INDICATORS OF SUSTAINABLE LAND MANAGEMENT FOR SLOPELAND FARMS

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ABSTRACT

Because of the marginal condition of slopelands and the pressure exerted by increasing migration from the lowlands, these areas are highly vulnerable to land degradation from human activity. Further development of these areas for agriculture will need land management systems that will be sustainable over time and space. This Bulletin presents the principles of sustainable land management (SLM), and how sustainability can be evaluated.

The use of indicators provides a rational basis for monitoring and evaluating the sustainability of land management systems, and serves as a guide in decision-making at all levels. Indicators for sustainable land management identified in earlier studies were applied in evaluating the sustainability of the farm production systems at an on-farm research site in the Philippines of the ASIALAND Network on the Management of Sloping Lands. The analysis showed that farms where conservation practices are employed showed a trend towards sustainability. The results could be aggregated to allow interpretation at a higher level, which might be useful in land capability assessment and land use planning.

INTRODUCTION

The quality and management of land resources in the Philippines has become an increasing matter of concern in recent years. This is because of the pressure of expanding populations and economic development. While there is still scope for the expansion of productive land in some areas, many developing countries are faced with a need to increase production from either land already in use or from the fragile and less productive slopeland areas.

In Southeast Asia, the trend is towards the utilization of slopeland areas, not only because of the limited area favorable for agriculture in the lowlands, but also because of the dominance of this kind of landscape in the region. Slopelands dominate most of the countries in Southeast Asia and China (IBSRAM 1992). For instance, the South China subtropical red and yellow soil regions occupy an area of 218 million ha, 90% of which is mountainous or hilly. In Thailand, about 35% of the country's land area is hilly or mountainous, especially in the northern and western parts of the country. Hilly lands in the Philippines are estimated to cover 9.4 million ha, or about 31% of the total land area. They occupy 4.7 million ha, or 36% of the total land of Peninsular Malaysia. In Vietnam, slopelands occupy 25 million, or 75% of the total area of the country.

Land use in such areas needs special attention because it is slopelands which are in the greatest danger of land degradation. To provide a rational basis for the development and utilization of these areas, appropriate classification of these areas, in terms of their capability and suitability for different uses, is needed.

The use of indicators in evaluating land quality and sustainability of land management systems is discussed in this Bulletin. Their application in

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assessing the sustainability of management practices in selected slopeland farms and their potential for land use evaluation are also discussed.

SUSTAINABLE LAND MANAGEMENT

Maintaining the productive potential of land resources, and checking for land quality degradation, are fundamental elements of sustainable land management (SLM).

WHAT IS SUSTAINABLE LAND MANAGEMENT?

Dumanski (Dumanski *et al.* 1991a) considers sustainable land management to be a package of technologies applied at all levels of land use, which individually or in aggregate contribute to sustainable agriculture. It aims at maximizing the efficient use of inputs in relation to the amount and quality of the outputs, while incorporating long-term environmental and social concerns associated with the outputs. It evaluates management, not only in terms of production efficiency, but also in terms of its impact on the environment and its ability to ensure equity down the generations.

Sustainable land management is an extension of “maximum economic yield”, in that it not only tries to maximize the efficient use of inputs, but also considers the long-term environmental and social costs (Dumanski *et al.* 1991b). It is also an extension of the concept of “Best management practices”, but treats each management technique as a component of a set of technologies, which act collectively on long-term sustainability. SLM does not consider the application of today’s technologies to solve today’s (and often yesterday’s) problems. It rather tries to develop recommendations, based on sound scientific principles, which simultaneously promote agricultural productivity, ensure economic and social returns, and protect or enhance the quality of the environment and the land. While sustainable agriculture addresses the need for agricultural production on a sustainable basis, SLM describes how this is to be achieved.

The International Board for Soil Research and Management (IBSRAM) looks at sustainable land management as combining technologies, policies, and activities aimed at integrating socioeconomic principles with environmental concerns. It should be able to address the five pillars of productivity, security, protection, viability, and acceptability. It should simultaneously: maintain or enhance production services (productivity), reduce the level of production risk (security), protect the potential of natural resources and prevent degradation of soil and water quality (protection), be economically viable (viability), and be socially acceptable (acceptability) (IBSRAM 1997).

Evaluating Sustainable Land Management

Agriculture will continue to be the engine of economic development in most developing countries. Sustainable land management becomes an integral part of the process of harmonizing agriculture and food production with the often-conflicting interests of economics and the environment. Evaluation should consider the intricate, inter-dependent economic, social and environmental issues. Furthermore, sustainability can be expected to change from one area to another and over time. Consequently, solutions will have to be location- and time-specific.

Sustainable land management can be perceived at several levels, depending on the scale for which evaluations are made (Table 1). In its simplest form, the basic units for evaluation are farmers’ fields (Dumanski *et al.* 1991b). On this scale, evaluation can be made in terms of cropping systems, changes in soil characteristics, the impact of soil degradation on yield, returns per unit of cropland, and so forth. On a larger scale, evaluation criteria may include changes in production potential, the on- and off-farm impact of degradation, a comparative assessment of the economic performance of various farming systems, a comparison of opportunities in agriculture *vs.* other land uses, etc. This range of options reflects the scale of applications for which the evaluation is being made. The concept of sustainable land management thus encompasses agriculture within a framework of environmental resource optimization and land use planning.

In the final analysis, however, it will be the land management practices of individual farmers that will primarily affect the sustainability of agriculture in the future. As the pressures on productive land intensify, it will become increasingly more important that land management practices become sustainable. It is the responsibility of the scientific community to develop criteria and indicators for evaluating whether land management practices will lead towards sustainability, or away from it.

Table 1. Levels of assessment of sustainability

Level of analysis	Typical characteristics of sustainability	Typical determinants
Field/production unit	Productive crops and animals; Conservation of soil and water; Low levels of crop pests and diseases	Soil and water management; Biological control of pests; Use of organic manure, fertilizers, pesticides, crop varieties and animal breeds
Farm	Awareness by farmers; Economic and social needs satisfied; Viable production systems	Access to knowledge, external inputs and markets
Country	Public awareness; Sound development of agroecological potential; Conservation of resources	Policies for agricultural development; Controlled population growth; Agricultural education, research and extension
Region/continent/ world	Quality of natural environment; Human welfare and equity mechanisms; International agricultural research and development	Control of pollution; Climatic stability; Equitable terms of trade and distribution

Source: Dumanski *et al.* 1991b

INDICATORS FOR SUSTAINABLE LAND MANAGEMENT

The term "indicator" in its normal sense means a number or other descriptor that is representative of a set of conditions, and which conveys information about a change or trend in these conditions. It can also represent in summarized form the total effect of many variables, as in the use of crop yield as an indicator of soil fertility. Indicators can be derived from qualitative and quantitative measurements. However, they become standardized and comparable only when they are transformed into a numerical form (Pieri *et al.* 1995).

Indicators are not merely descriptive. Their purpose is to guide policy changes and management decisions at all levels, from the farm to the national and even global level. Indicators are needed, for example, to monitor the effects of agricultural policies on soil fertility, including the response to fertilizer inputs. In regions where forest clearance, forest degradation and shortage of wood products are important land issues, indicators are needed to monitor changes in the condition of these resources over time, and to assess the effects on them of policy changes and management measures (Pieri *et al.* 1995).

Indicators are already in regular use in some areas, especially at a farm level. Indicators to evaluate changes in the quality of land resources at a national or district level still need to be developed. We particularly need indicators for evaluating the sustainability of land management systems.

THE PRESSURE-STATE-RESPONSE FRAMEWORK

In the development of land quality indicators, Dumanski and Pieri (1997) recognized the application of the pressure-state-response framework (Fig. 1). This is because quality should be viewed, not only in terms of the physical condition of the land, but also in terms of how land is being managed, and the political and social environment for instituting improvements in land management.

The framework is a convenient representation of the linkages among the pressures exerted on the land by human activities (pressure box), changes in the quality of resources (state box), and the response to these changes as society attempts to release the pressure or to rehabilitate land which has been degraded (response box). The interchanges among them form a continuous feedback mechanism that can be monitored and used for assessment of land quality. The framework can thus be used to structure and classify information, and to assist in the identification of the key set of indicators that best describe how farmers are managing their lands and the impacts of this management.

Examples of indicators according to the framework are given by Pieri *et al.* (1995). For slopelands where soil erosion is a major cause of land degradation, the following examples are given:
Pressure indicator: Extent of sloping land without adequate conservation measures
State indicators: Rates of erosion (mt/ha/year) obtained by field measurement or modelling; Loss of topsoil, soil organic matter and nutrients; Truncated soil profiles; Extent and severity of visible signs of erosion, e.g., thin or rocky soils, landslides, gullies, areas of abandoned land
Response indicators: Extent of adoption of soil conservation practices, by area or by farm; Number of farmers' associations active in conservation; Abandonment of land formerly cultivated

It should be noted that not all the indicators suggested can be precisely quantified. Some can potentially be quantified, although not always in a standardized way that will allow for the comparison of different regions. In many cases, neither standards nor threshold values have yet been developed.

THE FESLM FRAMEWORK

The international Framework for the Evaluation of Sustainable Land Management (FESLM) is closely related to the pressure-state-response framework for environmental reporting. The FESLM provides a practical framework that connects all aspects of land use under investigation with the interacting conditions of the natural environment, the economy, and the socio-cultural and political life (Dumanski *et al.* 1991b). It serves as a tool for identifying which systems are sustainable systems and which are not, by producing a checklist of variables and factors. These can be used to evaluate systematically the sustainability of a wide range of agroecological systems.

Integrating knowledge from diverse sources such as IBSRAM long-term experiments, FESLM on-farm research case studies, and informal technical innovation from progressive farmers, extension workers and experts (Fig. 2), Rais *et al.* (1997) developed SLM indicators based on the five pillars of sustainability listed above.

This analysis provided the threshold values, and the qualitative and quantitative ratings of each indicator. Table 2 gives the list of indicators identified under each of the five criteria. Case studies conducted in Indonesia, Thailand and Vietnam provided additional information on the effect of various land management practices, and

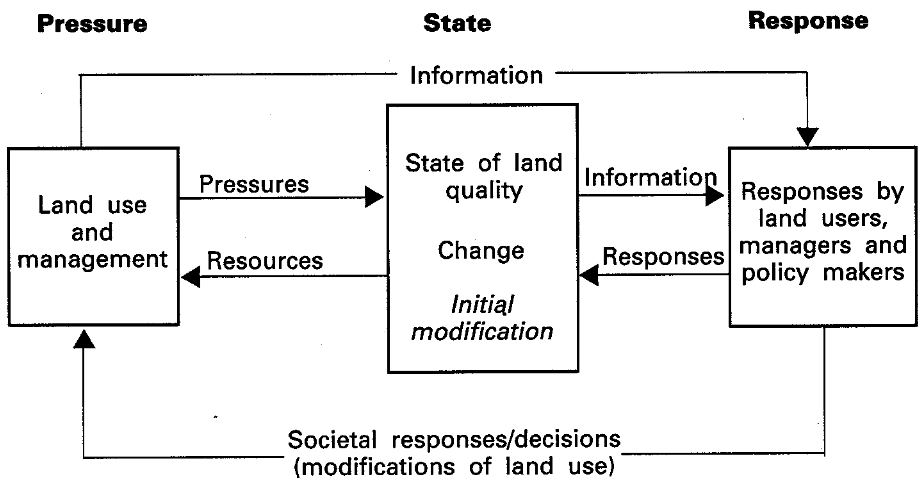

Fig. 1. The pressure-state-response framework (Modified from Pieri *et al.* 1995)

allowed the integration of local knowledge and scientific research (Gameda *et al.* 1998, Lefroy *et al.* 1998). These indicators were then used to develop an expert system-based decision support system (DSS). This in turn provides an opportunity to put the FESLM concept to practical use.

A simple set of indicators for sustainability has been developed in the Philippines and Australia (Gomez 1997a, and 1997b, Swete-Kelly and Gomez 1998). Through a screening process, they came up with two groups of indicators. One group dealt with resource conservation, and the other with the satisfaction of farmers. Under the indicators for resource conservation are:

- Organic matter (OM) content;
- Cation exchange capacity (CEC);
- Moisture content at 1/3 bar,
- Water dispersible solids,
- The presence of permanent ground cover, *and*
- Soil depth.

To measure farmers' satisfaction, indicators included:

- Gross returns;
- Cost of material inputs;
- Diversity index;
- Farm size;
- Membership in farming organizations, *and*
- The number of large animals raised.

Essentially, this is similar to the five pillars of sustainability mentioned above. Protection is the main component of resource conservation, while productivity, stability, viability and acceptability are integrated in the indicators of each farmer's satisfaction.

EVALUATING SLM INDICATORS FOR SLOPELAND FARMS

Maglinao et al. (1997) applied these indicators to evaluate the sustainability of farm practices employed by farmers in Ma. Paz, Tanauan, Batangas. This is the site of the IBSRAM ASIALAND network on the management of sloping lands in the Philippines. Information from 10 project farms and 10 non-project farms were used in the evaluation.

Sustainability Rating Using the Indicators for Resource Conservation and Farmers' Satisfaction

Based on the indicators for resource conservation, seven of the ten project farms followed sustainable practices, while the practices in all ten non-project farms were unsustainable (Table 3). This could be expected, as the technology introduced in the project has been shown to prevent or reduce soil erosion. All indicators favor the systems followed by the project farms. However, it is the ground cover which made the major difference between the project and non-project farms.

The indicators of sustainability for farmer's satisfaction also showed that more project farms (5 out of 10) had sustainable practices than the non-project farms (2 out of 10). However, not all five farms where the farmer was satisfied were also sustainable according to indicators for resource conservation.

While seven out of ten project farms were sustainable based on the indicators for resource conservation, only three of those had a sustainability rating of more than one for both categories. On this basis, only these three farms could be considered to be practicing a sustainable system. None of the non-project farms were sustainable.

DSS-SLM Assessment of Land Management Systems

Table 4 shows descriptive ratings of the 20 farms based on the five criteria for sustainability. All project farms met the requirements for protection and social acceptability, while five met the requirements for protection, acceptability and productivity. Of these five, only one met the viability criteria. None of the farms (project and non-project) met the requirement for security.

Among the non-project farms, one met the requirements for protection and acceptability, one for protection and productivity, two for acceptability, and one for protection. The sustainability of the rest was marginally above the threshold, marginally below the threshold, or did not meet the requirements at all.

Table 5 summarizes the sustainability status of the land management practices of the 20 farms. The data show that the project farms have better sustainability status than non-project farms. While this information may not show the status of each farm, it helps in identifying which criteria are not met and which should now be the focus of intervention. Just the same, both methodologies point to the effect of conservation technologies in promoting sustainability.

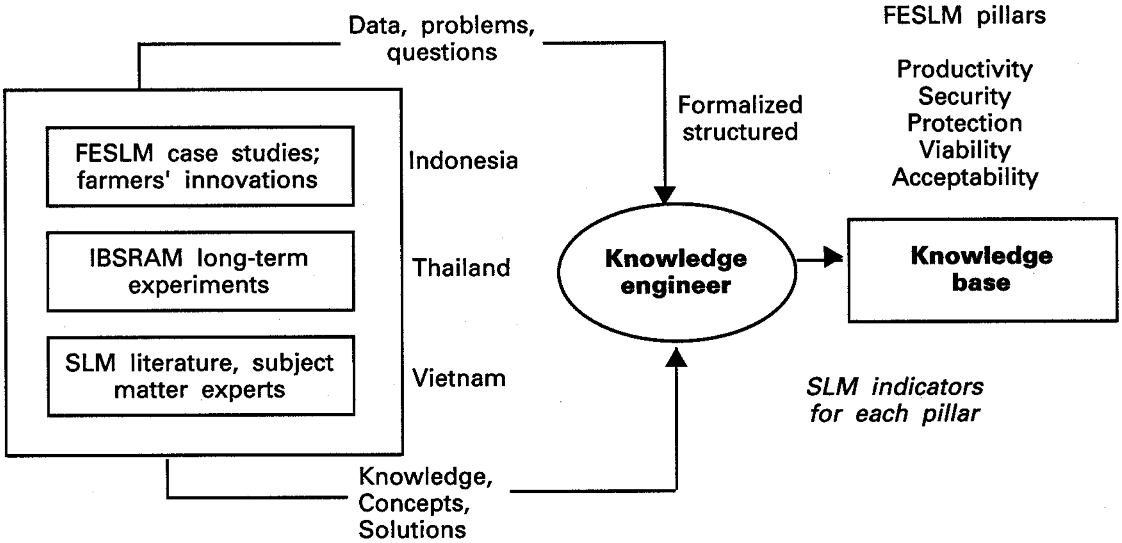

Fig. 2. Knowledge acquisition process for SLM indicators (From Rais *et al.* 1997)

Table 2. Sustainable land managment (SLM) indicators identified under each of the five pillars

Productivity	Security	Protection	Viability	Acceptability
Soil organic matter	Average annual rainfall	Erosion	Benefit/cost ratio	Land tenure
Available N	Biomass plowed back	Cropping system and extent of protection	Percentage of off farm income	Support for extension Services
Available P	Drought frequency		Difference between farm gate price and market price	Health and educational facilities in village
Available K			Availability of farm labor	Percentage of subsidy for conservation packages
			Size of farm holding	Training of farmers on soil and water conservation
			Availability of farm credit	Availability of agricultural inputs within 5-10 km radius
			Percentage of farm produce sold in the market	Village road access to main road

Source: Rais *et al.* 1997

Table 3. Sustainability rating of 20 farms in Ma Paz, Tanauan, Batangas

Farm No.	Resource conservation index	Farmers' satisfaction index	Sustainability rating
	Project farms		
1	0.884	1.37	-
2	0.896	0.32	-
3	1.148	0.71	-
4	1.284	0.56	-
5	1.206	1.51	+
6	1.240	0.66	-
7	0.956	1.24	-
8	1.368	1.20	+
9	1.120	0.63	-
10	1.012	1.81	+
	Non-project farms		
11	0.854	0.26	-
12	0.954	1.12	-
13	0.930	1.70	-
14	0.882	0.45	-
15	0.958	0.85	-
16	0.894	0.62	-
17	0.968	0.15	-
18	0.816	0.67	-
19	0.782	0.50	-
20	0.856	0.69	-

Source: Maglinao *et al.* 1997

SLM INDICATORS AND LAND USE EVALUATION

The results presented above show that a much deeper analysis still has to be done to make the indicators identified more useful. The analysis was done at the farm level. Some kind of aggregation is needed, for the indicators to be applicable on a larger scale. Nevertheless, this could serve as an initial step to help farmers in making decisions as to what practices they should use in their fields to maintain or enhance the productive potential of their farms.

Applying this approach at a higher level could be useful in land use evaluation. Since the sustainable management of our land resources depends on the state of this resource, the pressure that it is subjected to, and the response of land users to ease this pressure, indicators are needed to monitor land use changes and their impact.

CONCLUSION

Slopelands dominate the landscape of most of Southeast Asia. Because of their marginal and fragile nature, together with the pressure exerted by increasing populations, special attention should be given to this ecosystem. The development of sustainable land management systems is necessary to maintain and enhance the productive potential of these areas. As land management depends on the pressure on, and the current condition of, our land resources, the different land users should be provided with relevant information for decision-making. Classifying slopelands according to their capability and best use is basic to this requirement. Moreover, indicators to monitor and assess management practices as land use changes over space and time should be developed.

REFERENCES

Dumanski, J., H. Eswaran, E. Pushparajah and A. Smyth (ed.). 1991a. Evaluation for sustainable land management in the developing world. *Vol. 1. Towards the Development of an International Framework.* International Board for Soil Research and Management, Bangkok, Thailand. IBSRAM Proceedings No. 12.

Dumanski, J., H. Eswaran and M. Latham.

Table 4. Sustainability status of land management practices of 20 farms in Ma. Paz, Tanauan, Batangas

Farm No.	Productivity criteria	Security criteria	Protection criteria	Viability criteria	Acceptability criteria
			Project farms		
1	2	4	1	2	1
2	2	4	1	2	1
3	2	4	1	2	1
4	1	4	1	2	1
5	2	4	1	2	1
6	1	4	1	2	1
7	1	4	1	1	1
8	1	4	1	2	1
9	1	4	1	2	1
10	2	4	1	1	1
			Non-project farms		
11	2	4	2	2	4
12	2	4	1	2	1
13	2	4	2	4	4
14	1	4	1	2	4
15	2	4	2	2	1
16	2	4	2	2	4
17	2	4	4	4	4
18	2	4	1	2	4
19	2	4	4	3	1
20	2	4	4	2	4

1 Practices meet sustainability requirement
2 Sustainability is marginally above the threshold
3 Sustainability is marginally below the threshold
4 Practices do not meet sustainability requirements

Source: Maglinao *et al.* 1997

1991b. A proposal for an international framework for evaluating sustainable land management. In: *Evaluation for Sustainable Land Management in the Developing World, Vol 2,* J. Dumanski, E. Pushparajah, M. Latham, R. Myers and Collin R. Elliot (Eds.). Technical papers. Bangkok, Thailand: International Board for Soil Research and Management, 1991. IBSRAM Proceedings no. 12,2, pp25-48.

Dumanski, J. and C. Pieri. 1997. Application of the pressure-state-response framework for the land quality indicators (LQI) programme. In: *Land Quality Indicators and their Use in Sustainable Agriculture and Rural Development.* Proceedings of the Workshop organized by the Land and Water Development Division, FAO Agriculture Department and the Research, Extension and Training Division, FAO Sustainable Development Department. 25-26 January 1996, pp. 35-36.

Gameda, S., M. Rais, E.T. Craswell and J. Dumanski. 1998. Integration of local knowledge and scientific research for an expert system on sustainable land management: A South-east Asian case. (Unpublished Mimeograph).

Gomez, A.A. 1997a. Evaluating the sustainability of the agricultural systems at the farm level. Paper presented during the SAI Workshop. 17 February 1997, PCARRD Los Baños, Laguna, Philippins. (Unpublished mimeograph).

Gomez, A.A. 1997b. Indicators of sustainability. Presented at the National Workshop on the Development of Sustainable Agriculture Indicators: Case Study Presentations and Analyses. 16-17

Table 5. Sustainability status of land management practices of project and non-project farms in Ma Paz

Criteria	Project farms	Non-project farms
Productivity	• 5 meet requirements • 5 marginally above the threshold	• 9 marginally above the threshold • 1 meets requirements
Economic	• 2 meet requirements • 8 marginally above the threshold	• 7 marginally above the threshold • 1 marginally below the threshold • 2 do not meet requirements
Protection	• All meet requirements	• 3 meet requirements • 7 do not meet requirements
Security	• None meet requirements	• None meet requirements
Social acceptability	• All meet requirements	• 3 meet requirements • 4 marginally above the threshold • 3 do not meet requirements

Sourve: Maglinao *et al.* 1997

December 1997. SEARCA, College, Laguna, Philippines. (Unpublished mimeograph).

IBSRAM (International Board for Soil Research and Management). 1992. Technical report on the management of sloping lands for sustainable agriculture in Asia, Phase 1, 1988-1991 (IBSRAM/ AASIALAND). Network Document No. 2). (Unpublished mimeograph).

IBSRAM (International Board for Soil Research and Management). 1997. *Towards Sustainable Land Management in the 21st Century: The IBSRAM Vision. Bangkok, Thailand.*

Lefroy, R., D.B. Bechstedt and M. Rais. 1998. Indicators for sustainable land management based on farmer surveys in Indonesia, Thailand and Vietnam. Paper presented at the 16th World Congress of Soil Science, 20-26 August 1998. Montpellier, France. (Unpublished mimeograph).

Maglinao, A.R., A.B. Armada and T.Q. Correa, Jr. 1997. Evaluating indicators of sustainable agriculture: The case of the production systems in Ma. Paz, Tanauan, Batangas. Paper presented at the National Workshop on the Development of Sustainable Agriculture Indicators: Case Study Presentations and Analyses. 16-17 December 1997, SEARCA, College, Laguna, Philippines. (Unpublished mimeograph).

Pieri, C., J. Dumanski, A. Hamblin and A. Young. 1995. *Land Quality Indicators.* World Bank Discussion Papers. The World Bank. Washington, D.C.

Rais, M., E.T. Craswell, S. Gameda and J. Dumanski. 1997. Decision support system for evaluating sustainable land management in sloping lands of Asia. (Unpublished mimeograph).

Swete Kelly, D.E. and A.A. Gomez. 1998. Use of resource management domains to expand the application of farm-based sloping land technologies. In: *International Workshop on Resource Management Domains: Proceedings of the Conference on Resource Management*

Domains, J.K. Syers and J. Bouma (Ed.). Held in Kuala Lumpur, Malaysia 26-29 August 1996, Bangkok, Thailand: IBSRAM, 1988. IBSRAM Proceedings no. 16. pp. 175-185.

DISCUSSION

During the Discussion after the paper presentation, a participant from Taiwan pointed out that soil erosion is probably the single most important indicator of land quality. However, erosion is difficult to measure, and measurement must be carried out over a long time. There seems to be no quick and easy method. Even if a reservoir is constructed to catch sediments, the results may be very variable. For example, erosion is reduced if rainfall is low. In other words, many factors influence erosion, and land use is only one of them. Furthermore, erosion must also be measured over a long period of time. It may take decades to judge whether conservation measures are really effective.

With regard to modeling, he suggested that while models are useful, they can be misleading. If models are developed overseas, e.g. in the United States, they cannot just be imported. They have to be tested and verified in the Asian countries where they are being applied..

Dr. Maglinao agreed that measurement of erosion is still a problem, and that long-term study is needed. Sometimes erosion stops because there is no more soil left to erode!! He agreed that just measuring data from a site may not be very reliable, which is why he was so interested in measuring the on-site and off-site impact of erosion.

One participant referred to a World Bank report on a conservation program which involved planting trees in an upper watershed in Pakistan. After some years, the erosion rate had not been reduced, and the program was seen as a failure. However in fact, the early erosion had been from the soil disturbance when the trees were planted. After only a few years, there had not been enough time to for the trees to grow large enough so that their canopies and leaf litter protected the soil. Seen in terms of its long-term impact, the program was successful.

A scientist from the Philippines suggested that erosion cannot be seen simply as causing an immediate loss of fertility. To understand erosion, we need to understand the process of sedimentation. Sheet erosion involves the mass downward movement of sediments. This is very different from the rapid movement of soil sediments down a gully into a stream. In sheet erosion, losses of sediments downhill are often balanced by gains from above.

Rather than erosion, sediment transport may be a better measure of possible losses or gains in fertility. Whereas gully erosion always represents a net soil loss, other kinds of erosion may represent almost an equilibrium. Erosion, after all, is a process of stabilization. If erosion is very active, this is because the cycle of repose has been violated by inappropriate land use. This is why fertilizer use in upland areas is a very complex problem.

Participants also discussed the problem of how recommendations for sustainable land use can be made acceptable to farmers. It was generally agreed that this is easier when farmers are moving into a new area, especially if farmers are involved at the planning stage. It is more difficult to persuade farmers to change what they are already doing in order to restore damaged land.

In the selection of indicators, it was suggested that since measurements of land use impact is expensive and takes a long time, it might be better to search for minimum indicators. For example, crop yield shows the combined impact of many factors, and is easy to measure. Dr. Maglinao agreed. He also raised the question of how often monitoring of an indicator needs to be carried out, whether the intervals between measurements should be monthly, annual or every cropping season. In conclusion, while useful indicators have been proposed, there is still a great deal of work to do in developing and testing them.