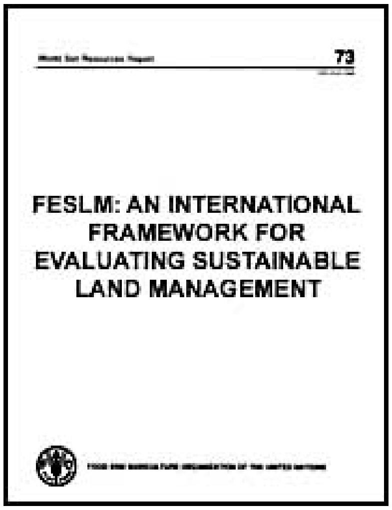


FESLM: An international framework for evaluating sustainable land management

Table of contents

World Soil Resources Report

Food and Agriculture Organization of the United Nations 1993

A Discussion Paper

A.J. Smyth
J. Dumanski

with contributions by

G. Spendjian
M.J. Swift
P.K. Thornton

Jointly sponsored by:	
FAO	Food and Agriculture Organization of the United Nations
IBSRAM	International Board for Soil Research and Management
ISSS	International Society of Soil Science
TSBF	Tropical Soil Biology and Fertility
IFDC	International Fertilizer Development Centre
ICRAF	International Centre for Research in Agroforestry
CTA	Technical Centre for Agricultural and Rural Cooperation ACP-EEC
ACIAR	Australian Centre for International Agricultural Research
Agriculture Canada United States Department of Agriculture-Soil Conservation Service (SMSS)	

Land and Water Development Division

Food and Agriculture Organization of the United Nations 1993

M-59

ISBN 92 - 5-103419-2

Contents

Foreword

This working document has been prepared as a focus for future work on the development of an International Framework for the Evaluation of Sustainable Land Management (FESLM).

The Framework is designed as a structured, logical pathway for making decisions on whether or not a carefully defined form of land management is likely to prove sustainable in a defined situation over a defined period of time. The logical pathway approach was selected because our knowledge of sustainability will always be imperfect. This approach assists us in making decisions that can be substantiated without having to wait for all the final data.

The development of the Framework and the preparation of this document have been guided by an international working group for this purpose. Membership in this working group is: J. Dumanski (Agriculture Canada), Chairman; M. Latham (IBSRAM), Secretary; C. S. Ofori (FAO); R. Hanson (TROPSOILS), H. Eswaran (USDA-SCS), P.K. Thornton (IFDC); and A.J. Smyth (Private). This working group has been ably assisted from time to time by J. K. Syers, E. Pushparajah, M. Mausbach and R.L. Sawyer. This document represents the collective wisdom from this entire group.

This document makes no attempt to review the rapidly expanding range of literature on sustainability but is based on four seminal documents and on discussions in Working Groups organised by the International Board for Soil Research and Management (IBSRAM) at Chiang Rai, Thailand in 1991; Nairobi, Kenya in 1992; in Washington DC, USA in 1992; and in Lethbridge, Canada in 1993. The documents that have shaped the current form of the FESLM are:

- Public Advisory Committees to the Environmental Council of Alberta. Alberta Conservation Strategy: Framework for Action: A Draft for Public Discussion. Edmonton. 1990.

- Dumanski, J., Eswaran, H. and Latham, M. Criteria for an International Framework for Evaluating Sustainable Land Management. International Workshop on Evaluation for Sustainable Development in the Developing World. Chiang Rai, Thailand. IBSRAM Proceedings 12, Vol. 2, Bangkok. 1991.

- Dumanski, J., Eswaran, H., Pushparajah, E. and Smyth, A. (eds.). Evaluation for Sustainable Land Managements in the Developing World. Vol. 1: Towards the Development of an International Framework. IBSRAM Proceedings 12, Vol. 1. Bangkok, Thailand. 1991.

- Dumanski, J. and Smyth, A. The Issues and Challenges of Sustainable Land Management. International Workshop on Sustainable Land Management for the 21st. Century, University of Lethbridge, Alberta, Canada. 1993.

The document that follows, prepared and revised by A. J. Smyth and J. Dumanski at the request of FAO, with specific contributions from M. J. Swift (Biological factors), P.K. Thornton (Economic factors) and G. Spendjian (Social factors), draws together the ideas expressed in these sources with some additional

connecting material and very valuable constructive comments received orally and in writing at and between the various meetings of the Working Group. All these contributions, too numerous to list, are most gratefully acknowledged.

Contents - **Next**

Introduction

Issues of sustainable land management

Perceived wisdom in the approach to evaluation, use and management of land resources is changing rapidly and dramatically. Past emphasis on land 'development', focused on maximizing production and return from land use investment and planned against a background belief that suitable lands for expansion could always be found somewhere, is forced to give way to a more cautious approach-one that recognizes the finite extent of fertile land and the seemingly insatiable demands of a growing human population.

Globally, and in many individual countries, there is clear evidence of impending land shortage. Areas in which the combination of land and freshwater resources is moderately or well suited to agriculture are, for the most part, already in use. Efficient use of these lands is becoming a matter of life or death for increasing millions of mankind. Future generations in still larger numbers are more seriously at risk-their livelihood endangered by present production choices that degrade the very resources on which future agriculture depends. Global production must increase dramatically to meet foreseen demand but the levels and means of production targeted locally must be those that can be maintained on a sustained basis. Global, and even local agriculture must be sustainable.

"We need a value system which enshrines the principle of sustainability over generations. Sustainable development may mean different things to different people, but the idea itself is simple. We must work out models for a relatively steady state society, with population in broad balance with resources and the environment." (Tickell, 1993).

The concept of sustainability includes notions of limits to resource availability, environmental impact, economic viability, biodiversity and social justice (Dumanski *et al*., 1991; Harmsen and Kelly, 1992). The concept of sustainability is dynamic in that what is sustainable in one area, may not be in another, and what was sustainable at one time may no longer be sustainable. Although sustainability cannot be measured directly, assessments of sustainability can be made on the performance and direction of the processes that control the functions of a given system at a specific location (Dumanski and Smyth, 1993).

The concept of sustainability is pertinent only against a background of limits to resource availability and use. If no such limits exist, or they are not perceived to exist, then it is common that resources are overexploited; under restraints, however, the concept of sustainability becomes increasingly important, rising as the scarcity of the resource increases. Our perception of scarcity and our knowledge of alternate resource possibilities for the same applications, determine the important factors to be considered in the supply-demand equation of sustainability and sustainable land management.

The first of these factors is the fixed supply of land suitable for agriculture and food production. The World's total ice-free land area is approximately 13.4 thousand million hectares, but of this only 24 percent or 3.2 thousand million hectares are potentially arable, i.e. land that can be cultivated and/or maintained in productive pasture. Of this, about 40 percent (1.3 thousand million hectares) is highly to moderately productive and 60 percent is of low productivity. Currently the best of these lands, about 1.5 thousand million hectares, are used for cropland, and the remainder are in permanent pasture, forest and woodland (Buringh and Dudal, 1987).

The second factor is the impact of competition between increasing numbers of people for the same land area. Each year global populations increase by about 90 million people. Since the best lands are almost all in use, necessary further expansion of agriculture will come increasingly at the expense of pasture lands and forests; lands usually of marginal quality where the risks of crop production are higher and the returns lower. Over the last three hundred years, human-induced land use change has resulted in a net gain of approximately 12 m km^2 of cropland but net losses of 6 m km^2 of forests and 1.6 m km^2 of wetlands. Even over the past two decades the global extent of cropland has increased by 9.1 percent, whereas pasture and forest lands have decreased considerably. Currently, the rate of tropical deforestation, primarily for agricultural purposes, is estimated at 17 million hectares (0.9 per cent) per year, sharply increased from the rate of 11.3 million hectares (0.6 percent) per year estimated in the early 1980s (WRI, 1992). Temperate and boreal forests suffered in the past, but they are no longer subject to acute deforestation; in fact, forest in these areas may have increased by about 5 percent since the early 1980s.

Since the middle of this century human-induced land use change has become so drastic, so rapid and so global that its impacts are affecting processes that sustain the interacting systems of the geosphere-biosphere (IGBP, 1992). The direct effects of these changes on global systems remains poorly understood but there is general agreement on the potential impacts. For example, expansion of agro-ecosystems over the last 150 years has resulted in a net flux of CO_2 equal to that released by burning fossil fuel during the same period; current release of CO_2 from land conversions is between 10 and 30 percent of that from fossil fuel combustion; land conversion is also the largest human-induced source of N_2O, which contributes to greenhouse gas accumulation and ozone depletion.

With or without climate change, the conversion of natural habitats for agriculture and other uses is recognized as a major cause of loss of genetic stock and of genetic diversity. At current rates of conversion, it is estimated that 25 percent of the World's plant species will disappear in the next 50 years (IDRC, 1992). Modern agriculture, with its trends towards monoculture is particularly vulnerable; already only 20 crops provide 90 percent of the World's food; and wheat, rice, maize and potato contribute more than all other crops combined (IDRC, 1992). Only four varieties produce 75 percent of all wheat grown on the Canadian prairies whilst, in India, where as many as 30 000 varieties of rice were planted 50 years ago, it is estimated that by the turn of the century three quarters of the rice fields will be planted to only 10 varieties.

The pending onset of climate change, the narrowing genetic stock and the disturbance of global biogeochemical cycles all add considerable uncertainty to the evaluation of sustainability.

The third major factor in the sustainability equation is the depletion of biological production potential by the insidious processes of soil and land degradation, often accelerated by human activities. Although the extent of global soil degradation is not known with certainty, current best estimates are that approximately 1.2 thousand million hectares of agricultural, forestry and range lands have been affected by moderate to extreme soil degradation (75 percent of this is moderate degradation and 25 percent is severe to extreme). A further 750 million hectares have been affected by slight degradation. This degradation is caused by human related activities, namely: overgrazing (35 percent of degraded land); improper agricultural practices (28 percent); deforestation and overexploitation for fuelwood (37 percent); and industrial pollution (about 2 percent). A secondary effect of land degradation, often at least as serious in its local consequence as the loss of soil material, is the pollution of surface and groundwater. Transposed and dissolved materials may cause salinization, alkalinization, and other forms of toxification and eutrophication. The impact of these effects may be felt far from the site of initial degradation. Within this century the impact of land degradation on production has been masked by greatly increased fertilizer use and other inputs, but it is obvious that productivity increases would have been much higher in the absence of degradation.

Challenges for the future

The evidence is mounting that global agriculture is at a watershed. Soon, for the first time in history, we will have run out of good land for agricultural expansion. For the first time we are faced with the imperative of increasing production on lands already cultivated in a manner which does not degrade productive resources. The magnitude of the task is illustrated by a calculation that shows that if we are to meet the needs of the anticipated global population, the amount of food we must produce in the next 50 years equals the total production of the past 8000 years of agricultural history (IDRC, 1992).

If the forms of agriculture used to achieve this increased production are to be sustainable they must be based on sound agronomic principles, but they must also embrace understanding of the constraints and interactions of all other dimensions of sustainable land management. Yields will have to increase but, at the same time, production risks will have to be controlled to ensure more reliable cash flow and permit confident planning. Soil resources will need to be controlled and water pollution cannot be tolerated. Production systems will have to be flexible, diversified and developed on a broad genetic base to ensure the possibility of rapid response to changing conditions. Land management practices, in large measure, control processes of land degradation and their efficiency in this respect will largely govern the sustainability of a given land use. However, institutional, political, social and economic pressures and structures can cause or exacerbate environmental problems and control of their influence must form part of the solution.

This immense challenge for global agriculture will require that the principles and concepts of sustainable land management become entrenched in the policy arena no less than amongst rural populations. Some major changes in economic theory and in systems of national accounting are required to ensure that the loss of options for the future consequent upon depreciation of natural resources-loss of a nation's true 'wealth'-are properly recognized. Procedures of national accounting, for example, that mistakenly assume that natural resources are so abundant that they have no marginal value must be seen to be unacceptable.

Technical and scientific advances will be instrumental in the transition to sustainable agriculture, but they will need to be tailored to local environmental conditions-much more site-specific than has been the case in the past. The 'Green Revolution' continues to achieve considerable success with the use of high yielding crop varieties, highly responsive to fertilization, irrigation and other inputs. Such successes, however, are usually achieved on sites that enjoy a narrow range of highly suitable soils and climates, are not without environmental costs. Also, they incur a margin of risk which often is higher than with more traditional means. Attempts to transfer intensive forms of agriculture to the marginal and submarginal areas in which a large majority of the world's poorest farmers live has led, all too often, only to disaster and degradation. These regions have yet to receive the research effort necessary to devise sustainable systems of agriculture capable of sustaining foreseeable levels of population.

Clearly, no 'technological fix' will prove effectively sustainable unless it is acceptable and beneficial to the people on the land and to society in general - but an improved technological and knowledge base will surely be a required part of the solution. It is the responsibility of the scientific community to develop criteria and indicators for evaluating whether land management practices will lead towards sustainability or away from it. They must, however, work with the farm community to ensure that recommendations that arise are realistic, efficient and acceptable.

Objectives of the report

This report proposes a strategic framework approach for evaluating sustainable land management. This approach is advocated because the concept of what constitutes sustainability cannot be rigid, it needs to be capable of change from area to area and over time. As solutions become mare precise they will have to be increasingly location and time specific. A strategic framework approach offers the possibility of providing preliminary estimates' of acceptable reliability, without waiting for all of the final data. The approach is intended to be generic and universal and it assists in organizing the concepts and principles to be used in deriving a solution. It is intended as an aid to guide decisions towards sustainable management, to increase the probability of success and/or identify potential failures. It should certainly assist in interpreting the results of the very many research initiatives that are now in progress in the search for sustainability.

The evaluation of sustainable land management is an integral part of the process of harmonizing agriculture and food production with the, often conflicting, interests of economics and the environment. Agriculture is expected to continue to be the engine of economic development in most developing countries but, for this to be realistic, agriculture in the future will have to be increasingly more productive, more economically efficient and more environmentally friendly-in a phrase, more sustainable. Although sustainability will continue to be elusive, learning to evaluate sustainability must begin now. The task is too important to wait until we have all the answers.

Aim

The FESLM is designed as a pathway to guide analysis of land use sustainability, through a series of scientifically sound, logical steps.

The Framework pathway seeks to connect all aspects of the land use under investigation with the multitude of interacting conditions-environmental, economic and social-which collectively determine whether that form of land management is sustainable or will lead to sustainability.

The FESLM is concerned with evaluation. It does not encompass planning or development; although it can make an important contribution to both. Choice between alternative forms of land use or between ways of improving a land use system may not depend on sustainability alone; but the FESLM can contribute to decision making in these areas also.

The concept of evaluating sustainability can be most easily understood in respect to a very small area of land given up to a single use, such as a small field under a single crop. If the field is small enough it can be assumed that the influence of variables which might change the acceptability of the land use is spatially almost uniform. If examination of these variables and projection of their influence over a defined time period implies that the changes wrought will not, for any reason, render the land use unacceptable the land use is deemed 'sustainable' - for that time period.

Detailed sustainability analysis of the kind just described will employ the whole sequence of procedures of the FESLM and will be costly. The time and money spent on such analysis will be fully justified, however, in appropriate circumstances-in the design, execution and monitoring of long term 'sustainability' experiments, for example, or in tests to confirm the validity of generalized sustainability analysis of much larger areas. In these contexts the FESLM will play a vital role in all forms of sustainability research-that of evaluating whether 'improved' methods are, in fact, sustainable.

Society, however, rarely makes decisions on individual fields, but seeks guidance on much larger and more complex areas. The FESLM provides a systematic basis for a generalized approach to sustainability investigation within large areas. This is achieved by selecting and conceptualizing the more significant influences on environmental change.

It is intended to present the FESLM in a form that is easily accessible and intelligible to the lay public, to farmers and other land users so that, understanding its approach and principles, they can have confidence in its findings.

Especially in the early days of its development and use, however, the FESLM will call for expert contributions from a wide range of specialists who will identify and interpret the factors influencing sustainability. Subsequent experience will confirm, or point the need to adapt, the initial projections. Over time, an encyclopedic check list of experience in different environmental situations will be built up to guide and simplify future evaluations.

The FESLM will be designed and the check list structured so that the huge volume of data collected can be stored, handled and eventually, to a large extent, evaluated by computer.

A Master (or 'Reference') version of a fully developed FESLM will include, in addition to details of the evaluation procedure, a comprehensive Checklist (databank) recording environmental influences adverse to stable land management and would relate these:

- to environmental indicators (selected factors) that reflect each influence;
- to actions that can be taken to minimize instability in each instance;
- to criteria (factors, numerical relationships, formulae, more complex models) that relate environmental change to observable and measurable attributes; and
- to measurable threshold values which determine at what level each influence is a threat to sustainability.

The Master Framework procedures will be independent of scale and it is intended that, eventually, the check list will be worldwide in scope. Together the information in the Master Framework will permit rapid construction of Action (or 'Local') Frameworks to be used in evaluating the sustainability of a specific form of land use in a specific locality at a specific scale of investigation-a crucial contribution to sound land use planning and environmental conservation.

Experience in applying these Frameworks will draw attention to gaps in knowledge and assist, therefore, in defining research needs in the scientific development of land management packages.

Scanning the relevant sections of the check list will provide a safeguard against any oversight of potential problems during the planning stages of land development.

Finally, the Framework is planned to provide a structured system for monitoring the progress of development; using the diagnostic pathway for periodic evaluation of any change in the sustainability prognosis.

Chapter 1: Background and principles

Nature of sustainable land management (SLM)

Many definitions have been proposed to describe aspects of 'sustainable development'. Their variety reflects the complexity of relationships involved. Environmental characteristics, market forces, social ambitions, development objectives and conservation aims are but examples of the forces and factors that interact to determine sustainability. Definitions of sustainable management differ because observers place differing importance on these various factors.

Recognizing that a clear objective is essential to successful evaluation, the FESLM Working Party, in Nairobi (1991), laid a foundation for the following definition of SLM:

> *"Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:*
>
> *- maintain or enhance production/services (Productivity)*
> *- reduce the level of production risk (Security)*
> *- protect the potential of natural resources and prevent degradation of soil and water quality (Protection)*
> *- be economically viable (Viability)*
> *- and socially acceptable (Acceptability)."*

These five objectives of Productivity; Security; Protection; Viability and Acceptability are seen to be the basic 'pillars' on which the SLM edifice must be constructed and against which its findings must be tested and monitored[1]. Each objective is complex, and requires further brief examination:

Productivity: the return from SLM may extend beyond material yields from agricultural and non-agricultural uses to include benefits from protective and aesthetic aims of land use.

Security: management methods that promote balance between a land use and prevailing environmental conditions, reduce the risks of production; conversely, methods that destabilize local relationships increase that risk.

Protection: the quantity and quality of soil and water resources must be safeguarded, in equity for future generations. Locally, there may be additional conservation priorities such as the need to maintain genetic diversity or preserve individual plant or animal species.

Viability: if the land uses being considered are locally not viable, the use will not survive.

Acceptability: land use methods can be expected to fail, in time, if their social impact is unacceptable. The populations most directly affected by social and economic impact are not necessarily the same.

[1] The objectives of the FESLM intentionally embrace the totality of on-going experience on Earth. They allow for consideration of the effects of everything on any activity. It is right that they should do so, for it is not possible, in a global context, to exclude as irrelevant any influence on the future development of any activity. This is true in principle. In practice, if the size of the task is to remain within acceptable limits, it is obviously necessary to restrict the investigation of sustainability to those interacting influences that appear most significant to the directions of development of the land use in question. Conscious limitations have to be placed on the range of investigation and, in reporting the findings of evaluations achieved using the FESLM, these limitations must be stated.

One consequence of this complexity is that evaluation of sustainability can scarcely be contemplated in terms even approaching the complexity of the real world on areas larger than a small field - an area small enough to ensure that, within it, physical, biological, economic and social influences operate almost uniformly. Planners, however, will require estimates of sustainability relating to larger areas, but it must be made clear that these will be based on selected, simplified concepts of the more complex reality. The FESLM is designed on this understanding.

These primary requirements of sustainability must be viewed in a positive light. Some 'trade-off' between objectives may be unavoidable-for example, lower productivity and profit may be accepted if this is necessary to achieve the required level of environmental protection-but all five 'pillars' must be soundly developed if the SLM itself is to be sound.

Aspects of sustainability

'Sustainability', within the context of the FESLM, is a measure of the extent to which the overall objective of SLM (as defined above) can be met by a defined land use on a specific area of land over a stated period of time.

Definition of the land use and specification of the relevant area serve to define a unique evaluation exercise. It is important to emphasize that the primary objective of the FESLM is evaluation. It may be that sustained production could be most easily achieved by doing something else, perhaps elsewhere, but uncovering planning solutions of this kind is not the immediate object of evaluation. It is also true that the route to sustained production may involve adaptation of the form of use with time. Progressive change of this kind can be built into the description of the use for evaluation - but, obviously, only to the extent that the need can be foreseen. Evaluation is not planning; but, as discussed later, the FESLM is designed to directly assist planning by assisting comparison of alternative forms of use.

The phrase 'over a stated period' is also important. It introduces a controlled variable into the process of evaluation. It recognizes that indefinite sustainability is unreal and that such concepts as "sustainable into the foreseeable future" are almost meaningless. By assigning a fixed period of time to an evaluation, the evaluator provides a measure of the confidence with which sustainability has been assessed-a measure of the apparent stability of the system. As discussed later, these measures could provide a basis for classifying differing degrees of sustainability.

Recognizing a time period over which sustainability is evaluated permits some flexibility in achieving the 'pillar' requirements-so long as these requirements are met over the period as a whole. Patterns of productivity, in particular, must be flexible. In an agricultural context the time scale might include regular regenerative fallows leading to cyclical changes in productivity, fertility etc. Short term climatic variation might give rise to similar year on year differences but, provided there is no progressive decline over the stipulated period, sustainability may be unimpaired. This degree of flexibility is essential if SLM overall is to be a realistic objective.

The initial definition of the land use should not be so tightly drawn as to preclude minor flexibility in the nature and volume of inputs as needs arise (of fertilizers, herbicides, farm equipment, for example, in the case of agriculture); provided always that such introductions do not change the basic nature or objective of the use and are both economically and socially acceptable within the system.

Sustainability and suitability

'Land suitability' has been defined as the fitness of a given type of land for a specified kind of land use (FAO, 1976). The authors might helpfully have added 'or vice versa'.

The interactions between environmental factors which determine 'suitability" at a given moment are largely the same as those which decide whether the same land use is 'sustainable' through a period of future time on the plot in question. Whilst suitability evaluation calls for observation and measurement of these factors in the present, sustainability evaluation requires that the future, possibly changed, states of these factors are predicted.

A form of land use may be regarded as 'sustainable' if no permanent or progressive deterioration of its 'fitness' (i.e. its 'suitability') to the land in question is foreseen over a reasonably lengthy period of future time. In other words, sustainability can be considered to be an extension in time of the concept of suitability.

The Framework for Land Evaluation, published by FAO in 1976 and still widely used in various forms, established a set of procedures for determining land suitability. Because these procedures take account of economic and other rapidly changing factors, the validity of suitability assessments is recognized to be short lived. Even with this understanding, the authors recognized that it was not sensible to declare a particular use 'suitable' if it was known that, in time, this use would degrade the quality of the land. Uses that were not sustainable were specifically excluded from consideration. This view is enshrined in one of the six 'Principles' that govern the FAO Framework; this states that "suitability refers to use on a sustained basis".

The Land Evaluation Framework fails to explain in any depth how the sustainability of a proposed land use is to be assessed, but the procedures developed by FAO for analysing suitability provide a good starting point for sustainability evaluation - before embarking on the more demanding task it makes sense to ensure the current fitness of the use in question! Characterization of the site and other basic data collection required to determine suitability provide a sound foundation for evaluating sustainability.

Sustainability and stability

Environmental factors differ greatly in 'stability'; that is to say in the likelihood and rapidity of their expected change with time. In the context of the FESLM, the time scale is that of the evaluation.

Some factors, such as topographic form or geology, are very stable-unlikely to change significantly, even over periods that are long in human terms. Others, notably economic factors, such as profit margins, but also events like the incidence of pests or disease, are very unstable-likely to change frequently and rapidly. Between these extremes there are many factors in which change is either uncertain, as with climate; or gradual, as with population growth or genetic crop improvement.

Of course, change is not necessarily undesirable in relation to the requirements of sustainability. The effects of change in one unstable factor may be more than offset, in a positive or negative sense, by change in some other factor. Herein lies the difference between stability (concerned only with the likelihood of change) and sustainability (concerned with the balance between positive and negative change in relation to a particular system).

Changes in a land use system with time reflect instability in one or more individual factors. An understanding of the likely direction and nature of such instability provides a basis for evaluating sustainability. As discussed in more detail in a later section, factors which are relevant to the continued success of a land use and which respond to environmental stress in a predictably unstable manner are called 'Indicators' of sustainability. Certain critical levels (expressions) of these indicators are called 'Thresholds' since their prediction provides direct guidance in evaluating sustainability.

It may be possible to compile the interacting stabilities of individual factors to assess the 'stability' of an entire land use/environment system; but it is usually more helpful, in the context of the FESLM, to think in terms of the stability of individual factors. A measure of the reliability of each evaluation may be obtained by combining our understanding of the stability of the various factors and of their individual importance in achieving the pillars of sustainability. This measure-one of confidence-could provide a basis for classifying sustainability.

Classifying sustainability - Stability and confidence

We have defined 'sustainability' as a measure of the extent to which a form of land use is expected to meet the 'pillar' requirements of Productivity, Security, Protection, Viability and Acceptability into the future. Sustainability is a dynamic concept; for it can be assumed that the determinative factors and their interactions, will change with the passage of time. Only if there is a continuing positive balance of effect of these interactions with respect to the requirements will the land use remain sustainable.

It can be argued that a land use is either sustainable or it is not - that recognition of shades of sustainability is not meaningful. Literal interpretation of the word 'sustainable' suggests this. Yet it is apparent that on different lands some forms of land use call for more effort, more inputs, to sustain than do others. Generally speaking the more productive the land use (the more that is taken out of the land as 'product') the more difficult it is to achieve sustainability.

Failure to meet any one of the 'pillars' renders a land use unsustainable, but the ease with which the different ''pillars' are achieved will certainly differ from one use to another. In this sense, some forms of land use can be considered more 'sustainable' than others.

In planning land use in the future, as pressure on available land increases, great human and financial importance will be attached to decisions on whether or not a particular land use system is sustainable. In marginal situations, of which there will be many, planners will require more guidance than can be expressed by a Yes/No decision. They will need guidance on the relative sustainability of alternative uses.

Equally, those undertaking sustainability analysis may feel themselves unequal to the responsibility of presenting Yes/No advice, especially if the range and reliability of diagnostic data at their disposal are less than optimal.

Regrettably, in many parts of the world, the land use options available to planners may all be unsustainable - often clearly so, certainly in the long term as human population increases. The planners' need will then be for comparisons of relative unsustainability.

Procedures are required, therefore, for classifying both sustainability and unsustainability. A different approach to the two circumstances may assist definition of class limits. In neither case will this be easy. Both approaches depend, directly or indirectly, upon the stability of the factors which determine the status of sustainability in each situation.

The following class distinctions are proposed for discussion and investigation:

	Class	**Confidence limits**
SUSTAINABLE	1. Sustainable in the long term	25 years +
	2. Sustainable in the medium term	15 - 25 years
	3. Sustainable in the short term	7 - 15 years
UNSUSTAINABLE	4. Slightly unstable	5 - 7 years
	5. Moderately unstable	- 5 years
	6. Highly unstable	less than 2 yrs.

The time periods listed against each class under 'Confidence limits' require explanation. They are intended to illustrate the length of time expected to elapse before continued use of a system would become unacceptable. They may be interpreted as a measure of the evaluator's confidence in the stability of factors affecting the system.

In the case of 'sustainable' classes, the initial balance of instability effects is positive in relation to each of the required pillars of sustainability. In contrast, in the unsustainable classes, this initial balance is negative in respect to one or more pillars.

In the classification proposed, systems with a 'life' of 7 years or more are classified 'sustainable'; those with less are 'unsustainable'. The choice of 7 years is arbitrary and could be adjusted to meet local circumstances.

Some may protest that even 25 years is too short for a satisfactory measure of sustainability. A much longer period, a 100 years or even 'in perpetuity', may be a more desirable goal. Some threats to sustainability, such as diminishing soil fertility or slow erosion, may be predictable over such time scales. There is no reason why such predictions might not be reported as a qualification of the classification. But there will always be unforeseeable threats that will limit the value of forecasts over these longer periods - human unrest or warfare being, perhaps, the most probable.

It will be apparent also that, in many parts of the world, there are active land use systems which should be placed in Class 6 - 'Highly unstable', since they palpably fail to meet some or all of the 'pillar' requirements (eg. they generate an economic loss or a conservation disaster) but which, for a variety of reasons, not all bad, are expected to continue for far more than 2 years. Whether continuation reflects artificial subsidy, irresponsibility, indifference or a lack of any identified alternative, classification as 'Highly unstable' should draw desirable attention to a serious situation.

In fact, all of the time values shown as confidence limits are intended to be indicative only. These or other values would be considered and adopted locally; the choice being guided by the need to pass on the most pertinent information from local evaluation findings. Clearly, class limits would be standardized within a single evaluation study but, with present knowledge, attempts to correlate sustainability classes recognized in different studies is likely to prove more hazardous than fruitful.

As a footnote to this section, it should be said that some may suggest a distinction between classes of sustainability based on foreseen differences in future economic, social, or 'productivity' parameters - eg. Use 'A' is more sustainable than Use 'B' because, in future, it will yield a more desirable return. But these are distinctions of future suitability, not of sustainability.

Sustainability and scale

The immense range and complexity of diagnostic data associated with sustainability evaluation increases with the size of the study area (see Footnote 1, p. 7). Therefore, if the study area is enlarged, it becomes increasingly necessary to select and generalize the data used. This is true of all kinds of spatially arranged resource analyses, but it is made much more difficult in the context of sustainability by the complexity of factors involved and their anticipated change with time.

Values of 'scale' (eg. 1:5000 or 1:100 000), reflecting that of the land resource maps on which the evaluation is based, should be used to denote the level of detail of a particular local sustainability evaluation. Because of great differences in the nature and the spatial basis of the data used (physical, economic, social etc.), the scale 'value' will be seen only as a crude measure of the relative detail of separate evaluations.

Particular problems relating to 'location' arise in attempting to evaluate sustainability over an area larger than a small field. The characteristic of 'location' itself is of particular importance to sustainability. Location has a direct bearing, for example, on the distance (and difficulties of access) to markets and sources of supply. If a large area is evaluated the sites of specific evaluation interest (those with the specified form of land use) may be found in a number of different places each with different location characteristics.

Other related problems can all be described as "off-site" effects since they depend, not on characteristics within the area(s) examined but on the positioning of these area(s) within the surrounding region and on characteristics of this surrounding countryside. Factors in this category, which are discussed separately in chapter 4, include pollution hazards (to or from the site), flood hazard, and problems of population movement. Such factors can be assessed directly in respect of a small field. Within a larger region, in which the land use to be evaluated may occupy several areas, they have to be conceptualized and averaged in some potentially complex manner.

'Detailed' and 'generalized' forms of sustainability evaluation

Closely related to 'scale, are the considerations which distinguish detailed sustainability evaluation (based on the whole pathway of the FESLM) from more generalized evaluations of large areas, in which FESLM procedures may be short cut.

In a detailed study, at a 'scale' of 1/10 000 or less and relating to no more than a few hectares of land, most factors that are diagnostic of sustainability can be expected to act uniformly on the land use in question-which is assumed to occupy most if not all of the land. Moving into the future, the factors continue to act uniformly over the land, although their status may change and new factors may become important. What is crucial in this context is that the situation being evaluated approximates closely to reality. The evaluator is not free to choose the environmental factors which he/she evaluates; these, in all their complexity, are intrinsic to the specific site. He/she is free to select the factors he/she thinks are most significant and does so by working through the whole pathway of the FESLM.

In contrast, when the sustainability of a specific land use is studied within a large area it is likely that the use occupies only parts of the area as a whole and that there will be minor differences, at least, between these parts. With the passage of time the use may be extended to new, presumably similar, sites within the area and will cease to occupy others. In these circumstances it is apparent that sustainability can only be evaluated in terms of conceptual 'average' values of the environmental characteristics and that factors relating to 'location' must be averaged also.

The larger is the area studied, the more difficult it is to ascribe representative "average' values to environmental characteristics and the greater are the uncertainties of change within the area with time. Differences in the influence of separate factors on sustainability are themselves likely to differ within a large area. Faced with these uncertainties, it is pointless to pursue subtleties of evaluation or to apply diagnostic criteria to possibly unrepresentative data. Instead the evaluation must focus on broad 'indicator, attributes and 'thresholds", all expressed in rather generalized terms as discussed further in chapter 4.

Clearly 'detailed' and 'generalized" sustainability studies differ in kind. If the latter can be supported by the former on representative sites, so much the better.

Principles of sustainability evaluation

The procedures advanced in the FESLM are intended for practical application and it is hoped to provide maximum flexibility in their application to meet local circumstances. Nevertheless, certain principles are considered fundamental to the approach and methods employed. These Principles are intended to govern the further development and use of the FESLM in all circumstances. Some of these principles (Nos. i, iii, iv) are shared, in essence, with the Framework for Land Evaluation (FAO, 1976). The Principles are:

i. Sustainability is evaluated for defined kinds of land use: minor change in the objective of a land use, or in the means employed in achieving this objective, can alter the sustainability of the use. A sustainability evaluation is meaningless unless both aspects of land use are adequately defined and remain substantially unchanged or are the subject only of foreseen and defined modifications.

ii. Sustainability Evaluation relates to specific land sites: the character of the land is no less fundamental than that of the land use in deciding sustainability. Given the importance of economic and social factors in sustainability evaluation the precise location of the site may be crucial.

iii. Sustainability Evaluation is a multi-disciplinary activity: all aspects of the human environment-physical, biological, economic and social-may bear upon sustainability and so may require specialized investigation. All parties with a legitimate interest in an evaluation need to be identified and involved as early and as thoroughly as possible to ensure cooperation and achieve a widely acceptable solution.

iv. Evaluation is made in terms relevant to the physical, economic and social context of the areas concerned: It is not realistic to recognize as sustainable forms of land use which, although successful elsewhere, depend for success on factors such as available manpower, marketing infrastructure, or transport which are lacking in the area concerned. In presenting an evaluation it will usually be desirable to state what local constraints on land use choice have been taken into account.

v. Sustainability relates to a defined timeframe: to attempt to predict sustainability over indefinite periods would be unrealistic.

vi. The processes and practices of any existing present land use should be fully understood and its present suitability established before change based on sustainability evaluation is recommended: to do otherwise is to risk costly waste of time in evaluation and unreliable recommendations.

vii. Evaluation is based on scientifically valid procedures and data and on a choice of criteria and indicators of sustainability which reflect understanding of causes as well as of symptoms: only on this basis is evaluation likely to lead to prevention and cure of degradation and instil confidence.

One further principle governing the implementation of evaluation findings is desirable to ensure that the work consistently achieves positive results. This is:

viii. Introduction of new or modified practices will be made initially on an experimental scale and its subsequent progress carefully monitored: field validation is necessary to avoid costly mistakes.

Chapter 2: FESLM - The general approach

The general approach to sustainability appraisal

Using evaluation factors

As discussed in Chapter 1, land use 'sustainability' can be seen as an extension of land use 'suitability' into the future. Exact definition of a form of land use suited to present land conditions is the objective of the FAO Framework for Land Evaluation (FAO, 1976). It is also a wise starting point for the FESLM.

Faced with a challenge to determine whether a particular land use activity can be sustained, the first task must be to examine and analyse the exact objective of the activity and the means by which it is being, or is planned to be, achieved. Once identified, these characteristics of the use may be related to those of the environment at the planned location; leading to a decision on the extent to which the latter meet the requirements of the former and will aid or constrain performance.

In essence, this is the approach adopted in the FAO Framework to determine whether a use is 'suitable'.

Experience and common sense provide the first measure of the likely impact of environmental characteristics on land use performance. Actual experiment and observation of like situations elsewhere provide more precise, even quantitative, evidence of cause and effect. Then, as observational evidence accumulates, increasingly reliable mathematical models can be developed to relate environmental characteristics to land use performance. Using these models, values for effects can be interpolated, or extrapolated, for situations in which land characteristics differ from those of the observed site.

Various ways of projecting response from one situation to another have been demonstrated. These include the use of direct measurements, simulation models or empirical assessments of assumed relationships between benefits and diagnostic criteria (FAO, 1976, pp. 36-37). Finally, a measure of 'suitability' is achieved by summing all the perceived positive and negative effects of present day interactions between land use and environment.

Similar methods can be used to predict sustainability within the FESLM, but because the FESLM looks to the future, there are two very significant complications:

- all trends of change with time need to be identified in the environment of the investigated site;
- the state of evaluation factors after predicted change must also be predicted, for they cannot be measured.

If these difficult steps can be achieved, an integrated assessment of 'suitability' at various future times (based upon the predicted status of the evaluation factors) effectively provides an assessment of sustainability throughout the period investigated.

Procedures for selecting environmental attributes for use as evaluation factors in sustainability analysis are discussed later in the context of constructing an Action Framework (see Chapter 4).

Indicators, criteria and thresholds

Certain attributes may prove especially helpful in evaluating the sustainability of particular uses-because their status is highly relevant to performance and because their instability in relation to known environmental pressures is highly predictable. Such attributes have been described as 'Indicators' of sustainability.

Sometimes specific levels or conditions of an Indicator attribute are seen to have special significance in sustainability evaluation and are described as 'Thresholds'. A 'Threshold' level might be one at which a significant change in the influence of an indicator occurs, or one beyond which further change in the indicator attribute would be unacceptable. The interacting processes and factors which determine 'Threshold' levels are termed ''Criteria'.

The FESLM Working Group has defined 'Indicators', ''Criteria' and 'Thresholds' as follows:

- INDICATORS: Environmental statistics that measure or reflect environmental status or change in condition (eg. tonnes/ha of erosion; rate of increase/decrease in erosion)
- CRITERIA: Standards or rules (models, tests or measures) that govern judgements on environmental conditions (eg. impact assessment of the level of erosion on yield, water quality etc.)
- THRESHOLDS: Levels beyond which a system undergoes significant change; points at which stimuli provoke response (eg. a level beyond which erosion is no longer tolerable).

The recognition of 'thresholds' (by applying 'criteria' to measurements of 'indicators') will provide powerful tools in deciding whether or not a chosen land use will be sustainable.

Achieving flexibility of subject matter

Flexible procedures are a great advantage in any diagnostic system. If well chosen, flexibility can prevent a procedure coming to a premature stop by providing an alternative path forwards. Considerable flexibility is achieved in FAO's Land Evaluation Framework by allowing the evaluator to continuously adapt his land use definition to meet environmental constraints as these are recognized. This 'two steps forward one step backward process' known as 'iterative matching' - can be pursued until, hopefully, a complete management package capable of meeting all the local environmental constraints is designed - a 'suitable land utilization type'. This final package, indeed a variety of alternative packages, may bear little resemblance to the land use originally explored or the use currently occupying the site (FAO, 1976).

This approach is well suited to Land Evaluation for which the main aim is to identify alternatives of land use suited to the site in question. It is less appropriate for sustainability evaluation for which the initial aim, at least, is to determine the sustainability of a particular form of use-normally the present use of the site. A client, having asked whether a certain use is sustainable, may not be content with an evaluation of a different use-certainly not if the use objective is different!

At the same time, it has to be recognized that adaptation of a land use system in response to changed circumstances is normal practice in all fields of land use. In the FESLM a sharp distinction is drawn between the 'objective' of a land use and the 'means' by which it is achieved.

The FESLM does not claim to cope with unforeseen change but, if change is foreseen, the procedures allow for adaptation of the use in one of three ways:

- the definition of the use to be evaluated can stipulate the need for progressive or step-wise adaptation as foreseen changes occur (the evaluation would then take account of these changes as the analysis proceeds - the need for adaptation being agreed with the client in advance).

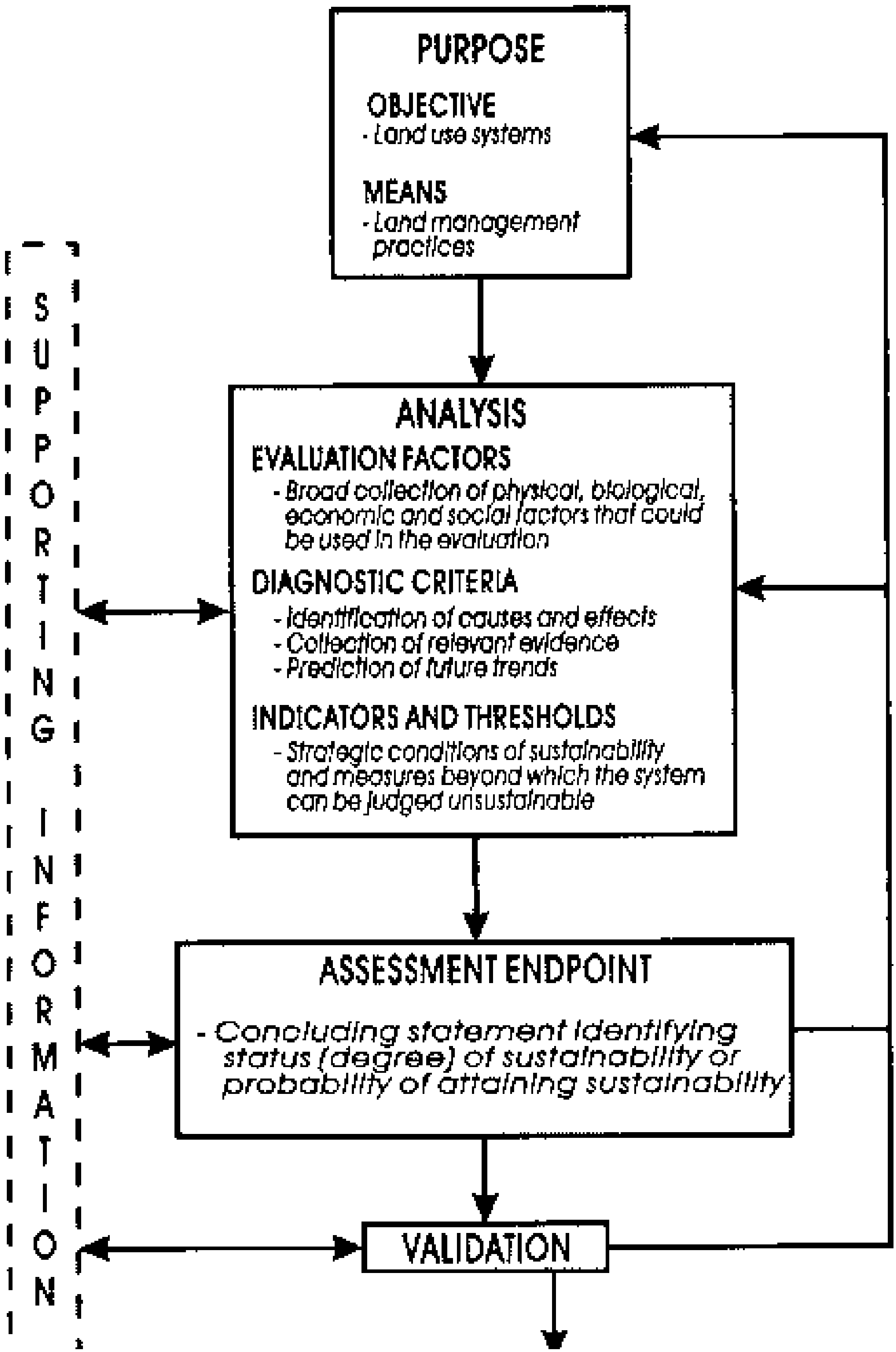
- if a future need for minor changes in the means employed (not in the use-objective) is detected as the evaluation proceeds these can be incorporated in the final report as a qualification of the definition of the No.1 Use evaluated (minor change in fertilizer usage, introduction of pesticides, change in marketing policies etc., would be examples in an agricultural context of the kind of minor change envisaged).

- if, when the evaluation is already underway, a need is detected for future significant change in the means employed this implies that the investigated use, as originally defined, is unsustainable. This will be reported. Meanwhile, the evaluation can be restarted to re-explore the original use-objective but with redefined 'means' - means modified in the light of the earlier evaluation findings. (These modified means become a part of the definition of 'Use No. 2' within the original evaluation).

Note, none of these alternatives allow for a change in the use-objective. One cannot begin to evaluate arable farming and end up proposing a golf course! A new use-objective becomes the subject matter of a new evaluation.

Thus, although the FESLM lacks the flexibility of subject matter enjoyed by the FAO Framework, some measure of flexibility remains.

FIGURE 1: Outline FESLM



The framework structure

The structure in outline

Earlier in this text the Framework has been called 'a logical pathway' - a pathway that seeks to connect the form of land use under investigation with the multitude of environmental characteristics which, together, seem likely to determine whether that form of land use is sustainable. It does so through a series of pre-determined stages.

So large is the range of environmental characteristics potentially bearing upon sustainability that, without a systematic approach, it would be impossible to identify any but the most obvious factors influencing a specific use, much less the complex interactions known to affect sustainability. In time, as our understanding of these problems increases, the range of factors and interactions to be considered will be so extensive that only a computer could handle the number of comparisons that will need to be made. Indeed, the sooner the Framework is computerized the better. A logical pathway is essential, of course, to computerized analysis.

The FESLM pathway is shown, in simplified form, passing through the centre of Figure 1.

There are two main stages of the pathway. The first stage, with two levels, defines the purpose of the evaluation-WHAT is to be evaluated. The second stage, with three levels, defines the process of analysis-HOW the evaluation is done.

The titles and intentions of the 5 levels are as follows:

The Purpose: (What?)

> **Level 1: Objective:** identifies the land use system to be evaluated in terms of its purpose, its location, and the time period for sustainability
>
> **Level 2: Means:** defines the management practices to be employed to attain the Objective

The Analysis: (How?)

> **Level 3: Evaluation Factors:** identifies the qualities, attributes, processes, controlling interests or constraints which affect sustainability in the context of the evaluation and against which the sustainability analysis is conducted

Level 4: Diagnostic Criteria: (causes, effects and observations): identifies how the selected evaluation factors impact on sustainability - through analysis of available information, modelling, expert systems and, if need be, experimentation

Level 5: Indicators and Thresholds: identifies measurable or observable attributes which, in time projection, reveal the future status or condition of the evaluation factors and which individually, or together, provide a measure of sustainability

Conclusions on the probable sustainability of the land use system are drawn together in an 'Assessment end point'. These conclusions require to be validated by re-examination of all the steps in the analysis. In particular, this reexamination should ensure that there has been consistency throughout in the application of the Framework Principles and procedures and in teens of the five principles of sustainable land management.

A family of frameworks

The range of circumstances in which sustainability may need to be evaluated is immense. For this reason it is planned that the FESLM should embrace two kinds of framework:

• ***A 'Master' (or 'Reference') Framework:*** a reference text. Not tied to any specific land use objective, any specific location, any scale of interpretation or any stated period of time; but describing and explaining the complete diagnostic pathway and (eventually) including a comprehensive checklist of factors, criteria, indicators and thresholds that may be relevant to sustainability evaluation in all foreseeable circumstances

• ***'Action' (or 'Local') Frameworks:*** each developed to investigate the sustain-ability of a specific kind of land use, at a specific location, at a specific scale, over a stated period of time; using the pathway, and factors, criteria, indicators and thresholds selected from the Master Framework as relevant to the specific conditions.

The complete structure of the Master Framework and the method of constructing an Action Framework are described in Chapter 3 and 4, respectively, which follow.

Chapter 3: Structure of the master framework

The reader will have appreciated that the pathway shown in Figure 1 is a drastic simplification of the actual form of the FESLM structure. In reality, the pathway will divide repeatedly at each level; and additional complications of separation and feedback are necessary to reflect the processes of establishing cause and effect and to recognize the differing nature of the evaluation factors and the differing expertise required to unravel them.

In principle, the planned form of the Framework is part hierarchy, part matrix. Basically, the Framework is hierarchical, like a family tree, descending vertically from the defined land use at the top through a succession of diagnostic levels (the horizontal parts of the frame). At each level the pathway divides into more and more branches, each reflecting a sharpening focus on separate environmental criteria or factors relevant to land use. The intention is to identify, at the lowest level of the Framework, actual 'threshold' values of relevant environmental 'indicators' which, together, will assist the user to assess and monitor sustainability.

In the lower, diagnostic, part of the Framework it is thought necessary to further separate the structure into vertical columns which reflect different subject areas (disciplines) in the total environment. In the early stages of analysis, at least, practical reasons make it desirable to separate factors which belong respectively to the physical, biological, economic and social environments. The 'factors', 'indicators', 'criteria' and 'thresholds' relevant to each of these environments differ greatly in kind and require different specialist expertise in their investigation.

Effectively, the separate environmental columns divide the hierarchy into separate diagnostic frameworks. But the whole is best seen as a connected matrix underlying the hierarchy. Viewed in this way, the horizontal levels of the hierarchy are seen not only to cut across but also to connect the vertical columns-thus drawing attention to the important inter-relationships between the physical, biological, economic and social environments. These relationships can have a crucial bearing on sustainability and must always be kept in mind.

Figure 2 merely shows, in sketch form, how the combination of hierarchy and matrix is envisaged. Figure 3 shows how this structure is applied to the FESLM itself. Note, in particular, in Figure 3, that the analytical sub-framework is repeated in each column of the environmental matrix and that the whole environmental matrix, with included sub-frameworks, is repeated for each use.

FIGURE 2a: Simple hierarchal framework

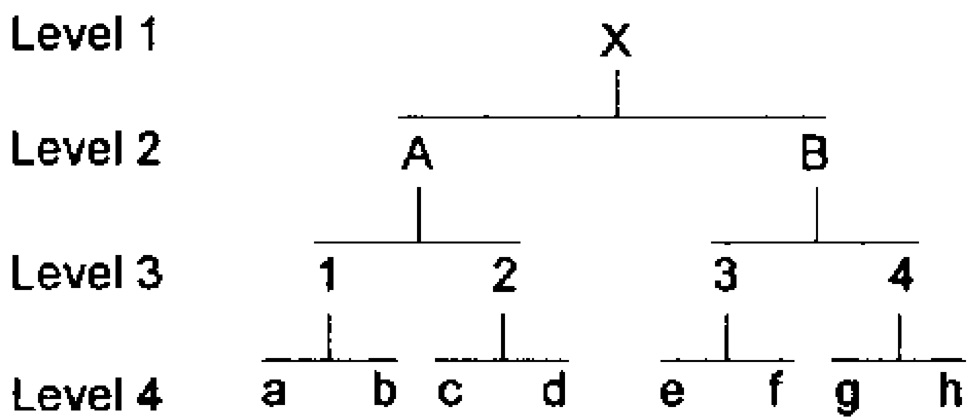


FIGURE 2b: Simple matrix

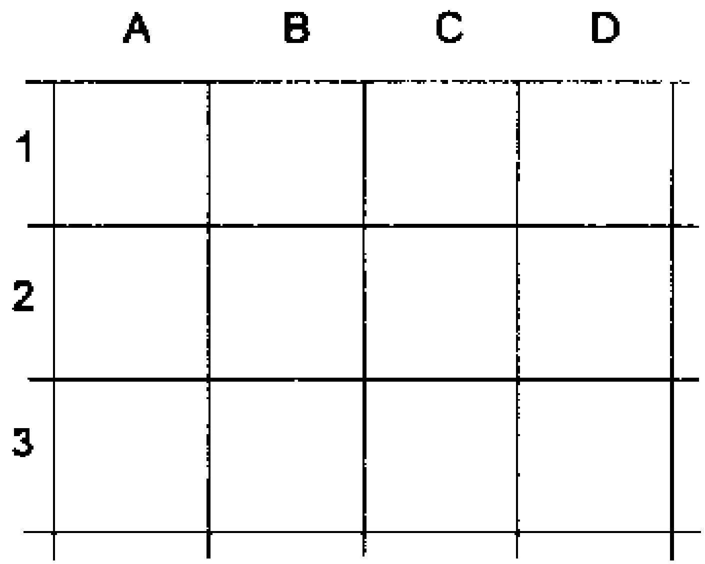
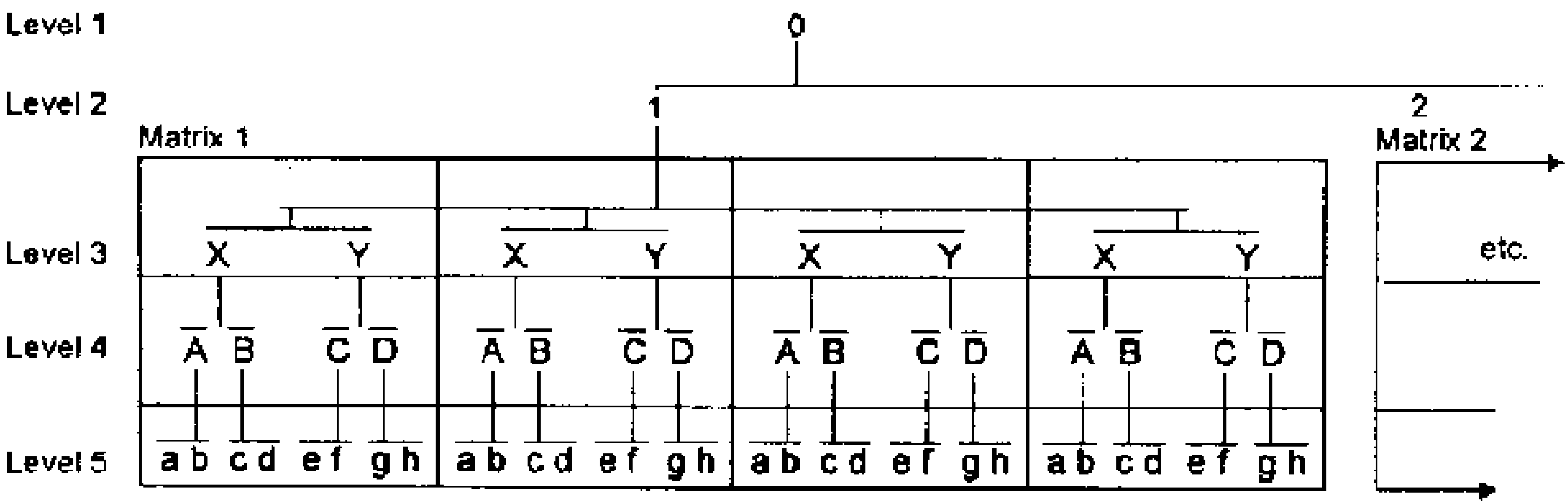
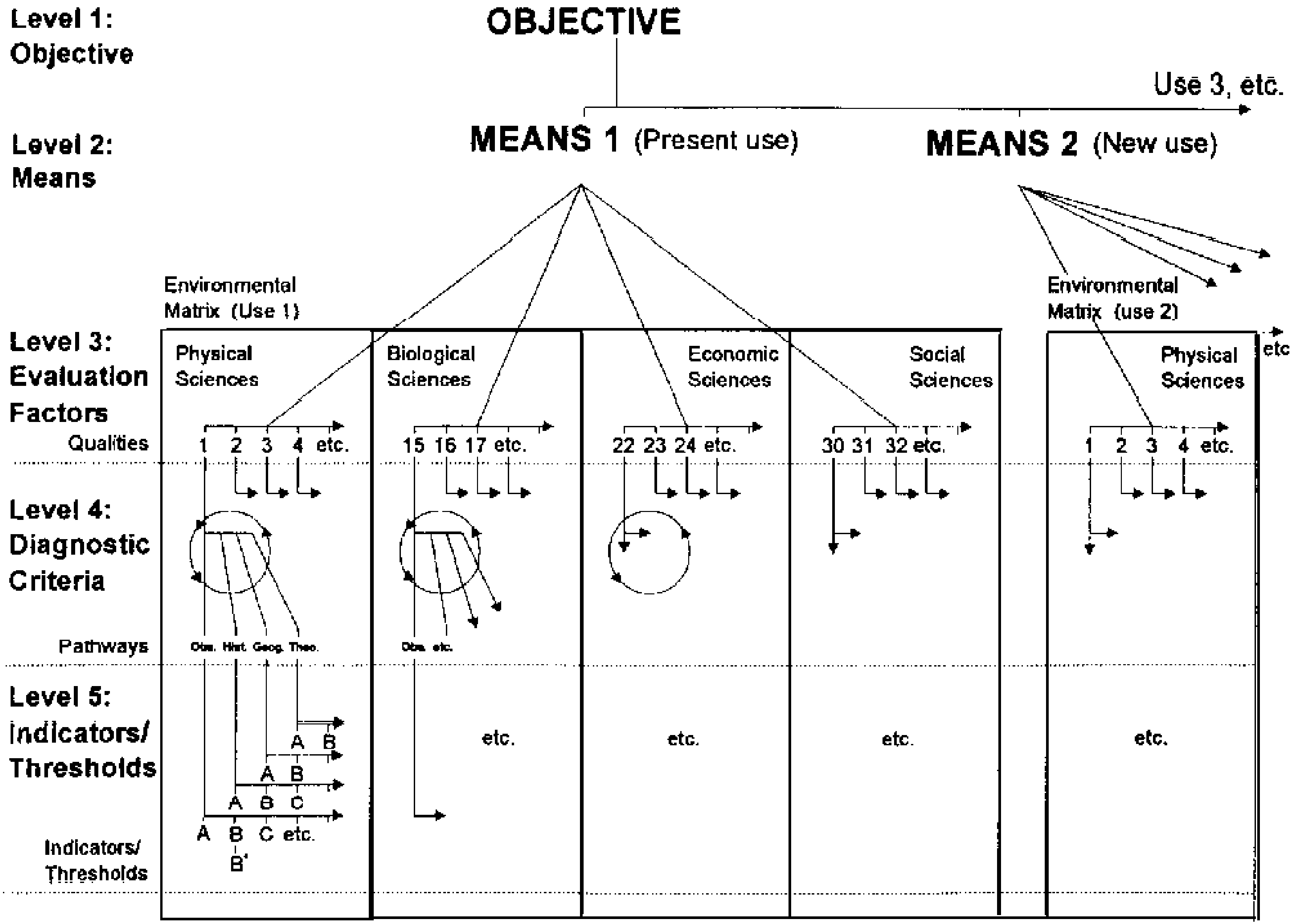


FIGURE 2c: Combined hierarchy and matrix



NOTE: In the FESLM (see Figure 3) the structure of the lower levels (3-5) of the hierarchy is repeated in each of the vertical columns of the matrix on which the hierarchy is superimposed. The matrix and the lower levels of the hierarchy are all repeated for each use.

FIGURE 3: FESLM - a diagrammatic representation



The names of the separate levels of the hierarchy shown in Figure 3 are those described previously (Chapter 2) and are repeated here only for convenience:

Group	Level	Name

Purpose	1.	Objective
	2.	Means
Analysis	3.	Evaluation Factors
	4.	Diagnostic Criteria (cause and effect and observations)
	5.	Indicators and Thresholds

The intention and content of these separate levels is explained in Part 4 in the context of constructing an Action Framework.

Experience in using the Framework may show it to be desirable to increase the number of columns in each matrix so that separate aspects of the different environments may be analyzed separately; eg. soils and climate (within the physical environment) or legal, political, and administrative considerations (within the social environment). Increasing the complexity of the matrix would complicate the Framework as a whole, but the degree of specialist knowledge associated with each environmental aspect may make this step desirable.

The complete Framework is likely to be so complex that presentation in graphic form would not be useful even if, indeed, it were feasible. The associated data will be most conveniently stored and used within a computer, but it could also be published in book form; the data being organized into chapters and subdivided into sections in accordance with the columns and horizontal layers (or vice versa) of the matrix.

The Master Framework is conceived as embracing all environmental factors which bear upon sustainability without reference to their importance to any particular use or any specific locality. Through its various levels it will seek to show the relationships which, in general terms, identify certain factors as 'indicators' of sustainability and the 'criteria' which determine what levels (or expressions) of each 'indicator' may be regarded as diagnostic 'thresholds'. Eventually, the Master Framework will provide a comprehensive checklist of these evaluation factors.

In principle, there will be only one Master Framework, applicable globally, but, in practice, it may prove more satisfactory to develop separate Master Frameworks for each major ecological region. If so, cooperative development and close coordination of content will be essential to avoid confusion and duplication of work.

The Action Frameworks, of which there will be as many as there are uses to consider and locations to evaluate, will have the same structure as the Master Framework; but all those factors in the checklist which are not immediately relevant to the use and locality under consideration will be ruthlessly eliminated. The construction of an Action Framework and this process of elimination is discussed in Chapter 4.

Chapter 4: Constructing an action framework

Getting started with an action framework

Action (or 'Local') Frameworks are the cutting edge of the FESLM, the part where theory changes to action. They use the principles, procedures and structure advocated in the Master Framework and eventually will draw from it a selection of indicators and thresholds with which to evaluate the sustainability of a specified use. The generalized guidance provided by the Master Framework has to be refined and fitted to a pattern determined by the precise objectives of the local investigation.

Before starting work on sustainability, the evaluator can expect to have at his disposal, or will need to acquire:

• a wide range of information relating to the natural and human environment of the site;

• a systematic land evaluation confirming that the use to be investigated is suited to the present conditions of the site.

The need for prior suitability evaluation has been queried, but it should be noted that the requirements of systematic sustainability evaluation and those of suitability evaluation are very similar, in terms of data collection and diagnosis. Insisting on the latter as a prelude to the former should lead to very little duplication of activity, yet ensures that sustainability evaluation is started on a sound foundation. Knowledge that a use is sustainable is unlikely to be encouraging unless the use is known to be well suited to the site in the first place!

Assuming this to be the case, the FESLM approach is to examine the stability of the individual factors that bear most directly on the present suitability. If all are stable, it is reasonable to assume that the use will continue to be suitable into the future. If the factors show signs of instability it becomes a matter for evaluation to determine whether the use, once suited to the site, will remain so.

Establishing the purpose

It will be recalled that the first two levels of the FESLM, call for statements that define the Purpose of the evaluation. These comprise:

1. The Objective: the land use purpose; the location; the scale; and the time period
2. The Means: the means to be employed to achieve the land use purpose

TABLE 1: List of attributes (measured or assumed) that may contribute to the description of a 'land utilization type' (adapted from FAO, 1976, p. 10).

Objectives	- produce, including goods (eg. crops, livestock, timber), services (eg. recreational facilities) or other benefits (eg. wildlife conservation)
	- infrastructure (eg. sawmills, tea factories, agricultural advisory services)
	- size and configuration of land holdings; consolidated or fragmented
	- land tenure; legal or customary rights to land; by individuals or groups
	- income levels; *per caput*/area/production unit
Means	- capital intensity
	- labour intensity
	- power sources (eg. human labour, draught animals, fuel-driven machinery)
	- technical knowledge and attitudes of land users
	- technology employed (eg. Implements and machinery, fertilizers, livestock breeds, farm transport, methods of tree felling, etc.)

The combination of 'objective' and 'means' constitutes a fully defined land use (a 'land utilization type' in FAO Land Evaluation terminology):

OBJECTIVE + MEANS = DEFINED LAND USE

The separation between 'objective' and 'means' is made to allow hypothetical changes in the 'means' employed to be tested for their effect on the sustainability of an unchanged objective. This provides flexibility within a single framework (see Chapter 2). The need for such changes may be revealed by the evaluation process itself, and is handled within the FESLM by creating alternative 'Means' statements. Whether the changes call for recognition and evaluation of a new land use depends on the significance of the adjustments made. In any case, the changes would necessitate some re-analysis.

This capacity for changing the terms of reference ('moving the goalposts') whilst the evaluation is in progress is of great importance in increasing the capacity of Action Frameworks to assist local planning and development.

Thus, whilst there is only one 'objective statement' in each Action Framework, there may be several 'means statements' which, by qualifying the objective statement, define alternative forms of land use to be evaluated separately.

Level 1: The objective statement

Level 1: Aim, problems and procedure

AIM: To provide a concise statement of the evaluation task to be performed - to evaluate the sustainability of land use for a defined purpose, in a defined site, at a defined scale, over a stated time period.

The Objective statement provides the foundation on which each local action framework is built. It can be regarded as 'given' information.

PROBLEM: Knowing what details must be included in the Objective statement. In principle, the objective statement should not be changed without starting a new evaluation. In practice even quite minor changes could lead to confusion. (The 'stated time period' provides an exception to this ban on change. The hoped for 'time period' should be 'pencilled' in before the evaluation starts but in the understanding that it may have to be changed in the light of evaluation findings.)

PROCEDURE: It is the evaluator's job to ensure that the 'Objective statement' is complete and unambiguous. For example, if the land use has multiple purposes, each purpose must be described. In agriculture, all the important crops and other product(s) need to be identified. If production is centred on a particular crop variety, or cultivar, this must be stated (otherwise the choice of variety/cultivar can be included in the 'means statement'). If intercropping or agroforestry is to be evaluated, a similar choice between 'objective' and 'means' statements exists in describing the proportion of the land and of the cropping year occupied by each crop. The decision to be made is: are either of these factors essential to the concept of the use?

If the land use purpose is environmental, industrial, recreational or aesthetic, the aims and circumstances need to be just as carefully considered to ensure the use is fully characterized.

Table 1 lists some of the attributes of 'land utilization types' recognized by FAO in the Framework for Land Evaluation (FAO, 1976). The list provides a useful reminder of the wide range of distinctions that can be drawn between forms of land use. It has been adapted to distinguish those attributes which, at first sight, relate most closely to the Objective statement in the FESLM and those which are descriptive of the Means. It will be apparent that, of the attributes listed, all but the first-'the produce'-could be regarded either as essential to description, of the use (objective) or adaptable (means) depending on local circumstance and interpretative convenience.

Within the Objective statement the location to be evaluated must also be accurately defined. On those rare occasions when the site is a regular shape (eg. a rectangle) location can be defined by grid references (eg. latitude and longitude). More often the complex shape of a location must be shown on some convenient map of adequate scale.

The scale of the evaluation is stated in the form of a representative fraction (eg. 1:5000) which relates to the scale of the principal sources of mapped information used in the evaluation. (NOTE: Every effort will have to be made to ensure that all the data used in the study and in its eventual findings is at a level of detail commensurate with this reported map scale - this is not easy when data as diverse as soils, climate, economics and social information have to be included).

Information on the scales and sources of data used in the evaluation should form a separate section in the final report (see Chapter 6).

Often it will be more satisfactory to delay definition of the time-period until the analysis is completed and the reliability of all the factors of sustainability has been assessed. The client may seek assurance over a longer period but he/she should not be misled.

Examples of objective statements in local frameworks

Example 1. To evaluate the sustainability of a rainfed cropping cycle, primarily for subsistence; with a three year rotation of maize, cowpeas, cassava and five years of bush regrowth fallow; low capital input; hand labour; basic technology; on a 2 ha farm at a location indicated on an available map; over a fifteen year period.

Example 2. To evaluate the sustainability of continuous, rainfed maize cropping for the commercial market; high capital input; high technology; fully mechanized; on a 50 ha rectangular block (Grid Ref: 234.450 to 234.46 W and 100.455 to 100.460 N): over 20 years.

Example 3. To evaluate the sustainability of a nature reserve of mixed temperate forest; intended to maintain the existing range of plant and animal species whilst providing limited recreational facilities; in a 55 km^2 area at a location indicated on an available map; over a 50 year period.

Level 2: The means statement (present use)

Level 2: The aim, problems and procedure

AIM: To describe all aspects of the measures to be used to achieve the ends defined in the Objective statement; including management and organizational practices, technology, inputs and facilities. Together, the given Objective statement and the present Means statement define the first 'Use' to be tested for sustainability.

An evaluation of sustainability will not be meaningful if the definition of the land use investigated does not include an adequate description of the means to be employed.

PROBLEMS: The distinction between 'objective' and 'means' is not as clear cut as it may appear. Some aspects of descriptive information about the use could be at home equally well in either statement Information that crucially describes the nature of the land use purpose should be included in the 'objective' statement. Information on aspects of the approach that could be altered without significantly changing the intention of the use belong best in the 'means' statement.

PROCEDURE: Creating a satisfactory definition of the 'means' may not prove easy-even if the land use is in place to be examined at first hand-for there is always a great variety of aspects of management and physical input that could be described. Choice and definition must focus upon those aspects that are critical to sustainability. These may not be obvious, or easily described.

Table 1 again provides some guidance on attributes to be considered. In the context of the FESLM, special attention needs to be focused on the management practices employed. These practices, against a given socio-economic background, may determine whether or not the land use is sustainable.

In particular, the 'means' description of the FESLM should focus upon practices designed to minimize land degradation:

- erosion control measures (eg. contour ploughing, alley cropping, terracing etc.)
- nutrient control measure (eg. fertilizer regime, green manuring, fallowing, legumes, etc.)
- soil structure control measures (eg. tillage methods, mulch incorporation, land clearing methods etc.)
- moisture control measures (eg. types of irrigation, mulching, water harvesting, drainage methods)
- weed, pest, disease control measures
- reclamation measures (eg. lime, gypsum, ripping, deep ploughing etc.).

The 'means' statement should be selective - a compromise between a truly comprehensive essay (which risks obscuring critical facts amongst unessential details) and a terse telegram (which risks omitting facts that will prove important later).

The following example Means statements (A, B, C) are intended to correspond to the example Objective statements given earlier (1, 2, 3 respectively). Together, these pairs of statements (1A, 2B, 3C) constitute a Goal statement for Use 1. of their respective evaluations.

Example A. Existing management practices and inputs are: a cropping cycle (Yr.1 maize-cowpeas, Yr.2: maize-cowpeas intpl. cassava, Yr.3: cassava, Yr.4-9: fallow regrowth); minor interplanting (eg. melons, peppers) with all crops; land clearance by hand, burnt, soils ridged and tied by hand; planting materials local; up to 100 kg 10-10-8 fertilizer on maize; maize weeded twice, cowpeas once, no pest control; cassava harvested yr. 3 and 4.

Example B. Existing management practices and inputs are: high capital/low labour; tractor drawn trash cutting, mould-board contour ploughing, seedbed preparation; self-propelled harvesting; grassed contour ridges; hybrid seed (KK64x) at 90 000 plants/ha; chemical fungicides and pesticides when required.

Example C. Present practices and facilities are: No forest management; entry protected by game fence and two guarded gates; lakeside recreation area with toilets; two fire breaks (one along power line); 16

km unsurfaced roads, 42 km of bridleway; fire tower (not continuously manned).

Level 2: The means statement (additional uses)

If the present use is found to be unsustainable, the principle causes of instability should be apparent when sustainability analysis is completed. At that stage it will be worth considering whether stability could be increased by changing some aspect of management practice or providing some additional inputs.

For example, if the rate, or threatened rate, of erosion is unacceptable, consideration can be given to the possibility of introducing additional erosion control measures (eg. contour ploughing, contour strips, alley cropping or terracing). If one or more of these measures appears promising, the 'Means' statement is altered to incorporate the new measure and the evaluation is rerun on an hypothetical basis (paying particular attention to cost/benefit aspects). The new Means statement and the new evaluation relates to Use 2. If the new analysis suggests a need for further it may be necessary to consider Use 3, and so on.

If the changes are minor - eg. a small increase in the use of fertilizers or pesticides, or a minor change in the nature or timing of cultivation practices - it may be acceptable to incorporate the change within a recognized use provided that the change is recorded in the 'Means' statement.

Since it will not be possible to test the future effects of any proposed changes, it is essential to ensure that all newly proposed means are in keeping with the general socio-economic conditions of the surrounding area. It would rarely be sensible, for example, to propose the introduction of sophisticated technology in an area with no tradition or support for using such technology.

Undertaking the analysis

It will be recalled (Chapter 2) that the third, fourth and fifth levels of the FESLM relate to the process of Analysis, and comprise:

Level 3: Evaluation Factors
Level 4: Diagnostic Criteria, Cause and effect and observations
Level 5: Indicators and Thresholds.

The first step is to recognize all the factors that are likely to bear upon the sustainability of the use in question in the developing circumstances of the future. The second step is to develop criteria for assessing the stability and significance of each of these factors, alone and in combination, by understanding the causes and effects involved and making such observations as are possible to project the future. Using these criteria, the most significant of the factors ('Indicators') are identified in the third step and their future status in relation to critical levels ('Thresholds') is projected. In the final analysis all this information is brought together to provide an evaluation of probable sustainability [2].

[2] It is important to recognize that throughout this text, 'suitability', 'sustainability' and 'stability' are all conceived against a background of achieving and maintaining the five stated 'pillar' requirements of Sustainable Land Management (SLM), namely: Productivity, Security, Protection, Viability and Acceptability (see Chapter 1).

- *'Suitability' measures achievement of all these requirements in the present.*
- *'Sustainability' measures the likelihood of their achievement through the future.*

- *'Stability' measures the likelihood of changes that will impact on any, or all, of these requirements.*

This interpretation elaborates the definition, but does not offend the spirit of 'suitability' in FAO Land Evaluation. It also ensures that 'stability' is not interpreted in a narrow conservation context of maintaining the 'statue quo'.

The number of attributes of the human and natural environment which may influence sustainability and require investigation in the FESLM is very great-their variety no less impressive.

Differences in the nature of these influences, and in the kinds of action needed to modify them, is most marked between those which contribute to the natural (physical-biological) environment and those of an economic or social nature. Solely to illustrate the diversity of observations which may signal a threat to sustainability, one can cite: changes in productivity; changes in earthworm population; changes in climate; changes in financial return from labour; changes in the political system; changes in the size of farms or the attitudes of farmers, and many, many other kinds of change.

As explained in Chapter 3, the structure of the FESLM makes provision for this diversity by grouping factors in accordance with the differing specialized expertise required to identify and examine them most effectively. The groups are separated in the vertical columns of a matrix which is conceived to underlie the three lowermost levels of the hierarchy. The groups are then analysed separately, in parallel, through the lower levels before being brought together again in the final analysis.

In the structure shown in Figure 3, four columns separating expertise in the 'Physical', 'Biological', 'Economic' and 'Social' environments are proposed. This arrangement could prove suitable for many Action Frameworks but it is not sacrosanct. Different areas of expertise could be handled separately if circumstances, or the make up of the investigating team, so dictates. For example, experience may show that, in some localities, groups of 'Administrative', or 'Political' factors merit separate analysis (in Figure 3 it is assumed that these factors will be investigated within the Social environment)[3].

[3] *The grouping and separation of factors by expert discipline is proposed as a means of increasing efficiency in the early stages of data handling in the FESLM: it is not intended, in any way, to minimize the importance of inter-disciplinary co-operation and multi-disciplinary overview in sustainability evaluation. The crucial importance of interaction between disciplines is recognised in the emphasis placed on cross checking for interactions across the horizontal levels of the matrix (or hierarchy) especially in the validation stages.*

The discussion of the separate Analysis levels which follows assumes an FESLM structure as in Figure 3, and is divided by discipline in accordance with the matrix columns as appropriate.

Level 3: Evaluation factors

Level 3: The aim, problems, procedure

AIM: To develop a comprehensive list of the factors that individually, or in combination, exert a significant influence on the sustainability of the defined land use in the local situation.

The environmental factors identified at Level 3 form the subject matter of the remainder of the analysis. The choice of these factors is critical to success, since, if one important factor and its influence are overlooked, the outcome of the evaluation may well be entirely wrong [4].

[4] *The terms 'factor', 'attribute' and 'characteristic' are regarded, in this text, as interchangeable and all are deliberately accepted to be vague. The intention is to allow their meaning to accommodate a very wide range of things (eg. pests), processes (eg. erosion), constraints (eg. moisture shortage) and concepts (eg. gross margin); which may be expressed as measurements (eg. maximum temperature) or not (eg. farmer apathy); but all having a possible bearing on sustainability. This, it is hoped, will allow the evaluator maximum imaginative freedom to identify 'factors'.*

In contrast, the term "criteria' is used to describe mathematical functions and other understood rules and relationships, established by investigations of cause and effect, which link different factors and enable the direction and magnitude of change to be predicted when the interacting factors are placed under some form of environmental pressure.

PROBLEMS: At Level 3, the principal difficulties relate to the number and variety of factors that need to be screened. It is relatively easy to identify individual factors that, in a general context, are likely to affect sustainability. It is much more difficult to identify factors of only local significance; to determine their relative importance; and to ensure that the list of locally important factors is comprehensive.

Physical, biological, economic and social factors differ in kind. Methods and scales of data collection in these fields are correspondingly different. Common denominators have to be found so that interactions within this diverse data pool can be analysed in the lower levels of the FESLM.

PROCEDURE: It is planned that, eventually, the Master Framework will include a general list of factors relevant to sustainability, from which a choice of factors relevant to a particular study can be made. In the absence of such assistance, a choice will have to be made from a general list of local environmental factors drawn up from scratch; or, as suggested below, from lists drawn up locally in the context of 'suitability' evaluation.

There is need to eliminate insignificant factors prior to analysis to minimize the cost and effort of evaluation but the rigor of the selection process must be commensurate with ensuring that no important influence is overlooked.

In selecting factors for analysis, particular importance needs to be placed upon:

- Relevance; to the land use in question under present and changed conditions
- Stability; susceptibility to change in the face of other foreseen environmental changes
- Predictability; the possibility of predicting reliable values (preferably numerical values) of the quality or characteristic under foreseeable future conditions.

Guidance on the relevance of attributes will be obtained from a present suitability evaluation if, as is normally to be recommended, such a study (using the FAO Framework) precedes the sustainability evaluation. The process of 'suitability' evaluation includes identification of the environmental attributes relevant to that use at the particular site. One early FESLM task will be to examine a list of such attributes to determine which are likely to be most responsive to change with time and most relevant, therefore, to the evaluation of sustainability. It is possible that additional or different land characteristics will be important in the future. This too will need to be considered.

Environmental attributes which are judged to be reasonably stable can be assumed to have little effect on sustainability; after careful consideration, these can be disregarded in later stages of analysis. Those that are highly unpredictable can only be excluded from analysis; but their existence, as 'wild cards' in the game, must be noted and their change with time monitored-otherwise their unpredicted effects could invalidate the whole procedure.

Factors of the Physical Environment

Many factors of the physical environment pertaining to climate, topography, geology, soils, surface and ground waters, are well researched. Many lend themselves to precise measurement and much is known about their stability, and their influence on various forms of land use, especially in the agricultural sphere. A huge volume of data on spatial distribution of physical factors is available worldwide on maps, GIS etc., and gaps in this knowledge can usually be quickly filled using aerial and space imagery. Such maps, at appropriate scales, are likely to provide the spatial frame for any work on sustainability.

The concept of a 'land quality' may be helpful in identifying suitable attributes for sustainability analysis. Conceived by the late Professor J. Bennema within the methodology of the Framework for Land Evaluation, a 'land quality' has been defined as 'a complex attribute of land which acts in a manner distinct from other land qualities in its influence on the suitability of land for a specified kind of use' (FAO, 1976).

This independent action of the separate 'qualities' is crucial to the concept; in theory, the influence of each quality can be assessed without reference to the status of other qualities. Thus, 'moisture availability, 'oxygen availability', and 'nutrient availability' are identified as land qualities that jointly, but independently, influence plant productivity.

Table 2, borrowed from FAO's 'Guidelines: Land Evaluation for Rainfed Agriculture' provides, as additional examples, a list of 25 physical and biological land qualities that limit the production of rainfed crops.

The proposed use of 'land qualities' in the FESLM is confined to Level 3, where they would provide an initial grouping of factors - meaningful subdivisions of the total environment. Hopefully, their use will assist in ensuring that the range of attributes investigated is comprehensive-the 'qualities' identified at Level 3 need to embrace all the factors likely to influence the stability of the use being investigated.

The listed 'qualities' serve merely as indications of where potential instability must be sought. Some overlap between 'qualities' is inevitable-with individual attributes exerting an influence on more than one 'quality'. This is immaterial in sustainability evaluation for, inevitably, the bundles of attributes which constitute a 'quality' will be taken apart at Level 4, as the cause and effect of instabilities is examined, and at Level 5 where the stability of individual 'Indicator-factors' is examined. If some individual factors are involved in several 'qualities', this will be quickly exposed and accounted for.

TABLE 2: Some land qualities* influencing the productivity of rainfed crops (from FAO Soils Bulletin 52: Guidelines: Land Evaluation for Rainfed Agriculture, 1983)

Land Quality	
1	Radiation Regime (sunshine)
2	Temperature regime
3	Moisture availability
4	Oxygen availability to roots (drainage)
5	Nutrient availability
6	Nutrient retention
7	Rooting conditions
8	Conditions affecting germination and establishment
9	Air humidity as affecting growth
10	Conditions for ripening
11	Flood hazard
12	Climatic hazards
13	Excess of Salts
14	Toxicities
15	Pests and diseases
16	Soil workability
17	Potential for mechanization
18	Land preparation and clearing requirement (vegetation/weeds)
19	Conditions for storage and processing
20	Conditions affecting timing of production
21	Access within the production unit
22	Size of the potential management units
23	Location
24	Erosion hazard

25	Soil degradation hazard

*For a thorough discussion of the nature of these qualities, their evaluation factors, units of measurement and use in assessing the suitability of land for rainfed crops, the reader is referred to FAO Soils Bulletin 52 (Rome, 1983).

Independent factors (i.e. individual environmental characteristics) may be identified which do not conveniently form part of any recognized 'land quality'. There is no reason why such factors, together with their interaction with other factors and qualities, should not form independent subjects in the subsequent levels of analysis.

Factors of the Biological Environment (by M.J. Swift)

The Check List of Biological Factors

The list of biological factors that influence sustainability is potentially extremely large. Some of the qualities listed in Table 2 are clearly biological in nature (i.e. pests and diseases; weeding; and storage problems). Table 3, with its annotations, provides a general, systematic check list of major categories of organisms and associated attributes which can be utilized by investigators to identify the dominant biological factors within a given land-use system. The check list is presented in the form of a matrix organized on the following basis:

• Functional Groups: Biological factors have been grouped in relation to functions or roles in biological productivity and sustainability:

  • The productive biota: eg. crop plants, livestock, timber trees etc. producing food, fibre or other products for consumption, use or sale; this term is used in the broad sense of any product used outside the production system (eg. to include medicinal products, construction materials etc.). This component of the biota is deliberately chosen by the land user and may be the main determinant of the biological diversity and complexity of the land-use system.

  • The beneficial biota: these are organisms which contribute positively to the productivity and sustainability of the system but do not generate a product directly utilized by the land-user; examples are many of the plant species of fallows or cover crops used to manage soil fertility, and similar species used in weed control; other examples are the soil flora and fauna which may benefit soil fertility; and the predators and parasitoids of pests and diseases.

  • The destructive biota: weeds, animal pests and microbial pathogens. In the case of weeds, this would include intractable plant species dominating abandoned land.

  Dependent on the Objective and Means of the land-use, this primary list can be made by general classification (eg. cereal crops; leaf borne diseases) plus some quantitative assessment score (see below), or preferably by listing species or at least dominant species in each category, again with a quantitative score.

• Attributes: secondary biological factors which are quantitative or qualitative attributes of organisms and which have some direct bearing on sustainability, eg. influence on yield, nutrient cycling etc.

TABLE 3: Check list of biological factors for sustainability evaluation*

Productive Biota	
crops	form:genome:Nfix:mycorrhiza:residues
trees	form:genome:Nfix:mycorrhiza:litter
livestock	feed:excreta
Beneficial Biota	
natural vegetation	type:form:period
fallow	type:form:period clearing
intercrop	type:form:inputs residues
predators	key groups:
soil fauna	key groups:
micro biomass	
Destructive Biota	
pests, a/g	type:reservoir
pests, b/g	type:reservoir
pathogens, a/g	type:reservoir
pathogens, b/g	type:form:residue
weeds	

***form** = shape (physiognomy) which may influence ground cover, competition with other plants; ideally includes roots as well as above ground canopy, etc.
genome = genetic characteristics which influence sustainability, eg. resistance to diseases and pests.
residues & litter & excrete = use within or transport from system; ground cover, etc.
vegetation type = broad floristic grouping to avoid detailed species lists (form as above, i.e. saplings, trees, herbaceous, etc.).
a/g = above ground
b/g = below ground
reservoir = source of pest/pathogen (eg. in soil, alternative host, etc.).

Measurement of Biological Factors

Quantitative measures will be needed for many biological factors to assess their role in sustainability. How many such measures are needed is best decided when the qualitative check list has been completed and a preliminary assessment made of dominant and indicative factors. Measurements that are likely to be useful are as follows:

• for crops and other significant plants, residues etc.: yield, biomass or abundance per unit area; area occupied (cover), site; quality (nutrient content etc); genetic diversity (variation)

- for pests, pathogens, predators, soil fauna etc.: intensity (damage to crops or prey, casting or burrowing activity etc.); number or biomass per unit area etc..

Spatial and Temporal Relationships of Biological Factors

Because of the strong microclimatic, competitive and other interactive influences that may be involved, description should also be made of the structure of the system in space (eg. for the plants, vertical profile and horizontal distribution in relation to the topography and other features of the physical environment); and in time (eg. within season phenology, annual trends and oscillations).

Off-site Effects of Biological Factors

Because of the highly interactive capabilities of many organisms across the landscape (eg. movements of pests and diseases; nutrient transfer by tree roots etc.), consideration should be given both to the actual site and to the surrounding areas with respect to possible off-site influences.

Diversity and Complexity of Biological Factors

Biodiversity and system complexity have been hypothesized to play an important role in sustainability. If the list of factors is constructed on the basis of individual species and with some quantitative measures of frequency and abundance, then it will be possible to calculate diversity indices (eg. Shannon-Weiner or Simpson). Similarly, the spatial and temporal descriptions enable some assessment to be made of the relative complexity of the ecosystem.

Factors of the Economic Environment (by P.K. Thornton)

Table 4 lists a selection of measures and attributes of the economic environment, each of which could be important, in appropriate circumstances, in evaluating sustainability. The separate 'factors' or 'qualities' listed may serve as criteria, indicators, or thresholds (or all three). The purpose of the list is to identify some system 'factors' that, having been recognized at Level 3, can be broken down and analysed in Levels 4 and 5 of the framework, to give an indication of where potential or actual unsustainability may exist in a system.

To an extent perhaps greater than with factors of the physical environment, there will often be overlap between these measures; and many of them will be highly correlated. This is unavoidable, for most economic factors are composites, that is to say they are functions of many variables. Measures such as "net farm income" and "enterprise gross margin per hectare", for example, both depend on variables not only of the economic environment (eg. costs and prices, competing uses of resources) but also of other environmental aspects - the physical (eg. soil conditions), the biological (eg. weed density), and the social (eg. effects of customs, religion, seasonal migration on labour resources).

In practice, some of these 'measures' are difficult to estimate precisely, and others may be difficult or impossible to quantify. As with other factors used for determining sustainability, the time component should be understood as being a key element in the analysis; the trend of a particular quality in the past, and its likely trend in the future, are considerations of the first importance.

The factors listed in Table 4 are divided into four 'functional groups' as follows:

- Resources: these relate to what the household or farm has on hand to carry out agricultural activity, such as land, labour and capital. The most significant facts relating to the resource base should be stipulated in the Means statement (Level 2), but the economic consequences of these factors, particularly of interactions between resources, need to be evaluated. There is need also to consider how, and to what extent, farmers can change their resource base, as well as the things that affect access to resources. Also of special economic importance are measures of efficiency of resource use for particular management purposes.

• The Economic Environment: this grouping refers to factors that are usually considered exogenous to the farming system but have implications for the farm household, such as costs, prices and credit. In other words, these are generally 'given' for a particular parcel of land or household. An understanding of how these factors change over time (such as seasonal variations in costs and prices) is also required.

• Attitudes: this grouping includes factors associated with the farmer or household members that bear on farm decision making. Clearly these factors have sociological overtones, but it is the economic consequences of the attitudes that are examined here. Again, the influences that bear on these factors are often considered "exogenous" to the system itself-in that, if change in farming practice is thought to be desirable, it is generally more realistic to seek new practices that fit with existing attitudes than to attempt to change attitudes themselves. Objectives, attitudes and expectations are often difficult to measure, but may be of crucial importance in determining future developments in land use.

• Complex Qualities: this is a somewhat loose grouping of summary, composite factors defining various aspects of system performance that may be of use in determining sustainability. These 'factors' can normally be broken down into other, less complex qualities at later stages in the analysis. Some of these complex factors are comparatively straightforward to measure, however, and could well be amongst the first economic factors to be quantified in an analysis using the framework.

TABLE 4: Factors of the economic environment that may influence sustainability of farming systems

FACTOR GROUP	MEASURE OR ATTRIBUTE
Resources	
land	farm size; fragmentation (1. Simpson index of diversity); type of tenurial system
labour	family labour availability; hired labour availability; seasonality of labour profiles
capital	returns to capital; gearing ratio; options for surplus disposal and deficit reduction
knowledge	literacy rates; education levels, access to extension advice
draft power	type; use
efficiency	land/labour, capital/labour use ratios; returns to input use
Economic Environment	
production costs	levels; seasonal and yearly variation; associated uncertainty
product prices	levels; seasonal and yearly variation; associated uncertainty
credit	availability, types and use; interest rates
markets	infrastructure; access, distance to input and output markets

population	level; rate of change: seasonal migration patterns
Attitudes	
objectives	objective function involving profit or utility maximization, risk reduction, safety first, etc. planning horizon; time preference
risk aversion	coefficients of absolute, relative, partial risk aversion
expectations	yield and price expectations
Complex Qualities	
income	household income; income per head: proportion of household income from off-farm activity, net farm income
profitability	gross margins/ha; net returns/ha
consumption	total consumption; proportion spent on food
poverty indices	percentage of total consumption expenditures on food and standard of nutritional adequacy

Suggestions regarding the measurement of some factors are made in Table 4. Some of the methods suggested are well known, others less so, such as measures of land fragmentation and Lipton's absolute poverty criterion. Many of the factors listed have the potential to be useful indicators of sustainability for, although the data requirements for their quantification may be substantial, they can be fairly well-defined and are likely to prove reasonably consistent from one situation to another; comparatively straightforward to collect; and sensitive to changes in the system over time.

Because the present emphasis of the FESLM is on analysis of sustainability on a particular site, Table 4 does not give explicit consideration to environmental accounting or to factors that relate to an extended population (such as equitability-which might be measured in terms of landless households, women land owners, or income inequality, for example).

As discussed in Chapter 6, the off-site or secondary effects of particular land use practices may be of immense importance, and the economic consequences of such effects will sometimes have to be addressed. There are ways of incorporating environmental costs into analyses at enterprise or farm level. For example, costs of production may be modified in the light of tangible or intangible costs to the environment (such as a recalculation of gross margin in terms of a polluter tax on a farm chemical, a government subsidy, or a value to take account of "loss of amenity value "). The intangible costs are very difficult to quantify, but may be an integral part of an analysis at higher levels of aggregation-such as the watershed or regional level.

Once indicators have been assembled, subsequent stages of the FESLM will generally require further analysis of the economic environment. The long-term economic health and sustainability of a household may not be immediately obvious - even if measures for appropriate factors are quantified; our knowledge of the underlying processes is, in general, much less extensive, than comparable knowledge of physical or biological processes. Nevertheless, a great variety of economic tools (procedures) has been developed that can be used in attempting to establish cause and effect in the economic environment. Each tool has advantages and disadvantages (both methodological and practical) and is only appropriate for particular classes and levels of problem. Once the appropriate level of analysis has been decided upon (parcel, enterprise, farm, household, village, watershed, or region), the capabilities of the various analytical techniques can be compared and considered. However, special regard should be paid to the following:

- Can the technique handle secondary effects, such as the off-farm impacts of chemical use on a particular farm?
- Is production risk of importance, and can it be incorporated into the analysis?
- Is the analysis capable of handling multiple periods of time?
- Is the analysis capable of handling multiple, competing objectives, such as those that may exist at the household level and between producer and consumer?
- Are resource allocation issues handled explicitly?

Examination of some of the indicators listed in Table 4 will help to determine the need, and guide the choice of further analyses designed to recognize and establish root causes of any unsustainability in the economic environment of particular land management practices.

Factors of the Social Environment (by G. Spendjian)

The question "acceptable to whom?" provides a starting point in attempting to define the scope of an evaluation of the "social acceptability" of a particular land management practice. All of the various stakeholders interested in the use or management of a particular resource need to be identified.

Those extracting 'rent' from a particular resource and exerting pressures on it may be either directly occupying the area in question, or be removed from it but exerting no less an influence as a result of their need to derive surpluses from the land use system. Forward and backward linkages from the actual production system (eg. value adding post production employment, employment in provision of services to the productive process) tie in a further set of individuals all of whom have a stake in, and therefore influence, land management. Not just the benefits of land use, but also its costs, frequently occur off-site.

The reasons for the concern outside the immediate area can vary. For example, land management practices can have an immediate practical impact on the livelihood of those living in contiguous areas. Or they can be unacceptable to certain groups far removed from the area in question, and this for purely aesthetic or ethical purposes, such as consumers in Europe boycotting wood products cut from primeval forests. In other circumstances governments may be the determinants of 'acceptability' by the demands they make on the land in question or the policies they put in place.

Social acceptability can be seen, therefore, as an aggregate of the views of various individuals and groups which in turn are a reflection of their attitudes, knowledge, beliefs, and norms, and on their relationship to the specific land management approach in question. The different views will influence overall social acceptability-usually in proportion to the strength of these views and to the relative power and authority of the players. Factors which are largely within the control of individuals, and others which for the most part lie outside their control but which exert a strong influence, will together determine overall social acceptability.

Thus, the principal "social" factors to be considered within the FESLM involve:

- the identification of 'Who?' - dependent directly and indirectly on the outputs from the production system in question,

- determining if those concerned can derive an acceptable standard of 'sustainable livelihood' from the land management option in question, into the foreseeable future, and
- identifying what other interests exist in the use of the resource in question (for economic or non-economic purposes).

The 'rent' derived from a specific land use practice is determined in large part by factors exogenous to the area under investigation, to availability of markets, to the existence of infrastructure, to a complex system of private and public entities which determine prices of inputs and outputs. This is to underscore the fact that factors such as the cost of living greatly influence whether a 'sustainable livelihood' is derived from a certain land management practice.

Some Social Issues

Understanding and characterizing social formations: The social context which constitutes the subject of investigation within the evaluation framework must therefore be seen in its full complexity-as a nested set of individuals and social units; within and between which exist interactions, relationships and links of various sorts. To understand such social formations associated with a particular land management or production system, several fundamental questions need to be answered:

- What are the major social units in the system (eg. families, kinship groups, communities, cooperative institutions, political groupings)?
- What are the power relationships, hierarchies, links, and organizing principles in general, within and between those units?
- What are the social rules or conventions which govern the division of labour, access to resources, access to the outputs of production systems, and the distribution of wealth?
- What are the social processes governing decision-making, especially those associated with production systems?

Looking at the social context with this schema in mind will facilitate the exploration of the factors outlined in Table 5 and elaborated upon further.

Assessment of the macro-social political and economic climate vis-a-vis social justice, equity and participation: Identification of social factors in evaluating the sustainability of land use and management must begin with the premise that sustainability is difficult, if not impossible, to attain in a context not characterized by social justice, equity, participation, and the existence of demographic institutions. While it is possible to conceive of maintaining for a while the productivity-or the sustainability-of the resource base in a specific location where there is extreme poverty and social deprivation, this is very unlikely to happen without highly oppressive and autocratic control systems being in place. The evaluation should, therefore, make a qualitative assessment of whether these macro-social, political, and economic conditions exist in the particular social context framing the land use in question. This, in part, involves making an assessment as to whether there exists a generalized appreciation (within the society in question) that the function of the socio-economic system is to provide 'sustainable livelihoods' for all, and a consensus as to what that implies.

The policy environment and legal, fiscal and regulatory frameworks: These are all parts of the overall social framework. All need to be considered in evaluating the sustainability of land management. Input subsidies, prices, taxes, credit mechanisms, punitive measures, laws regarding resource use, are parts of the structure of incentives which, undoubtedly, have an enormous impact on the behaviour of economic agents (and on the livelihood which can be generated from resource utilization). They strongly influence sustainability, therefore, and the rate of environmental degradation.

TABLE 5: Factors of the social environment to consider in evaluating sustainable land management

CATEGORIES OF SOCIAL FACTORS TO CONSIDER	RELATED CHARACTERISTICS TO ASSESS
Macro-social, economic, and political	Overall commitment to social justice, equity, participation, and democratic institutions
Legal, fiscal, and regulatory frame work overall policy environment	Existence of appropriate incentive and control structures promoting sustainability
Meeting physical and strategic needs	Existence of opportunities within and outside the resource utilization system, distribution of wealth within and between social units
Ratio of resource availability to population's overall needs	Existence of mechanisms to reduce pressure on land use system
Conflicts over resource use	Extent of conflict, and existence of accepted conflict-resolution mechanisms, social participation in decision-making
Access to resources and to outputs	Equity of land tenure system, extent of access to credit and other resources, gender equity as related to access
Meeting individual costs of sustainable behaviour through social investment	Existence of transfer and compensatory mechanisms
Local "affordability" of sustainable behaviour	Labour requirements and material and other costs are within capabilities of those immediately affected
Security and the level of risk	Risk reduction in the short and medium term, increase of
Attitude changes, knowledge, beliefs, values	Investment in environmental education, communication
Working with the socio-cultural grain	Responsiveness to felt needs, local participation, "fit" with local systems of knowledge, beliefs, and values

The evaluation needs to establish whether the components of the overall policy environment and the resulting legal, fiscal and regulatory frameworks work for or against sustainable resource utilization. Do they give the 'wrong' or 'right' signals with regard to promoting the long-term view over the natural tendency to further short-term interests? The answers are not always intuitively obvious, and care must be taken in making these judgements.

Needs, and the opportunities to meet them: On a more micro level, the most important social factors to consider are the opportunities which exist in the area under investigation (both within and outside the immediate social setting) for individuals, families, and communities to meet their overall needs. These needs range from absolute or basic needs of food, shelter and clothing to no less important strategic and socio-culturally determined needs, be they material, cultural, aesthetic or spiritual. It must be emphasized that many of the latter are extremely elastic in modern market-oriented societies. There is a qualitative as well as a quantitative shift which occurs when those occupying a certain land area move from subsistence agriculture or land use, to being intimately connected to the demands of a modern consumer society. This must be kept in mind in the investigation of whether a particular land management option does or does not meet people's 'needs'.

Population pressures: The environmental pressure on a particular unit of land under evaluation depends on how much must be extracted from it in terms of 'rent' to satisfy the 'needs'. This in turn is a function of the population dependent on it and the nature and extent of its 'needs' (as well as of the particular production 'technologies' used). In turn such population pressures on the resource base depend very much on the availability of economic options outside the natural resource utilization sector.

Conflict and systems of conflict resolution: When different groups occupy the same contextual environment from which they derive their needs, the potential for conflict increases dramatically as pressure on the resource base increases. This underscores the next social factor which needs to be considered in evaluating land management practices, viz. the potential for conflict as a result of different stakeholders different objectives for a particular resource, and whether there are in place systems of conflict resolution, characterized by equity, justice, and participation, to deal with such conflict?

Participation and involvement in decision making: The involvement of local populations in decision making associated with particular land use practices can be an important factor in resolving conflict. Participatory approaches, in general, are more likely to generate behavioral changes which promote sustainability. The extent of local involvement in decision making should be examined therefore within the FESLM.

Land tenure, access to resources and to outputs of production: Land tenure and the existence of property rights, as well as the more generalized access to resources and to the outputs of production systems, frequently have an impact on whether or not necessary investments are made to promote sustainable land use. The evaluation framework should look, therefore, at what conditions exist in the particular social context under investigation.

The issues of access to productive resources and land tenure are also very much linked to questions of equity. Frequently, the concentration of the most productive resources in the hands of a few who do not utilize them for the benefit of large numbers, leads directly to severe population (and therefore environmental) pressure on more marginal resources. The FESLM needs to consider, therefore, what options, if any, exist for relieving pressures on unsustainable managed or inappropriately used lands.

Identifying 'costs; and 'benefits' for different stakeholders: The goal of long-term sustainability frequently implies certain 'costs', or the foregoing of certain 'benefits', for specific groups of people. Frequently those who are asked to bear the cost and those who benefit from 'sustainable' land use practices are not the same set of individuals. Instituting sustainable hillside farming practices may involve an immediate cost in materials and labour to those involved, while benefits are derived at least in part by downstream dwellers. Equally, the conservation of certain areas for either leisure-related practices or for the maintenance of biodiversity may entail immediate costs to those seeking to derive their immediate existence from the use of the particular resource.

Social of sustainability and the need for transfer mechanisms: It is unreasonable to expect individuals or communities to bear the costs of modifying their practices or production systems if they (or at least their progeny) are not to be the ones reaping the rewards. The evaluation should look therefore at the fundamental question of whether there exists the political will and the institutional mechanisms for the wider social system to bear, or at least share, the costs associated with maintaining or promoting sustainability. This implies a transfer to, or compensation of, those who are foregoing benefits. This may range from compensation for leaving land unused (eg. debt for nature swaps), to provision of grants to cover the cost of actions and behaviour which promotes sustainability (eg. for labour or material inputs, or against foregone income).

Acceptability vis-a-vis requirements for labour, material end financial inputs: In the simpler scenario where those bearing the costs in the present are also the ones benefitting from the investment in the future, the evaluation should ask if the land management option being evaluated is in fact 'affordable' to those directly involved. Additional labour requirements, the investment of financial resources, and the foregoing of present income should all be looked at in this light.

Security of income streams: Apart from profitability in the short-term, security in both the short and the medium-term is of importance to those highly dependent on the outputs of the resource base. The evaluation should assess whether recommended practices increase or decrease risk in the short-term and determine how acceptable this is to the individuals and groups in question. Given that promotion of sustainability frequently involves immediate costs but longer term benefits, it is important that sustainable land management systems involve mechanisms which can generate income in the short-term as well. Making an income stream more continuous over time may in turn necessitate the existence or establishment of institutional structures, such as cooperatives, for sharing costs and benefits over time, or the development of alternative employment in, for example, small scale industries.

Attitudes, knowledge, beliefs and values: Sustainable land management implies sustainable behaviour on behalf of social, economic, and political agents. Besides the requirements for meeting these agents' practical and strategic needs, such behaviour is, in turn, governed by their knowledge and their systems of beliefs and values. The level of understanding and awareness of short- and long-term impacts on the resource base of production practices needs to be ascertained; as should the value placed on long-term resource conservation. Again it should be stressed that such assessment may need to be made for the variety of social actors involved, from farmers themselves to policy makers-depending on the links identified. Also, the evaluation should assess whether there exists an institutional base for human resource development and training adequate to promote the attitudinal changes which underpin changes in individual and group behaviour.

Working with the grain: The poorest populations may be highly risk-averse but, frequently, they are also desperate for information and knowledge of alternative land use techniques and approaches suited to their circumstances which will increase their economic returns without degrading their productive resource base. Possible recommendations should be tested to ensure that they respond to local needs and fit into local systems of knowledge and belief. Again, participatory approaches will ensure "working with the grain" and greatly enhance the probability of a socio-cultural and economic 'fit'.

Health-related issues: Health is one of the principal social indicators. The evaluation should ascertain whether the land management practices under investigation have negative or positive health impacts. These may relate to the impacts of production processes (eg. from the misuse of pesticides), or to those of production outputs (eg. on nutrition).

Level 4: Diagnostic criteria: (cause/effect and observations)

Level 4: The aim, problems, procedure

AIM: The actions at this Level are intended to expose trends of change in the local environment and, by recognizing and explaining the causes of these trends in the past, project the pattern of future change and its effects on sustainability. Specifically to:

• identify which factors and component attributes (from amongst the evaluation factors chosen at Level 3) show trends of change in the recent past;

• establish the causes which effect these changes and determine whether interacting change is likely to continue in this or other directions in the future;

• develop an overall picture of the pattern of change in the local environment with time (the future scenario);

• develop criteria, based on understanding of cause and effect, to determine the likely status of different evaluation factors at future times.

PROBLEMS: The need to predict the future is problem enough at this stage!

PROCEDURES. At first sight nothing short of a crystal ball can achieve future prediction but, in practice, reasonably confident progress can be made using data drawn from each of four approaches:

• observing present evidence of trends (Observation)
• researching historical evidence of the site (Historical)
• comparing geographical evidence of similar sites (Spatial)
• theoretical projections (Modelling).

In each approach the intention is to assess the stability of the Evaluation Factors (identified in Level 3). The existence and direction of trends would be established first and then, if possible, the rate of change would be assessed. The most reliable conclusions can be expected when evidence from all four approaches converge, and all four should be attempted where feasible.

In most cases, the Evaluation Factors will, themselves, be complex-their character being a reflection of interactions between a number of component attributes. Very often it is the component attributes that can be measured, observed, or estimated most easily along the approach paths listed above. Sound understanding of cause/effect relationships is needed before component attribute values can be used as a guide to the status, and change of status, of the complex attributes (Evaluation Factors) to which they contribute. Table 6 provides examples of some complex and component attributes.

TABLE 6: Relationship between complex and component attributes: some examples

Complex Attribute (Level 3)		Component Attribute (Levels 5 and 6)		
1.	Nutrient availability	1.1	Topsoil nitrogen	%
		1.2	Topsoil available P	ppm
		1.3	Topsoil available K	meq/100 g
		1.4	Soil acidity	pH
		1.5	Subsoil weatherable minerals	%
		1.6	Subsoil total P	meq/100 g
		1.7	Subsoil total K	meq/100 g
2.	Flood hazard	2.1	Length of inundation at critical periods	days
		2.2	Depth of inundation at critical periods	m
		2.3	Frequency of damaging floods	
3.	Pests and diseases	3.1	Severity of pest 'X'	damage %
		3.2	Severity of disease 'Y'	damage %
		3.3	Local factors favouring pest 'X'/disease 'Y'	
4.	Gross expenditures	4.1	Cost of seeds	money
		4.2	Cost of fertilizer	money
		4.3	Labour costs	money
		4.4	Fuel costs	money
		4.5	Replacement costs of equipment	money
5.	Gross returns	5.1	Returns from land	money/ha
		5.2	Returns from labour	money/man/day
		5.3	Returns from capital	%
6.	Land tenure	6.1	Average size of holdings	ha
		6.2	Form of ownership	
		6.3	Basis of acquisition/inheritance	
7.	Population	7.1	Total numbers/rate of change	
		7.2	Distribution by age/sex	
		7.3	Available labour force	
		7.4	Migration into/out of locality	

Diagnostic evidence: The approach paths

The following notes may clarify the differences and limitations of the four approach paths:

- Present Evidence: A wide variety of on-site evidence of environmental degradation (instability) may be visual. The following are examples;

  - erosion: rills, gullies, scars, downslope accumulation
  - soil structure: surface crusting, poor emergence
  - nutrient status: poor growth, deficiency symptoms
  - excess water: waterlogging, plant communities
  - salinity/toxicity: poor growth, plant communities, surface salts
  - pests and diseases: poor growth, visible symptoms
  - poor stewardship: neglect of equipment and buildings, weed growth, overgrown access, degraded terraces, in-filled drains etc.
  - socio-economic problems: poverty, low morale, ill health, voiced complaints

  More detailed site investigations (relationships of soils, topography, vegetation) - possibly as an extension or repetition of work done for site characterization or in suitability evaluation may reveal, explain or clarify present trends in attribute stability.

- Historic Evidence: Any historic records of the site, or of the immediate locality, may assist explanation of present observations or draw attention to potential problems. Past crop yields, profit margins, or social history may provide direct pointers to trends. Failing this, if the land has been newly brought into use, local climatic records (particularly rainfall) may assist interpretation of, and future projection from, present observations.

- Spatial Evidence: Experience of comparable forms of land use in different stages of development under comparable environmental conditions may provide clues to trends in change with time. Clearly, the very greatest care must be taken in making the initial comparisons. A seemingly minor difference, such as distance to markets, availability of supplies or social unrest, could completely invalidate a comparison between environments that appear physically identical.

- Theoretical Projections: At best, these will only be as good as the quality of the data available to feed them, and as reliable as the depth and breadth of the experience on which they are formulated. A practical objection to computer modelling in 'a black box' is that few but the author know, for sure, what pathways, connections and approximations exist within the box. Nevertheless, the development of projection systems are an important research objective, and in time we can expect to have increasingly reliable systems suited to a widening range of uses and conditions.

Evaluation factors: Complex and component attributes

Many evaluation factors identified at Level 3 are complex - their influence reflects the interacting influences of their component attributes. Some examples of complex and component attributes are listed in Table 6.

Knowledge of the make up of complex attributes, and of the potential interactions of their components, forms part of the understanding of 'cause and effect' that needs to be established at Level 4.

In developing the FESLM, it will be necessary to explore and test a wide variety of complex and contributing attributes to decide which have most general use in the assessment of sustainability.

These examples are purely illustrative. The attributes on the right do not represent a unique or complete breakdown of the more complex attributes on the left but are chosen rather to underline the heterogeneity of the attributes that can be tested for stability. The value of some of these component attributes as indicators of stability is discussed briefly later.

Criteria: Understanding cause and effect

Diagnostic Criteria have been defined as: 'Standards or rules (models, tests or measures) that govern judgements on environmental conditions'.

In sustainability analysis, criteria based on an understanding of cause and effect are needed to serve several functions:

- to interpret component factor relationships and interactions that determine the stability and direction of change in evaluation factors (see above)
- to provide predictions on the future status of factors so that they may be used as indicators of change
- to interpret the effect of interacting environmental changes on sustainability.

Fortunately, in our context, much is already known in general terms about cause and effect, especially in relation to the physical environment, so well known in many instances as to be second nature-a matter seemingly of 'common senses.

In many instances this understanding has been developed into numerical ''criteria' (equations and other more complex mathematical models) that allow us to predict effects-given certain observations.

The Universal Soil Loss Equation (USLE) of Wischmeier and Smith (1978) is a very well known example of an equation that goes far to meet the first and second criteria-objectives above:

$A = R \times K \times L \times S \times C \times P$

Having obtained experimental evidence of the relationship between the rate of erosion (A) and the rainfall factor (R) on a certain soil (K) under a certain use (C, P) on a certain slope (L, S) the equation can be used to predict the increase in erosion if the rainfall factor rises.

In recent years, computer modelers have explored widely the kinds of relationships in environmental systems that need to be understood to develop satisfactory sustainability criteria. Most of this work relates to the present environmental condition-to the 'matching' of widely separated environments for purposes of technology transfer, for example-but some modelers are beginning to tackle the prediction of trends and future values. A great deal more research needs to be done in this direction in support of sustainability analysis.

In the Framework diagram (Figure 3) and in the FESLM Flow Chart (Chapter 5) the action of developing criteria - discerning cause and effect - is shown as a circle surrounding the approach pathways. This form of presentation is intended to stress the iterative nature of investigation at Level 4-two steps forward, one back to revise!

Level 5: Indicators and thresholds

'Indicators' and 'Thresholds' are defined within the FESLM as follows:

Indicators: environmental attributes that measure or reflect environmental status or condition of change.

Thresholds: levels of environmental indicators beyond which a system undergoes significant change; points at which stimuli provoke significant response.

Level 5: The aim, problems, and procedure

AIM: To select from the range of Evaluation Factors identified at Level 3 (and their component attributes) those which bear most directly on the sustainability of the defined use in the defined locality; and to further identify threshold levels of special significance for each of these selected indicators.

PROBLEMS: The most difficult consideration associated with preparing a range of indicators for evaluating sustainability is that of ensuring that no significant influence for future change in the system has been omitted. Levels Three and Four of the FESLM are largely concerned with safeguards against this, but this effort will be wasted if the final range of indicator attributes, on which evaluation is finally based, is incomplete.

Examination of a single 'indicator' attribute may serve to show that a given use is unsustainable, but only a complete range of 'indicators', covering all potentially unstable aspects of the system and its surroundings, can guide a confident assessment of 'sustainable'.

In many situations the unsustainability of a land use system is obvious. The FESLM is needed when this is not the case. The more marginal is the decision on sustainability, the more likely it is that the status of some obscure indicator will determine the issue.

PROCEDURE: 1. Selection of Indicators

Indicators are selected from a broader range of factors by more rigorous application of the same criteria of 'Relevance', 'Stability' and 'Predictability' used to distinguish Evaluation Factors at Level 3.

Many attributes are quite obviously indicative of degradation and likely unsustainability (eg. erosion, product quality, yield). Others, perhaps less obvious, may yet be identified without the assistance of the FESLM. Table 7, drawn up from the pooled experience of a multi-disciplinary group, shows the more important indicators of sustainability for six broad agricultural systems across the whole of Australia. In drawing up this list, the criteria to be met were that the indicators could be measured or reported and that they reflected known good or bad farming practice (Hamblin, 1992). The widely ranging nature of the chosen indicators is of particular interest.

A sequence of selection stages is proposed in the FESLM to arrive at a manageable number of (mainly) component attributes for evaluation in detailed sustainability evaluation. For a specific land use system:

1. Recognition of the full range of Evaluation Factors that bear upon land suitability (Land evaluation)

2. Selection from 1. of those factors that are predictably unstable (FESLM Level 3)

3. Breakdown of complex factors from 2. and identification of the most significant component attributes (Cause and effect analysis, FESLM Level 4)

4. Final selection of factors/attributes for use as Indicators in evaluation (FESLM Level 5)

TABLE 7: Important primary indicators of sustainable agriculture in Australia (Hamblin, 1992)

AGRICULTURAL SYSTEMS	PRIMARY INDICATORS		
	Management Level	Production Balance	Resource Base
Rain-fed crops & animals	Farm management skills, cash flow, equity planning	Water use efficiency; yield/area/rainfall	Soil health; pH, nutrient balance, biota
High rainfall pastures for animals	Production/area; animal weight/hectare	Plant growth/cover; % greenness, species/area	Soil big-indicators; worm, termite etc., numbers and species
Low rainfall range land for animals	Management capability; planning debts, asset condition, record keeping	Animal health and productivity; liveweight gain, quantity/quality, fleeces, carcasses	Pasture and soil condition; % bare ground, pasture composition
Irrigated crops and pastures	Farm and district profitability; debt equity etc. for farm level, true cost versus benefit inc. envir/al. costs at district level	Water use efficiency; plant use/water applied, water table trends crop/weight/water used	Soil health; infiltration rate, % subsoil compaction, biomass act/y, chemical residue level
Intensive horticulture and viticulture	% integrated pest management adopted in industry; chemical sales, grower records, fauna surveys	Nutrient balance; yield and nutrient contents, fertilizer sales, surface water composition	Soil permeability/waterbases; irrig/tn. water use, piezometry, soil infiltration
High rainfall tropical systems	Diversity of production; no. of land uses or crops, no. isolated vegetation patches	Water quality; surface water composition, blooms, pesticides, sediments	Soil productivity; trends pH, O.M., subsoil compaction, soil struct. condition

Discussion of some of the individual component attributes listed in Table 6 may assist understanding of the final selection stage to identify useful Indicators:

1.1 Topsoil Nitrogen %: An important determinant of successful plant growth but probably subject to too much variation in short spans of time and distance to be a satisfactory parameter of sustainability.

1.4 Soil acidity (pH): important factor in soil use, particularly in relation to its influence on nutrient availability and certain toxicities. Changes in acidity arise from complex causes that need to be evaluated, but trends in acidity are valuable primary indicators of instability.

1.5 Subsoil weatherable minerals (%): reflect a reserve of plant nutrients important in assessing soil suitability, particularly for perennial crops. However, in the absence of serious erosion, change in the content of weatherable minerals is likely only in the very long term. Thus their value as an indicator of sustainability is limited.

2.3 Frequency of damaging floods: this is an example of a local attribute of obvious importance in the evaluation of suitability and of sustainability (if the frequency is changing) but one that very probably reflects causal changes (deforestation?) operating far from the investigated site.

3.1 and 3.2 Severity of specific pests/diseases: These are examples of factors that have to be sharply defined to be valuable in either suitability or sustainability evaluation. Because different pests/diseases are encouraged by different conditions (see 3.3) specialist local knowledge to identify them is essential.

3.3 Local factors favouring pest 'X'/disease 'Y': because most pests and many disease vectors are fairly mobile, this is an example of an 'attribute' which calls for knowledge of a wider area than the investigated site itself (within which there may be breeding sites or foci of infection or conditions, such as free water surfaces or high humidity, which favour build up of a particular pest or disease). Change in risk of pests or disease, perhaps from off-site causes, may have an important bearing on sustainability.

4 and 5 Gross expenditure and Gross returns. These examples illustrate the flexibility that exists in dividing complex attributes into their components. Gross expenditure has been divided into expenditure on separate items (although these could doubtless have been subdivided further). Gross returns show division into broader groupings. The choice between, or combination of, the two approaches rests on striking a convenient balance between the detail of available information and the needs of effective sustainability analysis. Decisions on such issues will have to be made in drawing up a global Master framework.

6.3 Basis of acquisition/inheritance: This is an example of a social attribute, typically difficult to assess other than in qualitative terms, but potentially important to sustainability - change in inheritance custom may lead towards, or away from, fragmentation of holdings to an impractical or uneconomic size.

Summing up, the most useful environmental attributes in the context of sustainability evaluation are those that

- reflect environmental changes important to the continuing success of specific forms of land use;
- show steady, reasonably predictable response to environmental change; without significant fluctuation over short time periods or short distances (trends can be measured with reasonable confidence);
- are a clear measure of a cause having a well understood effect;
- can be measured and expressed in numerical terms.

Attributes which fulfil all these requirements are justifiably described as 'indicators' of sustainability. A final step in the selection process must be to ensure that the complete list of 'indicators' adequately reflects the complete range of factors recognized at FESLM Level 3.

TABLE 8: Some environmental qualities and diagnostic factors (possible 'indicator' attributed) - illustrating the rating of land suitability in terms of requirements of sugarcane. (Extracted from Table C2 of Guidelines: Land Evaluation for Rainfed Agriculture (FAO, 1983)). The data are illustrative and should not be taken as authoritative in any specific locality.

LAND USE REQUIREMENT			FACTOR RATING			
LAND QUALITY	**DIAGNOSTIC FACTOR**	**UNIT**	**Highly Suitable**	**Moderately Suitable**	**Marginally Suitable**	**Not Suitable**
Moisture Availability	Growing period	days	315-365 (-)	230-315	210-230	< 210
	Rel. Evapo-Trans (1-ETa/ETm) for total gr. Period	ratio	< 0.17	0.17-0.55	0.55-0.65	> 0.65
Oxygen Availability (Drainage)	Soil Drainage(class)	class	well drained	moderately well, imperfectly	poor	very poor
	Depth to water table over sign. Periods	cm	> 180	50-180	20-50	< 20
Nutrient Availability	Reaction	pH	6.0-7.0	4.5-6.0 7.0-8.0	4.0-4.5 8.0-8.5	< 4.0 > 8.5
Nutrient Retention	C.E.C. 0-20 cm	meq %	>15	6-15	4-6	< 4
	Base Saturation (lower horizons)	%	> 50	20-50	10-20	< 10
Excess of Salts Salinity.	EC of saturation extract	mS/cm	< 2.5	2.5-9	9-11	> 11

PROCEDURE: 2. Recognition of Thresholds:

Existing environmental knowledge, strengthened by understanding gained by 'cause and effect' investigations at Level 4, provides the basis for recognizing 'threshold' values.

The concept of 'threshold' values of 'indicator' attributes in the FESLM is very similar to that of 'critical values' of 'evaluation factors' in later applications of the Framework for Land Evaluation (see FAO, 1983). Thus, Table 8 shows how specific values of certain factors are regarded as diagnostic of suitability class limits in relation to the general factors are regarded as diagnostic of suitability class limits in relation to the general requirements of sugarcane. Each critical value is diagnostic only with respect to that particular factor. In land evaluation, the overall suitability class of the land unit, for the crop in question, usually reflected the lowest value of class-determining factor observed.

An important difference in the FESLM is that, in the defined circumstances of each evaluation, there will be only one threshold' value for each 'indicator'-the level of that indicator beyond which the land use is no longer considered sustainable.

Referring to the data in Table 8, it will be noted that there is variety in the kinds of data used to establish class limits; measured values, percentages, ratios, and in one instance (soil drainage) classes of another kind. Even greater variety is to be expected when the concept of 'thresholds' is extended to indicators within the economic and social disciplines.

The use of classifications, such as the soil drainage classes, to provide critical limits (possibly 'thresholds') is interesting; for it allows very complex inter-relationships between individual attributes to be lumped together and treated as one complex attribute or 'quality'. To be useful, such a classification needs to have a basis that can be recognized and reproduced by different observers, and must have an established relationship with the performance of the land use being evaluated. Other classifications which FAO has proposed might be used in this way include: soil workability classes, root penetration classes, terrain classes etc. (FAO, 1983).

'Crop yield' and 'Gross return' are examples of still more complex attributes which embrace the interaction of all aspects of the site. On their own, these values are too complex and potentially too misleading to provide a useful measure of sustainability, but historical trends in their value may provide unrivalled warning signals of change and, in the final analysis, values of yield and financial return may be the prime determinants of sustainability.

Referring again to the data in Table 8, it might be suggested that the critical values which separate the ' not suitable' land from lands which are, at least, 'marginally suitable', can be regarded as ' thresholds ' of sustainability. Certainly, a given land use will not remain sustainable on land which develops physical conditions that render it unsuitable. But application of the concept of sustainability thresholds is not quite as simple as these examples may suggest; for it involves the passage of time.

As soon as we try to project future values of a single indicator, we appreciate that trends in status may be influenced by other interacting attributes which together determine the significant critical values at which change develops in the future.

Final analysis

General Considerations

The first step in the final analysis of sustainability is to draw up a projection of the expected pattern of environmental change in the years to come. This will be based on the trends of change identified in Level 4, set against a background of generally accepted regional and global trends (see discussion of Off-site effects in Chapter 5).

Against a projection time scale of 20 years, or more, such global trends as population increase, climatic change, impact of AIDS and other epidemic diseases, and flows in international trade are too important to ignore. Yet their likely effects at local level are still, to say the least, uncertain. Until these things are better understood it may be necessary to draw up alternative scenarios for the future against which the local thresholds can be set (eg. longer/shorter rainy seasons; higher/lower rainfall).

Given a projected pattern of future change, sustainability analysis becomes a matter of using criteria (developed at Level 4) to establish likely values of selected indicators at successive time intervals, and comparing these with accepted threshold values for each indicator.

If the status of any single indicator falls significantly below its required threshold, the system examined is, very probably, not sustainable. It may be sustainable over a shorter time period, however, and this provides a basis for classifying and comparing sustainabilities (see below).

It would be unreasonable to suggest that just because one factor appears unstable and seems likely, in time, to reach a value on the wrong side of a required threshold, the use must automatically be declared 'unsustainable'. Judgements have to be made on the assessment of each factor, firstly on its reliability and secondly on its significance in relation to the overall assessment of sustainability.

There is certain to be wide variation in the confidence with which differences in the stability of individual factors are assessed in the course of the evaluation, particularly in relation to the different approach paths of the assessment - from observation on the site or from theory, for example. Unavoidably, the data available will be speculative, since it relates to the future.

In judging significance, account may need to be taken of foreseeable changes in other factors which may augment or reduce the effects being assessed. Such checks form part of the validation procedure (see Chapter 6).

Experience in the development and use of thresholds (and related 'criteria') can be expected to reduce the need to rely on personal judgement in evaluating sustainability, but it is probable that such judgement will always play a major part.

Classifying sustainability

Chapter 1 includes discussion of the need to recognize classes of sustainability and describes a system of classification based on the number of years that the use in question can be sustained.

Classification on this basis adds little to the difficulty of evaluating sustainability if the approach described above is used; provided that the time intervals into the future at which the assessments are made are the same as those used to distinguish the classes.

Confidence in the reliability of the diagnostic data must also play a part in classification. Class placements should not exceed what is reasonable in terms of data reliability. Where there are special doubts, these should be stipulated.

Generalized ('Regional') sustainability evaluation

In Chapter 1, a distinction was drawn and differences discussed between 'detailed sustainability evaluation' of small areas and 'generalized sustainability evaluation' of much larger areas.

Most of the discussion in Chapter 4, above, is concerned with detailed sustainability evaluation requiring full application of all levels of the FESLM. Application of this exhaustive process uniformly over large areas is not feasible-the range of variation, not only in the land but also in the land use, is certain to be too great. With an eye to the future, it may not be possible to state where the investigated land use will be located, for locations within the study area may change if other 'suitable' sites exist! The fact that two sites are suitable does not ensure that their characteristics, or their potential for sustainability, is the same.

The principles and procedures of the FESLM can be applied for regional assessments and for broad scale evaluations by 'generalizing' the process for broad level applications. Fine scale evaluations are easily conceptualized because they reflect entities with which we are totally familiar, eg. individual farm fields.

Although such entities serve as the bases for scientific study, not all important considerations can be expressed at that level. This means that the entities of understanding, the field, must often be 'coupled, to other levels where there are valid, but less tangible entities, eg. landscapes, agro-ecosystems, etc. Although such levels of generalization are troublesome, they are very important because society often perceives pressing problems predominantly at these smaller scales, and evaluations for such problems must be developed. This requires some guidelines for the generalization of the FESLM guidelines and procedures for regional scale applications.

Currently there are no easy solutions to the problem of data generalization; at this point it has tended to be more of an art than a science, based almost entirely on the experience and depth of understanding of the investigator for the problem to be evaluated. However, some techniques are beginning to surface, such as Hierarchy Theory, metamodelling and others, which can assist the process.

The principles of Hierarchy Theory provide some guidance in generalizing data for different scales. Hierarchies are used to describe complex systems, such as land, where differences in organization of data and dynamic behaviour of major processes make simple aggregation of lower levels insufficient to explain higher levels. This is illustrated in hydrology, where simple aggregation of thousands of estimates of moisture diffusion will not result in estimates of stream discharge.

Hierarchies are characterized by surfaces (scales) which help to define the entities to be investigated at each level, and by observation sets (data) which identify how the investigator views the system and what he/she considers to be important phenomena or processes. Observation sets go beyond simple collection of data, and include criteria for identifying significance and the major processes which are important at any given scale.

Two characteristics, called 'grain' and 'extent', determine the distinction (fineness) that can be made in a set of data, and identify the level or scale of the data. The 'grain' of the data can be increased by making increasingly finer observations and/or sampling more often. This results in finer resolution, and moves one down the scale of hierarchies. 'Extent', on the other hand, can be increased by sampling over larger areas, using coarser resolution and/or sampling over greater time periods. Increasing the extent of the data moves one to higher levels on the hierarchy. Grain determines the lower level of resolution of the data set, whereas extent determines the largest, and these detection limits are absolute.

It follows from this that each data set is particular to a given level of hierarchy (scale). However, one can generalize the data (move to higher levels of the hierarchy) by varying the extent; conversely one can provide greater resolution (move to lower levels in the hierarchy) by increasing the grain of the data. The same effect, however, can be achieved by changing the criteria of observation between levels. In practice this is achieved by recognizing that different phenomena and processes become predominant at different scales and that the criteria for observing (sampling) these phenomena or processes vary accordingly.

These principles can be used to 'generalize' data for regional evaluations of sustainability. Aggregation of the results of evaluations from many small fields will not result in a generalized evaluation of a region. The latter, however, can be achieved by recognizing that different but related processes and phenomena are important at the regional scale and that different (kinds of) indicators will have to be applied. Similarly the 'extent' of the data used for analyses will have to be varied to match this scale of generalization and the indicators of sustainability.

Chapter 5: Off-site evaluation

General

Some issues that do not relate directly to characteristics of the investigated site and do not fit comfortably, therefore, within the framework procedures of the FESLM, may be important in decision making on sustainability. These issues may be distinguished as 'active' or 'passive' depending on whether the causal agent is within or outside the evaluated area:

• Active Off-site Issues: Effects which arise away from the site but are caused by on-site activities (eg. pollution of groundwater).

• Passive Off-site Issues: Effects which are felt upon the site and which alter sustainability but which are caused by change in conditions or activities away from the site itself.

It is apparent that conditions at the site must always be evaluated within the context of the surrounding environment (eg. the climate, the road network, the economic and the social scene). Normally this environmental envelope is assumed to be stable, but here we are concerned with anticipating and evaluating the effects of change outside the site.

A form of land use which is profitable and stable but which damages the surrounding land is clearly unacceptable to the community at large. A system of sustainability evaluation which lacks the capacity to consider this possibility is inadequate. Equally inadequate, would be a system of evaluation that accepts as sustainable a form of land use uniquely adapted to present surroundings when all around is about to change.

The basic procedures of FESLM are focussed on the site itself (including those attributes which form part of the environmental envelope). These procedures need to be extended to include examination of the possibilities of 'active' or 'passive' change in the surrounding area. If change is anticipated, the effects of such change have to be fed back into the FESLM procedures. How far afield these additional investigations should range, and the detail in which they should be carried out, is a matter for judgement based on local circumstances.

Active off-site effects

In developed countries, nitrate pollution of rivers, lakes and groundwater caused by excessive use of fertilizers or intensive animal production is a well publicized off-site, ill effect of agriculture. Other forms of toxic pollution may also need to be monitored. Civic pressure may prevent continuation of such land use through legislation, or impose changes in management that make the use unsustainable.

In developing countries the most serious off-site effects relate to poorly designed irrigation and drainage systems that lead to salinization, alkalinization and/or waterlogging of surrounding land.

Wherever the proposed land use involves intensive production with fertilizers and/or irrigation and drainage' the possibilities of off-site effects need to be specifically investigated.

Forms of land use that create problems of large volume waste disposal (wood processing, intensive animal husbandry etc.) threaten surrounding land in a variety of ways which also need consideration.

More subtle are possible economic and social effects of new production on local markets, labour availability, and so forth. The prevailing surrounding situation in these contexts will be examined, of course, within the FESLM but if production and employment on the site itself will be large this may create local imbalances which need to be projected and fed back into the analysis.

Passive off-site effects

Population growth, climate change and pandemic disease are examples of predicted change on a global scale that may affect the investigated site and its surrounding areas. The prospect of such change promotes active concern for sustainability but current knowledge leaves us incompetent to predict what the changes will be. As suggested in discussing the final stages of analysis, these current uncertainties may require separate consideration of alternative future scenarios; "informed guestimates" of the pattern of future change.

At a regional level, political upheaval, wars and 'acts of God' in the area surrounding the site may be even more difficult to predict. However, not all regional changes that could significantly affect performance on the site are so obscure.

Examples of impending change that might reasonably be foreseen include:

- Changes in the Regional hydrology: Many human activities (such as dam building, deforestation, town and road building) affect the hydrology of a region. The effects may not be predictable exactly, but trends in change important to sustainability on a particular site may be identifiable - such as the level and frequency of floods or the level of groundwater.

- Changes in pest or disease incidence: Historical evidence in particular, coupled with knowledge of impending regional control measures, may guide understanding of the development and movement of centres of infection/infestation.

- Changes in regional infrastructure: Development of new roads, railways, storage facilities, markets etc. may affect prospects not only on the investigated site but also in areas with a competitive product.

• Changes in human population: Absolute numbers, age distribution, urban migration etc. will assuredly affect markets, labour availability and the sustainability of some forms of land use.

Allowing for off-site effects

Passive off-site effects, those which originate at a distance but may effect the site itself, need to be considered very early in the evaluation, since they might influence a wide range of the indicators on which the evaluation will rely.

Little can be said about the precautions to be taken, since the range of possibilities in any one site is so large, but, before embarking on a detailed study of the site itself, a rapid overview of the surrounding country for evidence of impending change could be very worthwhile. If change is foreseen, the implications of such change on the environmental indicators of the site will have to be introduced into the evaluation.

In contrast, the implications of active off-site effects, arising from the planned activities on the site, cannot be fully assessed until a late stage in the evaluation when all the foreseeable interactions of land and land use have been projected.

Again, it is not possible to enlarge on the form the assessment should take, beyond the indications of the most obvious risks given above. There may be local, legal constraints to guide a judgement on sustainability if the possibility of harmful effects on the surrounding countryside, or population, is foreseen. More often, the evaluator will be required to judge whether continued development of foreseen effects can be regarded as acceptable.

Chapter 6: Using the framework

The sequence of actions required to develop a complete Action Framework for detailed sustainability evaluation is shown below and, more succinctly, in the Flow Chart which follows:

Summary of actions:

1. Define the PURPOSE:

1.1 Define location aspect of OBJECTIVE statement

[1.2 Fully characterize physical, biological, economic and social aspects of the location site]

[1.3 Confirm 'suitability' of present land use on the site (using FAO Framework for Land Evaluation); includes adjusting management inputs, as necessary, to ensure present 'suitability']

NOTE: Activities 1.2 and 1.3, shown in [ ], are external to the FESLM.

1.4 Define 'land use purpose' aspect of OBJECTIVE statement (from details confirmed at 1.3)

1.5 Define management and other inputs in MEANS statement (from details confirmed at 1.3)

NOTE: 1.4 together with 1.5 define USE 1 of the FESLM

2. Off-site change: Complete rapid overview of areas surrounding the site for evidence of impending change that may influence sustainability on the site itself ('passive' off-site effects). Particular attention to possible changes in regional hydrology, infrastructure, pests and diseases, and human population distribution.

3. Apply the ANALYSIS levels of the FESLM to parameters of the physical environment

3.1 EVALUATION FACTORS: List physical environmental attributes (qualities/characteristics) relevant to sustainability of USE 1; by selection from those listed in the Master Framework or, failing this, from those which formed the basis of 'suitability' evaluation (1.3) and adding any additional qualities/characteristics thought to be relevant to the sustainability of USE 1.

3.2 DIAGNOSTIC CRITERIA: Apply cause/effect considerations to break down complex Evaluation Factors (identified in 3.1) into component attributes and seek evidence for trends of change in these attributes with time, by:

- present observation of the site itself
- examining historic records relevant to the site
- comparing effects of closely comparable uses on closely comparable sites elsewhere
- considering theoretical models that embrace circumstances similar to USE 1 on the defined site. Make any necessary observations, measurements, tests etc. to establish or confirm any suspected trends of change

3.3 INDICATORS and THRESHOLDS: From the evidence of cause and effect, and observations made (in 3.2), seek to identify and, where possible, quantify, physical INDICATORS, THRESHOLDS and related CRITERIA which will help in assessing, and later in monitoring, the sustainability of USE 1 on the defined site.

4. Apply the Method Statements of the FESLM to parameters of the biological environment

4.1 to 4.3 Activities precisely analogous to 3.1, 3.2, 3.3, but pertaining to biological environments are undertaken.

5. Apply the Method Statements of the FESLM to parameters of the economic environment

5.1 to 5.3 Activities precisely analogous to 3.1, 3.2, 3.3, but pertaining to economic environments are undertaken.

6. Apply the Method Statements of the FESLM to parameters of the social environment

6.1 to 6.3 Activities precisely analogous to 3.1, 3.2, 3.3, but pertaining to social environments are undertaken.

[NOTE: Activities 4 to 6, relating to separate environmental fields, can be undertaken concurrently, or in any sequence-depending on the availability of the necessary expertise.]

7. Off-site effects: Determine in what way, if any, planned activities on the site will affect surrounding areas in the future (active off-site effects). If these effects are deemed unacceptable, the USE must be ruled unsustainable.

8. FINAL ANALYSIS: Form a judgement on the sustainability of USE 1 by drawing together the evidence exposed by activities 3 through 6, (modified as need be by evidence gained by activities 2 and 7) with particular reference to threshold values of indicator attributes.

9. IF SUSTAINABLE:

9.1 Form a judgement (from the rapidity of trends etc.) on the time period in years over which USE 1 is likely to remain sustainable. Enter this information in the OBJECTIVE statement.

9.2 Final Validation

9.3 Assessment End Point. Report to 'client'

10. IF NOT SUSTAINABLE:

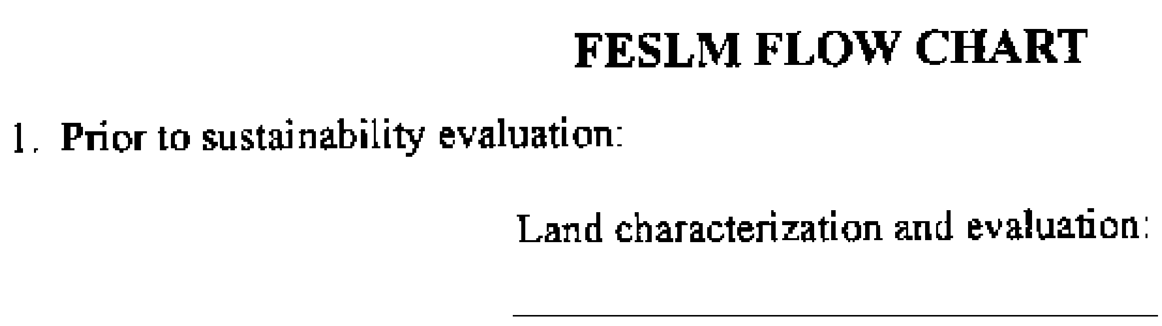
10.1 Re-examine results of activities 4 through 6 to determine whether the causes of instability could possibly be offset by changes in the management practices or other inputs prescribed in the MEANS statement for USE 1. (For example, if erosion is a particular threat, consider strengthening anti-erosion methods.) If so;

10.2 Redefine the MEANS statement accordingly, confirm present suitability (land evaluation) and repeat the whole FESLM analysis for USE 2. Repeat for USE 3; USE 4, etc. if this seems justified.

NOTE: The gamut of possible change is huge and caution is needed to avoid 'improved' management proposals that would be socio-economically inappropriate or otherwise unworthy of analysis.

10.3 Report to client on how the OBJECTIVE can be sustainably achieved (USE 2?,3?,4?) - or advise a complete change of land use!

FIGURE 4: The flow chart



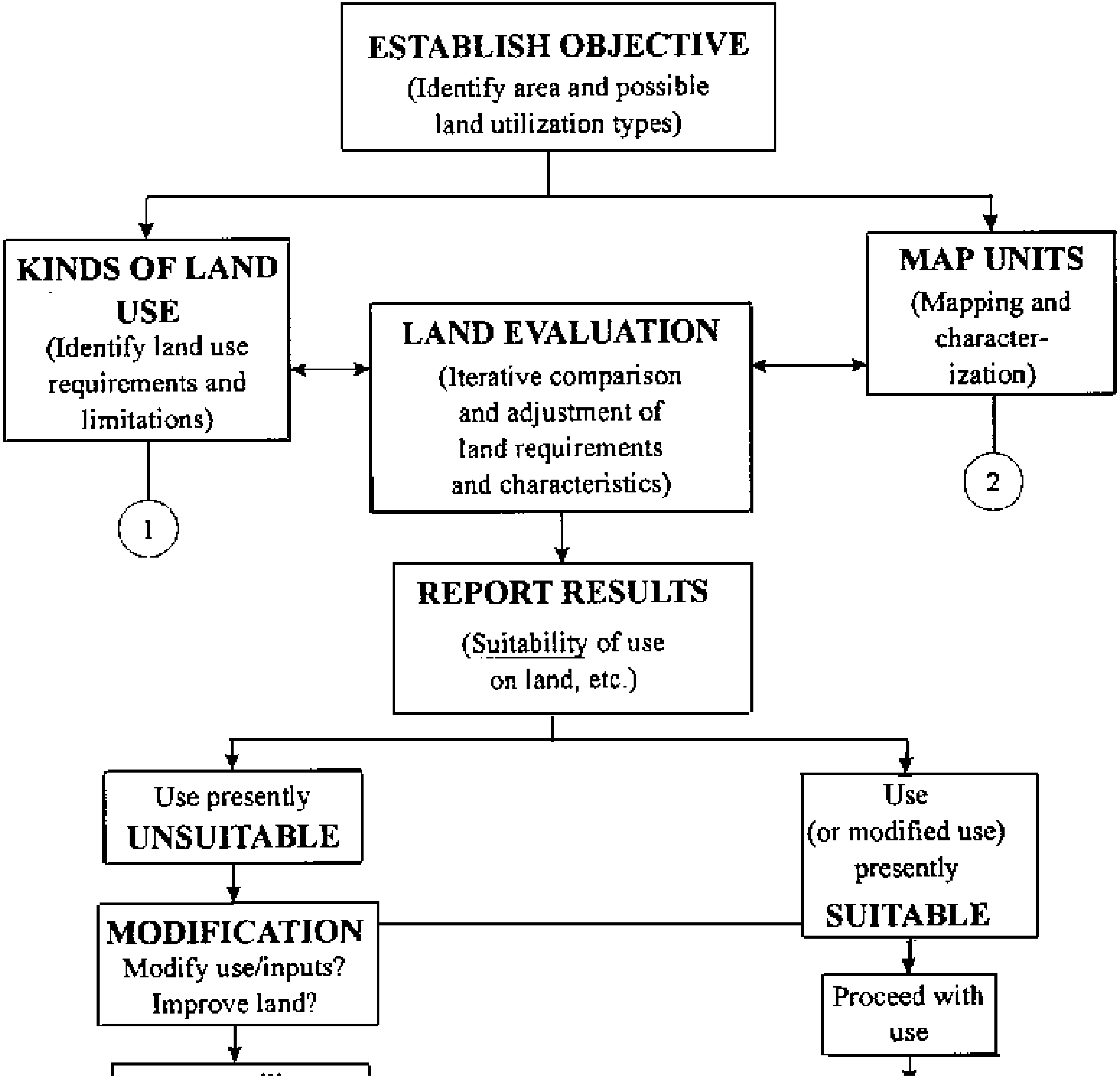
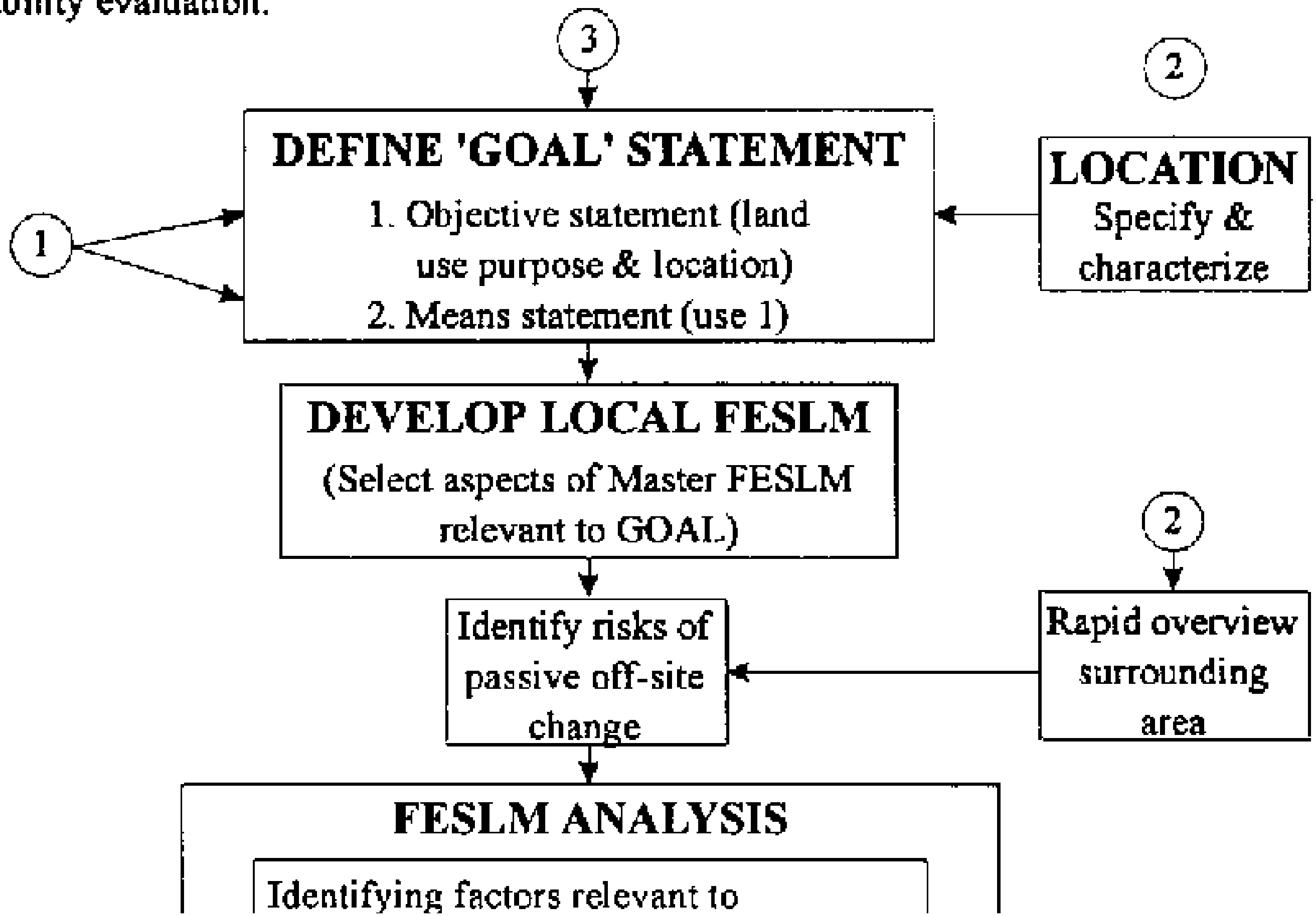

ESTABLISH OBJECTIVE
(Identify area and possible land utilization types)
KINDS OF LAND USE
(Identify land use requirements and limitations)
LAND EVALUATION
(Iterative comparison and adjustment of land requirements and characteristics)
MAP UNITS
(Mapping and character-ization)
1
2
REPORT RESULTS
(Suitability of use on land, etc.)
Use presently UNSUITABLE
Use (or modified use) presently SUITABLE
MODIFICATION
Modify use/inputs?
Improve land?
Proceed with use

FIGURE 4: The flow chart (continued 1)

2. Sustainability evaluation:



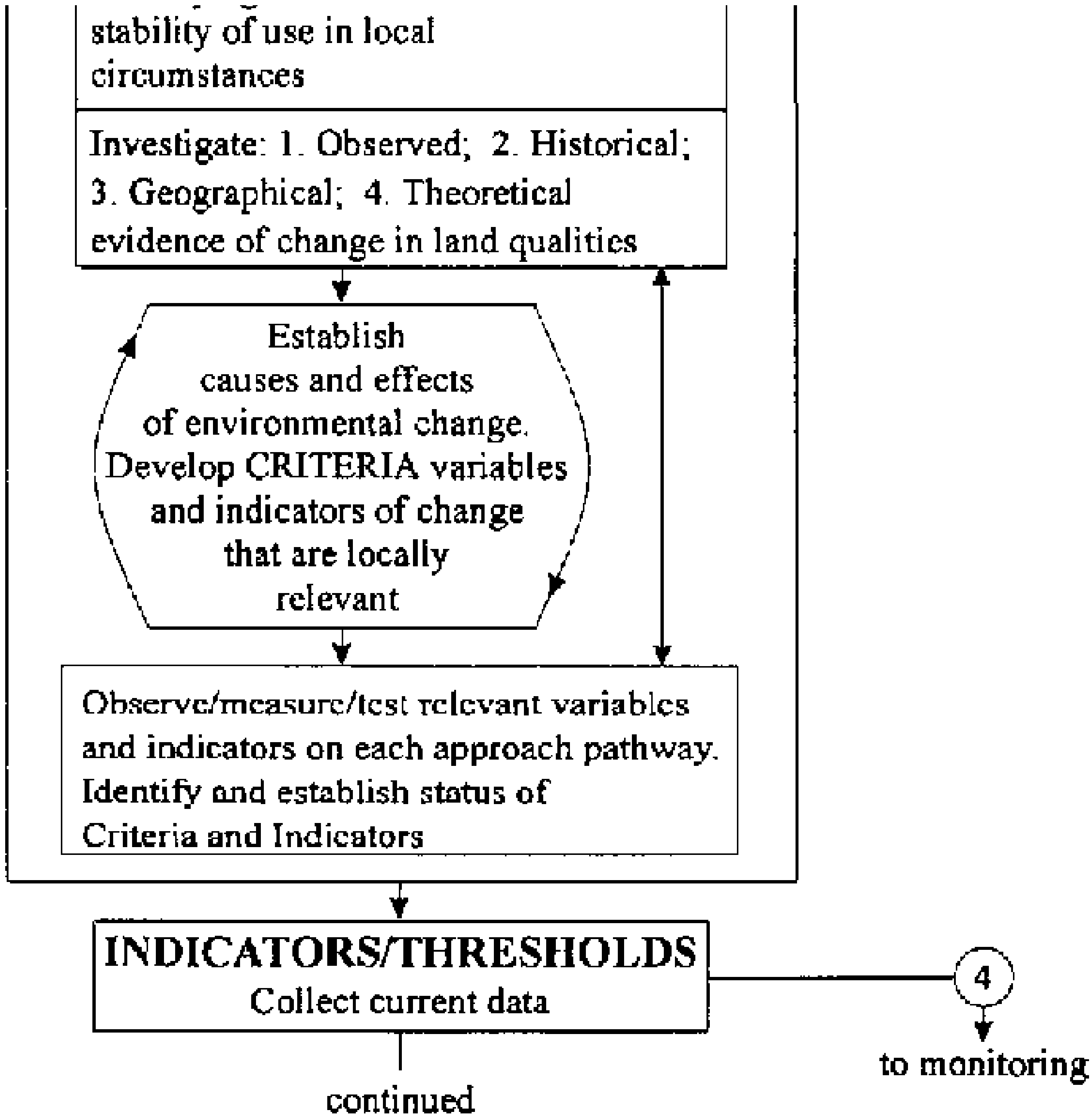
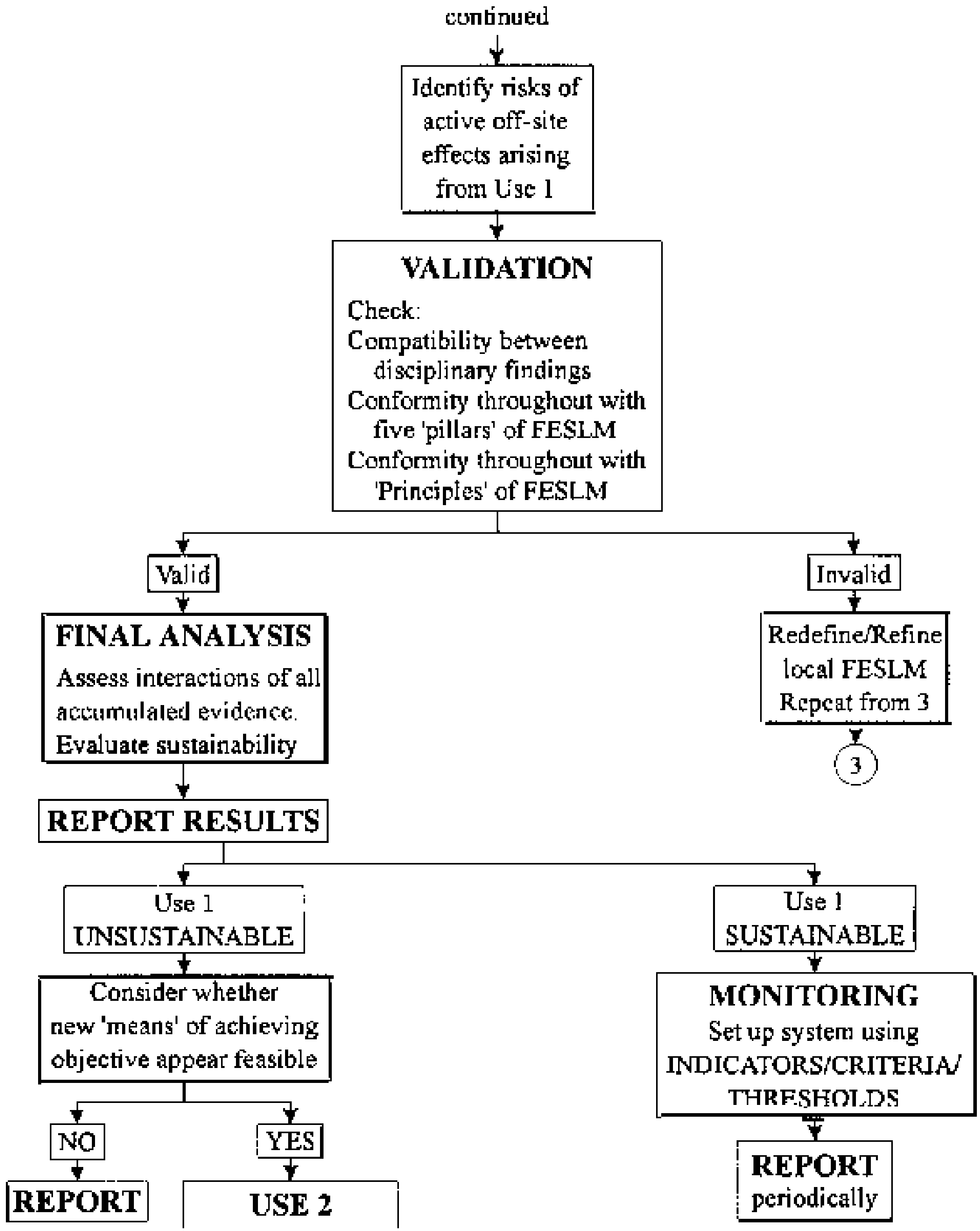
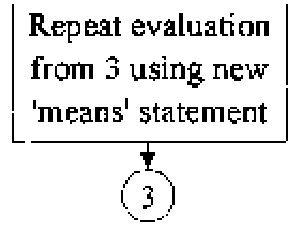


FIGURE 4: The flow chart (continued 2)


continued
Identify risks of active off-site effects arising from Use 1
VALIDATION
Check:
Compatibility between disciplinary findings
Conformity throughout with five 'pillars' of FESLM
Conformity throughout with 'Principles' of FESLM
Valid
Invalid
FINAL ANALYSIS
Assess interactions of all accumulated evidence.
Evaluate sustainability
Redefine/Refine local FESLM
Repeat from 3
3
REPORT RESULTS
Use 1 UNSUSTAINABLE
Use 1 SUSTAINABLE
Consider whether new 'means' of achieving objective appear feasible
MONITORING
Set up system using INDICATORS/CRITERIA/ THRESHOLDS
NO
YES
REPORT
USE 2
REPORT periodically


Repeat evaluation from 3 using new 'means' statement
3

Chapter 7: Validating, reporting and monitoring

Validating the analysis

The reader will recall that by definition (Chapter 1) sustainable land management is required simultaneously to:

• maintain or enhance production/services (Productivity)

• reduce the level of production risk (Security)

• protect the potential of natural resources and prevent degradation of soil and water quality (Protection)

• be economically viable (Viability)

• be socially acceptable (Acceptability).

These "pillars" of sustainability support all the activities of the FESLM. As the evaluation proceeds, each step should itself be measured against each and all of these required achievements. In particular, each threshold of each indicator attribute must be established with these five aims in mind.

In practice, some flexibility in the interpretation of these aims will be unavoidable. They represent an ideal goal which, in local circumstances, may be impossible to achieve. For example, where soils are to be cultivated, it may be impossible to entirely eliminate soil erosion, rendering impossible the achievement of environmental stability.

In determining thresholds it will be necessary in some instances to recognize an acceptable, rather than absolute, level of achievement of one or more of these aims. In part, this is foreseen in the FESLM, which requires that the time period over which sustainability is evaluated be stipulated. What is important is that any departure from the ideal towards lesser, 'acceptable', standards should be fully reported in the evaluation.

During the course of the evaluation, especially in the later stages when the findings in different environmental disciplines are brought together, it will be important to check the interactive implications of predicted change on the other aspects of environment. The effect of foreseen change in one aspect may be to create, amplify, or diminish, expected change in another. The possibility of such interaction has to be checked, its magnitude assessed, and the combined effects introduced into the analysis.

Validation activities are periods of maximum inter-disciplinary activity in the FESLM. Representatives of each discipline need to check their colleagues' work and conclusions across all the 'levels' of the Analysis matrix.

If a change with time is anticipated in the 'physical environment', for example, specialists working on the 'biological', 'economic', and 'social' environments will need to examine whether the foreseen change will influence the changes they had anticipated in their own specialist environments. It will be seen that this procedure calls for an iterative approach - forward and backward between disciplines - and the closest possible cooperation.

To avoid the need for dramatic revisions in the final stages, it is clearly desirable to maintain as active a measure of inter-disciplinary validation as possible throughout the evaluation process.

Interaction between different environmental aspects needs to be checked with special care if a change in management practice is proposed to meet foreseen future circumstances. For example, an increased use of fertilizer might be recommended to maintain soil fertility, but such a change could be unacceptable in relation to foreseen trends in market prices for the crop or for the fertilizer, or transport difficulties, or a host of other reasons.

Reporting

Of course, an FESLM report must supply verdicts on sustainability for each of the evaluated uses, but, if the report is to be of lasting value, it must also explain the assumptions on which these verdicts have been reached in sufficient detail to permit subsequent monitoring.

Thus an FESLM report needs to include:

[Summary statement of findings] - optional

The Purpose

- A comprehensive description of the 'Objective' and 'Means' of each use evaluated
- A precise description of the location of the site evaluated. Usually a large scale map showing the boundaries of the site and a small scale map showing location within surrounding areas will be necessary.

Background Data

- A brief, but reasonably complete, description of the site (physical, biological, economic and social characteristics)
- A list of reference sources; scales and subject matter of maps and imagery; GIS, data banks, census and other sources of information on site characteristics, suitability evaluation data, population etc.

Analysis

- • A listing of land qualities, component characteristics, indicators and thresholds identified as bearing upon the stability of each use (a tabular presentation similar to Table 3 in this document may be appropriate).
- • A listing and justification of criteria developed to analyse cause and effect, and to identify and assess component characteristics, indicators, thresholds and sustainability
- • An analysis of evidence (Observational; Historic; Geographic; Theoretical)
- • An assessment of possible active and passive off-site effects relevant to each use and their bearing on sustainability.

Findings

- • A projection of future events anticipated on the site arising from this analysis.
- • Final verdicts on sustainability of each use, together with any qualifications, limitations, restrictions etc. of each verdict.
- • Recommendations for monitoring future environmental development.

Monitoring

A particular strength of the methodology proposed for the FESLM lies in the foundation it provides for subsequent monitoring.

The method calls for identification and, where possible, quantification of all factors that bear upon the continuing stability of the defined use at the defined location. All that is required for monitoring is periodic observation and remeasurement of these factors to ensure that they are not changing in ways that were not foreseen in the evaluation.

As suggested in the previous section (on reporting), analysis of site indicators should provide a projection, or forecast, of the direction and anticipated magnitude of environmental change on the site with time. Real change with time should be monitored periodically to ensure that the pattern of change follows the forecast.

Inevitably, departures from the forecast change will occur, and completely unforeseen events may intervene. It will then be necessary to decide whether these departures from the expected course invalidate the original evaluation, taking care to assess the effect such change may have on other environmental aspects (i.e. cross checking the horizontal levels of the environmental matrices of the FESLM).

References

Buringh, P. and Dudal, R. 1987. Agricultural land use in space and time. In: *Land Transformation in Agriculture*. M.G. Wolman and F.G.A. Fournier (eds.). John Wiley, New York. pp. 9-45

Dumanski, J., Eswaran, H., and Latham, M. 1991. *Criteria for an international framework for evaluating sustainable land management.* Paper presented at IBSRAM International Workshop on Evaluation for Sustainable Development in the Developing World. Chiang Rai, Thailand.

Dumanski, J., Eswaran, H., Pushparajah, E., and Smyth, A. (eds.). 1991. Evaluation for sustainable land management in the developing world. Vol. 1: Towards the development of an international framework. *IBSRAM Proceedings* No. 12, Vol. 1.

Dumanski, J. and Smyth, A.3. 1993. *The issues and challenges of sustainable land management.* International Workshop on Sustainable Land Management for the 21st. Century, University of Lethbridge, Alberta, Canada.

FAO. 1976. A framework for land evaluation. *Soils Bulletin* 32. FAO, Rome.

FAO. 1983. Guidelines: Land evaluation for rainfed agriculture. *Soils Bulletin* 52. FAO, Rome.

Harmsen, K. and Kelly, T. 1992. *Natural resource management research for sustainable production.* Draft report for the Joint TAC/CDC Working Group on Ecoregional Approaches to International Research (unpublished). pp. 25.

IGBP (International Geosphere-Biosphere Program). 1992. Relating land use and global land-cover change. *IGBP Report* No. 5.

Public Advisory Committees to the Environmental Council of Alberta. 1990. *Alberta conservation strategy: Framework for action.* A draft for public discussion. Edmonton, Alberta.

Tickell, Sir C. 1993. The human species: a suicidal success? *The Geographical Journal* Vol. 159, Pt. 2, Royal Geogr. Soc., London.

Wischmeier, W. H. and Smith, D. D. 1978. Predicting rainfall erosion losses - a guide to conservation planning. *Agric. Handbook* 537, US Dept. Agric. Washington DC.

WRI (World Resources Institute). 1992. *World Resources 1992-1993*. Oxford University Press, New York.

Glossary

ACTION (or LOCAL) FESLM (FRAMEWORK): a procedure for evaluating the sustainability of a specific kind of land use, in a specific location, over a specific period of time; using the pathway, aims, approaches and actions identified in the Master Framework (qv) expressed in terms of selected indicators, criteria and thresholds.

CRITERIA: standards or rules (models, tests or measures) that govern judgements on environmental conditions.

*DIAGNOSTIC CRITERION (or FACTOR): a variable, which may be a land quality (qv), a land characteristic (qv) or a function of several characteristics, that has an understood influence on the output from, or the required inputs to, a specified kind of land use, and which serves as a basis for assessing the suitability or sustainability of a given type of land for that use. For every diagnostic criterion there will be a critical value or set of critical values which are used to define class limits. (cf. 'Indicators' and 'Thresholds' used in the FESLM)

INDICATORS: environmental statistics that measure or reflect environmental status or change in condition.

*LAND: an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these activities exert a significant influence on present and future uses of the land by man.

LAND (or ENVIRONMENTAL) ATTRIBUTE: a deliberately vague concept covering a wide range of factors, qualities, or characteristics of the total physical, biological, economic and social environment.

*LAND CHARACTERISTIC: an attribute of land that can be measured or estimated.

*LAND EVALUATION: the process of assessment of land performance when used for specified purposes, involving the execution and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation.

*LAND QUALITY: a complex attribute of land (qv) which acts in a manner distinct from the action of other land qualities in its influence on the suitability of land for a specified use.

*LAND SUITABILITY: the fitness of a given type of land for a specified kind of land use.

MASTER (or REFERENCE) FESLM (FRAMEWORK): a procedure for evaluating the sustainability of a land management package expressed in general terms and not tied to any specific land use goal; comprises a diagnostic pathway and (eventually) a comprehensive checklist of indicators, criteria and thresholds relevant to sustainability evaluation in all foreseeable circumstances.

*MATCHING: the process of mutual adaptation and adjustment of the descriptions of land utilisation types (qv) and the increasingly known land qualities.

STABILITY (in the context of the FESLM): a measure of the likelihood of significant change in a particular attribute during the time scale of a sustainability evaluation.

SUSTAINABLE LAND MANAGEMENT: a combination of technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to manage land in a way that will simultaneously:

- maintain or enhance production/services
- reduce the level of production risk protect the potential of natural resources and prevent degradation of soil and
- be economically viable, and
- be socially acceptable.

SUSTAINABILITY: a measure of whether or not a defined system of land use can be maintained at acceptable levels of productivity or service with realistic levels of input yet without progressive physical, biological, economic, or social damage to the environment on a specific site over a stated period of time.

THRESHOLDS: levels of environmental Indicators (qv.) beyond which a system undergoes significant change; points at which stimuli provoke significant response.

* denotes a definition taken from the FAO Framework for Land Evaluation (FAO, 1976)

(qv) crosscheck within this Glossary

World soil resources reports

1. Report of the First Meeting of the Advisory Panel on the Soil Map of the World, Rome, 19-23 June 1961.**

2. Report of the First Meeting on Soil Survey, Correlation and Interpretation for Latin America, Rio de Janeiro, Brazil, 28-31 May 1962**

3. Report of the First Soil Correlation Seminar for Europe, Moscow, USSR, 16-28 July 1962.**

4. Report of the First Soil Correlation Seminar for South and Central Asia, Tashkent, Uzbekistan, USSR, 14 September-2 October 1962.**

5. Report of the Fourth Session of the Working Party on Soil Classification and Survey (Subcommission on Land and Water Use of the European Commission on Agriculture), Lisbon, Portugal, 6-10 March 1963.**

6. Report of the Second Meeting of the Advisory Panel on the Soil Map of the World, Rome, 9-11 July 1963.**

7. Report of the Second Soil Correlation Seminar for Europe, Bucharest, Romania, 29 July-6 August 1963.**

8. Report of the Third Meeting of the Advisory Panel on the Soil Map of the World, Paris, 3 January 1964.**

9. Adequacy of Soil Studies in Paraguay, Bolivia and Peru, November-December 1963.**

10. Report on the Soils of Bolivia, January 1964.**

11. Report on the Soils of Paraguay, January 1964.**

12. Preliminary Definition, Legend and Correlation Table for the Soil Map of the World, Rome, August 1964.**

13. Report of the Fourth Meeting of the Advisory Panel on the Soil Map of the World, Rome, 16-21 May 1964.**

14. Report of the Meeting on the Classification and Correlation of Soils from Volcanic Ash, Tokyo, Japan, 11-27 June 1964.**

15. Report of the First Session of the Working Party on Soil Classification, Survey and Soil Resources of the European Commission on Agriculture, Florence, Italy, 1-3 October 1964.**

16. Detailed Legend for the Third Draft on the Soil Map of South America, June 1965.**

17. Report of the First Meeting on Soil Correlation for North America, Mexico, 1-8 February 1965.**

18. The Soil Resources of Latin America, October 1965.**

19. Report of the Third Correlation Seminar for Europe: Bulgaria, Greece, Romania, Turkey, Yugoslavia, 29 August-22 September 1965.* *

20. Report of the Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Bonn, Federal Republic of Germany, 29 November-3 December 1965.* *

21. Report of the Second Meeting on Soil Survey, Correlation and Interpretation for Latin America, Rio de Janeiro, Brazil, 13-16 July 1965.**

22. Report of the Soil Resources Expedition in Western and Central Brazil, 24 June-9 July 1965.**

23. Bibliography on Soils and Related Sciences for Latin America (1st edition), December 1965.**

24. Report on the Soils of Paraguay (2nd edition), August 1964.**

25. Report of the Soil Correlation Study Tour in Uruguay, Brazil and Argentina, June-August 1964.**

26. Report of the Meeting on Soil Correlation and Soil Resources Appraisal in India, New Delhi, India, 5-15 April 1965.**

27. Report of the Sixth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Montpellier, France, 7-11 March 1967.**

28. Report of the Second Meeting on Soil Correlation for North America, Winnipeg-Vancouver, Canada, 25 July-5 August 1966.**

29. Report of the Fifth Meeting of the Advisory Panel on the Soil Map of the World, Moscow, USSR, 20-28 August 1966.**

30. Report of the Meeting of the Soil Correlation Committee for South America, Buenos Aires, Argentina, 12-19 December 1966.**

31. Trace Element Problems in Relation to Soil Units in Europe (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Rome, 1967.**

32. Approaches to Soil Classification, 1968.**

33. Definitions of Soil Units for the Soil Map of the World, April 1968.**

34. Soil Map of South America 1:5 000 000, Draft Explanatory Text, November 1968.**

35. Report of a Soil Correlation Study Tour in Sweden and Poland, 27 September-14 October 1968.**

36. Meeting of Rapporteurs, Soil Map of Europe (Scale 1:1 000 000) (Working Party on Soil Classification and Survey of the European Commission on Agriculture), Poitiers, France 21-23 June 1967.**

37. Supplement to Definition of Soil Units for the Soil Map of the World, July 1969.**

38. Seventh Session of the Working Party on Soil Classification and Survey of the European

Commission on Agriculture, Varna, Bulgaria, 11-13 September 1969.**

39. A Correlation Study of Red and Yellow Soils in Areas with a Mediterranean Climate.**

40. Report of the Regional Seminar of the Evaluation of Soil Resources in West Africa, Kumasi, Ghana, 14-19 December 1970.**

41. Soil Survey and Soil Fertility Research in Asia and the Far East, New Delhi, 15-20 February 1971.**

42. Report of the Eighth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Helsinki, Finland, 5-7 July 1971.**

43. Report of the Ninth Session of the Working Party on Soil Classification and Survey of the European Commission on Agriculture, Ghent, Belgium 28-31 August 1973.**

44. First Meeting of the West African Sub-Committee on Soil Correlation for Soil Evaluation and Management, Accra, Ghana, 12-19 June 1972.**

45. Report of the Ad Hoc Expert Consultation on Land Evaluation, Rome, Italy, 6-8 January 1975.**

46. First Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Nairobi, Kenya, 11-16 March 1974.* *

47. Second Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Addis Ababa, Ethiopia, 25-30 October 1976.

48. Report on the Agro-Ecological Zones Project, Vol. 1 - Methodology and Results for Africa, 1978. Vol. 2 - Results for Southwest Asia, 1978.

49. Report of an Expert Consultation on Land Evaluation Standards for Rainfed Agriculture, Rome, Italy, 25-28 October 1977.

50. Report of an Expert Consultation on Land Evaluation Criteria for Irrigation, Rome, Italy, 27 February-2 March 1979.

51. Third Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Lusaka, Zambia, 18-30 April 1978.

52. Land Evaluation Guidelines for Rainfed Agriculture, Report of an Expert Consultation, 12-14 December 1979.

53. Fourth Meeting of the West African Sub-Committee for Soil Correlation and Land Evaluation, Banjul, The Gambia, 20-27 October 1979.

54. Fourth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Arusha, Tanzania, 27 October-4 November 1980.

55. Cinquième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Lomé, Togo, 7-12 décembre 1981.

56. Fifth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Wad Medani, Sudan, 5-10 December 1983.

57. Sixième réunion du Sous-Comité Ouest et Centre Africain de corrélation des sols pour la mise en valeur des terres, Niamey, Niger, 6-12 février 1984.

58. Sixth Meeting of the Eastern African Sub-Committee for Soil Correlation and Land Evaluation, Maseru, Lesotho, 9-18 October 1985.

59. Septième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Ouagadougou, Burkina Faso, 10-17 novembre 1985.

60. Revised Legend, Soil Map of the World, FAO-Unesco-ISRIC, 1988. Reprinted 1990.

61. Huitième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Yaoundé, Cameroun, 19-28 janvier 1987.

62. Seventh Meeting of the East and Southern African Sub-Committee for Soil Correlation and Evaluation, Gaborone, Botswana, 30 March-8 April 1987.

63. Neuvième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Cotonou, Bénin, 14-23 novembre 1988.

64. FAO-ISRIC Soil Database (SDB), 1989.

65. Eighth Meeting of the East and Southern African Sub-Committee for Soil Correlation and Land Evaluation, Harare, Zimbabwe, 9-13 October 1989

66. World soil resources. An explanatory note on the FAO World Soil Resources Map at 1:25 000 000 scale, 1991.

67. Digitized Soil Map of the World, Volume 1: Africa. Volume 2: North and Central America. Volume 3: Central and South America. Volume 4: Europe and West of the Urals. Volume 5: North East Asia. Volume 6: Near East and Far East. Volume 7: South East Asia and Oceania. Release 1.0, November 1991.

68. Land Use Planning Applications. Proceedings of the FAO Expert Consultation 1990, Rome, 10-14 December 1990.

69. Dixième réunion du Sous-Comité Ouest et Centre africain de corrélation des sols pour la mise en valeur des terres, Bouaké, Odienné, Côte d'Ivoire, Côte d'Ivoire, 5-12 November 1990.

70. Ninth Meeting of the East and Southern African Sub-Committee for Soil Correlation and Land Evaluation, Lilongwe, Malawi, 25 November-2 December 1991.

71. Agro-ecological land resources assessment for agricultural development planning. A case study of Kenya. Resources data base and land productivity. Main Report. Technical Annex 1: Land resources. Technical Annex 2: Soil erosion and productivity. Technical Annex 3: Agro-climatic and agro-edaphic suitabilities for barley, oat, cowpea, green gram and pigeonpea. Technical Annex 4: Crop productivity. Technical Annex 5: Livestock productivity. Technical Annex 6: Fuelwood productivity. Technical Annex 7: Systems documentation guide to computer programs for land productivity assessments. Technical Annex 8: Crop productivity assessment: results at district level. 1991.

72. Computerized systems of land resources appraisal for agricultural development, 1993.

73. FESLM: an international framework for evaluating sustainable land management, 1993.

** Out of print

This *World Soil Resources Report* outlines a strategic framework approach for evaluating sustainable land management. The framework is designed as a pathway to guide analysis of land use sustainability: it comprises a series of scientifically sound logical steps connecting all aspects of the land use - environmental, economic and social - which collectively determine whether that form of land management is sustainable or will lead to sustainability.

Contents - **Previous**