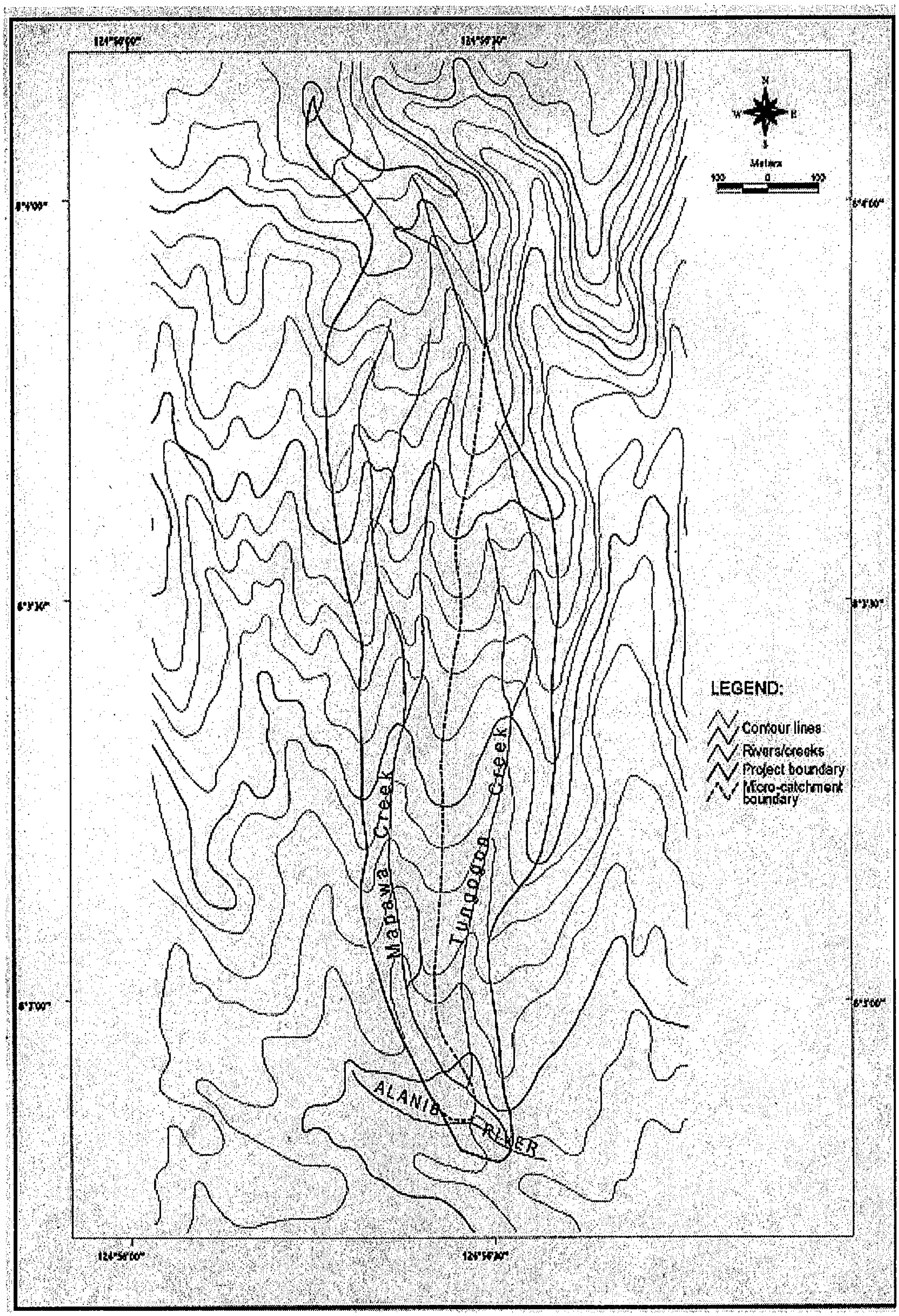

Figure 6. Drainage pattern of Mapawa Catchment.

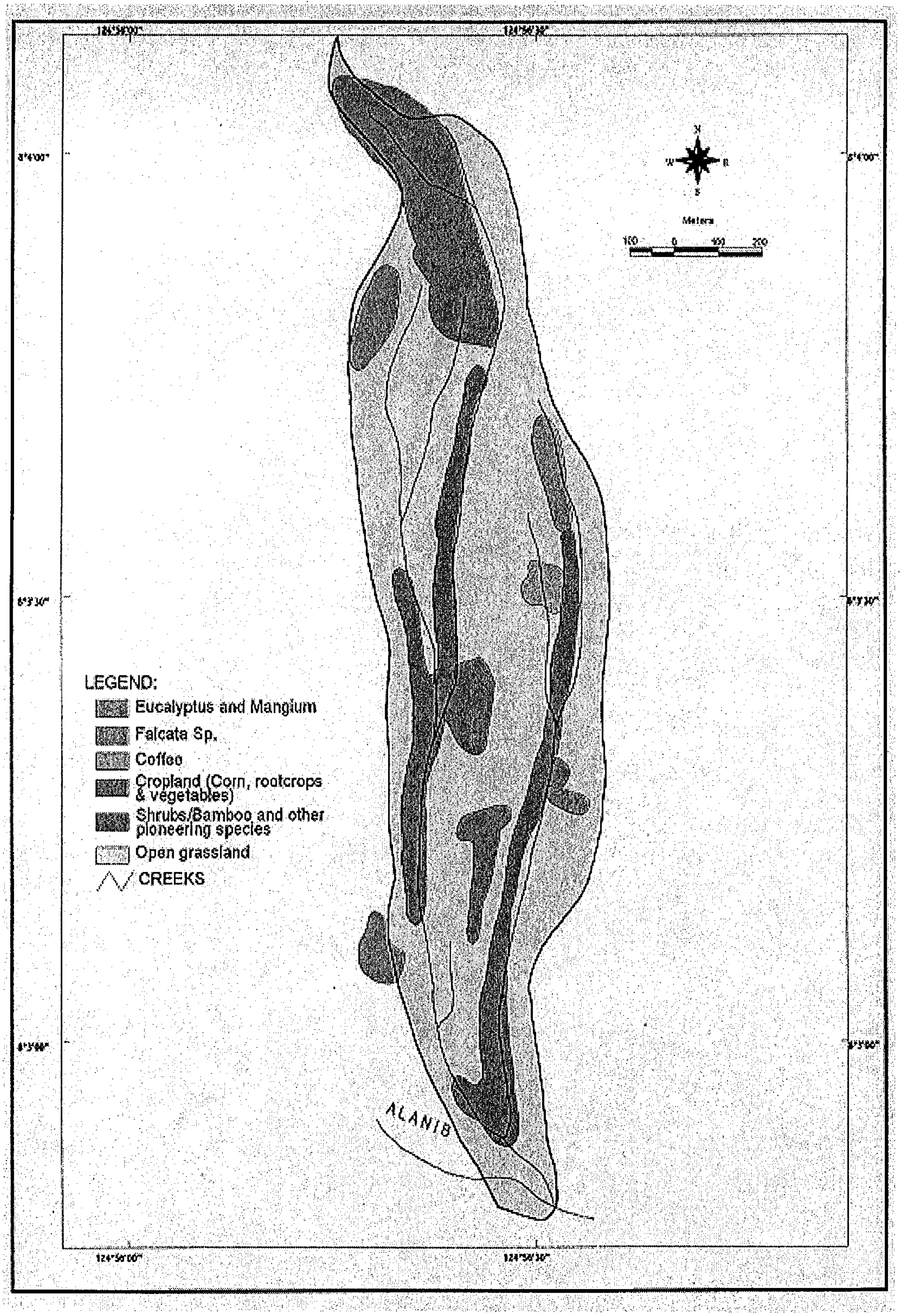

Figure 7. Vegetation/land use map of Mapawa Catchment, 1999.

erosion. In general, the movement of the population in the uplands is due to an expanding need for cultivable land.

Information on the settlement and land use history of Mapawa came from the participatory rural appraisal (PRA). Table 5 shows the key events in the history of Mapawa Catchment from the time it was established to the present. The table indicates that several land use interventions have been introduced in the area. Most of the interventions introduced concern soil conservation. These projects/programmes have increased the farmers' perceptions of soil erosion. The farmers identified soil erosion as a problem, although they did not consider it a major one. Soil erosion reduces soil fertility and consequently yield is also reduced. However, the farmers identified lower yield as a minor problem. Since decline in productivity due to soil erosion can only be evident after a relatively longer time, the farmers may not have yet fully realized the impact of erosion.

Table 5. Key events in Mapawa Catchment, 1972–2000.

Year	Key event
1972	Sitio Mapawa was established with only 5 households
1973	Inauguration of Sitio Mapawa; long drought; trees died
1978	Start of logging, all trees were felled
1979	Start of 'kaingin'
70s – 80s	Many people planted potato but did not succeed due to bacterial wilt (BW)
1981	Coming of MMWDP. People planted various trees (*Gmelina*, falcata, pine trees)
1983	Long drought; trees were burned
1989	Extension school was established but burned down in the same year
1990	Start of planting cabbage in lieu of potato; this did not succeed due to diamond back moth (DBM)
1993	PPAEP came and held seminar on contour farming
1994	SANREM research started; distributed tree seedlings
1994	Philippine Eagle came in, conducted training on soil conservation and introduced livelihood projects through loans
1994	NPAs started where promotion of protecting the natural resources was held; farming on protected areas was strictly prohibited
1995	Start of ICRAF research. Also conducted training on natural vegetative strips (NVS) technology
1997	El Niño phenomenon; remaining trees were burned
1999	Start of MSEC Philippines project
2000	70 households were established in Sitio Mapawa

Composition of the village population

The Tala-andig tribe is an ethnic group in the area. However, migration of the farmers from other places has slowly reduced the percentage of the Tala-andig population. Of the 31 farmers currently cultivating in the catchment, 39% are Cebuanos and 35% are Tala-andigs. The rest are Boholano (10%), Igorot (10%) Misamisnon (3%), or Davaoenio (3%). The migrants have brought with them their cultural practices, which are significantly different from the indigenous Tala-andigs. The settlement pattern of the catchment reflects the history of Lantapan.

The Tala-andigs practice their traditions and beliefs, which are associated closely with the environment where they live. Although they have been overtaken by the Cebuanos in terms of population, the Tala-andigs still have a major influence in the area. Understanding their beliefs and their bases are important especially when developing and planning interventions. These interventions have to build on their existing indigenous knowledge and traditions. For instance, before any work in the farm begins, they perform a ritual to ask for a blessing. The farmer together with his family and other participants pray to the spirits, and offer food, wine, and coins. They believe that the offering will bring more from their labour. They also offer sacrifices. Dressed and cooked chicken is placed on a bamboo table with flags or white cloth. The offerings should not be placed on the soil, otherwise they will offend the spirits. Rich farmers usually offer pigs instead of chickens. These rituals are however slowly disappearing especially among younger farmers who have embraced other religions.

Predominant occupations and typology of farming practices

Farming is the major occupation of most of the occupants in the catchment. Other occupants are either carpenters, businessmen, or privately employed. The farmers in the area prefer to plant corn, potato, and trees (*Eucalyptus spp.*, mosisi), cabbage, sweet peas, snap beans, and sweet potato. Other crops grown are coffee, banana, onion, sayote, tomato, carrots, Chinese cabbage, bell pepper, squash, and cassava. The most common cropping patterns in the area are corn-corn; potato-cabbage; corn-sweet pea; cabbage-corn-potato-snap beans; snap beans (monocrop); sweet potato-corn; and sweet pea (monocrop).

The farming systems in the catchment are based on the production of corn and rootcrop vegetables for subsistence and for sale. Hence, on-farm income is obtained from the sale of these crops. Figure 8 shows the crops planted by the farmers in the catchment and the relative position of farms where these crops are produced.

Chemical fertilizers, pesticides, and fungicides have become the most indispensable inputs in vegetable farming according to the key informants. They reported the following rates of application on a per hectare basis:

- For leafy vegetables like cabbage, lettuce, wongbok, and cauliflower, three bags of complete fertilizer are applied at planting time and two bags of urea (46-0-0) are used as sidedressing.
- For fruit and root crops like white potato and tomato, one bag of complete fertilizer (14-14-14) and two bags of compost as sidedressing.
- Organic fertilizers like chicken manure are also applied at planting at the rate of three spoonfuls per hill whenever they are available.

Chemicals applied to control insect pests include Cymbus and Kocide. These are applied based on the recommended dosage. Fungicides like Maneb and Dithane M-45 are also used whenever there is a need to control fungus infestation.

Access to markets

The participatory agricultural and rural systems appraisal (PARSA) conducted in Barangay Poblacion, Lantapan reported that there is only one dealer of agricultural input in Lantapan (Villancio *et.al.*, 1995) Agricultural inputs are purchased either from this dealer or from the markets in Valencia and Malaybalay. Farmers who have capital, go to these markets to buy the agricultural inputs they need. Those who do not have enough capital get their inputs from private traders who provide advance financing to the farmers. In return, the farmers should sell their produce to these traders at a lower price.

The farmers sell their produce to nearby towns or to the middlemen who pick up their farm produce. A dirt road, which is too difficult to traverse, especially during the rainy months, is used by the residents to transport agricultural produce from their farms to a small trading post in Barangay Songco. The road stretches 3 km from sitio Mapawa to this trading post. Transporting produce from sitio Mapawa to this point costs the farmer P20.00 for an animal-drawn sled.

Farmers usually sell their produce in Aglayan, the nearest market. It costs P17.00 from the Songco trading post to Aglayan by jeepney. Other markets are in the cities of Malaybalay and Valencia.

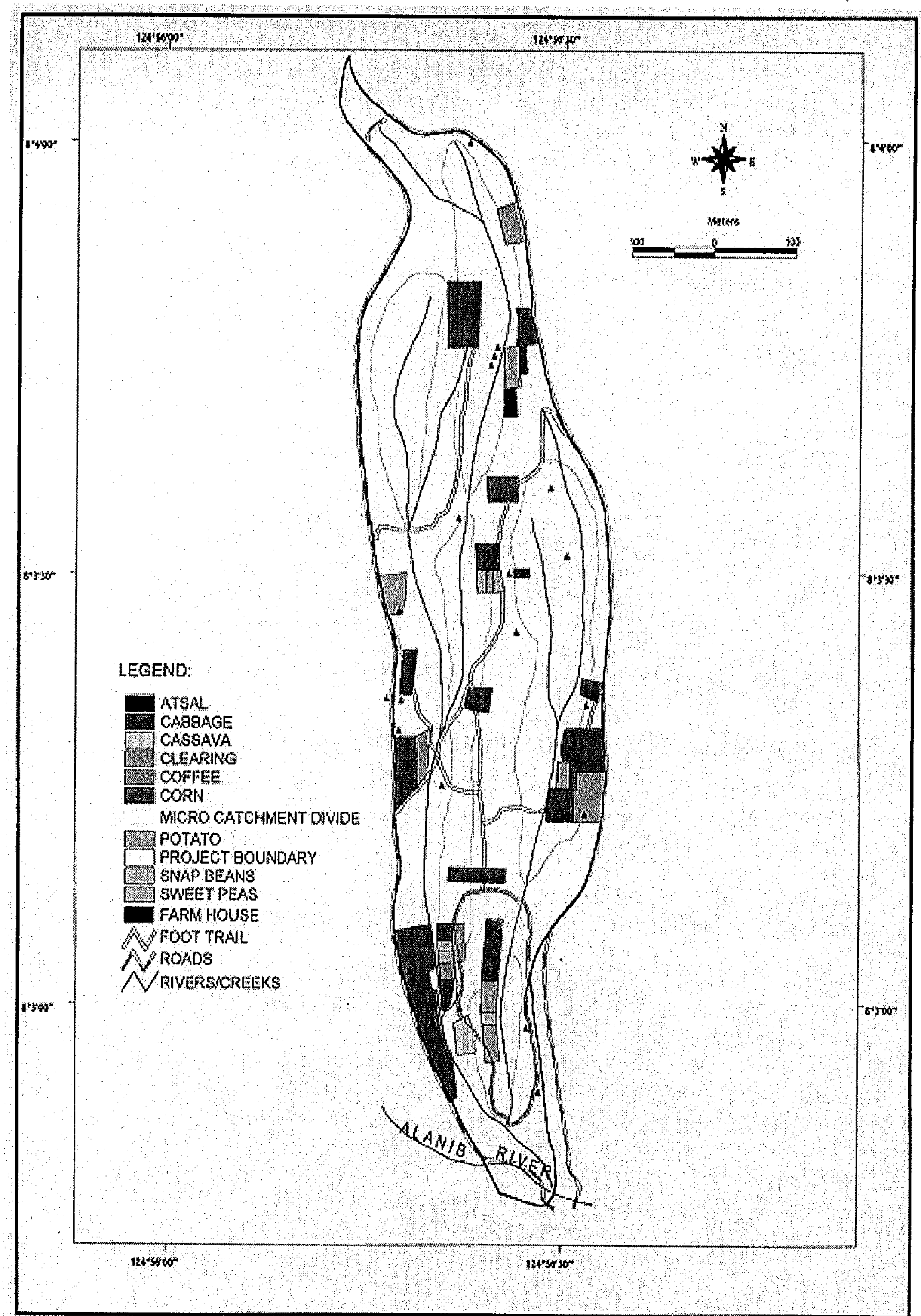

Figure 8. Crops Planted.

The high costs of transportation could significantly reduce the profit of farmers. The costs and returns analysis of producing the various crops in the catchment indicates that transportation cost is a major component of cash expenses. For potato, transportation cost amounts to about 17% of the total cash expenses and is the third major cash expense item after labour and fertilizers.

The farmers ranked bad roads as their number one problem. The state of the road undoubtedly influences the choice of crops to grow. The farmers tend to grow crops with little transport losses as evidenced by their crop preferences. Among the reasons why corn and potato rank highest in the farmers' crop preference is that these crops are not highly perishable and there is no trucking damage.

Access to agricultural information and credit

The agricultural technicians (ATs) of the Lantapan municipality are the main source of information on agricultural innovations. These ATs are assigned by the municipal government to provide assistance to the farmers. Collaboration with the municipal government through the ATs is therefore crucial in soliciting the participation of farmers in designing, testing, and transferring soil management technologies.

The farmers in the catchment cited lack of capital as their second most serious problem. Crop production requires substantial cash outlays for inputs such as fertilizers and pesticides and for transporting the products to the market. Having no capital on hand, the availability of credit would be crucial for the farmers to obtain adequate inputs needed to optimize crop production.

An earlier survey (Villancio *et al.,* 1995) reported that a rural bank (Lantapan Rural Bank) provides credit services to farmers. In 1995, the bank participated in providing agricultural loans and other credit services. It also participated in the special financing scheme under the various government programmes. However, the bank suffered from low repayment. At present, the bank provides loans only to those with collateral to offer. Land titles are acceptable common collateral.

Structure and function of local organizations

The general principles for the control of degradation are similar worldwide, but each country must develop its own conservation and rehabilitation policy, strategies, and programmes, tailored to its own unique circumstances. A fundamental requirement is that governments provide the back-up services the land users need if they are to contend with land degradation problems. These include strengthening and rationalizing relevant government institutions, establishing an advisory system as well as attending to the legislation, training, and research needs of the conservation effort (FAO, 1995).

There are several community-based organizations/projects within and outside the MSEC catchment site. The MSEC and SANREM projects conducted in the area are coordinated by PCARRD. They are implemented by various agencies such as Department of Environment and Natural Resources (DENR), Central Mindanao University (CMU), and University of the Philippines Los Banos (UPLB). The International Center for Research in Agroforestry (ICRAF) is also conducting activities in the area and works in a consortium involving the UPLB and CMU. The municipal government of Lantapan assigns ATs who provide technical assistance to the farmers. Each AT is assigned to one or several barangays. Other organizations conducting activities in the area are the Kitanglad Integrated NGO (KIN) which is a non-government organization (NGO), the Mapawa Integrated Social Forestry Association (MAISFA), and the Mapawa Tribal Council (MATRICO).

At the municipal level, PCARRD established the Lantapan Project Holders' Committee (LPHC) composed of a Steering Committee (SC) and the Technical Working Group (TWG). The SC is composed of representatives from national and international agencies with projects at Lantapan such as PCARRD, Southeast Asia Regional Center for Graduate Study in Agriculture (SEARCA), Australian Center for International Agricultural Research (ACIAR), and ICRAF. The Northern Mindanao Consortium for

Agriculture and Resources Research and Development (NOMCARRD), Bureau of Agricultural Research (BAR), CMU, Lantapan Local Government Unit (LGU), Province of Bukidnon as well as the regional offices of the Department of Agriculture and DENR are also represented in the SC. The TWG is composed of coordinators/project leaders of the various research and development projects being implemented in Lantapan municipality. Also included are NGOs and the Municipal Agricultural Office. The LPHC is the integrating mechanism at the municipal level, NOMCARRD at the regional level, while PCARRD integrates MSEC R&D activities at the national level.

Conflicts and land tenure

Administrative conflict is almost nil since the catchment is within only one barangay, a political administrative unit under the municipality of Lantapan. Linkage with the political setup would be easier since only one administrative head, the barangay chairman, has to be consulted.

Erosion control technologies require an initial investment, which produces benefits in the long term. Farmers who do not have long-term rights to the land they cultivate have shorter planning horizons and are therefore seldom interested in improving or protecting that land.

Most of the land within the Mapawa Catchment is considered private land. Areas have been declared public land such as those that are located at the centre of the sitio. Other areas considered as public land are found in the upper portion, which belongs to another sitio. Some farmers only till the land and pay rent to the owners.

EVALUATION OF THE ON-SITE EFFECTS OF SOIL EROSION

Location and drainage area of the microcatchments

The catchment which is shaped like an elongated narrow leaf, covers 91 ha. Four microcatchments, with size ranging from 0.94 to 24.93 ha have been delineated within the boundary. The coordinates of the five weirs and rain gauges, determined by the GPS GARMIN III Plus are shown in Table 6. Figure 9 shows the location of weirs and the rain gauges.

Table 6. Drainage area of the microcatchments in Mapawa and the location of weirs and rain gauges

	Location		Drainage area (ha)
	Latitude (north)	Longitude (east)	
A. Weirs			
Main weir	08 02' 51.7"	124 56' 31.2"	91.00
Weir No. 1	08 03' 03.8"	124 56' 33.7"	24.82
Weir No. 2	08 03' 32.7"	124 56' 27.5"	16.74
Weir No. 3	08 03' 33.2"	124 56' 23.8"	14.90
Weir No.4	08 02' 59.8"	124 56' 28.0"	1.50
B. Rain gauges			
Rain gauge 1	08 02' 53.1"	124 56' 25.9"	
Rain gauge 2	08 03' 00.5"	124 56' 35.4"	
Rain gauge 3	08 03' 19.8"	124 56' 37.3"	
Rain gauge 4	08 03' 18.2"	124 56' 22.5"	
Rain gauge 5	08 03' 31.7"	124 53' 20.8"	
AWS	08 03' 11.1"	124 56' 29.8"	

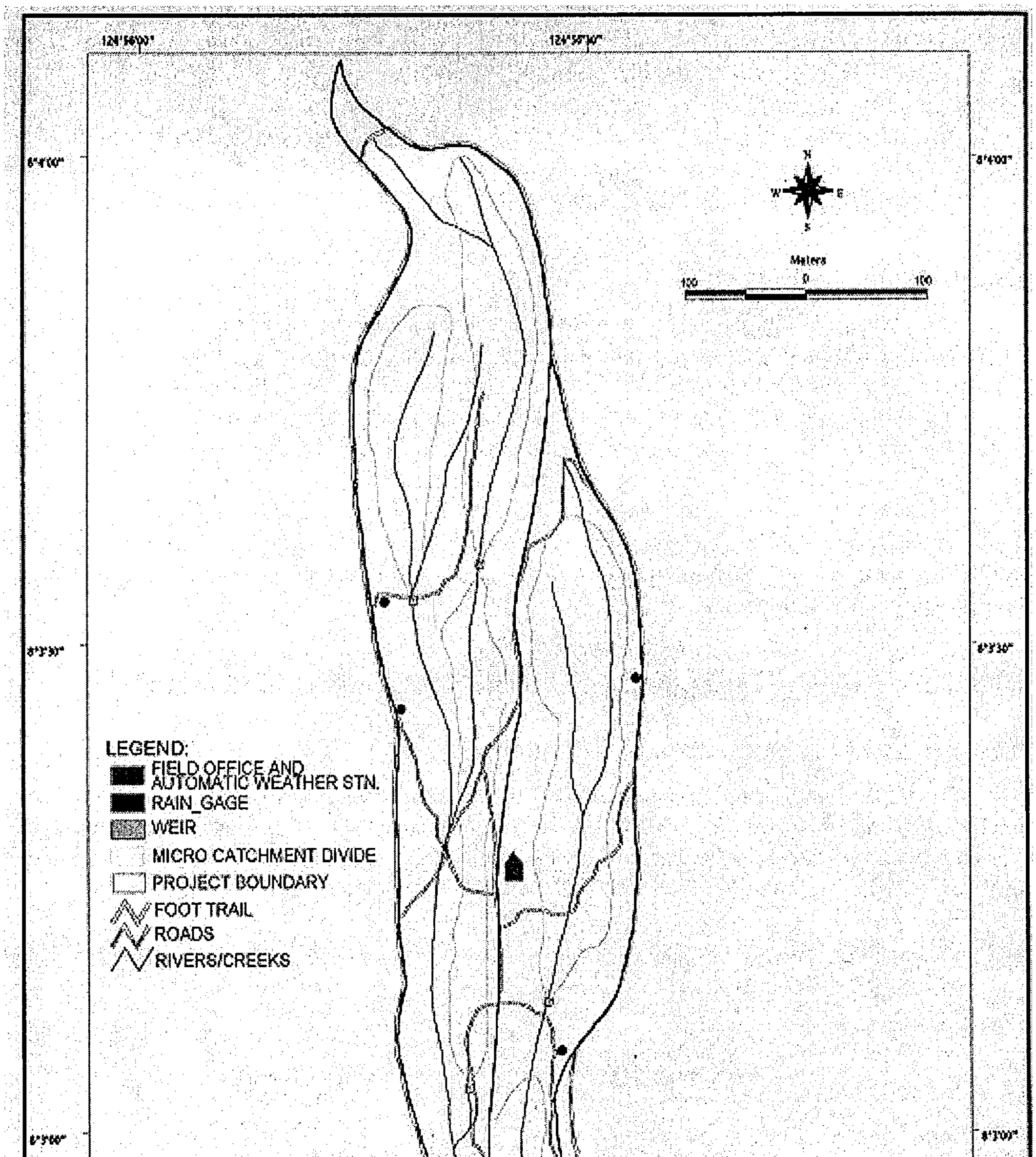

Figure 9. Location of instruments.

Erosion and land use

About 35% of the 91-ha area catchment is planted to food crops (vegetables, rootcrops). The rest is composed of bamboo stand, open grassland, trees (*Eucalyptus spp. A. falcataria*) and settlement. The soil loss from the whole catchment from April to July 2000 measured at the main weir is 28,888 kg. or an average of 318 kg ha^{-1}.

Table 7 shows the erosion rates, land use, and shape of the four microcatchments. On a per hectare basis, the magnitude of erosion is in the order of Microcatchment 4 (MC 4) >>>>> MC 3 > MC 2 >> MC 1. MC 4, for a period of four months, lost 23,028 kg (53%), while MC 1 recorded only 1,364 kg (3%) for the same period. This discrepancy is very noticeable since MC 4 occupies only 0.94 ha or 2% of the aggregate area of the four microcatchments, while MC 1 occupies 48%. MC 1 is occupied mostly by grassland and bamboo, hence, the low soil loss. Also, the cultivated patches in MC 1 are far from the stream.

It is to be noted, as indicated in Table 6, that 50% of MC 4 is intensively cultivated and planted to crops. The area is fallowed after harvest although 0.1 ha is tilled continuously after harvest of sweet potato to prevent the buildup of *Pseudomonas solanacearum*, the soil-borne pathogen causing bacterial wilt. The farmer applies fertilizer only to sweet potato planted in this 0.1 ha. Further, the cultivated portions are adjacent to the stream.

Erosion loss in MC 3, which is occupied mostly by houses and other structures, is also relatively high. This may be attributed to the erosion from the foot trails and road network.

Table 7. Land use and soil loss from April to July 2000 from the four microcatchments in Mapawa Catchment.

Microcatchment		Land use	Shape	Soil loss (April to July 2000)	
No	Area (ha)			Total (kg)	kg ha^{-1}
MC 1	24.93	20% cultivated to vegetables and root crops 80% falcata, Eucalyptus, grassland, cultivated areas far from stream	Triangular	1,364.0	54.71
MC 2	17.88	40% cultivated 60% grassland	Elongated	12,319.6	689.02
MC 3	7.96	10% settlement, 90% grassland	Elongated	6,886.1	865.09
MC 4	0.94	50% cultivated (14% of cultivated area is left bare) 50% grassland, trees	Rectangular Cultivated area adjacent to stream	23,028.6	24,498.51

Soil and nutrient loss

Table 8 shows the nutrient content of the sediments. The amount was computed by taking into account the soil test values for organic matter, available phosphorus, and exchangeable potassium and the volume of the eroded soil for each weir per month. For instance, the sediment load of 106 kg collected during July at Weir 4 has 5.7% OM, 1.6 mg kg^{-1} available P, and 111mg kg^{-1} exchangeable K. This translates into 6.05 kg OM, .2 g of P, and 11.7 g of K. If the OM contains 5–6% nitrogen, the N content of the sediment amounts to 302 g of nitrogen. The calculated monetary value of the lost nutrients is shown in Table 9.

Table 8. Amount of nutrient losses due to soil erosion at the four microcatchments from April to July 2000.

Micro catchment/ month	Soil loss (kg)	Organic matter (kg)	Extractable P (kg)	Exchangeable K (kg)
MC 1				
April	366.9	21.6	0.0015	0.1530
May	138.9	91.4	0.0005	0.0480
June	589.5	79.8	0.0014	0.2768
July	268.7	22.6	0.0007	0.1314
Total	***1,364.0***	***215.4***	***0.0041***	***0.6092***
MC 2				
April	689.4	32.8	0.0021	0.2312
May	5,698.8	178.4	0.0175	0.8399
June	4,646.2	342.1	0.0129	1.5810
July	1,285.2	86.0	0.0048	0.4357
Total	***12,319.6***	***639.3***	***0.0373***	***3.0878***
MC 3				
April	501.3	33.8	0.0016	0.0883
May	3,650.7	251.8	0.0088	0.6432
June	2,560.1	303.3	0.0067	0.4947
July	174.0	11.8	0.0005	0.0799
Total	***6,886.1***	***600.7***	***0.0176***	***1.3061***
MC 4				
April	648.9	29.7	0.0060	0.0981
May	16,022.4	969.1	0.0238	2.0656
June	6,251.7	371.6	0.0116	0.7690
July	105.6	6.0	0.0002	0.0117
Total	***23,028.6***	***1,376.4***	***0.0416***	***2.9444***

Table 9. On-site cost of soil erosion at the four microcatchments April to July 2000.

Catchment	**Soil loss,**	**Nutrient replacement cost (PHP)**			
	Kg	**N**	**P_2O_5**	**K_2O**	**Total**
MC 1	1,364.0	231.35	0.20	9.54	223.09
MC 2	12,319.6	633.33	1.82	48.36	683.51
MC 3	6,886.1	595.09	0.86	20.46	616.41
MC4	23,028.6	1,363.32	2.03	46.12	1,411.47

PHP 49 = USD 1

EVALUATION OF THE OFF-SITE EFFECTS OF SOIL EROSION

Potential off-site effects of soil erosion

Soil erosion from the MSEC Philippines site ends up as sediments in the reservoir of the Manupali River Irrigation System (MRIS) which is located at the lower part of the Manupali Watershed. The MSEC site is one of the catchments that contribute to the sedimentation of the reservoir. The MRIS is an irrigation system operated by the National Irrigation Administration (NIA) mainly to provide irrigation to the rice farmers in the towns of Valencia, Lantapan, and Malaybalay in Bukidnon Province. The MRIS has 10.7 cm designed intake diversion capacity that can irrigate 5,700 ha of farmland. Currently, the system serves 4,395 ha. The MRIS receives water from the Manupali Watershed which is 45,400 ha. The 91-ha MSEC site is part of the Manupali Watershed. Area-wise, the MSEC site is 0.2% of the Manupali Watershed. In terms of contribution to sedimentation of the irrigation system, the MSEC site may contribute around 0.5% considering that the MSEC site is located in the upper part of the watershed and is considered to be highly eroded.

The construction of the Manupali Diversion Dam started in 1983 and was completed in 1986. The main canal is 26.8 km and the laterals total 55.8 km. The MRIS was constructed at a total cost of P199,926,883 and officially started operation on 1 October 1987.

The problem of rapid siltation of the diversion dam and canals during heavy rains and flash floods has been recognized as evidenced by the regular dredging of the system. Table 10 shows the estimated volume of sediments trapped by the dam and the canals of the MRIS. It shows that a total of 73,321 m^3 of sediment have been taken out of the Manupali River Irrigation System over a six-year period. With an estimated 0.5% of this volume coming from the MSEC site, then 366 m^3 sediment have been contributed by the MSEC site to the sedimentation of the irrigation system.

An interview with key informants indicated that each rainfall event results in the murkiness of the Alanib River (a major tributary of the Manupali Watershed). They notice, however, that the Alanib River becomes clear after only a short time. This could be because the water has already carried much of the suspended sediments downstream. The MSEC site is only about 250 m from the Alanib River and is contributing much to the suspended solids in the Alanib River (based from observation and preliminary data from the main weir). Key informants from the area noted that the Alanib River is an efficient carrier or transporter of eroded soil downstream. Based on this, the project team estimated that around 5% of the eroded soils from the MSEC site ends up in the irrigation system. This figure will be validated later, as more data are collected.

Table 10. Volume of sedimentation, Manupali River Irrigation System, 1995–2000.

Year	Location	Volume of sediment (m^3)
1995	Main canal/laterals	611
1996	Main canal/laterals	13,437
1996–1997	Diversion dam	3,079
1997–1998	Main canal/laterals	19,680
1998	Main canal/laterals	7,071
1998–1999	Diversion dam	4,021
1999	Main canal/laterals	10,776
2000	Main canal/laterals	14,646
Total		**73,321**

Economic evaluation of the potential impact

The costs of dredging of the Manupali River Irrigation System from 1995–2000 are shown in Table 11. The table shows that the total cost associated with sedimentation over the six-year period is P2,260,244, 0.5% or P11,301 of which is due to sedimentation contributed by the MSEC site.

Estimates of the off-site costs of soil erosion indicate that soil erosion in the upstream areas of the watershed causes damage downstream. In this case, the sedimentation of the irrigation system imposed additional cost to the government in terms of the cost of dredging the diversion dam and the canals/laterals. The cost of dredging may be viewed as an avoidance cost or preventive expenditures because these are expenditures that could be avoided if soil conservation measures are adopted.

In true economic sense, however, these avoidance costs are not true benefit measures. They do not reflect consumers' willingness to pay. However, in some situations it is impossible to derive any measure of willingness to pay and then these measures from "the cost side" may be helpful to provide minimum values of the environmental impact (Hufschmidt *et al.*, 1983).

Table 11. Cost of dredging at the Manupali River Irrigation System, 1995–2000.

Year	Total cost (PHP)
1995	9,924
1996	333,401
1996–1997	82,240
1997–1998	554,982
1998	119,426
1998–1999	112,349
1999	454,751
2000	593,171
Total	**2,260,244**

CONCLUSIONS AND RECOMMENDATIONS

1. Available tools and techniques exist that could be employed in catchment characterization. However, the data and information needed for characterization that would allow "scaling out activities" have still to be defined.
2. Collection of data and information needs may have to be done either at macro- or microlevel depending on the nature and use of the data. For instance, access to market has to be assessed both at the macro- and microlevel. The data/information for off-site effects will have to be collected also at the macro level.
3. The general approach and methodology employed in characterization of the Mapawa Catchment are sound, but the specific data and information required should have been defined beforehand as well as the level at which they should have been collected. This would have facilitated collection of data and information.
4. It is necessary that the technique in participatory rural appraisal and group discussion should be complemented by and validated by formal interviews using structured questionnaires.
5. It is necessary to also determine erosion at the field or farm level to assess quantitatively the erosion and productivity relationship.
6. There is a need for a good, accurate, and reliable base map, from which other thematic maps may be derived.
7. The high rainfall coupled with steep slopes and the prevailing farming practices will make the catchment susceptible to soil erosion. The drainage pattern and density indicate that the catchment will experience flooding downstream especially as most of the area is cultivated.
8. Soil erosion is not yet perceived by most of the occupants as a serious problem.
9. Placing a price tag on the full cost of soil erosion through economic assessment methods will help in sensitization of policy- and decision-makers on the need for soil conservation.

REFERENCES

BARBIER, E.B. 1996. The Economics of Soil Erosion: Theory, Methodology and Examples.
EEPSEA Special Paper. Singapore: Economy and Environment Program for Southeast Asia.

CRUZ, W., FRANCISCO, H.A. and TAPAWAN-CONWAY. Z. 1988. The On-site and Downstream Costs of Soil Erosion. Working Paper Series No. 88-11. Los Baños: Philippine Institute for Development Studies, University of the Philippines.

CRUZ, M. C., MEYER, C.A, REPETTO, R. and WOODWARD, R. 1992. *Population Growth, Poverty and Environmental Stress: Frontier Migration in the Philippines and Costa Rica.* World Resources Institute.

ENTERS, T. 2000. *Methods for the Economic Assessment of the On- and Off-site Impacts of Soil Erosion* (2nd ed). Issues in Sustainable Land Management No. 2. Bangkok: IBSRAM.

FAO. 1995. The conservation of lands in Asia and the Pacific (CLASP): A framework for action.

FELIZARDO, B., BUNOAN, J.C. Jr, CORPUZ, I.T., COSICO, W.C., DAVIDE, J.G., LAPID, F.M., MIRANDA, S.M., TILO, S.N., DEL ROSARIO, B.T. and ESPIRITU, B.M. 1982. *The Philippines Recommends for Soil Fertility Management.* PCARRD Technical Bulletin Series No. 36. PCARRD, Los Baños, Laguna.

FRANCISCO, H.A. 1998. *The Economics of Soil Conservation in Selected* ASIALAND *Management of Sloping Lands Network Sites.* Issues in Sustainable Land Management No. 5. Bangkok: IBSRAM.

HUFSCHMIDT, M.M., JAMES, D.E., MEISTER, A.D., BOWER, B.T. and DIXON, J.A. 1983. *Environment, Natural Systems and Development. An Economic Valuation Guide.* Baltim re and London: The John Hopkins University Press.

HABER, W. 1994. System ecological concepts for environmental planning. In: *Ecosystem Classification for Environmental Management* (Frans Klyn, ed.).

LANDON, J.R. 1984. *Booker Tropical Soil Manual.* London: Booker Agric. International Ltd.

LAURENTE, L. and MARIBOJOC, T. 1999. *Rainfall Data in SANREM Project Area.* Bukidnon: SANREM-CRSP, CMU.

PCARRD-DOST-DENR-FMB-DA-UPLB-CFNR-FDC/ENFOR. 1999. Guidelines for watershed management and development in the Philippines. Los Baños, Laguna.

SOUTHGATE, D. 1998. The Economics of Land Degradation in the Third World. World Bank Environment Department Working Paper No. 2.

VILLANCIO, V.T., NALLANO, T., LUBOS, L., PAGALING, E., LINAO, J. and AMBRAD, U. 1995. Participatory agricultural and rural systems appraisal (PARSA) of the farming systems interactions in the landscape/lifescape of barangay Poblacion, Lantapan, Bukidnon.