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Off-Site Costs of Soil Erosion and Watershed Degradation in the Philippines: Sectoral Impacts and Tentative Results

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Philippine Institute for Development Studies

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October 1994

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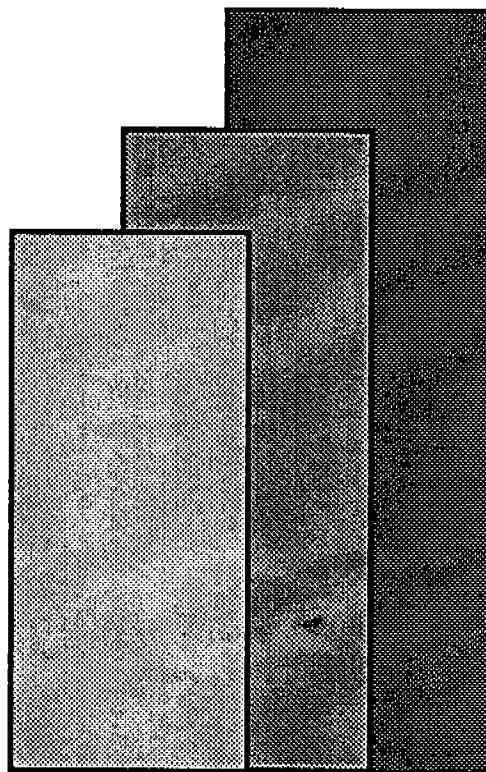
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OFF-SITE COSTS OF SOIL EROSION AND WATERSHED DEGRADATION IN THE PHILIPPINES: SECTORAL IMPACTS AND TENTATIVE RESULTS*

Olli Saastamoinen**

I. INTRODUCTION

Land degradation and soil erosion are among the most serious environmental problems in the world. In the Philippines erosion and watershed degradation are also cited as one of the major longterm environmental hazards (e.g. Saplaco 1979, David 1984, Arocena-Francisco 1986, Porter and Ganapin 1988, USAID 1989, PCARRD 1991, Sajise et al 1992).

While natural soil erosion and accelerated erosion are physical phenomena driven by natural forces such as rain and wind both of them have deepgoing economic impacts. In case of natural erosion economic impacts might be predominantly positive: during the centuries most fertile agricultural soils have been a result of gradual transport of nutrient rich topsoil of upland forests.

Accelerated soil erosion, which is usually due to degradation of watershed vegetation, may as well have few marginal positive impacts but the scientific and public concern on it has been due to far reaching adverse impacts. Soil erosion and watershed degradation decrease on-site soil productivity and cause downstream or off-site economic damages to other sites and downstream industries. On-site and off-site costs of accelerated soil erosion are not only the two sides of the same coin; they are closely related to each other. Both may occur in scales significant to the society. This paper will be focused only on downstream costs of soil erosion and watershed degradation.

A joint characteristic both to physical processes and impacts of accelerated soil erosion and to its economic implications is their dynamic complexity and multidimensional linkages. A good illustration is a predicted pathway of soil eroded from the forest floor as it passes to the sea on coral reefs (Figure 1, from Hodgson and Dixon 1988). One is dealing with, as USAID (1989) concludes, "a very complex process, the exact economic cost of which cannot be quantitatively evaluated until the processes are sufficiently understood".

*This is a revised and expanded version of a project paper of the Philippine Master Plan for Forestry Development Project (DENR/ADB/FINNIDA 1990). Help and support given by the Master Plan Team, the participants of two consultative meetings on the topics in 1990 and numerous sectoral experts in preparing the tentative calculations are acknowledged. However, any failure and omissions are due to the author. The author also wishes to thank the Philippine Institute for Development Studies (PIDS) for an opportunity to work at the institute during January-February 1993, Dr. Marian S. delos Angeles (PIDS, the Philippine Natural Resources Accounting Project) for her comments and cooperation, and the Academy of Finland for a research grant.

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The quantification problems are real both in biological-technical and economic terms. They are met while determining soil erosion and, indeed, are further complicated when the pathways and damaging impacts of eroded soil are to be traced. However, assessing soil erosion as such is hardly anymore a major obstacle. Increasing knowledge and improved methodology has made it possible to produce estimates of soil erosion rates in the varying conditions of vegetative cover, land use and geographical factors as evidenced by a growing bulk of scientific publications and feasibility or follow-up studies of specific watershed areas (e.g. David 1984, Cruz 1992). However, the existing methodology is largely concentrated to determine sheet erosion while rill and gully erosion and mass landslides are much more difficult to predict (David 1987). Besides that, quantification problems lie mainly in the complexity and process-chain properties of the off-site effects of soil erosion and watershed degradation which still are poorly known.

However, recent pioneering case studies on soil erosion and watershed degradation costs in the Philippines (Arocena-Francisco 1986, Cruz et al 1988, Hodgson and Dixon 1988) not only show the possibilities of economic analysis but also demonstrate that cooperation of ecological and economic sciences can overcome many of complicated quantification problems. These case studies focusing on specific watersheds and areas also logically raise the question what are then the nationwide off-site costs of soil erosion and watershed degradation? This has been an issue met and discussed in many contexts, among them also in a nationwide forestry sector planning effort in 1989-1990 in the Philippines (Master Plan 1990).

The purpose of this paper is to introduce the approach, methodology, assumptions and tentative results of the nationwide off-site cost evaluation of Master Plan for Forestry Development described briefly in appendix 19 of the main report (Master Plan 1990). This paper also includes the technical contents of a Master Plan project paper (Saastamoinen 199) with some minor revisions and amendments and also reviews some recent literature and information, which may be useful in evaluating and further developing the approach and its results.¹

II. THE APPROACH AND ITS RATIONALE

A. Rationale

When only few site and impact specific studies have been done and when the complex physical relationships and linkages between soil erosion and watershed degradation and downstream activities are inadequately known, one should first pose a question is it at all possible to include all monetary impacts for all sectors and activities and for the entire country?

¹The text of Chapters II.B-D and III mainly follows the technical contents of an original 15-page project paper (Saastamoinen 1990) with minor revisions and some amendments. The calculations presented are unaltered and the tentative results of nationwide off-site costs (Chapter IV) are also the same as presented in the Philippine Master Plan for Forestry Development (1990). Chapters I and II.A and IV are extensively rewritten and Chapter V is new. Included here is also Appendix 2, which illustrates assumed or calculated distribution of the costs by four damage components.

The adequate answer, especially in the time limits of the planning project, was, of course, that it is not feasible. However, what was felt at that time being possible, and worth of trying, was the following:

- a) To identify the downstream major sectors of the economy affected by soil erosion and watershed degradation;
- b) To identify the impacts and study possible ways and mechanisms through which those sectors are affected;
- c) To develop, when seen possible, model calculations reflecting economic impacts on some of the important sectors identified to have suffered from accelerated erosion;
- d) In other cases to approximate or assume a tentative proportional degree of damage to other sectors identified as either being less impacted or for which no basis for any calculation is found, due to time limits or other reasons.
- e) By summing up those rough estimates to get a preliminary or tentative estimate, that may approximate the order of magnitude of national off-site costs adequately enough to be useful as such for policy planning and for environmental-economic analysis of the study; and,
- f) To supply basis for further and more detailed studies.

A basic rationale for an estimation effort was, that the problems of soil erosion and watershed degradation were considered to be so important not only for the forestry development plan but also for the development perspectives of the Philippine society that the attempt, even if it was known to remain rough and incomplete, was felt to be justified. It is further believed, that when the first monetary approximations has been exercised, it raises discussion and encourages further more detailed studies.

B. The approach

The approach was based on disaggregation of economic activities (using sectoral classification of National Accounts) and also on disaggregation of soil erosion and watershed degradation impacts by damage components (siltation/sedimentation, water supply change, flooding, water quality change).² The disaggregation of the affected sub-sectors and damage components was meant to facilitate more realistic estimates of the monetary ranges of possible impacts in relation to the official National Accounts figures of sub-sector production values.

²Further disaggregation demands are discussed in Chapter V.

A basic assumption was that for each (sub-)sector of the economy the cost increase or the benefit lost due to soil erosion and watershed degradation can be only a (small) fraction of total value added of the affected (sub-)sector. It was further assumed that with the help of available studies, specific impact calculations and sector expertise reasonable estimates of those fractions could be approximated.

The production values of economic sectors were gross value added figures, which are total value of production minus intermediate consumption (purchased inputs of production). Similarly, the impact measures derived were meant to be gross value added figures, i.e. labor component as well as profit and other gross value added components are included.

The cost increases/benefits lost referred to the year 1988 level of damage. However, one should also bear in mind the possible increases of losses due to cumulative nature of some processes which is an important factor when considering the future changes in annual impacts.

The benefits lost/cost increases are meant to be net values, some possible positive impacts added. However, only marginal effort has been given to identifying positive impacts.

C. Estimation procedures

In each case one of the two estimation approaches was used. In some cases more or less satisfactory data was available or could be estimated which allowed to make a direct (even rough) impact calculation. For instance, if in the case of irrigated agriculture area not irrigated due to erosion and watershed degradation could be approximated as well as irrigation benefit lost, then the economic impact of water supply reduction could be calculated. Impact calculation were attempted - but not always achieved - especially when major impacts were identified.

In most cases, however, the lack of available data (within the time limits of the study) left no other alternative than simply make on some grounds an estimation (or a deliberate guess) on probable (possible) percentage share of economic impact relative to the gross value added of sub-sector activity. In some cases, if there was enough evidence than an economic impact existed but no data or expert estimation was found, the mere existence of assumed impact was noted by using 0.1% (1/1000) as a smallest impact proxy.

Which of two methods (direct calculation, percentage approach) was used can be found in sub-sectoral comments of Chapter III. The presentation of impacts in Table 1 adopts for uniformity the percentage approach, therefore there may be some minor discrepancies between calculated values in the comments and in those presented in Table 1.

D. Some concepts

The concepts are here as given in the original project paper. PCARRD (1991) contains a more comprehensive list of the concepts related to watershed management.

Soil erosion: Transfer of soil from one place to another due to natural agents such as water, wind or gravity.

Watershed degradation: The deterioration of the capacity of the watershed to maintain adequate supply of water in terms of quantity and quality and to prevent soil erosion.

The disaggregated impact (damage) components of soil erosion and watershed degradation are the following:

Sedimentation/siltation: The process of deposition of eroded soil. Eroded soil which is deposited elsewhere is called sediment and that what is transported and deposited by water is called silt.

Water supply change: Adverse impacts of the change in quantity and timing of water supply.

Flooding: A flow of surface water over a certain magnitude causing damages through water and related debris load.

Water quality change: Any change in water composition due to erosion and watershed degradation having adverse impacts down-stream.

Watershed management - as given by PCARRD (1991) - is the management of the natural resources of a drainage basin primarily for the production and protection of water supplies and water-based resources, including the control of erosion and floods, and the protection of esthetic values associated with water.

III. SUB-SECTORAL IMPACT IDENTIFICATION AND COST ASSESSMENT

A. Irrigated agriculture

Value of irrigated agriculture is estimated to be 73% of total value of rice production.

Sedimentation of irrigation dams, irrigation channels, loss of soil fertility, flooding damages, and decline in irrigated area are the adverse impacts of watershed degradation resulting in decline of irrigated agriculture production.

Siltation raises the level of river base so that in some cases it is higher than surrounding rice fields. In the rainy season, the result is raging flood, in dry season, the rivers have too little current. Flooding brings boulders, stones and logs to canals and erode productive farm land.

In many run-of-the-river type irrigation systems, from 20 to 30% reduction in dry season irrigated areas had been experienced during 25 years (David 1988).

In Pangasinan and Ilocos Norte 41412 ha (21.9% of arable land in 1980) of rice lands were silted. Total value of production loss in the silted areas (include silting from mines) is valued at ₱208 million annually. In Ilocos Norte 4990 ha (14%) rice land silted, production loss estimated to be ₱100 M (Regional Development Council 1988).

Irrigation is categorized into three systems: National Systems are reservoir or river gravity fed schemes operated and maintained by NIA, Communal systems are small gravity, mostly river systems owned and operated by farmers and Pump systems, publicly or privately owned systems taking water from rivers with pumps. Profitability of rehabilitation investments are very sensitive to decline in cropping intensity (USAID 1989). Also Porter and Ganapin (1988) points out that irrigation comes more expensive and less effective.

The current NIA development plan concentrates on investment in rehabilitation and management of existing irrigation areas. The total irrigated area is estimated to be about 1.52 M ha (1988) or 49% of potential irrigable area of 3.126 M ha.

According to preliminary estimate of NIA Watershed Group, from the irrigated areas under national systems (design area 618,325 ha) 48% (or 296,000 ha) is not served during dry period and 29% (179,222 ha) during wet period. In addition 14,257 has was estimated to be affected by sedimentation (2%). A recent study of World Bank (1992 b) gives slightly different figures for national irrigation systems (NIS) in 1988: service area 614,000 ha, wet season area 445,000 ha and area not served during wet season 26%. Later on averages for 1979-89 are reported.

Calculation:

A	=	system
B	=	Total area, Mill. ha
C	=	Non-served, Mill. ha
D	=	% non-served
E	=	Assumed share % of D due to watershed degradation/dam sedimentation ³
F	=	Non-served area due to degr/erosion % of total (B)
G	=	Non-served area due to degr/erosion, Mill. ha
H	=	Irrigation benefit lost, P/ha (only dry season) 10,107 ⁴
I	=	Total loss, Mill ₪

A	B M ha	C M ha	D** %	E %	F %	G M ha	I Mill ₪
Nat.	0.618	0.296	48	50	24	0.148	1,499.86
Comm.	0.704	0.211	30	50	15	0.106	1,066.96
Ind.	0.226	0.045	20	50	10	0.023	228.46
Total	1.548	0.552	36		18	0.277	2,795.27

Besides the above water supply change it was assumed a separate siltation/sedimentation impact and flooding damage (1 and 2% of gross value added, respectively, see also Appendix 2).

B. Rainfed agriculture

Rainfed upland plains and hilly lands comprise 70% of the country's total agricultural areas. It is a dominant mode of production in about 89% of the country's arable land and generates 20% of the country's income. It is a major means of livelihood for about 36% of the population.

³There is no data about area non-irrigated in communal and individual systems, percentages here are assumptions. However, a recent study of Reyes and Jopillo (1989) cited in World Bank (1992b) report confirms that reduction of a mean declared service area over design service area in a sample of communal systems was lower than in national systems. It was 27% for participatory systems and 20% for non-participatory systems and thus somewhat better than assumed here.

⁴Irrigation benefit calculation is presented in Appendix 1. Here only dry season irrigation benefit loss is assumed.

An eloquent discussion on the benefits of forests to agriculture is given by Abadilla (1984). World Bank (1989) and USAID (1989) include observations on impacts of watershed degradation and erosion on rainfed agriculture.

Most important is the reduced water supply, sedimentation and decreased nutrient flow from eroded upper areas. Water retention capacity of rainfed areas is affected also. Soil moisture is a key productivity factor in rainfed agriculture. Coconut and some other agricultural areas have been reduced by river bed changes. Flooding removes nutrients and damages crops on those lowland non-irrigated areas which are prone to flooding.

Water is a key constraint in many upland areas, both for domestic and field use. The collection of drinking water occupies a considerable amount of household time and energy on daily basis. Microwatersheds with small dams are suggested to be developed to improve water supply (Fargher 1989). Due to the labour needed for water supply, there is an indirect adverse impact on farm productivity.

Due to lack of basis for calculations, only marginal impacts are assumed. Reduction assumption is 0.5%.

C. Livestock and poultry

The livestock industry covers feeding of hogs, poultry, goats and sheeps, beef cattle, carabao and dairy production. Backyard operations account for most of the supply of goats, cattle and pigs. Commercial production is strong in poultry and swine supply. Given the scarcity of protein feeds expansion of poultry and swine will be directly dependent upon larger imports of protein feeds. The Philippines is self sufficient in poultry, eggs and pork, while some beef and bulk of milk products are imported (ADB 1991).

ADB (1991) profile study doesn't mention any constraints and problems in livestock sector that could be due to soil erosion and watershed management.

Only marginal effects through water supply and quality are identified. Occasional flooding damages for livestock may occur. Forage productivity is to some extent affected.

Assumed reduction of production value is 0.3%.

D. Municipal fishing

About 75% of population lives on coastal zone. Some 574,000 fishermen are contributing 64% of total fish catch (1987).

Coastal areas are the most productive of all marine areas. Coral reefs, mangrove swamps and inshore waters provide nursery areas and breeding grounds for coastal and marine species. Sediment deposition damages coral reefs, mangroves and other areas reducing fish production.

Silt reduces light penetration and primary productivity in water column. Water temperature increases and in inshore waters nutrients fertilize aquatic weeds decomposing of which reduce oxygen in water. Many of impacts are long term but some effects can be seen very soon (see also Figure 1).

Siltation of rivers and lakes and current changes decrease the productivity of river, inland lake and artificial dam fishing. Inland fishing waters covers 809,231 hectares divided among freshwater lakes and swamps, brackishwater fisheries and fishponds, rivers and reservoirs. Inland fishing occurs on 6 major lakes and 52 minor lakes, productivity of which has damaged much due to pollution (Laguna, Lake Buhi) as well as due to siltation, among other reasons.

Many experts believe that sedimentation from upland sources is the greatest threat to coral reefs now and in near future (USAID 1989). In Bacuit Bay (Palawan) it was modelled, that heavy sediment input and deposition due to logging and logging roads will decrease fish catch in 10 years by 84% (Hodgson and Dixon 1988). Another study by McAllister (1988) estimated that coral reef production has declined by at least 37% between 1966-1986, with a loss in yield of 159,390 tons each year. The compound rate of annual decrease is 1.6%.

Calculation:

In 1987 total municipal marine fishery production was 816,247 tons.

Coral reef fish production loss (McAllister 1998), ton	159,390
Share of production loss due to sedimentation, %	30
Loss due to siltation/sedimentation, tons/a	47,817
Loss % from total production	5.9

The same percentage is adopted also for municipal inland fishing, which accounts for 23% of the production of the whole municipal fishing. However, the effect of soil erosion may be greater on inland water fishing.

The above estimates of loss are not taking into account the amount of the shallow marine resource gathering for sustenance food that does not enter in the commerce (McAllister 1988). One should also note, that the value added of municipal fishing probably does not fully account for sustenance and domestic use of fish and other coastal water products. It is estimated that perhaps 1/3-1/2 of catch is consumed outside official figures (White 1990, pers. comm.).

In addition, a recent agricultural sector survey of ADB (1991) states that deforestation in upland areas has dramatically increased sediment load in river systems in many parts of the country. High concentrations of suspended and settled sediment adversely affects aquatic life by reducing the availability of solar radiations for photosynthesis and by mechanically interfering with respiration. Certain types of mining activities and the disposal of municipal and industrial wastes, particularly in the vicinity of large population centers and inland water bodies which are also a source of fresh water fish for human consumption (ADB 1991). While at a general level

these problems are often recognized, there are yet too little research studying interrelationships and environmental costs of aquatic and land-based activities (delos Angeles et al 1990).

E. Commercial fishing

Part of commercial off-shore fish catch is dependent upon coastal ecosystems. White (1992), among others, emphasizes their decisive role in supporting the productivity of off-shore marine ecosystems. Part of commercial catch is done inside inshore area (same may be true for municipal fishing). However, the connections between inshore habitat and offshore catch are still poorly known. There is also an assumption that a part of nutrient increase may to some extent benefit off-shore fish populations.

An educated guess is that less than 1 % of offshore fish production is affected by siltation: 0.5% reduction is adopted here.

F. Aquaculture

Aquaculture includes the controlled rearing of aquatic plants and animals in fresh, brackish and maritime waters. About 80% of the area devoted to aquaculture consists of brackishwater ponds in coastal zone. The principal species cultivated are milkfish, shrimp, tilapia and seaweed. Aquaculture has increased rapidly and in 1989 covered 23% of total fisheries production (ADB 1991).

The major impacts are that water turbidity and siltation affects aquatic life and flooding damages the crops.

A marginal of 0.5% reduction assumed.

G. Forestry

While logging operations and road construction are among the original sources of soil erosion affecting other industries, these may have some "internal" adverse impacts on forestry infrastructure as well.

Increased run-off and flooding damage forest roads resulting in higher road maintenance and transportation costs. However, these potential impacts are not included here.

H. Mining and quarrying

Similarly to logging, mining and quarrying are industries, which have high transportation and related infrastructure costs. The potential impacts are marginal transportation and road maintenance cost increases. However, in present study no impacts are included.

One should mention here, that locally mining is a prominent source of erosion and mine tailings have large scale environmental impacts. They sometimes get mixed with and are difficult to separate from other erosion impacts.⁵ Briones (1986) has studied environmental costs due to mine tailings in the Baguio mining district.

I. Food manufacturing

Food manufactures are the largest industry group in manufacturing sector. Together with beverage industries (dealed separately in the next section) it covers about 40% of gross value added in manufacturing and is completely a forward linkage of the primary agricultural sector of the economy. It includes grains milling, dairy, bakery and confectionary products, processed fish, fruit and vegetables, coconut products, oil, sugar, coffee and miscellaneous products.

Many food manufacturing products require high quality water. It is assumed here that impacts are due to minor water supply/quality problems. Reduction in manufacturing potential due to production losses in agriculture and fishing are excluded here, while these secondary effects might be quite considerable. The focus here, however, is on primary effects, and secondary linkages are excluded.

Marginal 0.2% impact is assumed due to water supply and water quality problems.

J. Beverage manufacturing

The beverage industry consists of the manufacture of alcoholic and non-alcoholic drinks and is a large scale water consumer highly dependent on good quality water sources. Marginal additional cost increases were expected due to water supply and water quality problems.

Marginal 0.4% impact assumed shared between water quantity and water quality components.

K. Other manufacturing

Numerous other industrial sub-sectors and groups require lot of water for different purposes like for cooling, processing, washing, and as raw material, but here no impacts on other manufacturing are assumed.

L. House and building construction

Construction sector, considered to be among the affected sectors, is divided here into four groups: house and buildings construction, ports and harbor construction, highways and bridges construction and other construction.

⁵This point was raised by Dr. Candido Cabrido in the February 1993 meeting.

The major impact is damage and additional costs for construction sector caused by flooding. Heavy and disaster floods always have large-scale damage for different constructions and there has been always much discussion on the role of watershed degradation as a cause of heavy flooding. For example, Lamanilao (1991) expresses the common perception that land degradation increases the hazards of floods. While the increasing impact probably is correct, but the extent still is undefined, the popular view on forests' decisive role in preventing flooding get only limited support from the science of watershed management.

Forest cover and tree planting benefits may indeed be minor in reducing major flooding from infrequent major storms or monsoonal type rainfall. However, local stream flood peaks are delayed and stormflow volumes usually reduced (Hamilton 1986, Master Plan Watershed Management Study 1989). In addition, reduced sedimentation has flood reduction effect, when it slows down the filling of storage capacity of dams.

Lamanilao (1991) states that some of the subdivisions are located on very fragile sites with very unstable beds and subject to very intense erosion. Similarly, building of houses on flood-prone areas tend to increase hazards.⁶

A considerable part of flooding damages occurs on residential and other buildings. The costs associated are repair and reconstruction of buildings, cost of providing temporary shelter for people suffered from disasters, and additional costs needed in preparing buildings against flooding.

Marginal 0.2% impact is assumed.

M. Ports and harbor construction

Lowering of waters due to sedimentation increases port and harbor construction costs.

Marginal 0.2% increase in construction costs is assumed.

N. Highways and bridges construction

Increased run-off and marginal increases in flood peaks cause repair and reconstruction costs for highways and bridges and require also additional costs to make constructions able to sustain floods. Increased maintenance costs are excluded here and included in governmental services.

A moderate 1% increase in construction costs is assumed.

⁶In this context a potential positive impact of soil erosion pointed out by Dr. Danilo Israel and Dr. M.S. delos Angeles should be mentioned: in some cases sedimentation has direct economic benefit in soil reclamation. This may be relevant for the case of other fields of construction, as well.

O. Other construction

Marginal cost increases due to flooding damage or prevention activities for all other types of construction were expected.

A marginal 0.1% cost increase is assumed.

P. Hydropower construction

In 1988, the share of hydropower was 9.5% of primary energy consumption of the Philippines. The major energy source was oil consisting 60% of primary energy consumption. Nearly all (97.6%) of oil is imported.

Soil erosion and watershed degradation is generally considered having significant impacts on hydropower production. The major influences are the following (more details are given by Arocena-Francisco 1986, Cruz et al. 1988, and David 1988).

Due to siltation of active storage, shorter life span of dams occur. Life time of turbines is reduced and their maintenance costs are increased including off-operation time due to service/repair work. Anticipated soil erosion also increase the construction costs because of larger storage capacity is required.

In the following a calculation concerning the value of lost hydroenergy is presented. The calculation is based on alternative cost principle and thus gives a result which is higher than the direct value of energy loss. Alternative cost approach is based on the assumption, that the energy capacity of the country is fully needed and the lost hydropower capacity must be compensated with alternative sources. If this is not an actual case, alternative costs can be interpreted reflecting the lost value of energy not served. However, the latter approach might result in higher estimates because the calculations concerning the cost of energy not served in the Philippines have set the cost between ₱5-10/kwh already in 1985.

The average value of hydropower is ₱0.935/kwh price and total production of 6,212 MKwh hydroenergy. Production cost is ₱0.425 /kwh (NPC 1988).

In Manila generation charge of electricity is ₱1.12/kwh and distribution charge 0.55 (1989). Generally in Luzon the power prices are 1.5 - 2.2 ₱/kwh and in Mindanao 1.3 - 1,5 ₱/kwh. In some regions power prices are up to 3 - 4 ₱/kwh.

The cost of alternative power: oil thermal plant 1.5 - 2 ₱/kwh and 2.0 - 2.5 ₱/kwh for gas turbine plants (1989).

Calculation:

Annual hydropower loss due to soil erosion and watershed degradation was assumed to 3%. Of that 1% is assumed to be due to siltation of active storage, 1% due to lowering of head height due to backstream effect of riverbank erosion and 1% for all other factors (cost increases, off-operation time, water supply etc).

Quantity loss, %	3.0
Production, MKWH	6,212.0
Price ₱/kwh	2.5
Value of benefits lost, MP/a	465.9

Generally speaking electric power is judged to be underpriced in most developing countries. Prices are, on average, just above one third of supply costs and are half of those in industrial countries (Jimenez 1992, World Bank 1992). However, in the Philippines the cost of electric power is higher than in many other developing countries.

Q. Other electricity and gas

No impacts identified.

R. Water

The Philippines as a whole has been assessed having adequate surface and groundwater resources to meet projected demands. However, two of the twelve identified water resources regions will possibly experience long-run surface water problems: Central Luzon and Central Visayas. Groundwater resources are generally plentiful throughout the country. Local water supply shortages are experienced especially in highly urbanized areas such as in Metro- Manila and during critically dry periods. As of the end of 1987, 63% of population had access to public water supply systems. Rest of population, 37%, still depend on water from open dug wells, rain water cisterns, lakes and streams (National Water Resources Board 1988).

Under the service coverage of Local Water Utilities Administration, 461 water districts have been formed as of July 1989. Based on survey (1987) on water sources and facilities, 15.3 M people are adequately served and around 9.0 M people are inadequately served or their water sources are of doubtful quality.

Economic value of water is difficult to assess. It is vital for human life, health and welfare.

A common approach is assume that the water benefits at least equal the costs of water supply. In water development projects the benefits are sometimes calculated on the basis of costs related to an alternative means of water supply.

From the point of view of household, the benefit at least equals the cost of water charge. However, due to the vital importance of water the charges of it (water tariffs) are usually heavily subsidized and thus kept on lower level than the true costs of supply should require. This means that the water benefits based on nominal charges are inclined to remain underestimated. Often the costs of water supply do not even cover all the direct costs of water supply not to speak of capital costs or costs needed to conserve water supply resources.

The role of forests and other vegetation cover is important but still quantitatively inadequately known. Forests no doubt increase infiltration and support groundwater supply. PCARRD (1991) numerates the unique characteristics of forest and other vegetation as protective cover.

However, the relationship between the vegetation cover and water supply is more complicated than often popularly expressed: "When forests go the wells will run dry. this is what happened in Cebu" (Manila Bulletin Jan. 16, 1989). Besides the complexity of vegetation cover-water supply relationships, there may also be other reasons for supply shortage, as increased demand.

Sufficient good quality water for households is one of the basic necessities for health and well-being of people. It may appear in future that the support given by forests for adequate water supply of the growing population will be one of the most important functions of forests.

Water use is about 200 litres/day/capita = 73 m³/a/capita. Water tariffs are based (even not fully) on construction, operation and maintenance costs of water supply systems. Present water rates varies between 2 - 6 ₱/m³.

Calculation in the following is based on a mere assumption that water supply reduction due to watershed degradation is 5 % and the benefit lost is a difference between present unit cost and the cost of an alternative method of supplying water.

Domestic consumption, litres/day/capita	200.0
Annual consumption, m ³ /capita	73.0
Percentage of population served by water supply, %	63.0
Total population, M	59.0
Population served, M	37.2
Unit cost of water supply (construction, operation and maintenance costs of supply systems), P/m ³	3.0
Value of water used by people served by supply system (= supply costs), MPesos	8,140.2
People unserved, M	21.8
Domestic consumption, litres/day/capita	50.0
Annual consumption, m ³ /a	18.25
Unit cost of supply, P/m ³	1.0
Value of water used by unserved, MPesos	398.4

Total value of domestic water use by served and unserved people, MPesos	8,538.6
Assumed water supply reduction due to watershed degradation, % of total supply	5.0
Unit cost (benefit) difference between watershed supplied water and alternative method (e.g. deep well), P/M3	2.0
Water benefit lost by served people due to assumed watershed degradation caused supply reduction, MPesos	271.3
Unit cost (benefit) difference between watershed supplied water and alternative method, P/M3	1.0
Water benefit lost by unserved people due to assumed supply reduction due to watershed degradation, M Pesos	19.9
Total water benefit lost due to assumed rate of water supply reduction due to watershed degradation, M Pesos	291.3

It should be noted that this is a concept calculation and the figures need qualifications. However, the results were used as a loss estimate. As in the case of electricity, an alternative approach would be to calculate the costs of water not served, which will probably lead to higher cost estimate.

As mentioned above, a situation similar to the case of electric power prices, seem to prevail also in water case. Compared to consumers in most industrial countries, who pay all of the recurrent costs of both water and sewerage services plus a large portion of capital costs, in developing countries people pay less. A recent review of World Bank financed projects revealed that the effective price paid for water is only about 35% of the average cost of supplying it (Jimenez 1992, World Bank 1992).

S. Land transportation

Skewed run-off and increased flood peaks erode highways, which cause increased transportation costs due to increases in fuel consumption, spare parts, service life of cars as well as increased transportation costs due to lower velocity of vehicles.⁷

Assumed cost increase is 0.5%.

A general evaluation on the importance of infrastructure, which partially concerns also some of the other infrastructure related sub-sectors, is worth citing in this connection (Jimenez 1992):

⁷ These aspects were emphasized in a comment given by Dr. Stein Hansen, ADB Consultant, February 1990.

"As an intermediate input, physical infrastructure can reduce the costs of producing final products - such as lower costs in operating vehicles from improved roads or in producing food products from having more reliable electricity supply for refrigeration. Cross-country evidence finds that spending on transport and communications services has a significant effect on sectoral output, such as agricultural productivity. Infrastructure also produces externalities by enabling markets to work better. Transactions are made less costly and increases the benefits of trade. Domestically, infrastructure provision has made a considerable impact in marketing agricultural products. This is reflected in improved prices, diffusion of technology and use of appropriate inputs," (Jimenez 1992).

T. Water Transportation

Sedimentation of rivers, inland lakes and coastal areas increase marginally the costs of water transportation.

Assumed cost increase is 0.1%.

U. Other transportation and communication

No impacts identified.

W. Trade

No impacts identified.

X. Finance and housing

No impacts identified.

Y. Government services

For the Government and its agencies soil erosion and watershed degradation cause personnel and organizational costs and increased operation and maintenance costs due to works needed for example for roads and bridges, ports, irrigation, water supply, flood control and drainage. There are also research and development and some other public costs, which should be credited to erosion and watershed degradation.

These costs are assumed to be 0.4% of sub sector's value added.

Z. Hotels and restaurants (tourism)

The value of added of hotels and restaurants contains the core of tourism. However, the tourism sector covers many other sub-sectors and tourism income is distributed widely among those sectors (transportation, trade, communication etc), too.

The total tourism income in 1988 was ₱30,576 million (as compared to gross value added of hotels and restaurants ₱9,060 million as in Table 1) and the number of visitor arrivals totalled 1,043,114.

The impacts for tourism are reduction in water quality on beaches, sedimentation of coral reefs, which adversely affect the forms of tourism the country has a comparative advantage as beach resorts, scuba diving and sports fishing. However, potential positive impacts may occur in case of beach formation.

In a Bacuit Bay study in Palawan (Hodgson and Dixon 1988) logging versus fisheries and tourism were analyzed. The projected erosion losses caused by logging to fisheries and tourism were estimated to be larger than gross revenue from logging. Larger impacts were expected from scuba-based tourism development than from fisheries. Benefits from tourism were also expected to increase over time as demand and market expand.

The potential costs of soil erosion and watershed degradation for tourism development can be expected to be quite significant in the future not only due to above reasons but also due to good quality infrastructure services (water, roads etc) that tourists are expected to demand.

There are difficulties in assessing even a tentative impact for tourism subsector that are as large as they have been for the other sectors. It is placed here to be 0.5% of value of total tourism income (in Table 1) the corresponding percentage is roughly 3 times higher because it refers to value added of hotels and restaurants). One should note, that in this chosen approach there is a theoretical possibility for double-counting with other sectors.

Ä. Other private services

No impacts assumed

IV. TENTATIVE RESULTS

According to the approach adopted, the approximated sub-sectoral costs of soil erosion and watershed degradation present fractions of the value added of concerned sub-sectors of National Accounts. Therefore, if correctly calculated, they can be summed up without a danger of doublecounting. Some calculations presented in previous chapter may not be quite clean in this sense, as has been pointed out, but their practical impact is assumed to be so marginal that the problem has been omitted here.

A preliminary total estimate of annual nationwide off-site costs in 1988 is ₱6,700 million (Table 1). This figure must be seen only as a first and tentative estimate, being conditional to numerous straightforward assumptions presented above. While the assumptions generally have been tried to keep on a conservative side, further research no doubt will reveal that some

estimates will be too high and some too low. In the preceding section some of the sub-sectors will be discussed.

The present tentative estimate of total nationwide off-site costs is 0.8% of Gross Domestic Product in 1988. Whether this estimate is on a right track of magnitude, will be seen after more research is done and analytical improvements and better data has been accomplished. To some extent this will be discussed later on.

The tentative results anyway gives cause to some important observations, which - one must emphasize - will be based on the assumption that the calculations are on a right track.

First is that total off-site costs of soil erosion and watershed degradation seem to be - as in numerous contexts in the country has been discussed - indeed of significant magnitude that supports the national concern on watershed degradation and soil erosion. The national concern is even more justified when remembering that off-site cost is just the other side of the coin. According to the tentative estimates of the Philippine Forestry Master Plan the on-site costs of soil erosion and watershed degradation are about the same magnitude and together (after some deductions to avoid double counting with off-site costs) make tentatively 1.4% of Gross Domestic Product in 1988 (Master Plan 1990, Saastamoinen 1991).

Second observation is that off-site costs are spread on numerous sub-sectors and industries of the economy. In almost all (except a few important exemptions) cases the cost burden on each sector is more or less marginal, but summing up seems to give a total that hardly could be seen as a marginal one.

Third observation, already having been an object of detailed case studies (Arocena-Francisco 1986, Cruz et al 1988, Hodgson and Dixon 1989) and widely discussed, is that certain key sectors of the economy probably are suffering non-marginal losses due to soil erosion and watershed degradation. These are irrigated agriculture, rainfed agriculture, municipal fishing, hydroenergy and domestic water supply (Table 1). Irrigated agriculture seems to be suffering most both in absolute costs and in relative terms. A half (52%) of the total off-site cost estimate here is due to the losses of irrigated agriculture. Especially this sector requires more research. Some problems related to the performance of irrigated agriculture are reviewed in the next section. Of course, most future research should be addressed on the sectors which seem to be most impacted.

A fourth observation concerns the analytical uses of the approach and the tentative results or and even more the future improved ones. They can be utilized at macro level and micro level. At macro level the most potential uses are national economic and environmental planning and Natural Resources Accounting (delos Angeles 1991). In the Philippine Master Plan for Forestry Development a unit cost of soil erosion was calculated and used for environmental-economic analyses of the programs. At micro (e.g. project level, watershed level) the unit cost approach is also applicable, but requires a site specific analysis (Arocena-Francisco 1986, Saastamoinen 1991).

V. DISCUSSION

A. Some excluded impacts

Besides the above identified impacts of soil erosion and watershed degradation, there are other impacts which are not included above but which deserves attention. The most significant among them are the increased risks for human life.

Flooding and mass landslides hazard human life. Even if the role of forests is assumed to be more or less marginal in prevention of heavy flooding it surely is important in preventing mass landslides. However, the evaluation of monetary values of human life - what actually is routinely done in insurance business and discussed e.g. in health economics - is also left beyond the scope of this effort. This is neither because of the hazards on and losses of human lives were not regarded as having of fundamental value nor due to the valuation problems (brave assumptions have been done in other cases). Rather, including them would be against the chosen approach: to follow the structure and logic of the traditional National Accounts. What can only be added here is that perhaps a small part of the human life related costs may be understood to have been included into government services.

Another but minor impact is air carried erosion effects. Wind carried dust due to eroded non-vegetated land has some harmful effects for health and general well-being especially at local level. However, compared to other air pollution sources, it perhaps is not significant.

No doubt there are also other impacts such as loss of amenities and recreational values for local inhabitants, psychological influences of degraded landscapes but because those impacts are not included in the traditional system of national accounts they are neither discussed here.

B. Irrigated agriculture

As off-site impacts for irrigated agriculture were estimated to be the largest single cost component it is useful to review some recent studies and discussion on the performance of irrigated agriculture systems.

ADB (1991) refers to Bank's Impact Evaluation study on water usage in irrigation projects which identify heavy siltation and decreased availability and reliability of water supplies to be among the chief causes of failure of these projects and concludes that environmental degradation has deleterious effects on the entire agriculture sector.

Other reasons for poor performance of irrigation systems according to ADB (1991) are inadequate O & M activities such as deteriorating canals and structures, silted and defective diversion works, sloughed and silted drainage canals and poorly maintained service roads.

Urdan and Galvez (1992) list seven problems and constraint areas related to irrigation and drainage: competing uses of land and water (conversion of irrigated lands, priority of

highly urbanized areas over available water); increasing cost of irrigation development; rapid deterioration of existing facilities (natural calamities, particularly typhoons); irrigation water shortage and excess; long gestation period of irrigation projects; pollution of freshwater ecosystem (domestic and industrial wastes, mining); and watershed degradation.

Concerning watershed degradation (Undan and Galvez 1992) states that continued exploitation of forests and other natural resources has affected many watersheds of both existing and proposed irrigation systems. In many cases, watershed denudation often results in flush floods, deterioration of water supply both in quantity and quality, pollution from mine tailings, sedimentation and siltation of reservoirs and waterways. Existing irrigation systems require higher O & M cost because of large volume of sediments entering the system canals due to upstream erosion and mine tailings. Dry season water is significantly lowered particularly for systems which are direct river diversion due to denudation of watershed. On the other hand, wet season flood flows are higher than design values resulting to bigger damages on facilities and more expensive restoration.

World Bank (1992 b) notes that wet season irrigation intensities on national irrigation systems (NIS) averaged only about 75% of the inventoried service area during 1979-89 while dry season intensities averaged about 60%. However, services areas of national systems are known to over-state the areas that can be actually served and thus real intensities are somewhat higher than these figures indicate.

World Bank (1992 a) summarizes that agricultural performance in national systems has often fallen short of expectations, with service areas, irrigation intensities and incremental yields frequently below initial expectations. It is often argued that therefore schemes are operating well below their potential, a view used to justify some rehabilitation and modernization programmes. However, World Bank study (1992 a) emphasizes that water use efficiency is an ambiguous concept in run-of-the-river irrigation. For much of the time, water is in surplus while at times of scarcity farmers and managers are acutely conscious of shortages and little water is wasted. Even in storage-backed schemes, the only true efficiency criterion is whether there have been unnecessary releases, since in composite systems there are invariably large unregulated flows that cannot be saved. No doubt system design could be simplified, O & M improved and the farmer participation strengthened. Maintenance allocations have been far from adequate, with siltation a major problem (World Bank 1992 a).

While admitting that siltation is a particular problem affecting many NIS and in recent years has been aggravated by upstream development like mining, forestry, shifting cultivation etc. the cited report (World Bank 1992 a) suggests that disappointing results have been more due to unrealistic expectations than to poor performance as such.

A recent IRRI study on long-term trends in agricultural performance of National Irrigation Systems in Luzon concludes that the decline in rice area can be attributed to the degradation of irrigation infrastructure and the quality of irrigation (Masicat et al 1990). However, the results of similar nationwide evaluation presented in World Bank (1992 b) report

failed to confirm the degradation trends suggested in the above study; conclusions do not rule out the possibility of improved performance nor do they understate the dangers of degradation due to factors which are either NIA's control like O & M and rehabilitation or beyond its competence like sedimentation due to catchment exploitation, degradation of the paddy environment and stagnant yield frontier (World Bank 1992 b).

Svendsen and Rosegrant (1992) states that irrigated area can be lost from a variety of causes: reservoir siltation, deferred maintenance, watershed degradation changing river's hydrography "falshier" and less stable, waterlogging and salinization, decline of productivity of wells.

Among the major findings of post evaluation of 11 completed projects and programs of ADB were that intensive assessment of river hydrology is needed for irrigation projects particularly in degraded or rapidly degrading watersheds. To prevent siltation, irrigation projects need to incorporate and undertake explicit measures of watershed management along with appropriate system intake facilities several years before irrigation system become operational (ADB 1991).

Besides the watershed degradation and operational performance of irrigation system, also other factors causing production losses for irrigated agriculture should be mentioned. Habito (1990) and Lamanilao (1991) discusses trends of loss of prime agricultural areas, among those irrigated areas, into residential and industrial areas, which could lead to dramatic drops in agricultural productivity, wasted investments in irrigation, ecological implications and inequitable distribution of gains. In addition, marginal costs of providing irrigation services to entirely new areas will continue to increase, following the trend already established. To the extent that externalized costs of drainage remediation are brought into the cost structure, the cost of irrigation water could raise still further (Svendsen and Rosegrant 1992).

To summarize, irrigation losses are due to various reasons. While it may be difficult in practice to separate the impacts of each of them without the necessary research efforts, there is a danger of attributing soil erosion solely to watershed degradation.

C. Rainfed agriculture

The impacts assessments on rainfed agriculture as well requires more consideration. Some topics are covered in the following discussion, which also touches problems in delineating off-site and on-site costs.

Upland farmed land has declined in productivity because of environmental degradation (soil erosion caused by steep terrain, rising population pressure, and the introduction of clear weeded crops such as rice and corn). Soils of upland areas are characteristically of low fertility, acidic type (Department of Agriculture 1991).

While productivity of the rainfed areas is declining it is, as in the case of irrigated agriculture, difficult to estimate, the role of external or off-site factors (and off-site costs) versus what is due to internal factors (and should be regarded as on site-costs). Fernandez et al. (1989) after stating the declining productivity refer to internal reasons: although commercial users seeking short term profits have aggravated the problem, the rural poor also adopt strategies that threaten sustained production of the rainfed areas. Declining resource productivity is particularly severe in the upland areas.

About 2.0 million ha. of the 3.5 million ha of rice areas and almost all of the 3.4 million ha of corn areas are planted under rainfed conditions. Of these rainfed rice and corn areas, significant portions are grown under upland conditions where the soil and topography are poorly suited to annual crop production, resulting in severe soil erosion and deterioration in soil fertility and crop yields (ADB 1991).

The monsoon rainfall is sufficient to support an upland crop of corn with a growing season of three-four months, but moisture availability is a major problem for increased output and the year-to-year stability of supply. Soil moisture is often inadequate (Department of Agriculture 1992).

Horticulture crops, i.e. fruits, nuts, vegetables, rootcrops and flowers represented about 33% of crop production value in 1989, with rice, corn and coconut together contributing a further 55%. Banana, pineapple and mango were the main fruits, cassava and sweet potatoes the main rootcrops and tomato, garlic and eggplant the main vegetables (Department of Agriculture 1991).

Yields of fruit and vegetables reported for commercial crops are very much lower (only half or one third of the expected) than trial plantings, theoretical growing conditions and the experiences of other countries would suggest. Horticulture sector study (Department of Agriculture 1991) enlists as reasons inaccurate data, production and marketing losses and not adopting existing technology packages by farmer due to risks, profitability, food security, land tenure, lack of knowledge, access to credit and extension services, uncertainty about markets and difficulties with input supplies. It is also recognized that production of short season vegetables on upland sloping soils when clean cultivation is used has been environmentally damaging where appropriate land management techniques (such as SALT) has not been adopted (Department of Agriculture 1991).

One of responses to upland problems is Integrated Social Forestry Programme. Tolentino (1991) reports that aggregate programme funds for Integrated Social Forestry Programme for 1990 were ₱327 million (USD\$ 11.8 million). The programme has multiple targets to involve forest occupants in sustainable food production and rehabilitation of forest lands as well as to maximize land productivity, enhance economic stability and improve the socio-economic conditions of forest occupants.

Generally, the impacts of watershed degradation and soil erosion for agriculture are very essential but difficult to assess. One can only hope that the case is not that dramatic as Abadilla (1984) puts it: "... as forestry goes, so goes agriculture. And as has been the case throughout our history, as agriculture goes, so goes the entire Philippines."

D. Hydropower production

Power crisis in the Philippines has not yet been won. Compared to the year 1988 it may even have become even more acute than during the past years. No doubt the present role of watershed degradation also in this sense is getting even more concern than earlier. For example, the "Philippine recommends for watershed management" PCARRD (1991) gives special attention to watershed management for hydroelectric power development.

Against above lengthy discussions only two brief notes will be done here. The first is the present rising estimates concerning the costs of power not served. The other point is to refer to the methodological discussions on energy costs relevant also from the point of view of this study, provided by a recent study on environmental aspects in energy development (ADB 1992).

E. About the future value of water

While there is a need to consider similarly all the other sectors significantly affected, the discussion on impacts will be here limited only to some references related to the value of water.

The costs of soil erosion and watershed degradation will probably increase due to a tendency of increasing value of water and fertilizers. This is relevant to both on-site and off-site costs.

Svendsen and Rosegrant (1992) have stated that central feature of new economic policy regime establishing itself across Asia is adjustment of prices of agricultural inputs and outputs to levels consistent with a free market regime. This has resulted in higher prices for fertilizer and other production inputs and has provided precedent and rationale for increases in water tariffs as well. Increasing competition for water from other users may also tend to force water prices up.

As the scarcity value of water rises and as publicly distributed production inputs shifts toward private sector, conditions for trading and selling of short and long term water rights will become more favorable. Still the emergence of water markets in surface water is likely to be a slow and lengthy process. Meanwhile markets in groundwater can be expected to continue to expand, since water right and water control issues are not significant problems here (Svendsen and Rosegrant 1992).

Also Wolff and Hubener (1992) predict that water as a production means will become increasingly scarce and expensive, making high on-farm irrigation efficiencies and precise control of water applications indispensable. They also state that alongside the rising income

expectations and standards of living, an increased agricultural yield levels will become necessary. Land which has been regarded fairly fertile will become marginal and the previous marginal land will go out of production. Agriculture and especially irrigated agriculture will concentrate more and more on highly productive land only (Wolff and Hubener 1992).

F. Some further study directions

In the preceeding chapters and sections it already has been pointed out some research needs for further studies and a need for qualifications of the present tentative results. In this final section the needs for further disaggregations are first emphasized.

A major disaggregation direction in studying off-site impacts is spatial. The spatial dimension can be watersheds, local community or regional. However, the most relevant direction would be that of watershed areas. One should systematically collect, develop and update existing data on the infrastructure and sub-industries potentially impacted by each watershed areas. As enough data is available, and as impact assessment and cost evaluation methodologies will be improved, it might be possible to attain a realistic off-site cost assessment for each watershed. The pioneering Magat and Pantabangan case studies (Arocena-Francisco 1986, Cruz et al 1988) provide good basis for continuation. A recent report in Cagayan Valley (Romero 1992), among others, indicate the growing interest on the topics. Numerous finished and on-going watershed project studies also provide increasing bulk of data to start with and further develop.

Those industries and activities National Accounts that appear suffering from soil erosion and watershed degradation can further be reflected in to disaggregated. Disaggregation increases the homogeneity of the sub-sector and makes impact (and cost impact) assessments more reliable. The development of cost assessment methods no doubt requires more research and should be encouraged.

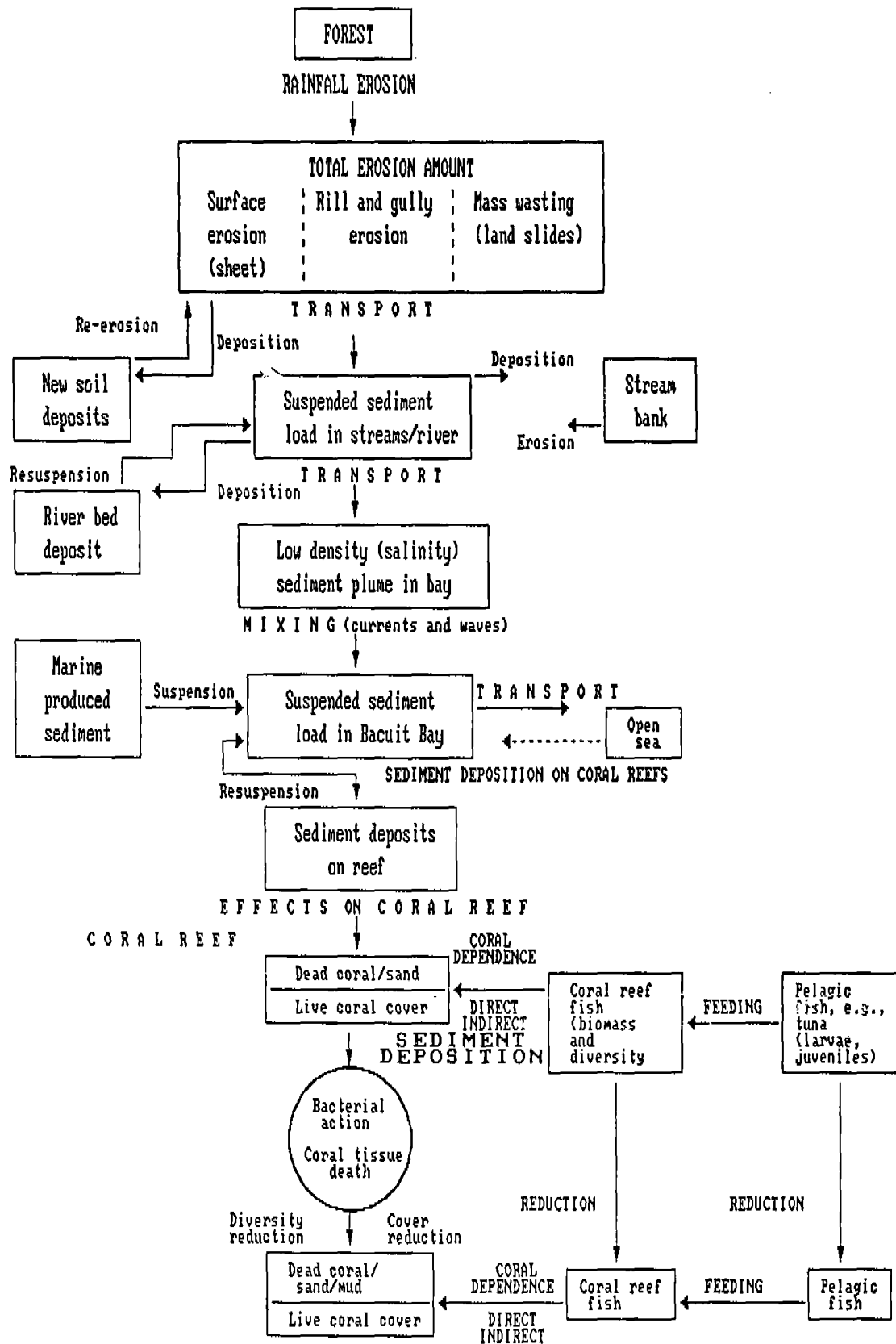
The efforts required to make detailed watershed-based off-site cost estimates, will no doubt be considerable. The Philippines is drained by 421 rivers with catchment areas ranging from 40 km² to 25,469 km² and by a large number of very small streams which flow directly to the sea (draining only a small proportion of the area of the country). Of 421 river principal basins 18 are classified as a major and 403 as minor. There are ten river systems with drainage basin areas greater than 3,000 km², and the aggregate of these basins is 85,270 km², or about 28% of the total area of the country. The remaining 411 river systems have catchment areas of less than 2,000 km² and the majority have catchments of less than 500 km². (World Bank 1992 b, PCARRD 1991). A potential strategy, therefore would be to start with one or few of the ten large river systems.

There is also an urgent need to develop watershed based, regional and nationwide estimates of surface and total soil erosion.- A geographic information system of NAMRIA/DENR (e.g. Master Plan 1990) together with methodological improvements in soil

erosion modelling (e.g. Cruz 1992) would provide a good basis for that development. No doubt further field experiments for calibrations are also needed.

Watershed-based soil erosion estimates together with watershed-based off-site cost estimates they can be used directly for analyzing economic profitability of watershed management and rehabilitation operations. Besides that, watershed-based results will provide a firm basis for a more accurate nationwide estimates of off-site costs due to erosion and watershed degradation.

Figure 1
PREDICTED PATHWAY OF SOIL ERODED FROM THE FOREST FLOOR AS IT PASSES TO THE SEA



Source: USAID 1989; Hodgson & Dixon 1988.

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