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EVALUATION FOR SUSTAINABLE LAND MANAGEMENT IN THE DEVELOPING WORLD

Volume I: Towards the Development of an International Framework

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PREFACE

Population growth, deterioration in soil and water quality, and concern for the environment and the conservation of natural resources lead to uncertainties in meeting future demands for food and fibre production, and call for a "sustainable" perspective in agricultural research and development. Procedures for quantifying sustainability are urgently needed. The FAO *Framework for Land Evaluation*, published in 1976 and widely adapted since, provided a method for assessing the suitability of land-use alternatives on specific kinds of land. However, no procedures for assessing the sustainability of land-utilization types were included in the *FAO Framework*. This workshop was therefore organized with a view to initiating the development of a framework for sustainable land development which would provide a logical and practical method of fulfilling this need.

The workshop was a joint effort of many organizations, which were involved both in the planning and financial aspects of the event. The workshop was held in Chiang Rai from 15-21 September 1991, and was attended by 210 participants from 49 countries, with representation from developing countries (12 in Africa, 14 in Asia, and 5 countries from the the Pacific Islands) and developed countries.

The workshop provided 3 keynote papers, 8 lead papers, and 19 support papers, which were discussed over nine technical sessions. In addition, 44 papers were presented in two poster sessions (with the posters on display throughout the workshop). The six working groups with their discussions and recommendations on the framework for sustainable land management, were a central feature of the workshop.

The proceedings of the workshop are published in three volumes, namely *Towards the Development of an International Framework* (vol. 1), *Technical Papers* (vol. 2), and *Summaries of the Poster Papers* (vol. 3).

We are pleased to acknowledge the support of the many agencies, academic centres, and institutes who have contributed to the success of the workshop, and in the present context are especially mindful of the support of the FAO and the Technical Centre for Agriculture and Rural Cooperation, ACP-EEC Lomé Convention (CTA) for having provided additional support for the publication of the proceedings.

Marc Latham
Secretary, Organizing Committee
International Workshop on Evaluation
for Sustainable Land Management
in the Developing World

EXECUTIVE SUMMARY

Sustainability is a multifaceted concept which is difficult to define, but the 210 participants from 49 countries at this workshop were in no doubt of its importance for the future of mankind. Nor did they have difficulty in addressing their discussions to pragmatic issues relating to the actions necessary to monitor and ensure man's capacity to produce food and fibre from the land. The management practices that are needed, and ways of evaluating whether these practices measure up to the challenge of sustainability, formed the subject matter of the workshop.

The workshop was informed that to meet the needs of an expanding population, global production in the next 50 years will need to exceed all that was produced in the past 12 000 years. At the same time, there is evidence that approximately 1 ha of land is lost to production from all forms of degradation every 6.6 seconds; that 20 million ha become uneconomic for farming each year, and that an additional 6 million ha are degraded annually beyond the point of reclamation. The capacity to expand the presently cultivated areas on soils well suited to the purpose is severely limited in nearly all countries. Agriculture has therefore reached a threshold beyond which increased production must come from existing cropland, and productivity must be sustained even in less-favoured areas.

The current situation and prospects for action were presented to the participants in two keynote and 27 lead and supporting papers, grouped in relation to six main sections of the workshop, namely soils and agroclimate, environmental issues, agronomy, economics, stewardship, and methodology/quantification. The gist of these papers is given in the attached report, and full texts will be published in the proceedings of the workshop. These presentations served to underline the breadth and complexity of the issues which bear upon the development of sustainable land management. Country and site-specific information which added to the quality of the workshop came from the forty poster papers. In addition, the two field-trips to well-selected sites in northern Thailand added the practical dimension to the questions at hand.

With this background information, the participants divided into their respective working groups for discussions, debated the more important issues, and developed the action and approach statement entailed in the formulation of a framework for the evaluation of sustainable land management. These statements became the foundation for the framework for sustainable land management. Although the time available to the working groups was limited, they were able to identify ways forward in the development of the framework, and to identify actual approaches and associated actions (the lowest levels of the framework), in their respective areas of expertise.

This has permitted a restatement in the attached report of the structure and characteristics of the proposed diagnostic framework, with examples of its formative statements from the working groups. It is now apparent that a framework of this kind would serve a valuable purpose not only in assessing whether or not proposed land management practices are likely to prove sustainable, but as a guide to the planning of both research and development.

A 'framework for sustainable land management' (FSLM) is needed to synthesize the concepts and provide the context to evaluate land. A strategic framework provides a structured and practical approach and the basis for making decisions, so that specific elements of land management are addressed in an orderly fashion with due emphasis being given to the tenets of sustainability. The characteristics of the framework which are now established comprise five levels of definition, ranging from an ultimate *goal*, through *objectives*, contributing *aims*, *approaches*, and specific *actions*. The whole framework takes a hierarchical form - to be constructed normally from the top, and most commonly used from the bottom upwards. It is envisaged that in time much of the operation of the framework will be computerized, using data sets, critical levels, and knowledge models to assess the probability of sustainability of a given practice in a specific locality.

It is stressed that the proposed framework is a structured methodology for evaluating land management decisions and an aid in such decision-making; it is not intended to be a recipe book for sustainable land management. Nevertheless a fully developed FSLM incorporating defined approaches and actions in all fields of natural resources and economic sciences would provide a check list of the issues which need to be considered at several different stages in land management planning. It would assist in identifying gaps in knowledge, and therefore research needs, in relation to scientific management practices. It will guard against oversight of potential problems in various subject-matter areas during the planning stages of development. Later it will serve to structure systematic monitoring of progress in development along a sustained productivity pathway, emphasizing the interactions of environmental, sociological, and economic parameters.

In their recommendations, the participants expressed their concern at production prospects and urged governments to devote greater resources to sustain global and local environmental resources. They welcomed the initiative on the development of the framework and, appreciating the progress made at the workshop, recommended that IBSRAM, ISSS, the FAO, and other agencies should support further work on its development. They also made a number of specific technical recommendations to the same end.

A framework for SLM is a long-term endeavour requiring the cooperation of a range of disciplines and the experience of scientists and land users from around the world. Developing the FSLM is a challenge for the next few years, and international organizations such as IBSRAM, ISSS, and FAO have already made a commitment towards this. A series of consultations, working meetings, and

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symposia are planned for the next few years. A proposed international working group will coordinate and guide these various efforts. The preliminary support from several donors is an indication of the usefulness of this task; the dedicated contribution of the scientific community as shown in this workshop is a sign of the commitment; and these areas of support coupled to the urgency of the matter (as evidenced from global political concern), collectively assures a valuable product in a short period of time.

PART I: INTRODUCTION AND BACKGROUND

Background

The workshop was organized jointly by the Department of Land Development (Thailand), the International Board for Soil Research and Management, the International Society of Soil Science, and the Technical Centre for Agriculture and Rural Cooperation, and was held in Chiang Rai, Thailand, from 15-21 September 1991. It was attended by 210 participants from 49 countries. The generous support from Deutsche Stiftung für Internationale Entwicklungslande (DSE); the Food and Agriculture Organization of the United Nations (FAO); Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ); the International Development Research Centre, Canada (IDRC); Swiss Development Cooperation (SDC), and the U.S. Agency for International Development (USAID), contributed to the success of the workshop.

Workshop objectives

The objectives of the workshop were:

- To develop the concepts and principles which are necessary for the evaluation of sustainable land management.
- To formulate some approaches towards evolving a framework for sustainable land management.
- To recommend follow-up activities leading to the development, testing, and validation of the framework for sustainable land management.

Workshop rationale

"We are during the closing decades of the twentieth century, approaching the end of the most remarkable transition in the history of agriculture. Before the beginning of this century almost all increases in agricultural production occurred as a result of increases in the area cultivated. By the end of this century there will be few significant areas where agricultural production can be expanded by simply adding more land to production. Agricultural output will have to be

expanded almost entirely from more intensive cultivation in areas already being used for agricultural production."

V.W. Ruttan (1987)[1]

The world's total ice-free land area is approximately 13.4 billion ha, but potentially arable land is only 3.2 billion ha, or 24% of the total. Most of the well- and moderately suited land (1.5 billion ha) is already under some form of cultivation (except for some parts of Africa and Latin America), and these lands are being threatened by land degradation and/or urbanization. About 60% of the arable land is of low productivity, subject to several kinds of stresses and requiring special management for sustainable production. With annual global population increases of about 70 to 90 million persons, and with many of the increases taking place in developing countries, there is an ever-increasing demand for food, fibre, and energy production which must be derived from a land-resource base which is now realized to be finite.

This resource base, however, is subject to an insidious process of depletion, caused by degradation, which has intensified in recent history. Consequently, global agriculture is at a watershed, since for the first time in history most of the additional production will have to be achieved through agricultural intensification rather than land expansion. This is in contrast to the broad-based and well-adapted genetic resource and biologically diverse production systems which were the essential components in the historic evolution of persistent and stable sedentary agricultural systems. This persistent and gradual depletion of the global stock of arable land, coupled with declines in biodiversity and the quality of the environment have brought about the necessity for new approaches to land use and the management of natural resources. Impending global climate change adds several degrees of uncertainty to this unfavourable situation, and thereby increases the urgency of seeking a more sustainable form of agriculture.

Sustainable land management - the challenge

"Sustainable agriculture should involve the successful management of resources to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources"

TAC Report (FAO, 1989)[2]

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1 Ruttan, V.W. 1987. Institutional requirements for sustained agricultural development. In: *Sustainability issues in agricultural development*, ed. T.I. Davis and I.A. Schrimer. Washington, DC: World Bank.

2 FAO (1989). *Sustainable agricultural production: implications for international agricultural research.* Compiled by the Technical Advisory Committee (TAC) of the CGIAR. FAO Research and Technical Paper no. 4. Rome: FAO. 131p.

"... the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in agriculture, forestry, and fisheries sectors) conserves land, water, plant, and animal genetic resources, and it is economically viable and socially acceptable."

FAO (1991)[3]

These definitions have much in common with the three basic components of sustainability of Douglas (1984):[4]

- *Sustainability as long-term food sufficiency, which requires agricultural systems that are more ecologically based and that do not destroy their natural resources.*
- *Sustainability as stewardship, that is, agricultural systems that are based on a conscious ethic regarding humankind's relationship to future generations and to other species.*
- *Sustainability as community, that is agricultural systems that are equitable.*

Sustainable land management is a package of technologies applied at all levels of land use, which individually or in aggregate contribute to sustainable agriculture. It aims to maximize the efficiency of inputs in relation to the amounts and quality of the outputs, but it also incorporates 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 intergenerational equity.

A 'framework for sustainable land management' (FSLM) is needed to synthesize the concepts and provide the context to evaluate land. A strategic framework provides a structured and practical approach and the basis for making decisions, so that specific elements of land management are addressed in an orderly fashion with due emphasis being given to the tenets of sustainability.

FSLM will have significant applications in all aspects of agricultural research and development and also in environmental assessment. It provides the scientific basis for evaluating the environmental impact of proposed land-use changes. It has the potential to be used for evaluating the consequences of projected global climate change. When coupled to recent computer technology such as simulation modelling, geographic information systems, and expert systems, it has the potential to emerge as one of the most powerful tools for the sustainable management of land.

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3 FAO 1991. *The Den Bosch declaration and agenda for action on sustainable agriculture and rural development: report of the conference.* Rome: FAO. 60p.

4 Douglas, G.K. 1984. *Agricultural sustainability in a changing world order.* Boulder, CO: Westview Press Inc.

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The immediate challenge is to develop a framework for sustainable land management that, once quantified in space and time, will become a tool for both research and developmental activities.

Sustainable land management - the issues

Land

Availability, quality and competing uses of land are the major issues of today. Since the land-resource base is finite, maintenance of quality and discriminatory use and management are especially important, and demand research and innovative development activities.

Water

More than 85% of arable agriculture is rainfed, and therefore water is a major limiting factor for most of global agricultural production. Although about 50% of the incremental production in the year 2000 may result from irrigation, only about 19.5% of the total irrigable land is expected to have some form of irrigation. The doubling of costs of irrigation, and problems arising as a direct result of irrigation, are expected to be deterrents to the amount of land eventually irrigated. The quality of water is becoming of increasing concern, and is expected to influence land management technology.

Soil

Improved soil management practices through appropriate tillage, land shaping, conservation farming techniques, and recycling of crop residues are among the primary measures for increasing food and other agricultural production. The soil physical and biological qualities form the basis for the establishment and production of sustainable crops and pastures, and at the same time conserve the resource base.

Fertilizer

Increased fertilizer supply still appears to be the primary means of meeting the need for an increased supply of food and fibre. Higher-yielding cultivars require better nutrition and demand enhanced judicious fertilizer use. The soil has limits to its ability to filter toxic compounds. Integrated nutrient management, which is largely a question of fertilizer efficiency in the context of soil and water quality, remains a major concern.

Germplasm

Despite tremendous strides in plant breeding and germplasm technology, some serious problems are still evident. High yields cannot be maintained consistently, some of the major crops have not responded to further advances in breeding, and clonal plantations have introduced a host of antecedent problems. Declines in the biological resource base due to the destruction of landraces, with consequent reduction in biodiversity, pose threats to the sustenance of germplasm.

Ecosystem integrity

Agriculture has not only encroached on special ecosystems, some of which are fragile, but has also emerged as the major cause of degradation in many of the ecosystems. Anthropically induced stresses have become a major cause of unsustainability. Deforestation, drainage of wetlands, irresponsible irrigation and other such activities act to degrade the ecosystem and also trigger climatic changes with their consequences.

Socioeconomic conditions

Tenure of land and water, aspirations of farmers and communities, matching of technologies to farmers' needs and abilities, and a desire to attain intergenerational equity, are all determinants of sustainability which have not received the attention they deserve. In recent years, economic growth in many developing countries has itself spurred unsustainability in land management. In other countries, the same economic growth has increased disparity between sectors in society forcing the very poor to greater use of marginal and fragile ecosystems due to an imposed scarcity of land.

Pests and diseases

Particularly in tropical environments, pest and disease management is an integral part of sustainable land management, since pests and diseases determine the economic success of the system and thereby form an indirect control on sustainability. The use of chemicals to reduce the impact of pests and diseases may contaminate both the product and the environment, and much work still needs to be done on 'safe chemicals'. Technologies that permit minimum levels of pests and diseases have some beneficial effects, and more research is needed. Little information exists to confidently relate the incidence of pests and diseases to factors of agroclimatology and soils. Integrated pest management is still in its infancy.

Sustainable land management - assessments

The following assessments of sustainable land management are excerpted from the papers submitted to the workshop, from the discussions following the oral presentations, and from the working group discussions. The papers are presented separately in the proceedings of the workshop. The assessment provides some of the current concerns, knowledge and research gaps, and some areas for attention, and is not intended to be a comprehensive review.

Environment

Emphasis on sustainability originated from the lack of attention to the environment, particularly the agroenvironment. Environmental degradation has been the by-product of development in most countries. The sectorial focus on land use and planning has produced an 'island' approach to resource utilization which invariably has attempted to internalize the benefits and externalize the resource utilization. Such an approach has taken no account of the interdependence of the environmental factors with the production function and the social fabric of society. The graphic consequences of this are the issues of biodiversity, global warming, and the international energy debate, which have reached the public agenda at a time when the array of environmental problems have not been adequately addressed by the scientific community.

The expectation that soil loss can be reduced to zero, water pollution eliminated, and tree cover restored to that of fifty years ago, is unrealistic if agricultural, industrial, and urban development are to continue. Conservation and development are not compatible, and reasonable 'trade-offs' must be socially and politically accepted. The scientific community must provide the rationale and

basis for these trade-offs. Only by appreciating the global perspective of local problems, can realistic long-term approaches be developed for the prevention of degradation and the achievement of sustainable land use. The framework for sustainable land management must facilitate and incorporate the increasing complexity of environmental concerns - including local, regional, national, and global dimensions.

Agroclimate

Climate and soil are often the most critical biophysical factors determining the growth potential, performance, and sustainability of agricultural systems. Accurate comparative prediction of crop production risks is an important dimension for evaluating sustainability. Yield estimates are often expressed as long-term potentials, but should perhaps be quantified in terms of variability, which would facilitate the evaluation of production risk. Production risks are a consequence of natural factors such as weather, crop pests, and soil variability, and natural risk is often beyond the ability of the farmer to control. Production risks can be mitigated to some degree by specific soil and crop management practices, but some degree of production risk will always remain and must be accepted. Due to the interaction of weather with other natural elements, various areas have different levels of production risks, this being generally highest in extreme climatic zones.

The evaluation of risks requires long-term climatic and crop (or other production function) data. This indicates the need for better integration of agroclimatic data with land-resource information for the evaluation of sustainable land systems in developing countries. Such data are scarce and, being prerequisites for evaluation, a concerted effort must be made to generate them. In addition, it will also require some new paradigms for information management and some new techniques for research.

Climate-induced risks are many and, particularly in disaster-prone areas, a framework for sustainable land management must consider:

- the kinds of disaster to which a country/region/farm is exposed;
- the effects which specific disaster types have on individual crops, farm animals, and land at specific times during the year;
- the degree of the risk, in terms of frequency and intensity;
- the opportunities that exist for resuming production speedily;
- the needs and opportunities to amend farming practices or the production environment so as to remove or reduce exposure to specific disaster types.

A component on extreme events in the proposed framework would be an initial step in the management of disaster-prone lands.

Soils

Soils are subject to resource limitations that require management goals of conservation and enhancement. Conservation focuses on the control of soil degradation processes, while enhancement focuses on the alleviation of soil-related constraints to specific uses. Lack of knowledge of the kinds and distribution of soils in many developing countries is a major constraint to implement conservation and enhancement technologies. Concern for the soil resource base relates not only to soil productivity but also to soil quality for a variety of uses, including water quality. Soil is a filter to many toxic compounds.

Soil quality is the capacity of the soil to function within the ecosystem boundaries to produce biomass and act as an environmental filter. Soil quality thus exerts a control on agronomic, ecological, and economic sustainability. There is an urgent need to develop minimum data sets to define soil quality in the context of sustainable land management. Such data sets will be useful to evaluate soils and monitor changes taking place. Established threshold values of specific attributes indicate when soil quality declines to critical values.

The dominant soil degradation processes are soil erosion, nutrient depletion, and organic-matter decline. If erosion is controlled at or below acceptable values, and if organic matter is managed by crop residue management and other techniques, many of the other soil-related constraints may also be controlled at acceptable levels. This underscores the interdependence of the biological, chemical, and physical characteristics of soils.

The major physical degradation processes are crusting, erosion, and compaction. These processes are initiated after the removal of organic matter, and lead to a collapse of soil structure. Surface crusts limit seedling emergence and impede water infiltration into the soil, thus reducing available water. Structurally degraded soils produce less biomass, with consequent reduction in organic supply to the soil. Thus the process of soil degradation is self-accelerating.

Current soil management practices are degrading soils in many parts of the world. Acidification of soils in the wet tropics caused by use of ammonium sulphate fertilizers is an example. A more serious situation is induced salinity due to irrigation. The collapse of irrigation systems established at high cost can be avoided by better design, management, and monitoring. Reclamation technology is expensive, though opportunities are available to introduce some degree of sustained production on these soils through research and development.

Wetlands present unique problems, and management of wet soils remains a continuing and special challenge. Current work suggests that even in favourable areas, the very high production levels of wetland systems may not be sustainable with current technologies; in unfavourable areas, production is low and highly variable because of the adverse environmental factors and lack of suitable

technologies. The challenges concerning sustainability are to improve water control, to conserve soil resources, to enhance nutrient cycling, to mitigate methane emission, to enhance integrated pest management, to suppress vector-borne diseases, and to diversify cropping and farming systems. Finally, wetland ecosystems are important and unique habitats for specialized plants and animals, but these habitats are increasingly threatened by demands for rice.

Traditionally, soil properties are not monitored, and degradation of the resource base is not suspected until the system is near collapse. There is an urgent need to develop methodologies to determine the rates and quantities of degradation processes.

Agronomy

Agronomic interventions are intended to enhance productivity whilst also enhancing the resource base. Integrated nutrient management is a key element in crop productivity. The manner in which nutrients are supplied varies with the nutrients and their interactions, the base fertility of the ecosystem, and the pressure on the system to produce food and fibre. In drylands and other areas with an unpredictable supply of moisture, there are strong forces competing for crop residues produced on the farm. Consequently, the nutrients available to crops are diverted to nonfarm sources, and there is a continuous decline in fertility. Even when manures and crop residues are available, they may not constitute an absolute enrichment to soils, since they are only transfers from one field to another. Some areas requiring research include:

- management of organic matter, as a source and sink of plant nutrients;
- nutrient supply systems, preferably based on local sources to reduce reliance on imports;
- cropping systems for degraded lands to both reclaim and improve productivity;
- employing weeds (particularly those that are unpalatable to animals) to recycle nutrients and serve as alternative hosts for pests and predators;
- identifying and monitoring nutrient contamination in groundwaters and irrigation waters;
- enhancing the sensitivity of crop simulation models to soil nutrient contents and temporal variability.

Tillage and crop management practices are some of the key components in the manipulation of land for sustainability. The more important aspects of conservation tillage include mulch farming, minimum-till methods, and other good farming practices such as crop rotation, cover crops, alley cropping and agroforestry. Frequently the challenge is not one of technology but the implementation of the

technology by farmers. Prior to recommending new farming systems or modifying current ones, the following steps have proved useful:

- an assessment of current practices, analyzing the constraints and their causes and the environmental integrity of the systems;
- an analysis of the biophysical and socioeconomic attributes of the farms; the latter includes access to credit, markets, supply services, profits and views of the farmers regarding their stresses and desires to change;
- testing of improved technologies on farmers' fields to evaluate not only the performance of the technology, but also its acceptability, and the degree of technology transfer to other farmers;
- monitoring the performance of the system, and the provision of services.

Productivity improvements in the livestock area of developing countries have been very modest, unlike the situation with major food crops. In part, this is because the feed value of the crop residues (the stems and leaves) of the new high-yielding crops has declined as the partitioning of plant nutrients by plant breeders has been directed towards the greater output and quality of grain. Accelerated soil erosion, rangeland degradation, and deforestation are amongst the consequences of unwise land use involving livestock. Livestock have an important role to play in developing countries in generating funds needed by small farmers to buy fertilizers and other inputs needed to increase crop yields.

Genetic resources

Superior, well-adapted genetic resources, biodiversity, and biodiverse production systems are essential tools in attaining the goals of sustainable land management. The importance of genetic resources and biodiversity to the sustainability of agricultural production systems is proportional to the severity of physical, biotic and economic stresses present in the production environment. These stresses are ubiquitous in both the developed and developing worlds. However, they are usually less severe and more easily overcome in the developed world, where capital and the necessary inputs are accessible and relatively cheap.

Selecting crops for adaptation to adverse edaphic or climatic constraints is relatively simple compared to selection for biotic constraints. For overcoming biotic stresses, which are often cyclical and always dynamic, as pathogens and predators evolve over time, another dimension is needed: biodiversity. Intraspecific genetic diversity clearly enhances the stability of crop resistance to pathogens and predators.

Finally, the importance of preserving of germplasm, including wild-crop relatives, must be emphasized to ensure preservation of the species. The advantage of *in situ* vs. *ex situ* preservation is that with *in situ* preservation, plants can evolve

in their natural habitats. This ensures the maintenance of evolution, which unfortunately is terminated when germplasm is stored in laboratory seed banks. The concept envisaged in the *Biosphere Reserves* of Unesco must be pursued, and agricultural stations in developing countries should be encouraged to create their own 'biospheres', and be supported in this endeavour.

Economics

The sustainability of land use is directly or indirectly dependent on decisions made at individual, family, community, national, and/or global levels. The essence of the problem of resource management is the value system to be placed on natural resources by those making decisions with regard to their use. The valuation is profoundly influenced by the decision-makers' view of who is important (self, family members, country, future generations, animals), and what is important (material wealth, power, community, democracy, equity, justice, nature, spirituality). Most views are increasingly characterized by short-term and self-motivated criteria, which become institutionalized as the only way of doing things. This is one of the causes of unsustainability.

Sustainable land management, to be successful, cannot be separated from the broader context of the sustainable development of society. The sustainable scale of output from renewable natural resources as measured by economic returns to labour and capital is bounded by physical factors which are much more limiting than, for example, industrial production or the production of services. Industrial production can multiply capital tenfold to a thousandfold, but this is not possible from the finite physical resource - a resource which requires transfer of resources from other sources of the economy. The important feature is that this transfer is not made on a charitable basis, but rather on the basis of higher rent rates. Thus in the economic analysis of sustainability, the natural capital stock should remain constant. The concept of economic efficiency then takes a new meaning, namely that all projects yielding net benefits should be undertaken subject to the requirement that environmental damage (natural capital depreciation) is zero or negative.

Economic efficiency is frequently linked to policy issues and decisions. The negative impact of many policy decisions based on sustainability criteria usually occurs because th decisions are serving some other purposes such as increased exports, responding to political pressures, or benefiting some segments of society, with little or no consideration being given to the environmental impact. Although many of the negative impacts are unintended, farmers do in fact suffer, poverty increases, and environmental degradation is accelerated.

Stewardship

Good stewardship normally requires wealth above subsistence levels; otherwise the resource base is continuously depleted to satisfy basic needs of food and shelter. The wealth required is seldom accumulated from agriculture alone. Indeed, where agriculture is dependent on inputs of technology, as in the developed world, increased production benefits the consumer more than the farmer, since production increases are equated to a decline in the product price. Subsidies designed to encourage conservation on a cost-sharing basis supplement net farm income, but often encourage overproduction on marginal lands and inflate land prices and input costs. Furthermore such subsidies disadvantage farmers in the developing world by causing the erection of trade barriers and distorting world prices.

The blame lies with a system that encourages production at the lowest cost, regardless of how it is achieved. To break this impasse, the public must be alerted to the nature and the magnitude of the problem, and the farmer must surrender some of his control over land management in return for payment by the general public of the cost of conservation and stewardship.

In the wealthy nations, there is a need to understand that poverty in the developing world reflects the poor quality of production resources and infrastructure, and not laziness or incompetence. In favoured areas, it may be difficult to destroy land quality, even by bad farming; but in much of the developing world it is difficult to avoid destruction no matter how good the farming practices are. The wealthy nations must be persuaded not only to restore the quality of their own environment, but also to help those who are less fortunate. Global sustainability has no national boundaries.

Public education needs to be followed by policies which reward efficient production. The product offered at the lowest price is too often produced by practices that are not in the public interest - public costs for private gains must be terminated. In Africa, Asia, and Latin America, problems of land tenure present particular obstacles to sustained agriculture. Clear-cut ownership of rights to land and water provide not only social status and prestige, but also long-term security - which is also the very basis of sustained production. Political pressure from large land owners against even modest land reform is especially detrimental to sustainability.

New technologies, centred on the use of computers, offer means of coordinating agroecological knowledge and/or refining estimates that will assist decision-makers to plan policy changes and resource requirements for establishing sustainable agriculture. The planned interventions need to be adjusted for farmer preferences and local customs before they are likely to be adopted. Experience in developed and developing countries has emphasized how important the adoption

of new initiatives is dependent on farmer assessment of their validity in socioeconomic as well as technical terms. Land management initiatives must have long-term objectives, but farmers, especially in developing countries, look to short-term benefits for their very survival. Planning may need to include provisions for such short-term benefits. Above all, the farmer must be convinced that the innovations are necessary and worthy of his time and labour. The innate conservation ethic within most active farmers must be stimulated to achieve benefits for production as well as for the environment. It will be the individual efforts of millions of farmers, individually and collectively managing their resources, which will ultimately be the deciding factor in implementing conservation.

Methods

The assessment of sustainability calls for unprecedented interdisciplinary effort. Each assessment requires understanding of the interaction between humans, plants, animals, and their environments, i.e. of the whole ecosystem. Furthermore, to bring about changes in land-use practices with the aim of bringing land into sustainable production requires understanding of those factors that make an ecosystem persistent. Interactions between the biophysical environment and socioeconomics are important. For example, proximity to markets may determine the economics of compensating for loss of fertility by increased fertilizer use.

Generations of evolution have gone into the establishment of many successful agricultural systems previously thought to be sustainable, including the traditional slash-and-burn or bush-fallow systems. It will not be easy to achieve comparable sophistication of environmental adaptation on the basis of relatively short-term scientific monitoring. Western agriculture has evolved through a process aimed at maximizing production against a background of assured inputs and a more conservation- conscious approach, while accepting lower production goals, must necessarily be based on new social, economic, and political thinking involving cost-sharing across society. A particular socioeconomic constraint on evaluation lies in the possible geographic separation of controls on agriculture and the effects of agricultural practices. Land degradation may be noticed first at farm or regional level, but production strategies are determined by factors external to the region, such as fuel costs, input prices, and markets.

The success of many natural and agricultural ecosystems is based on change. A succession of plant communities, shifting cultivation, and crop rotation are flexible responses to outside disturbance. But developed agriculture largely eliminates high successional changes, breaking natural cycles of replenishment and favouring enhanced leaching, decomposition, and actual loss of soil. The 'connectedness' of

natural system components would contribute to the resilience of production. Clear-cut forestry, arable agriculture and a socioeconomic organization based on inputs and outputs steered from outside the region conspires to reduce 'connectedness' and thus the resilience of agricultural systems. Studies of sustainability need to examine risk associated with this loss of resilience and the cost of external inputs - calling for an understanding of entire ecosystems.

No system is sustainable if outputs are greater than inputs. The export of nutrients in crops must be balanced by fertilizers or other inputs once the limiting levels in soils are reached. Many factors determine these limiting levels. Nutrient balances need to be assessed for individual nutrients to reflect differential uptake by the crop and the return in crop residues. The evaluation of long-term fertility requires understanding of the complex chemical and biological transformations that influence individual nutrients.

On a regional scale, the picture is still more complex. Sustainability is closely linked, for example, to events upstream, which may result in renewed sedimentation, water excess or shortage, or cause salinization. Sustainability in one place may be linked to the water balance of the whole region. Improved management of uplands may serve to stabilize agricultural potential in an entire continent.

Assessment of sustainability may call for different measurements in different ecosystems. Total soil organic matter is most important in temperate grasslands. In tropical savannas, active organic matter and some nutrient pools need to be determined, whilst in the tropical rainforest, nutrient cycling through the litter-root mat is critical. Thus ecosystems differ with respect to processes, and this must be realized to ensure productivity maintenance.

Geographic Information Systems (GIS's) coupled with simulation models are valuable tools in the evaluation of sustainable systems. Models have the capability of testing different scenarios, and so are also research tools. Although there are several models which evaluate components of systems, models to evaluate sustainability have yet to be devised, and remain a challenge for the future. The greatest constraint in the application of many models and of GIS technology in developing countries is the availability of data. Standardization and quality of data are additional areas of concern, and the application of computerized technology will be futile if improvements in these areas are not made.

PART II: A FRAMEWORK FOR SUSTAINABLE LAND MANAGEMENT

Background

Participants at the workshop agreed on the need for a standard, systematic approach to the assessment of the sustainability of land management practices. A procedure was needed that in principle could be applied internationally, in all environmental circumstances, and at all scales of generalization. At the same time, the approach needed to be simple in concept, comprehensive in its application, and capable of development, even of quantification, as knowledge and experience is gained with use. This is not a simple proposition.

A keynote paper given in the opening session of the workshop[5] provided some initial ideas and a focus for discussion on the development of a procedural framework. The following account reflects progress made at the workshop in developing these initial ideas.

Purpose

The *Framework for Land Evaluation* published by FAO in 1976 and widely adapted since, provided a method of assessing the suitability of specific alternatives of land use on specific kinds of land.[6] All stages in the processes of evaluation within the *FAO Framework* were required to conform to each of six basic principles, of which the fifth states that "suitability refers to use on a sustained basis". No procedures for assessing the sustainability of land utilization types were included in the *Framework for Land Evaluation*. It is intended that the proposed framework for sustainable land management (FSLM) should provide a logical and practical method of fulfilling this need.

It is stressed that the proposed framework is a structured methodology for evaluating land management decisions and an aid in such decision-making; it is not intended to provide a recipe book for sustainable land management. Nevertheless a fully developed FSLM incorporating defined approaches and actions in all fields of

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5 Dumanski, J., Eswaran, H. and Latham, M. 1991. An international framework for evaluating sustainable land management. This workshop.

6 FAO definites lands as "an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic attributes of the biosphere, including those of the atmosphere, the soil and underlying geology, the hydrology, plant and animal populations and the results of past and present human activity, to the extent that these exert a significant influence on present and future uses of the land. Land is thus a broader concept than soil or terrain."

natural resources and economic sciences would provide a check list of the issues which need to be considered at several different stages in land management planning. It would assist in identifying gaps in knowledge, and therefore research needs, in relation to scientific management practices. It will guard against oversight of potential problems in various subject-matter areas during the planning stages of development. Later it will serve to structure systematic monitoring of progress in development along a sustained productivity pathway, emphasizing the interactions of environmental, sociological, and economic parameters.

A strategic framework that would serve these purposes in an international context, in a very wide variety of circumstances, will take time and much cooperative work to develop. In the meanwhile, however, lesser frameworks may be constructed to serve local and immediate purposes. These may lack the security of internationally tested concepts, but will gain from their immediate application to local problems, and will at least provide a systematic approach to the evaluation of sustainability.

Similarly, in the early stages of development, assessments of the extent to which actions and approaches approximate to desired norms will have to be assessed largely on a basis of common sense. Later, through research and experience, it is expected that the basis of such comparisons will be quantified, providing data sets and critical values for numerical evaluation.

A fully developed and comprehensive FSLM could be expected to be complex, and possibly daunting to potential users. At all times, however, it should be possible to make a selection from the overall framework of those elements that bear directly on the immediate problem in hand. This would facilitate a conscious selection, made with reasonable confidence that no important issues have been overlooked.

The structure of the framework

It is proposed that FSLM be structured as a hierarchical system (Figure 1) with five levels. These levels, in descending order of generalization, are named and described as follows:

- GOAL: A general statement of *what* the framework is intended to achieve.
- OBJECTIVE(S): (A) specific statement(s) of what the framework is intended to achieve. Any objective will include explicit statements against which progress can be measured, and identify which things are truly important and the way in which they interrelate. Several objectives can be developed for a single goal.
- AIMS: Statements which represent different pathways between objectives and actions, called for by differences in the problems or the key resources involved. There may or may not be several aims to each objective.

- APPROACHES: Statements of *how* in general separate aims are to be evaluated or implemented, based on the scientific principles to be used in the evaluation. The approaches imply direct activity, and should lend themselves to rigorous measurement and the establishment of indicators to determine their contribution to the aims and objectives. Several approaches may pertain to each aim.
- ACTIONS: Statements of specific actions to be undertaken to accomplish the intent of each approach. Several actions may contribute to each approach.

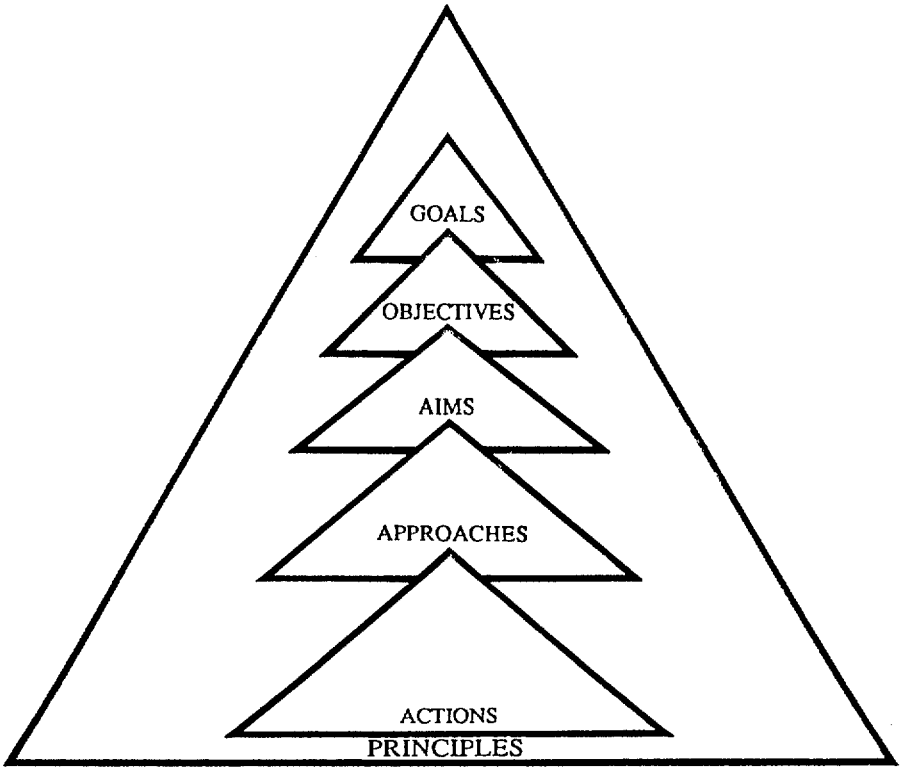

Figure 1. An international framework for sustainable land management.

A partial framework derived from discussions in the working groups at the workshop is shown in Table 1. This illustrates the kinds of statements that might

Table 1. A partial framework developed from the reports of three working groups at the workshop (soils and agroclimate, agronomy, and environment).

GOAL STATEMENT: To identify and evaluate sustainable land management practices, as a prerequisite for agricultural land development, research planning, and agrotechnology transfer.		
OBJECTIVE STATEMENT: To develop a science-based international framework for evaluation of sustainable land management practices which simultaneously: - maintain or increase production, - reduce the level of production risk, - do not deplete soil and water quality and achieve economic stability, - are economically viable and socially acceptable, - aid in decision-making in developing countries.		
AIMS STATEMENT (Soils and agroclimate) 1. To develop the basic principles and identify **physical** guidelines for sustainable land management, particularly agroclimatic and soils criteria.	AIMS STATEMENT (Agronomic) 2. To develop the basic principles and identify **agronomic** guidelines and criteria for sustainable land management.	AIMS STATEMENT (Environment) 3. To develop the principles and criteria to manage rural and urban environment so as to limit the on-site and off-site impacts of degradation, while maintaining sustainability, optimizing economic reliability, and ensuring social well-being.
APPROACH STATEMENT To ensure an adequate nutrient supply and minimize toxic/stress effects.	APPROACH STATEMENT To optimize the economics and the environment through the utilization and efficient management of external inputs.	APPROACH STATEMENT To apply and manage agrochemicals, manures and urban wastes to minimize adverse environmental effects on the land, ground, surface waters and the atmosphere.
ACTION STATEMENTS 1. Add and recycle organic materials. 2. Add suitable kinds of fertilizers in appropriate ways. 3. Use nitrogen-fixing plants. 4. Use pH-influencing amendments such as lime, gypsum, and sulphur.	ACTION STATEMENTS 1. Maintain the nutrient balance in relation to the ability of the soil to store and supply nutrients for crop growth, through the combined use of crop residue, legumes, manure, local agrominerals, and chemical fertilizers. 2. Optimize the use of amendments for the improvement of problem soils and degraded lands. 3. Integrate cultural practices and the use of herbicides and pesticides.	ACTION STATEMENTS 1. Develop a fertilizer code of conduct with reference to specific agro-ecological zones. 2. Promote integrated crop management. 3. Implement a pesticide code of conduct. 4. Develop mitigating options for methane and N_2O emissions and nitrate leaching.

appear at each of the five levels of the framework and the relationships between them.

The example statements in Table 1 are taken directly from the reports of three working groups, which are presented later. These particular approach statements and related action statements have been selected as illustrations, because they describe closely related problems, identified and examined independently by the three groups. No attempt is made here to reconcile the proposed actions, though some have close similarities. In developing a final framework some reconciliation of proposed actions by multidisciplinary teams is essential.

Constructing a framework

A FSLM is constructed from the top downwards by defining a goal and then developing appropriate objectives, aims, approaches and action statements relevant to this goal. Some working principles (Table 2) and guidelines (Table 3) are presented to illustrate the possible choice of statements and criteria at all levels of the framework.

Table 2. Working principles.

- The choice of criteria and the indicators of sustainability are based on an understanding of the causes as well as of the symptoms, to achieve both prevention and cure.
- The evaluation is based on scientifically valid procedures and data to ensure increased probability of successful solutions and to instill confidence.
- The collection and integration of data is carefully and consciously focused and directed on the real problem to be evaluated, in an attempt to achieve a reliable solution at an acceptable cost.
- Recommendations for changes are developed first of all on an understanding of existing processes and practices, to ensure that progress towards the intended goals are attained.
- Field validation should precede the widespread introduction of new practices to prevent costly mistakes (validation guidelines will have to be prepared).
- All parties with a legitimate interest in an evaluation are identified and involved as early and as thoroughly as possible to ensure cooperation and to achieve an acceptable solution.

Table 3. Some general guidelines for the FSLM.

The framework for evaluating SLM will:

- concentrate primarily on the field scale of sustainability, whilst providing mechanisms for integration with higher levels;
- be based on scientifically sound principles of soil management agronomy, land stewardship and economic farm management;
- focus on practical methods, measures and data for assessing environmental criteria, particularly those criteria whose impact on sustainability can be inferred most readily;
- take account of all the most important dimensions of sustainability;
- recognize that criteria and indicators of sustainability are dynamic in space and time;
- incorporate procedures for assessing the biological potential of the environment (involving the matching of innovations in applied technology with local environmental characteristics), but include recommendations for additions or manipulations, environmental resources where necessary to maintain, or enhance, the environmental inheritance of future generations.
- incorporate assessments of risk and production variability in the development of criteria and indicators of sustainability;
- recognize that indicators of unsustainability are as informative as indicators of sustainability.

Each statement in the framework must be tested in three ways to ensure internal conformity and consistency with the overall framework, and should conform to the following criteria:

- Each goal, objective, aim, approach, and action statement should be examined to ensure that it does not contravene any of the working principles (Table 2).
- The vertical conformity of the framework should be tested to ensure that no statement is at variance with statements linked above and below.
- The horizontal conformity of the framework should be tested to ensure that statements at the same level but relating, for example, to different objectives or aims are not at variance one with the other, notwithstanding that they may relate to different fields of scientific investigation.

Given the complexity of the real world and the present early stage of FSLM development, it is recognized that some flexibility must be permitted in this checking process. Rigid adherence to conformity in every word or phrase is not intended, but rather that checking should reveal any active violation of the working principles or active conflict within the structure.

The partial framework (Table 1) serves to illustrate the need to cross-check each horizontal level of the framework for conformity and repetition. No attempt has been made in Table 1 to reconcile statements of the different working groups. The different statements reflect different perspectives of problems, and at this stage in the development of the framework, they are useful in representing the different specialized concerns.

The more modest (more specific) the chosen goal, the less elaborate is the required framework likely to be. If, as has been suggested, a strategic framework is developed internationally, designed to meet all circumstances of sustainable land management practices, it can also be used to develop simpler frameworks for local use - by conscious selection of the relevant aspects of the larger framework.

Using the FSLM

Although a framework is constructed from the top down, it is normally used from the bottom up. This involves checking actions and approaches planned in a proposed project, against goal, objective and aims statements, and in relation to the context of the principles of FSLM. This checking is systematic, and is intended to ensure that the project and the framework are in conformity with each other.

Table 1 may be used as an example to cross-reference a report of a specialized group with the other disciplines. At a later stage in the development of FSLM, the linkages between the different speciality areas will emerge. As an example, if the aim from an agronomic point of view is to increase organic carbon content to a threshold level, and several approaches are recommended, the validity of the aim and approaches are then examined from an economic, social, and environmental point of view prior to arriving at viable options. The same procedure is followed for each of the latter evaluations. The horizontal component of the framework, when developed, will permit this final assessment.

Once numerical indicators and critical values have been assigned to actions and approaches that are quantifiable, the FSLM can be used to monitor the direction and progress of the project on a semiquantitative basis within established margins of sustainability.

PART III: WORKING GROUP REPORTS

Working groups

Working groups were an integral and an important part of the workshop. A total of six working groups were convened, and each group was assigned a defined aspect of the concept of sustainable land management. The groups dealt with soil and agroclimatic, agronomic, environmental, economic, and stewardship criteria. The last group discussed methods applicable to sustainability, particularly with regard to quantification. Although each group had specific terms of reference, they were requested to examine these in the context of sustainable land management as a whole.

To facilitate their work, each group received a set of instructions indicating the range of subject matter to be discussed and the expectations of the organizing committee. For most of the participants, the procedure was new, and some groups had difficulties in adjusting to the requests. The organizing committee prepared a set of GOAL and OBJECTIVE statements which were common to all groups. Each group was then requested to develop their specific AIMS, ACTION, and APPROACH statements in the context of the OBJECTIVE. The purpose of this approach was to enable the groups to become familiar with the strategic framework and to report difficulties in approach or concepts. In addition, the groups were requested to:

- examine the AIMS statement for relevance and pertinence and to prepare new statements if necessary;
- develop APPROACH and ACTION statements within their terms of reference;
- test each ACTION and APPROACH statement for congruence at higher levels of the framework and against the principles of the framework;
- examine the proposed definitions for sustainable land management and to suggest improvements;
- comment on the general usefulness of the proposed structure and to recommend improvements where necessary;
- identify practical but viable indicators and criteria that could be usefully employed to evaluate sustainable land management;
- develop recommendations for the organizing committee or others for further action.

The GOAL and OBJECTIVE statements were as follows:

GOAL STATEMENT: To identify and evaluate sustainable land management practices, as a prerequisite to agricultural land development, research planning, and agrotechnology transfer.

OBJECTIVE STATEMENT: To develop a science-based, international framework for the evaluation of sustainable land management practices, which would simultaneously:

- maintain or increase production;
- reduce the level of production risk;
- not deplete soil and water quality, and achieves environmental stability;
- economically viable and acceptable;
- be an aid in decision-making in developing countries.

The time available for the working groups was inadequate to respond to all the charges and also was not sufficient for the groups to interact between themselves. However, the group members made valuable contributions, which are presented later. They are necessarily not complete, but indicate the general structure and approach.

Group 1 - Soils and agroclimate

The charge of the working group was to evaluate sustainable land management practices in relation to land as a renewable, natural, living body, and not simply a factor of production or a medium for rooting or for tillage. Interactions among the factors of soil, agroclimate, and management that promote or detract from sustainability were to be examined, particularly as these relate to assessing and/or ameliorating production risks.

The working group discussed the role of soils as a vital, biological natural resource. Concerns over the soil resource must be expanded beyond soil productivity considerations to encourage the concept of soil quality. The group felt that there is a need for a more quantitative approach to determining sustainability. In particular, it saw an urgent need to prepare sets of relevant data and to develop sound, quantitative indices of soil quality and agroclimate. At an early stage, soil quality must be conceptualized and quantified, and short- and long-term indices should be developed from which sustainable land management practices can be assessed. A quantitative approach is necessary if modelling is to be used successfully in the evaluation of sustainable land management. The group recognized that there is usually a high degree of interdependence and interaction among the various factors and therefore requirements and actions must be site- and system-specific.

Soil organic matter is a key factor in sustainable land management because of its vital role in maintaining soil quality through its effects on soil structure, water-holding capacity, and nutrient supply. Soil organic matter is a dynamic resource which must be maintained and replenished. Functional and diverse soil organisms are central to organic matter flux, soil nutrient availability, and the development and maintenance of soil structure.

Physical factors affecting biological functions in soils include oxygen supply, water, temperature, and mechanical resistance. Air and water availability are influenced by the number, size, and continuity of soil pores, whereas storage depends largely on water-holding capacity, which is determined by organic-matter content, structure, and texture. Soil temperature and mechanical conditions can also have major effects on plant growth and development. Essential plant nutrients should be present in the soil in amounts which allow for optimal plant growth. In many situations, this can only be achieved by supplementation. In addition, toxic and stress effects in plants and other organisms can be caused by soil acidity, salinity, and alkalinity.

Soil erosion is often considered to be the most serious form of soil degradation. Erosion removes topsoil, which contains organic matter and plant nutrients, and may expose subsoil material which is less suitable for plant growth. Siltation of streams, lakes, and reservoirs is a common environmental consequence of soil erosion.

Management systems which optimize the climatic resources of an area and minimize the adverse effects of temperature, precipitation, or wind will assist in achieving the goals of maintaining or increasing production, reducing the level of production risk, and achieving environmental stability.

The working group developed the following AIMS, APPROACH, and ACTION statements as examples:

AIM:

To develop the basic principles, identify soil and agroclimatic criteria, and prepare guidelines for sustainable land management.

APPROACH AND ACTION STATEMENTS:

1. Achieve or maintain optimal levels of soil organic matter
   - use management practices, such as green manuring, incorporation of crop residues, efficient use of animal manures, etc.;
   - use appropriate farming systems.
2. Achieve or maintain functional and diverse soil organisms
   - manage soil reaction;
   - use agrochemicals judiciously, especially biocides.
3. Achieve or maintain desirable air, water, temperature and mechanical conditions
   - use practices such as mulching, and appropriate tillage, etc.;

- use structure-improving practices (such as the incorporation of organic materials, amendments) and grow deep-rooting crops;
- irrigate and/or drain.

4. Ensure an adequate nutrient supply and minimize toxic/stress effects
   - add and recycle organic materials;
   - add suitable kinds of fertilizers in appropriate ways;
   - use nitrogen-fixing plants;
   - use pH-influencing amendments, such as lime, gypsum, and sulphur.
5. Minimize soil erosion
   - maintain an adequate soil cover;
   - use infiltration practices, such as tillage, lime additions, etc.;
   - use soil conservation practices (such as strip cropping, terracing, windbreaks), and optimize animal-stocking density.
6. Optimize the use of climate resources and minimize climate related risks
   - match crops, cropping patterns, and other land uses with rainfall and temperature regimes;
   - apply mulch and use cover crops and/or windbreaks;
   - provide irrigation, flood protection, etc., and use water harvesting.

Group 2 - Agronomy

The working group was charged with the task of identifying agronomic practices that maintain and/or enhance soil and water quality and achieve environmental stability while maintaining the economic viability and social acceptance of the practices. Costs and benefits, labour requirements, crops and enterprise diversification, and risk ameliorations were to be considered.

The working group developed approaches and actions for sustainable land management in developing countries applicable to small-scale subsistence farmers and to large-scale commercial farming. They recognized that farming systems have to be adapted to the climate, soils, and socioeconomic endowments that prevail. They developed research and management recommendations so as to enhance or maintain soil and water quality, increase income and reduce risk, maximize production, conserve and use biomass, and increase the efficiency of inputs.

The working group adopted the AIMS statement assigned to it and developed APPROACH statements and a series of ACTION statements as examples for each:

AIMS STATEMENT:

To develop the basic principles and identify agronomic guidelines and criteria for sustainable land management.

APPROACH AND ACTION STATEMENTS:

1. Use traditional farming systems and land-use patterns as the basis for developing and improving sustainable land management practices
   - identify the role of biodiversity in reducing risks, conserving resources, and improving efficiency;
   - identify factors which determine farmer acceptance of new land management practices;
   - relate land-use systems (cropping practices) to the scale of catchments or even larger scales.
2. Promote farming systems and cropping systems to maximize diversity, reduce risks, enhance conservation, and ensure efficient use of resources
   - include intercropping, agroforestry, crop-livestock mixes, and crop rotations and sequences in relation to site conditions of the environment and socioeconomic constraints.
3. Improve the quantity and quality of soil organic matter by increasing the quantity and diversity of organic inputs, and by manipulating the rates of decomposition and synthesis of organic matter
   - include production systems which provide a range of organic inputs differing in rates of decomposition and mineralization;
   - include tillage, irrigation, liming, mulching, and other soil management practices so as to optimize patterns of nutrient release and soil organic-matter quantity and quality;
   - develop process-based models for production and monitoring of soil organic-matter dynamics in relation to the environment and management.
4. Optimize the economics and the environmental utilization and efficient management of external inputs
   - maintain the nutrient balance in relation to the ability of the soil to store and supply nutrients for crop growth, through the combined use of crop residues, legumes, manure, local agrominerals and chemical fertilizers;
   - optimize the use of amendments for the improvement of problem soils and degraded lands;
   - integrate cultural practices with the use of herbicides and pesticides.
5. Improve soil physical conditions for better crop establishment, root development, and erosion control
   - use tillage practices adapted to specific environmental and socioeconomic conditions;
   - use cropping patterns to encourage soil physical properties through root action, organic residues, etc.;
   - protect surface soil with cover crops and residues.

6. Maximize plant-available water, maintain adequate moisture conditions throughout the growing season, and minimize erosion and salinization
   - increase infiltration through improved soil physical conditions, land shaping and continued soil cover with plants and residues;
   - improve drainage conditions to increase aeration, reduce erosion, and prevent salinization;
   - adopt irrigation systems, levels, and scheduling to provide desirable soil moisture conditions while minimizing salinity by ensuring adequate drainage facilities.

Group 3 - Environment

The working group was charged with the task of developing practical guidelines and criteria to identify land management which maintains or enhances soil and water quality and promotes environmental stability. It was also asked to consider the impacts of degradation on risk, the amelioratory and off-site effects of pollution, and the preservation of the resource base in the context of sustainable land management systems.

The working group agreed that the implementation of sustainable land management practices are constrained by the belief that most of these practices will lead to reduced agricultural output, at least in the initial stages of implementation. Also, existing extension services are often ineffective in demonstrating the value of innovative techniques. There is also a lack of political support for new proposals, and there is a tendency to adhere to traditional practices, particularly those which are proven to be environmentally damaging. There is a need to ensure that social, economic, institutional, and political constraints be taken into account in the development and implementation of new technologies for sustainable land and water management and productive agricultural systems.

The rational and balanced use of agrochemicals and resources is essential for continued and sustained agricultural production to avoid exhaustion of the soil resource base. However, this use must be such as to minimize environmental hazards and pollution. Soil and water resources exist within particular environmental envelopes, with defined limits, and land-use and management impacts must be in balance with these limits. Geographic Information Systems, remote sensing techniques, and other such technology are useful tools to facilitate the matching of land use to the limits of environmental tolerance.

Overstocking of rangelands, leading to serious degradation and decreased carrying capacity, are common in many countries. There are mechanisms to prevent these with appropriate planning and management. There are many potential

synergisms to be realized by matching livestock and forage production with edaphic and climatic conditions. These include increasing residual soil fertility, interrupting disease and pest cycles, and reducing weed infestation. The absence of an adequate vegetative cover, shortened fallow periods, deforestation, overgrazing and improper methods of soil tillage are the chief causes of soil degradation.

Modern, economical agriculture has become increasingly biouniform, with the concomitant dependence on purchased inputs to control pests and diseases. This dependence and the antecedent costs can be reduced with appropriate biodiversity, including multilines or varieties and line mixtures, rotation, integrated grazing, biological control systems, and mixed-tree plantations. The conservation of the genetic resources is a key approach to environmental protection.

The working group developed an AIMS statement and five APPROACH statements, with a series of ACTION statements for each as examples:

AIMS STATEMENT:

To develop the priorities and criteria to manage rural and urban environments so as to limit the on-site and off-site impacts of degradation, while maintaining sustainability, optimizing economic viability, and ensuring social well-being.

APPROACH AND ACTION STATEMENTS:

1. Apply and manage agrochemicals, manures and urban wastes to minimize adverse environmental effects on the land, ground and surface waters, and the atmosphere
   - develop mitigating options for methane and N_2O emissions and nitrate leaching;
   - develop a fertilizer code of conduct with reference to specific agroecological zones;
   - promote integrated crop management;
   - implement an international pesticide code of conduct.
2. Rationalize land and water-resource planning, with on- and off-site environmental considerations
   - conduct agroecological zonation with particular attention to water availability and deep percolation;
   - assess surface and groundwater potential for agricultural and nonagricultural use and drought, or other climatic hazards;
   - apply integrated crop and crop-livestock management systems;
   - examine the conjunctive use of surface and groundwater, and the integration of irrigation and drainage schemes;
   - conduct impact assessments and monitoring at all stages of development.

3. Develop grazing and rangeland procedures to effect integrated livestock-cropping systems
   - determine and apply realistic long-term carrying capacity for grazing lands;
   - determine and apply rotational grazing;
   - make use of biological nitrogen-fixing fodder crops and crop residues to supplement ranges and pastures.
4. Maintain or establish soil cover, including forests, to enhance infiltration, reduce runoff, erosion, and weeds
   - integrate the use of cover crops, crop residues, mulching, biodegradable biological mulches, and conservation tillage (where appropriate) to protect the soil from the erosive action of rain;
   - promote agroforestry systems to intercept and lessen the erosive impact of rain;
   - promote techniques of water harvesting, particularly in arid and semiarid regions.
5. Maintain and enhance biodiversity and genetic resources
   - identify gene pools and enhance the preservation of the genetic resource base;
   - ensure a diverse genetic base for new cultivars;
   - maintain a source of genetic materials from existing farming systems and forests;
   - establish and maintain reserves, parks, and sanctuaries, of a size sufficient to support genetically healthy populations and animals.

Group 4 - Economics

The working group was charged with the task of examining and developing economic criteria and indices with which to estimate and predict economic performance and the long-term viability of different farming systems, related to the maintenance of the natural resource base. The group was also required to examine the need for new techniques for economic and environmental accounting, and to provide a proper balance between environmental and economic imperatives.

The working group maintained that the goals and objectives suggested by the organizing committee were inadequate, and it was of the opinion that if sustainable land management is to be characterized in economic terms, it must be framed within the context of the period of evaluation, the quality of life anticipated and the society under consideration.

The group used a systems approach to examine the economic dimensions of the proposed framework for evaluating sustainable land management, beginning with

farm-level criteria. At a higher level, macroeconomic considerations determine economic evaluation. It is also recognized that policy and programme decisions may often jeopardize decisions regarding sustainable land management. A continuous iterative approach was recommended to reflect changing conditions over time and space.

The group identified that improved environmental and social accounting methods are necessary to fully integrate and account for resource use and degradation assessment under different land-use systems.

The working group assumed the AIMS statement assigned to it, and it developed four APPROACH statements and several ACTION statements for each as examples. In addition, the working group developed some recommended indicators by which each action statement could be assessed, and thus progressed further than any of the other groups.

AIMS STATEMENT:

To develop the basic principles, and to identify economic guidelines and criteria for sustainable land management.

APPROACH AND ACTION STATEMENTS:

1. Maintain an economically viable operation that over time contributes to improvements in household income
    - establish baseline data from which to monitor change
    - review performance over time
    - adjust or modify as necessary

    Some indicators against which actions can be measured are: return on capital, return on labour, return on land, gross returns, cash expenditure, labour demand throughout the year and an assessment of economic viability and risks
    - assess economic variability and risk

    Indicators for assessing economic risk are: diversity and resiliency.
2. Ensure that agricultural policies do not jeopardize decisions towards sustainable land management
    - assess domestic market distortions
    - assess international market distortions

    Indicators for assessing effects of policies are: prices, government interventions, subsidies, trade barriers (including nontariff), and exchange rates
3. Ensure environmental and social accounting
    - assess off-site effects

    Indicators of off-site effects are: the environmental costs of the action, policy, or programme.
    - assess the equity effect

Indicators for assessing the equity effect are: the distribution of income, land, and other assets of wealth.

4. Ensure political accounting
   - decentralize decision-making responsibility
   - assure high congruency between involvement in and being effected by decisions

   Indicators of political accounting are the proportion of persons involved in and affected by a decision.

Group 5 - Stewardship

The working group was charged with the task of evaluating the special, political, policy, and infrastructure implications of sustainable land management, as these might affect farm-level decisions, and aspects of global environmental change. Considerations on the need for regulation and/or legislation were to be included where appropriate.

The working group agreed that its primary task was to identify and evaluate the sustainability of land management practices in terms of their social acceptance by farmers. The group developed a definition of stewardship as being sets of political, social and cultural values which ensure group self-regulation in and caring for the future.

The principles of stewardship require equal and unbiased opportunity for access to basic human needs. They also identify the right of future generations to land resources of at least equal quality to those of their predecissors. Stewardship requires the participating development of all individuals or all levels of society, based on freedom of belief and action, and predicated on the maintenance of the dignity and worth of individuals.

The concept of stewardship needs to be promoted at the farm level, but also throughout all levels of society. The farmer ultimately acts as the steward of the land, but the responsibility for stewardship must be shared by everyone. Sustainable land management practices must be consistent with the cultural values of the group for whom they are intended. The working group identified that ownership of land is more likely to ensure the necessary investments which would promote stewardship.

The working group accepted the AIMS statement assigned to it. They developed seven APPROACH statements as examples, and ACTION statements for five of them.

AIMS STATEMENT:

To develop the basic principles and identify stewardship guidelines and criteria for sustainable land management.

APPROACH AND ACTION STATEMENTS:

1. Ensure that local socioeconomic and cultural values are taken into account when developing sustainable land management for farmers
   - identify traditional practices that are considered to be sustainable;
   - evaluate changes that can occur which effect stewardship;
   - assist land users to respond to changes by improving farming systems compatible with their needs, knowledge, tools, and sites.
2. Ensure that the scale of sustainable land management is related to the land tenure, to the viable production unit, and to the family level
   - identify local perceptions and evaluate the amount of land and degree of security of tenure needed to encourage stewardship;
   - develop guidelines for the incorporation of a minimum living area and tenure conditions into government regulations.
3. Ensure that solutions on soil conservation are tailored to the nature and magnitude of the problems
   - evaluate the long-term impact of soil conservation on the productivity of society;
   - identify and evaluate solutions that are socially acceptable to farmers;
   - identify and promote policies that would ensure that solutions are accepted.
4. Ensure that sustainable land management would not advantage one group at the expense of others
   - evaluate the impact and cause of pollution as perceived by local farmers and communities;
   - provide information and education on the consequences of an absence of stewardship.

Group 6 - Methods

The working group was requested to investigate methods by which sustainable land management can be evaluated, given that sustainability requires a time dimension of some given duration. It was also requested to assess the types of experiments that will be necessary to research sustainability and to review experiences with empirical and mechanistic models.

The working group examined the strategic framework approach as proposed by the organizing committee, and concluded that it was inadequate. The strategic

framework is effective in integrating information vertically, but it currently lacks a structure to facilitate lateral integration among the components of sustainability. Such a procedure is essential for the further rational evolution of an international framework. However, the working group did not discuss specific recommendations on how this was to be achieved.

In examining methods to research sustainability, the group stressed the use of equipment with the capability of application in different situations. Reliance on sophisticated equipment is not essential, though eventually it is expected that computer-based systems will be developed to manipulate the framework. The group identified that detailed knowledge on the requirements and aspirations of the target group (farmers) is essential for the proper design of any evaluation system, and these have to be framed in the context of the prevailing social and political conditions.

The group developed a logical structure for experimentation and monitoring of sustainable land management. It further developed suggestions for each element of the structure, but it is emphasized that a set of 'tools and techniques' and 'evaluation and support' components are required by each element of the structure. The group also developed an AIMS statement and APPROACH and ACTION statements as examples for each identified component.

AIM:

To develop an approach for an evaluation of sustainable land management.

Inventory and systems analysis

- Use the physical and socioeconomic environment as well as the processes of change within the area of study to set priorities for the evaluation study, focusing on the probability of success and the potential pay-off, and avoiding projects that have only a minimal chance of success.
- Consider methods of data collection relative to scale and system boundaries, the sampling domain, and statistical principles of sampling.
- Consider methods that incorporate data generated by experiments, derived data, surveys, historical information, and indigenous knowledge.
- Develop minimum data sets of land attributes, appreciating that the objectives and methods will determine the kinds of data.

Action statements:

- Derive scale and system boundaries on the basis of systems analysis.
- Study in detail the components and dynamics of systems.
- Approach studies in a multidisciplinary manner.

Experiments

The approach to experimentation should focus not only on the components of the system, but also on a study of system dynamics. The intended output is a

quantification of sustainability. The following activities need to be carried out with careful attention:

- Identify the minimum duration of an experiment, particularly when components of sustainability are controlled by climatic events.
- Identify the requirements for replication and location of the experiments to obtain a better assessment of the land unit.
- Conduct an initial rapid appraisal to evaluate the magnitude of the task, followed by more organized approaches based on needs and facilities.

Action statements:

- Design experiments to quantify sustainability, either directly or by providing inputs into models.
- Incorporate design and analysis criteria and procedures based on acceptable experimental controls.
- Develop minimum data sets which include observable or measurable indicators of sustainability/unsustainability, and attributes of the environment.

Monitoring changes

Monitoring of properties and/or events is essential to understand the behaviour of the system and to detect deviations from intended trends. The performance of the systems over short and long time frames are equally important. The following actions are recommended:

- identify a set of early indicators of direction of change in a system;
- establish quantitative indicators of change as well as associated minimum data sets for the determination of trends.

Impact assessment

The evaluation of sustainable land management is based on the prediction of the future performance of the land-use system. When considering the attributes of the environment which affect the performance of land-use systems, a distinction has to be made between those that are effectively replaceable (such as nitrogen) and others that are not (such as soil depth). The evaluation should also address the impact of the land use considered on the aspirations of other land users such as downstream populations. Consequently:

- identify the attributes of the environment which affect the performance of land-use systems;
- investigate whether these attributes are replaceable or not;
- identify ways in which other land users are affected by the land-use systems considered;
- define the way in which the system's performance may be measured (e.g. production per animal, or production per hectare).

Tools and techniques

The evaluation of sustainable land management can be achieved by traditional agricultural experimentation, physical and socioeconomic surveys, and other related techniques. The efficiency of these methods can be enhanced by computer-based technologies such as DBMS, GIS, Expert Systems, etc. Consequently:

- develop a "tool-box" comprising an array of suitable computer-based techniques;
- identify techniques likely to contribute effectively to the process of evaluation.

Evaluation support

Each of the methods require coordination, training, and support services.

- design monitoring and evaluation procedures;
- identify a working group for designing and evaluating methodology and developing training modules;
- create a network of regional training centres.

PART IV: CONCLUDING REMARKS, RECOMMENDATIONS, AND ACKNOWLEDGMENTS

Concluding remarks

The workshop brought together a core of capable scientists from 49 countries and it has compiled one of the most comprehensive documents on the subject of sustainable land management yet available. The results of the workshop will be useful to all who are interested in the subject.

The workshop focused on the scientific principles, criteria, and procedures by which sustainable land management could be evaluated, and provided suggestions towards developing a framework for sustainable land management (FSLM). The lead papers, the poster sessions, and the debates in the working groups and the accompanying discussions identified practical approaches and actions for further evolution of the work. Many of the criteria developed can also be usefully employed in development projects and research activities. The current state of global natural resources has created an urgent need to address the issues and provide substantive action programmes to mitigate the processes leading to the decline of the resource base. Sustainable agriculture, though a common-sense subject, has proven elusive.

The thrust of the workshop was to develop the FSLM. An initial approach was tested by the working groups and valuable suggestions were made to improve and enhance the procedures. The need to define and quantify suitable indicators and appropriate criteria were recognized as key determinants for the FSLM. Data bases and knowledge bases, the latter specifically at the farm level, have to be developed and incorporated into the FSLM. This would require standardization and quality control at an international level. It was also emphasized that stewardship was essential to implement sustainable land management, and the groups made valuable suggestions to address this issue. Also experimental techniques for sustainable land management are still at their infancy. The working groups suggested that long-term, multilocational trials be established to evaluate the sustainability of the most promising technologies.

A framework for sustainable land management is a long-term endeavour requiring the cooperation of many disciplines and the experience of scientists and land users from around the world. Developing the FSLM will be the challenge of the next few years, and international organizations such as IBSRAM, ISSS, and FAO have already made a commitment towards this. A series of consultations, working meetings, and symposia are planned for the next few years. The complexity and size of the task should not be underestimated. At the same time, the preliminary support from several donors is an indication of the usefulness of

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this task. The decicated contribution of the scientific community as shown in this workshop, is a sign of the commitment, and this coupled to the urgency of the matter as evidenced from global political support, collectively assures a valuable product in a short period of time.

Recommendations and acknowledgements

General recommendations

1. **Deeply concerned** by the accelerating rate at which the world's land resources are degrading and the general neglect of the environment,
   Aware that improvement in technical measures of land management are essential at all levels, but particularly at the level of the individual farm,
   Equally aware that these will not resolve the problem without support from carefully directed education coupled, as need arises, with the incentives, legislation, and the political will to promote action,
   Urges all governments to support and participate in international efforts to sustain the earth's environmental resources, whilst investing their own human and financial resources to the special national and local problems that threaten the land resource inheritance of future generations of their people.
2. **Appreciating** the foresight and effort of the workshop organizers in developing the initial procedures, guidelines, and principles to be used in the systematic development of a framework for sustainable land management,
   Applauds the progress made during the workshop towards developing the framework.
   Recognizing that such a framework will be a valuable and basic tool for designing, monitoring, and evaluating sustainable land management research and development activities,
   Recommends to the International Society of Soil Science (ISSS), the International Board for Soil Research and Management (IBSRAM), the Food and Agricultural Organization (FAO) of the United Nations, and other national and international agencies to assist and contribute to the further development of the framework.

Technical recommendations

(The following were recommended by the technical working groups. They are directed specifically to the organizing committee of the workshop and to the

sponsoring organizations, but are equally relevant to other international organizations.)

Recognizing that sustainable land management is a relatively new concept requiring innovative approaches to research and development, and that there is an urgent need to develop the scientific basis, the participants recommend that:

1. Critical sets of land and environmental attributes be prepared according to internationally accepted standards and methods, and with due attention to scale and variations in space and time. These data will be used to develop indices to evaluate the sustainability of land management systems and for the quantification of sustainability.
2. A network of long-term, multilocational research trials be established in selected agroenvironments to monitor and evaluate sustainable systems and to validate the techniques needed to research sustainability.
3. Enhanced emphasis be given to social, cultural and anthropological issues, and to the role of women, in the design and implementation of sustainable land management initiatives.
4. Improved methods of environmental accounting, including valuation of the resource base, be developed as an important component of sustainable land management and in the context of stewardship.
5. An international working group be established to:
   a. review and evaluate proposed methodologies, standards, and guidelines for sustainable land management, with a view to developing a prototype framework.
   b. establish and maintain scientific liaison among all national and international institutions interested in such work.

Acknowledgments

We, the participants of the International Workshop on Evaluation for Sustainable Land Management in the Developing World, held at Chiang Rai, Thailand, wish to thank most sincerely,

- our hosts, the Royal Thai Government;
- His Excellency the Minister of Agriculture and Cooperatives;
- the Department of Land Development;
- the International Board for Soil Research and Management

for their most generous hospitality and for all their efforts to ensure the success of the workshop.

The participants also wish to thank the international donors and other organizations who have supported the workshop, namely:

- Technical Centre for Agriculture and Rural Cooperation, ACP-EEC Lomé Convention (CTA)
- Deutsche Stiftung für Internationale Entwicklungslande (DSE)
- Food and Agriculture Organization of the United Nations (FAO)
- Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)
- International Development Research Centre (IDRC), Canada
- Swiss Development Cooperation (SDC)
- U.S. Agency for International Development (USAID)
- The Australian Centre for International Agricultural Research (ACIAR)
- International Society of Soil Science (ISSS)

APPENDIXES

APPENDIX I: WORKSHOP PROGRAMME

Sunday 15 September 1991

	Participants arrive at Chiang Rai
	Registration
	Poster papers to be displayed
18.00-19.30	Welcoming reception

Monday 16 September 1991 **Day 1**

08.00-08.45	Registration
	Opening session
08.50	All participants to be seated
09.00	Welcoming address
	Khun Kamron Buncherd, Governor of Chiang Rai
09.15	Introductory remarks
	Khun Sitilarp Vasuvat
	Chairman of the Workshop Organizing Committee
09.30	Opening statement
	Dr. Marc Latham, Director of IBSRAM
09.45	Inaugural address
	H.E. Dr. Anat Arbhabhirama
	Minister for Agriculture and Cooperatives, Thailand
10.15	Break

Technical session no. 1: Keynote papers

	Chairman: Khun Sitilarp Vasuvat
	Director-General, DLD, Thailand
10.45	Keynote paper
	The dimensions and importance of sustainability in a global context
	W. Treitz
11.30	An international framework for evaluating sustainable land management
	J. Dumanski, H. Eswaran and M. Latham
12.15	Lunch

Technical session no. 2: Agroclimatic guidelines

Chairman: Mr. F.J. Dent
Regional Office, FAO, Bangkok

13.45	Leader paper Agroclimatic guidelines and criteria for the evaluation of sustainable land management W. Baier and J. Dumanski
14.15	Agroclimatic zonation and climatic risks to sustainable agriculture in the semiarid tropics S.M. Virmani and H. Eswaran
14.35	Agroclimate risks due to natural disasters H. Brammer
14.55	Discussions
15.15	Break

Technical session no. 3: Environmental guidelines

Chairman: Mr. B. Wayi
Department of Agriculture and Livestock
Papua New Guinea

15.45	Leader paper Environmental aspects and their impact on sustainable land management W.A. Watkins
16.15	Pollution and other off-site effects on sustainable land management Prinya Nutalaya
16.35	Genetic resources and biodiversity as tools in sustainable land management J.M. Spain
16.55	Discussions
17.15-18.15	Briefing of chairmen and rapporteurs of working groups

Tuesday 17 September 1991 **Day 2**

Technical session no. 4: Soil guidelines

Chairman: Dr. Sorasith Vachorotayan
Kasetsart University, Thailand

08.00	Lead paper Conservation and enhancement of soil quality W.E. Larson and F.J. Pierce

08.30	Methodological issues for soil conservation measures on sloping lands: a case study in Thailand Chaiyasit Aneckasamphant, Sawatdee Boonchee and Adisak Sajjapongse
08.50	Maintenance and enhancement of low-fertility soils C. Valentin, W. Hoogmoed and W. Andriesse
09.10	Managing salt-affected soils and poor-quality irrigation waters for sustainable crop productivity I.P. Abrol and Raj K. Gupta (Paper presented by Dr. P. Velayutham)
09.30	Conservation and enhancement of wetland soils H.U. Neue, C. Quijano and H.W. Scharpenseel
09.50	Discussions
10.30	Break

Technical session no. 5: Agronomic guidelines (1)

Chairman: C. Ofori
FAO, Rome

11.00	Lead paper Organic-matter management for sustainable soil fertility in tropical cropping systems M.J. Swift and P.W. Woomer
11.30	Plant nutrients in a sustainable land management system P. Stangel
11.50	Agroforestry as a means of sustained land management Rick van den Beldt
12.10	Discussions
12.30	Lunch

Technical session no. 6: Agronomic guidelines (2)

Chairman: Dr. I. Willett
ACIAR, Australia

14.00	Lead paper Tillage and crop management practices L. Seguy and C. Pieri
14.30	Water management N. Ahmad
14.50	Livestock, food production, and land degradation Peter Brumby (Paper presented by Dr. E. Pushparajah, IBSRAM)
15.10	Discussions
15.30	Break

16.00 Working Groups
Briefing on objectives and expected outputs
(*Participants subsequently reconvene in respective groups*)

Group 1 - Physical guidelines
Chairman: Dr. K. Seyers
Rapporteurs: Dr. Eduardo Paningbatan
Dr. W. Verheye

Group 2 - Agronomic guidelines
Chairman: Dr. I. Pla Sentis
Rapporteurs: Dr. B. Chishala
Dr. A.F. Mackenzie

Group 3 - Environmental guidelines
Chairman: Dr. R. Millington
Rapporteurs: Dr. D. Anderson
Dr. Zahari Abu Bakar

Group 4 - Economic guidelines
Chairman: Dr. H.P. Maag
Rapporteurs: Dr. Diane Sompongse
Dr. G. Ubdegraff

Group 5 - Stewardship guidelines
Chairman: Dr. Mokhtar Toure
Rapporteurs: Dr. K. Coughland
Dr. B. Hintze

Group 6 - Methodological guidelines
Chairman: Dr. F. Beinroth
Rapporteurs: Mrs. Nualsri Kanchanakool
Dr. R.J.K. Myers
Dr. Yvan Biot

Wednesday 18 September 1991 **Day 3**

Technical session no. 7: Economic guidelines
Chairman: Dr. M. Bosch
GTZ, Germany

08.00 Leader paper
Economic, social, and policy aspects of sustainable land use
G. Spendjian

08.30 Economic aspects of sustainable land management: regional experience
G.C. O'Brien

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08.50	Economic aspects of sustainable land management - Thailand's experience Tongroj Onchan
09.10	Discussions
09.30	Break

Technical session no. 8: Stewardship

	Chairman: Dr. A. Hamblin Bureau of Rural Resources, Canberra, Australia
10.00	Lead paper Wealth and stewardship J. Ragland
10.30	Farmers' perceptions and the adoption of sustainable land management technologies: Thailand's experience Sawaeng Ruaysoongnern and Aran Patanothai
10.50	Farmers' perceptions and the adoption of sustainable land management technologies: the Southeast Asian experience Sam Fujisaka
11.10	Discussions
11.30	Poster session

Poster presentations

Soil guidelines

Improving soil physical properties for sustainable crop production in Bangladesh
S.M. RAHMAN and M.I. KHALIL

Drainage as a sustainable land management practice in irrigated agriculture
A.T.A. MOUSTAFA, W.E. AHMAD and A.S. AHMED

The effect of traditional and alternative cropping systems on the soil quality in the highlands of northern Thailand
F. TURKELBOOM, S. ONGPRASERT, K. VAN LOOK, A. TANCHO and K. VLASSAK

Experience in the management of sloping lands for sustainable agriculture in Malaysia
E. ZAINOL, A.W. MAHMUD, A.M. MOKHTARUDDIN, GULAM HASHIM and MOHD. NOOR SUDIN

Soil agronomic criteria used in Cameroon for sustainable land development
R. AMBASSA-KIKI

Agronomic guidelines (I)

Soil organic-matter management for sustainable agriculture on sandy soils
J. KEITH SYERS, PUNTIPA VICHIENSANTH, ANTHONY G. O'DONNELL and PATMA VITYAKON
Sustaining productivity through biofertilization: the SWRI experience
Y.A. HAMDY and S.N. SHALAAN
Farming-by-soil in the tropics - results from detailed surveys on a sugarcane plantation in South Sumatra
J. LAMP, E. MUTERT and A. ARMANTO
Alleviation of soil acidity in Malaysia through the use of palm oil mill effluent and lime
J. SHAMSHUDDIN, I. JAMILAH and H.A.H. SHARIFUDDIN
The effects of organic recycling and tillage on the productivity of Tongan soils
SIOSIUA HALAVATAU
Sustainable sloping-land management experiences in Vietnam
THAI PHIEN and NGUYEN TRONG THI
The role of organic sources of nutrients in sustained soil productivity
M. SALIM and M.S. ZIA
Soil agronomic criteria used for sustainable land management in Nigeria
A. OLU OBI
Approaches to sustainable management of acid soils in the Philippines
CONRADO M. DUQUE Sr.
Sustainability of land-use systems in Zambia
B.H. CHISHALA
Management of acid soils for sustainable food crop production in south Kalimantan, Indonesia
RACHMAN SUTANTO
Traditional systems of steepland food production in north Pentecost, Vanuatu: are they sustainable?
V. TIOLLIER, I.S. WEBB and F. BULE

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The management of sloping lands in Thailand
SAWADEE BOONCHEE, PHITAK INTHAPAN, REWAT JIRAHATHAWORN and CHAIYASIT ANEKSUMPHANT

Soil conservation-oriented cropping for sustained crop production
ED PANINGBATAN

Agronomic guidelines (II)

An evaluation of recently introduced permaculture projects for sustainable agriculture in Zimbabwe
K. NYAMPFENE, J. WILSON and J. NYONI

Nutrient cycling in mixed-farming systems in the Sahel of West Africa
J.M. POWELL, C. KOUAME and J. BROUWER

Soil and crop management practices for sustainable production of cassava on sloping lands
S. JANTAWAT, S. PUTTHACHAROEN and R. HOWELER

Rehabilitation of antropic savanna on Ultisols in south Sumatra, Indonesia
H.R. VON UEXKULL, Y.C. WOO and SRI ADININGSIH

Sustainable crop production in Western Samoa
MALAKI IAKOPO

Fertility and weeds as indicators of sustainable land management - wet forest, Côte d'Ivoire
ANNEKE DE ROUW

Water management for sustainable agriculture and reducing risk of crop failure in semiarid areas
P. NYAMUDEZA

Land mismanagement and remedial measures in the Rewa river catchment area in Fiji
L. LIMALEVU

Water management for sustainable crop production on Vertisols in Kenya
F.N. MUCHENA, S.M. WOKABI, E.C. IKITOO and W.W. AORE

Economic and stewardship guidelines

The relationship between ethnic groups and sustainable land use in northern Laos
W. RODER, W. LEACOCK, N. VIENVONSITH and B. PHANTANOUSY

Sustainable land management in Vietnam
THAI PIEN and NGUYEN TRONG THI

Sustainable management of degraded forestland through community forestry projects: a case study in Bangladesh
MIYAN RUKUNUDDIN AHMED

Development of sustainable land-use systems by farmer evaluation and planning
CHRISTOPHER BACKHAUS and SOMJATE SRITHONGKAM

Methodology/Quantification

The "residual suitability" and "production half-life" of agricultural land: towards a quantification of sustainability
YVAN BIOT

A targeting procedure for identifying sustainable cultivation systems and/or degraded systems
G.S. HUMPHREYS, R.L. HIDE, R.M. BOURKE and B.J. ALLEN

Developing new concepts for land evaluation for sustainable agriculture in the tropics: an experience from Nigeria
A.O. OGUNKUNLE, A.A. AGBOOLA and G.A. OLUWATOSIN

Evaluation and management procedures for sustained cropping: a case study from the Senegal river basin
W.H. VERHEYE

Application of GIS technology in regional multipurpose land suitability evaluation
NI SHAOXIANG, HUANG XIANGUAN and XU SHOUCHENG

Sustainable land management in Bangladesh - a strategic overview
M.I. ALI

Developing land evaluation for sustainable land management
C.A. VAN DIEPEN

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GIS applications for sustainable land management: a case study in the upper Pa Sak catchment, central highlands, Thailand
IHIRAYUT CHITCHUMNONG, PRATUMPORN FUNNPHEN, SOMBOON MEKPAIBOONVATAN, SOMPORN PATINAVIN, KAMRON SAIFUK, KEES BRONSVELD and HERMAN HUIZING

The use of remote sensing and GIS in land degradation assessment: a case study from the Doi Tung area, northern Thailand
KAMRON SAIFUK, P. JAYAWARDHANA, G.S. HUMPHREYS, DAMRON BUAPRADABKUL, PRATHUMPORN FUNPHEN, SOMPORN PLATINAVIN and NUALSRI KANCHANAKUL

Modelling the soil moisture regime for evaluating the sustainability of land management
ILDEFONSO PLA SENTIS

A diagnostic method for physical changes in cultivated soils
A. MAPANGUI

12.30 Lunch

Technical session no. 9: Methodology/quantification

Chairman: Dr. M. Alan Jackson
CTA, the Netherlands

13.30 Lead paper
Concepts and methodologies for measuring the sustainability of managed ecosystems
H. Tiessen and D.W. Anderson

14.00 Use of remote sensing and GIS for evaluation of sustainable land management
Herman Huizing

14.20 Organic-matter C and soil microbial biomass C as indicators of sustainable land use
G.P. Sparling

14.40 Global change and research needs for sustainable land management
H.W. Scharpenseel and H.U. Neue

15.00 Discussion

15.30 Break

16.00 Working Groups (continued discussions)

Thursday 19 September 1991 **Day 4**

07.30-13.45	Field trip Travel by road to Doi Tung to see an IBSRAM experiment on the management of sloping lands and soil profiles (see Field Guidebook)
14.15	Working Groups (continued discussions)
16.00	Break
16.30	Poster session (Chairmen and rapporteurs of working groups to prepare reports)

Friday 20 September 1991 Day 5

Report and recommendations

	Chairman: Dr. R. Arnold USDA, USA
08.30	Report of Group 1 - Physical guidelines
08.50	Report of Group 2 - Agronomic guidelines
09.10	Report of Group 3 - Environmental guidelines
09.30	Report of Group 4 - Economic guidelines
09.50	Report of Group 5 - Stewardship guidelines
10.10	Report of Group 6 - Methodological guidelines
10.30	Break
11.00	Discussions on reports of working groups
12.15	Resolutions Dr. A. Smyth
13.00	Lunch

Rounding up session

	Chairman: Dr. Werner Treitz Chairman, Board of Trustees, IBSRAM
14.30	Keynote address Ensuring farmer acceptance of sustainable land management technologies Dr. Kosit Panpiemras (Presented by Dr. Suthiporn Chirapanda, Agricultural Land Reform Office, Thailand)
15.00	Summary of the workshop Emeritus Prof. C.F. Bentley

15.30	View of major users	
	NARS	Mr. Pitsanu Atthaviroj (Thailand)
		Ms. Fall Ba (Senegal)
	FAO	Dr. C. Ofori
	ISSS	Dr. Hari Eswaran
	Donors	Dr. H.P. Maag (on behalf of donors)
	IBSRAM	Dr. M. Latham

Closing ceremony

16.30	Concluding remarks Mr. Sitilarp Vasuvat, Chairman, Organizing Committee
16.40	Closing address Mr. Pravit Srisopon, Deputy Governor, Chiang Rai
17.00	Tea
19.00	Workshop dinner

Saturday 21 September 1991 **Day 6**

Optional postworkshop field visit

08.30	Depart Chiang Rai for Chiang Mai by road (Field trip to H.M. the King's Project at Hong Krai. See Field Guidebook)
16.30	Arrive in Chiang Mai Night in Plaza Hotel, Chiang Mai

Sunday 22 September 1991 **Day 7**

Departure from Chiang Mai

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