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SURVEYS, PLANS AND PEOPLE

A Review of Land Resource Information and its Use in Developing Countries

By

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PREFACE

*'I can tell you, sirs, what I will not have,
though I cannot what I would'.*

Oliver Cromwell 1641

This research stemmed from a conviction that natural resources information is not used to anything like its potential in support of decisions about land use and management. In writing frankly about our findings, we are conscious that many colleagues will be disappointed that we do not present a balanced picture - that we dwell on shortcomings rather than successes. True enough, yet many of our conclusions have been flagged before by distinguished professionals and we have to ask why there has been no effective action to remedy this state of affairs ?

There is no simple answer. Certainly, natural resources institutions and, particularly, consultants must secure work to stay in business. There is always economic pressure to bid for work and accept commissions, even when the professional staff are aware that the approach embodied in terms of reference is flawed. Conventional but ineffective practice is thus perpetuated. We also know of occasions when individuals or organizations have declined such work, but this receives little or no publicity.

Perhaps the messages have not reached, or even been aimed at decision-makers who can make a difference. Presentations at obscure conferences, papers in academic journals and reports in the 'grey literature' will not effect change. But, first of all, we must have proven, viable alternatives to the tried-and-tested-and-failed procedures in natural resources survey and land use planning. Then we must have a plan for change to identify and reach the key decision-makers (at whatever level), and support them with relevant information, backed up by education and training for both them and professional staff.

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CHAPTER ONE

EXECUTIVE SUMMARY

1.1 Background to the Study

Natural resources surveys provide the baseline information needed for effective development planning. But, often, large surveys have been undertaken without establishing who will be the users of the information, how it will be used and the institutional capacity to use it. Much information gathered by costly surveys has been underutilised and, effectively, lost.

Land use planning remains largely sectorised and unintegrated, is usually centralised and top-down. There is little effective participation in land use planning by the supposed beneficiaries.

These issues have been considered in collaboration with partner institutions in Sri Lanka and Tanzania who have undertaken separate country case studies. The work in Sri Lanka was done in collaboration with the Land Use Policy Planning Division of the Ministry of Lands. In Tanzania, the case study was conducted in collaboration with the Institute of Resource Assessment, University of Dar es Salaam.

This report reviews methods of resource survey and land use planning. Its purpose is to facilitate informed debate on the adequacy of the support provided to developing countries in the fields of natural resources surveys and land use planning.

1.2 The Research Behind the Report

Extensive consultations and interviews have been conducted with resource survey specialists, planners and decision-makers working in developing countries and, particularly, in the two case study countries. In addition, visits were made to several national and international organisations and consultancy companies involved in surveys and planning to conduct interviews and to consult documentation (FAO, Rome; the Winand Staring Centre and International Soil Reference and Information Centre - both in The Netherlands; CSIRO Division of Soils in Australia; the Land and Water Development Resource Centre of the Natural Resources Institute, Booker-Tate and Hunting Technical Services in the UK. Individual survey and planning specialists provided important information and guidance to source materials. Literature searches were conducted in several university and institutional libraries.

1.3 Scope of the Report

Chapter Two introduces key issues concerning resource assessment and land use planning: the needs of planners and decision-makers for natural resources information, how such information is used and the institutional setting into which it is delivered. The need for greater participation by local communities in natural resource management and planning is examined.

The present can be better understood by reference to the past and Chapter Three provides a historical perspective on the evolution of resource assessment and land use planning procedures in developing countries. Developments are traced through several phases, grouped for convenience as: early colonial times, the late colonial period following the end of the Second World War (1945-1960), the immediate

post-independence period (the 1960s), the international aid era (when aid agency activity grew in the 1970s - 1980s) and, most recently, the post-Brundtland period (following publication of the influential report of the World Commission on Environment and Development in 1987).

Chapter Four reviews the main approaches to resource assessment and their effectiveness. It covers soil survey, land systems, geomorphological survey, parametric mapping and interpolation techniques, forest inventory, wildlife resources and range management surveys, the generation of climatic and hydrological data and information about current land use. We have not reviewed the techniques of topographic survey, aerial photography or satellite imagery except in the context of interpretation of their basic data for other natural resource surveys.

In Chapter Five, the wide spectrum of methods of land evaluation are ordered according to their principles - from trial-and-error, to transfer of experience by analogy, to expert systems and modelling of natural processes. Several approaches depending on expert judgement are covered: land capability classification, the FAO Framework for Land Evaluation, the land classification system of the US Bureau of Reclamation, parametric methods and decision trees. The logic and assumptions of different methods are reviewed and a judgement is made of their success in providing the specific information about land behaviour needed by managers and policy-makers. This chapter goes on to discuss the objectives and methods of land use planning: in particular the recent FAO Guidelines for Land Use Planning (FAO 1993).

Chapter Six discusses the opportunities for improvement offered by participatory approaches and from working according to the principles of participatory inquiry. A typology of participation is presented. Some approaches to participatory planning are described and several examples are given which show considerable potential for scaling-up to involve more people and larger areas. These might link local initiatives with policy and planning processes and public institutions (linking bottom-up and top-down planning).

Chapter Seven presents lessons from experience of resource assessment and land use planning over the last half century. It considers the needs of developing countries for information on natural resources, and the problems they face in securing and making use of such information and in integrating it into planning and decision-making. Common limitations of natural resource surveys and the use of inappropriate planning methods and inappropriate data are described.

1.4 Conclusions and Recommendations

To develop a rational land use policy, to choose between alternative land uses or to direct investment where it will yield the greatest benefit, decision-makers need timely information about natural resources and the capability to make use of this information. In many cases, they are not getting information that they can use and cannot use the information that they are getting. Recommendations for improving this state of affairs follow. The situation is not new and several of the recommendations have been made before - but not acted upon.

1.4.1 Natural Resource Surveys

- ◆ Planners and decision-makers ask - or ought to ask - searching questions about natural resources and their development. Examples might include:

- What are the demands on the land and water ?
- Is there enough land and water to meet these demands ?
- Where are the usable areas, how extensive are they, and how are they used now ?
- Is the present use sustainable ? If not, what are the constraints on more sustainable use ?
- What land use options are feasible for areas of interest, and what levels of production or services can be expected ?
- Where and how can optimum returns on efforts and inputs be achieved ?

Answers to such questions are rarely simple. Some questions can only be answered by integrating environmental, social and economic information.

- ◆ Ideally, as policies, development programs or projects evolve, decision-makers and planners should refer continually to the relevant natural resources data. Interpretations of the basic data need to keep pace with the changing nature of the questions asked. Initially, general and qualitative information may be needed but, ultimately, very specific, detailed, quantitative information may be required.

In practice, land use decisions in developing countries are made in ignorance or with quite inadequate information. Several situations are commonplace:

Decision-makers are unaware of the utility or relevance of natural resources information.

Policy-makers, planners, project managers and planters do not know what information to ask for. They have no clearly-defined place for natural resources information in their decision-making procedure.

Without the support of high level decision-makers, the funding and political will to rectify the other failings will not be forthcoming.

Key data are lacking, incomplete, out of date or unreliable

There is a gap between the scale at which information is needed and the scale at which it can be provided quickly.

Survey coverage and recording networks are incomplete and there is no strategy for completion. Funding for basic survey is inadequate so that, in general, developing countries lack the capability to update and upgrade their natural resources data base. There is no continuity of planning, of survey effort or of professional staff - so methods are not compatible, a good level of expertise is not maintained and institutional memory is short.

Useful data exist but are not known to or not available to the decision-maker

There is little co-ordination of activities between institutions. Duplication of effort is common, e.g. new surveys are carried out in ignorance of earlier surveys and development is attempted without learning from the past. Such problems are compounded by inadequate archival services and short institutional memory.

Useful data are to hand but decision-makers are unable to interpret them

Much natural resources information is incomprehensible, even to professionals in allied fields. Jargon and the intimidating welter of detail are obvious reasons for this. Reports are quite clearly written for natural resources specialists and not for anyone else.

Executive summaries are good practice but are often turgid. Interpretations of technical data are rarely tailored to the special needs of individual decision-makers, and are usually carried out mechanically.

Information may be at a level of detail or generalization different from that at which the user is operating and may not coincide with the effective management unit (e.g. administrators work in terms of administrative units, not river catchments; farmers in terms of fields not soil mapping units) and it is difficult for users to re-organise the information to suit their needs.

Reports written in technical English are not understandable to decision-makers who are not comfortable with English, or whatever technical language is used.

Recommendations:

A range of initiatives is needed to develop land literacy and awareness of natural resources, the consequences of their mismanagement, and the value of natural resources information for environmental management and sustainable economic management

This is most immediately needed amongst policy-makers and task managers in both governments and aid agencies. High-level briefings and short residential courses might be amongst a range of initiatives from natural resources institutions and international bodies.

- ◆ This research confirms that there has rarely been any dialogue between policy-makers, project managers, and their natural resources specialists, or between natural resources specialists and the presumed users or beneficiaries of the information. As a result:
 - Often, large surveys have been carried out (and are still being carried out) without clearly establishing who will be using the information, how it will be used, or if there is the capability to use it.
 - Terms of reference for surveys are vague in respect of objectives, yet have laid down operational procedures in some detail - imposing standard recording of standard attributes, standard intensities of survey and standard interpretations. This criticism

applies to both donors supporting resource surveys and indigenous institutions that simply follow established, scientifically-respectable methods. Most of these methods originated in developed countries. They serve their original purpose well but they have been adopted subsequently in developing countries in quite different physical and economic environments, sometimes without modification. Established survey methods fail to address changing issues and priorities.

In feasibility surveys, excessive time is spent fulfilling 'to the letter' these inappropriate terms of reference whilst the main generalizations about the natural resources are not made available to other members of the planning team (e.g. agronomists, economists, engineers) at an early stage when they are framing their own concepts. Soils data, in particular, are often relegated to appendices that are collated long after the main recommendations have been formulated. These data remain largely unused.

Systematic national surveys often achieve little areal coverage, despite many years of work, and there is often a backlog of reporting. Thus, when a specific question is asked, the answer is likely to be 'We have no information about that'.

- The provision of natural resources information by the public sector is supply-led. Once a survey program or institution is established, it gains a momentum of its own: data collection becomes the end in itself. The basic data collected and the interpretations provided are fixed by professional interests, not by the needs of potential users of the information.

Recommendation:

Terms of reference for natural resources surveys for development planning should specify the goals, exactly what the data are to be used for, how they are expected to be used and by whom. Only then can the appropriate data be collected and relevant interpretations be provided. Box 1 provides a checklist for those who are writing specifications for natural resources surveys.

Recommendation:

The end-users of the information will not usually be natural resources specialists, so the data should be carried to the point of decision by appropriate specialists and not left to someone else.

Recommendation:

'Blunderbus' surveys of natural resources carried out on a gather-all basis should not be continued. If the immediate use of the data is not known, don't collect them.

1.4.2 Land Use Planning

- ◆ Land use planning has failed to live up to its promises. It remains mainly centralized, sectoral and top-down. Experts prepare maps that indicate in considerable detail how the land should be used. There is little participation of the target groups and, sometimes, little input from

Box 1: Checklist: Specifications for Natural Resources Surveys

- 1. What is the information going to be used for ?**
 - Are the goals of the development program and the specific uses of the natural resources data clearly defined ?
- 2. Who will use the data ?**
 - Have these users been involved in defining the goals and specifying the data needed - the scale, intensity of survey and format of the data ?
 - Are these people able to interpret the data requested and check their quality ?
 - There may be several categories of users, each with different requirements.
- 3. When will the data be used ?**
 - How soon are they needed ?
- 4. Do relevant data already exist ?**
 - Where are they held, are they accessible ? Do they cover the whole area of interest ? Are they up-to-date, reliable and at an appropriate scale - and who has checked this ?
- 5. Are the proposed methods of survey the most appropriate ?**
 - What alternatives have been considered ? Will the data be compatible with existing key data?
- 6. Who is best placed and best qualified to provide the data needed ?**
 - Are there local institutions, NGOs, local consultants or national specialist organizations that can undertake or contribute to the work ?
 - If expatriate consultants are selected, can they provide training for in-country staff ?
 - Can they supply data of the quality needed in time and within budget ?
- 7. What useful information is held within the local community ?**
 - What information is already used in land use decision-making ?
 - Are local methods of data collection, classification and analysis appropriate ?
 - Are the proposed professional staff experienced in techniques of participatory inquiry that can tap/find/elicit locally-held information ?
 - At the completion of the survey, the results should be explained to all stakeholders both for their information and for immediate correction of obvious errors using local experience.
- 8. What support is there for the project at every relevant level of government and across the local community ?**
- 9. Are there adequate resources to complete the work to the standard needed and to implement any recommendations ?**

agencies charged with implementing the plans. The supposed beneficiaries of development plans have neither the opportunity to articulate their needs, nor to contribute their own local knowledge. Except in command economies, most of these plans have remained just plans!

Recommendations:

The missing link in land use planning is a platform for negotiation between all the stakeholders - land users, rural people, urban people, government, business and others. Governments must learn the limits of their own capacity and competence. They should provide an enabling environment and facilitate informed decision-making, rather than attempt to direct and police land use in every field and on every hillside.

Planning agencies need to be more sensitive to the experiences, priorities and aspirations of local communities. This, in turn, will require greater awareness of and skills in methods of participatory inquiry. More effective participatory planning must include:

- Devolution of authority, especially over 'common property resources';*
- Recognition of indigenous knowledge and management practices as a basis for the development of better systems of management;*
- Attention to the question of land tenure;*
- Attention to local institutions - their effectiveness and governance - including appropriate technical support and adequate financial and managerial support*

Democracy of information is essential to the process of negotiation. All parties need access to intelligible, accurate and up-to-date information about natural resources as well as economic projections.

- ◆ Participatory (bottom-up) planning is now promoted as an alternative to top-down planning. Participation means different things to different people. Consultation and participation are not the same thing. Top-down consultation by which people are asked to provide facts or opinions, usually about proposals drawn up by others, tends to disillusion and rarely reveals the full range of information available. Participation means people being actively involved in identifying needs, making plans and implementing them.

Box 2 lists some of the questions that should be asked, answered and acted upon at the outset of planning at the local level.

Participatory approaches have been limited mainly to local-level developments. However, some initiatives show potential for scaling-up to involve more people and larger areas, linking local initiatives with higher-level policy and public institutions (e.g. the Gestion de Terroir approach in Sahelian West Africa). At present, participatory planning faces problems of poorly-developed local institutions, undefined lines of authority, opposition from central institutions and a weak base of information and management skills. Decisions should be made where the information is. For questions of detail, this is at local level but local institutions rarely have a formal systematic way of gathering and interpreting natural resources data.

Recommendation:

Procedures for survey and planning are needed that can be implemented by modestly-funded and inadequately-staffed institutions. Research is needed to support the development and testing of locally-specified 'do-it-yourself' tool kits for natural resources survey and interpretation. These kits should include simple methods of survey and calculation to gather the data needed and knowledge-based systems ('expert' systems) to support local decision-making. These systems need not necessarily be computer-based.

Box 2: Basic Questions for Local Level Planning

1. What are the different groups within a community (e.g. women/men, better/worse-off, younger/older) and which ones have access to and control over particular natural resources (e.g. grazing, water, forest) and which do not? What conflicts exist over access to resources? What does this imply for planning the sustainable use and management of these resources?

How can the interests of less-powerful people be protected in the planning process?
2. What ways have local people developed to assess and manage their resources?

What local indicators or categories are used to assess the condition of their resources (eg, presence of particular plant species to indicate soil type or condition)? What can we learn from these approaches that might be useful to other communities?
3. Are the local people interested in sharing their 'know-how' with other communities? Are other communities interested in learning from them? Can we assist them in this process?
4. How have land and resource use patterns and practices changed over time within the area? What factors have influenced the present situation, and what situation do local people envisage for the future with and without changes to current practices?
5. Do the local people want any help, bearing in mind that particular groups within the community may hold different views? If so, how can we help them to improve what they are already doing? How can we help them to identify gaps in their information gathering/analysis process and how can we help to plug these gaps. Are approaches or methods from outside useful and appropriate?
6. What local institutions (e.g. village committees) are involved in or can assist land use planning?
7. What external services (e.g. government, private sector, NGO) are needed by local people to assist in the process, e.g. technical assistance, finance, etc.
8. What would be the impacts of intervention in local level planning by external agencies? How might these affect the balance of 'power' within the community and the subsequent use of resources?

- ◆ Top-down and bottom-up planning are not alternatives. *Links must be forged between these two approaches*. Clearly, there are development issues that are national in scope, e.g., development of a major catchment for hydro-electric power or the establishment of a national park, where decisions have to be taken in the national interest. There are other matters where the initiative should rest with local communities.
- ◆ Greater environmental awareness, exemplified by the 1987 Brundtland Report, has focussed attention on the need to integrate social, economic and environmental aspects of development. Developing countries are now being asked to respond to a range of international initiatives. Examples include Agenda 21 (one of the main accords agreed at the 1992 UN Conference on Environment and Development) which calls for a significant expansion in baseline surveys to provide natural resources information for planning; and the preparation of National Sustainable Development Strategies. Yet the institutional capacity for interdisciplinary, cross-sectoral planning is weak. The lack of a career structure outside the established, sectoral institutions is a serious constraint. Secondment of staff from established institutions is universally unsatisfactory.
- ◆ There is a critical shortage of competent land resources specialists in specialist natural resources institutions and in other organisations (e.g. planning and engineering agencies, public administration) where they could provide in-house support. Symptoms of this lack of support include the continued, unchecked use of obviously unreliable and out-of-date data passed on from one development project to another, and the unquestioning use of methods of data collection and analyses devised for quite different conditions in developed countries.

While information gaps can be plugged by overseas-funded and managed survey projects, such assistance does not provide continuing management support or the in-country capability to update and re-interpret the natural resources data base.

- ◆ There has been a reduction in the training opportunities offered in natural resources survey and land use planning. These are not fashionable academic disciplines in developing or developed countries, not least because of the scarcity of career opportunities.

Recommendation:

Technical training in natural resources survey, participatory inquiry and land use planning is urgently needed for young professional staff in developing countries - and would be best if carried out in the developing countries themselves. Training offered in developed countries emphasises hi-tech methods and laboratory techniques at the expense of basic and field-based work. This is inappropriate when state-of-the-art technology cannot be realistically funded or staffed. Training will be more realistic in the physical, economic and social environment of the trainees' country itself or of a regional centre.

The FAO Guidelines for Land Use Planning (FAO 1993) is a useful starting point for appropriate training.

- ◆ An example of technology driving planning and training is the current emphasis on GIS and computerised databases in the prevailing absence of reliable basic data with adequate cover, and also in the absence of staff capable of operating these sophisticated systems and judging the quality of both inputs and outputs. Another is the continued reliance on remote sensing for collection of information on a wide range of land qualities that cannot be determined without rigorous fieldwork.

Recommendation:

Before a GIS is introduced, it is only sensible to ensure that basic natural resources data of reliable quality and sufficient cover are available: also that a GIS is the most effective way of meeting the established need and the system can be serviced and maintained locally.

CHAPTER TWO

INTRODUCTION

In countries where capital and skilled manpower are scarce, most people depend directly on natural resources. Obviously, their decision-makers need good baseline information about the land. Equally, they need information about the development opportunities open to them; about the impact of each option on social and economic goals like employment, food security and export earnings; and they need information about the impact of land use on the land itself - whether the land use is sustainable or will progressively destroy the resources on which it depends.

Information about land resources is conventionally gathered by surveys: topographic survey, surveys of geology, soils and land use, forest inventories, biological diversity stocktakings and systematic recording of climatic and hydrological data. It is characteristic of developing countries that the coverage and quality of these data are patchy.

The basic data are rarely in a form that can be used by decision-makers and interpretation of these data in terms of development options and their consequences has rarely been provided. As a result, decisions have been taken, and are still being taken, in ignorance. The situation can be summed up from two different points of view. Decision-makers complain 'What I'm wanting I'm not getting. What I'm getting, I'm not wanting'. According to the land resources specialists, 'We have been pouring information into the sand'. This dilemma has been recognised for some time. More than 20 years ago, Robertson and Stoner (1970) commented:

'It is alarming to observe how little of the land resource data investigated and mapped is actually used in development plans - though one must recognise that its lack of use is by no means always related to irrelevance to the objectives in mind or to the form in which it is presented....

....frequently, public organisations gather routine data without any clear idea whether it can be used, until the point is reached where it cannot possibly be handled. And yet the collecting process continues. Experience teaches us to beware of massive data gathering programmes. Such programmes can be expansionist and obsessive in their demands on the investigators' time until merely collecting data becomes an end in itself.'

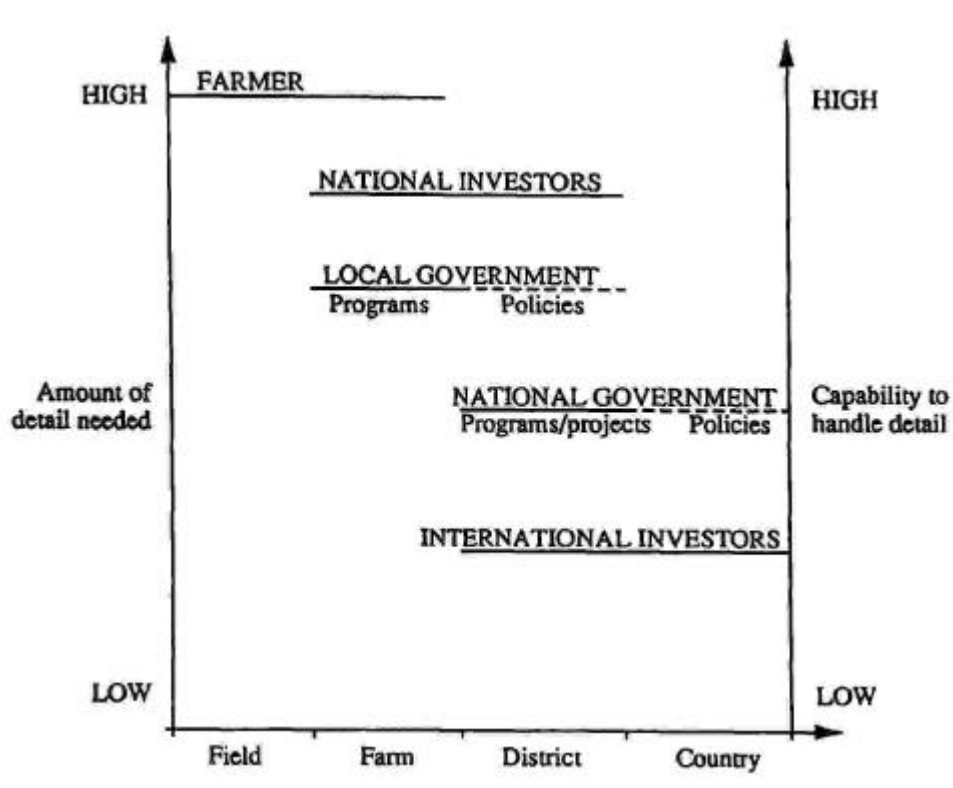
In seeking to establish how this situation has arisen and how it may be rectified, this review addresses both sides of the question: first, the methods of survey, presentation and targeting of natural resources information and, secondly, the needs and capabilities of decision-makers within the institutional framework of land use planning.

2.1 Natural Resources Surveys

Often, large surveys have been carried out without clearly establishing who will be using the information, how it will be used, and what is the capacity of institutions and individuals to make use of the information. We do not argue that all natural resources research should be driven by specific requests from the immediate users of the information but, at the outset of a big survey program, there is a need to establish what data are needed, by whom and for what purposes.

There are many different decision-makers and they have different needs (Figure 1).

Figure 1: Information Needed and Capability of Using it at Different Levels of Decision-Making, after Dent 1993



Different kinds of information in different degrees of detail are also needed at different stages in a development project. Ideally, decision-makers need to use their fund of information iteratively, so there is a need for interactive ways of presenting and manipulating the data to match them with the questions of the moment. And if the millions of land users and local communities who need natural resources information are to get the local, detailed data that they require for daily decisions about land use, they must participate in its gathering and analysis. There can never be enough natural resources specialists to do it for them.

2.2 The Needs of Decision-Makers and the Institutional Capability for Land Use Planning

This is the root of the matter. Land use planning aims to provide support for decisions about the use of natural resources, environmental management and economic and social development. Without an appreciation of natural resources, decision-makers cannot specify the information they need or comprehend the choices to be made. Unless there is a recognised place for natural resources information in the process of decision-making, there will be no demand for this information and no way of using it.

Without a strong institutional capability in land use planning, decisions will continue to be made on short-term political and financial grounds, and potentially-useful natural resources information will be unused and, therefore, lost. Inadequate archival services and short institutional memory resulting from frequent changes of staff also contribute to the loss of information.

National development planning is dominantly sectoral. Plans for agriculture, forestry, fisheries and wildlife management are usually undertaken independently by the responsible government departments with little inter-departmental dialogue. Inevitably there is duplication of effort, different departments working at cross-purposes, and even neglect of some services that do not fall clearly into the province of one department or another. While integrated planning has been advocated often (e.g. Clarke 1992, World Bank 1992, FAO 1993, IIED/IUCN 1993), it has been practised seldom. Major efforts in institution-building will be needed in most developing countries to co-ordinate the efforts of individual, and often rival, sectoral agencies.

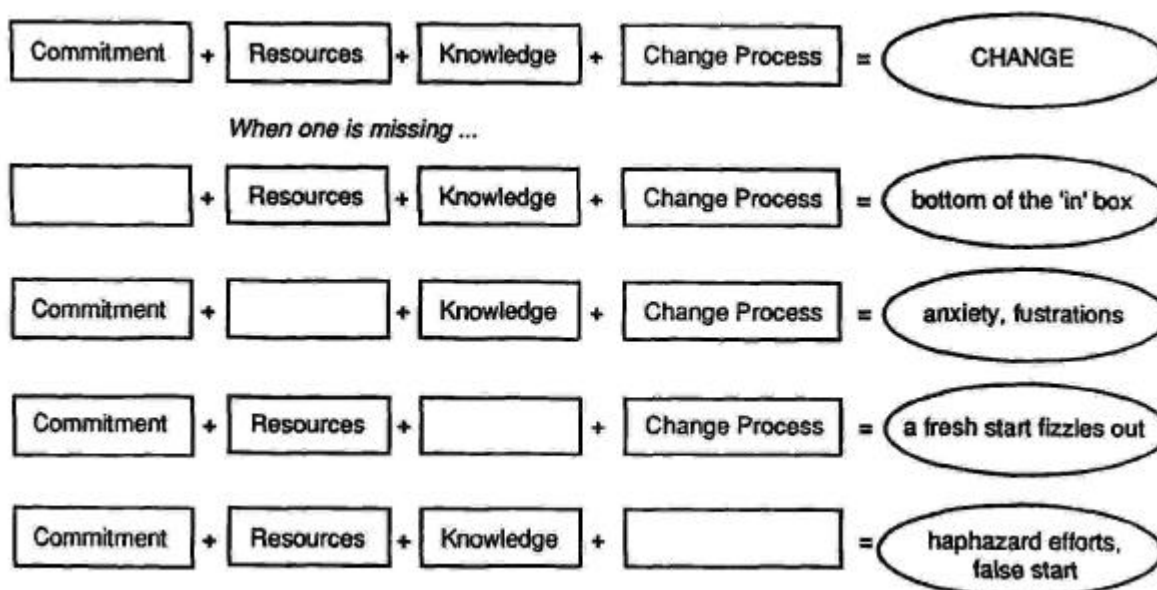
Within the framework of land use planning, the role of natural resources specialists should go beyond the mere collection of data. They need to be involved in the analysis of land use problems and opportunities; in the specification of the data needed; in the analysis, generalisation and interpretation of the data right up to the point of decision; in the monitoring and evaluation of land use plans; and in the continued maintenance of the natural resources database.

2.3 The Need for Participation

There are not many examples from developing countries of land use planning achieving more sustainable land use. This failure cannot be attributed solely to lack of, or inadequate use of, natural resources information. Change of land use also requires commitment, financial and/or human resource inputs, and a process or mechanism of change (Figure 2). Voluntary change of land use will come about only if the land users want it. Their commitment is given only if the new system or pattern of use is technically feasible, profitable, not too risky, socially acceptable, and preferred to what they are doing now.

Figure 2: A Model for Change

After Campbell 1993



Commitment has rarely been achieved by centralized, top-down planning because there has rarely been any participation, or even consultation, of the target groups. Sometimes there has not even been any input from the agencies charged with implementing the plans. Without local participation in planning, people have no stake in the plan and planners are denied a fund of local knowledge and skills. Broadly-based participation of the community in data collection, planning, implementation and monitoring can:

- mobilize the energies and skills of a wide range of people;
- facilitate an equitable definition of needs and distribution of responsibilities and benefits;
- secure commitment of these people to the plan.

Experience shows that methods of participatory inquiry can be more effective in terms of cost and time than most conventional, long-term surveys. Comparisons from a growing number of cases from Africa and Asia indicate that the results of participatory analysis are largely verified by subsequent formal surveys. In situations where human and financial resources are scarce in relation to the size of the task, and where approximate results are acceptable, a participatory approach is often the best and, sometimes, the only option. In other more complex or large-scale investigations, it can be used in conjunction with more conventional methods.

In the procedure of land use planning - the change process - there has to be a platform for negotiation between all the stakeholders if the inevitable conflicts of interest are to be resolved and a plan for change is to be given widespread acceptance. This platform must involve the participation of all interest groups (land users, rural and urban people, government, etc.) and access to relevant natural resources information for all parties.

In Chapter Six, we discuss methods of participatory inquiry and provide some examples of the use of participatory approaches in planning.

2.4 Purpose of this Report

This review of the methods of resource survey and land use planning examines the strengths and weaknesses of different approaches, particularly as applied in developing countries. We hope that the review, together with the country case studies, will stimulate a debate about the relevance, suitability and adequacy of the natural resources information provided, and that this debate will take place within and between organisations in developing countries responsible for resource surveys and land use planning, within external organisations and consulting companies contracted to undertake survey and planning work, and amongst aid agencies providing financial and technical support to such work.

CHAPTER THREE

HISTORICAL PERSPECTIVE

The focus of resource assessment and land use planning has changed significantly over the last half century, even though many of the techniques have continued in use. The evolution of resource assessment and land use planning procedures in developing countries can be traced through several phases, grouped for convenience as: *early colonial* times; the *late colonial* period following the end of the Second World War (1945-1960); the immediate *post-independence* period (the 1960s); the *international aid era* when aid agency activity grew in the 1970s-1980s; and, most recently, the *post-Brundtland* period following the publication of the influential report of the World Commission on Environment and Development (the Brundtland Commission) in 1987. These are not sharply-defined chronological periods and activities characteristic of one phase have sometimes overlapped or continued through later ones.

While there is a lot of documentation on the aims and practices of resource assessment in respect of Africa, less is ready to hand for Asia and Latin America.

3.1 Early Colonial Influences

Colonial intervention was accompanied by European economic priorities. Gleave (1987) notes that:

'the needs of the metropolitan markets for raw materials and tropical foodstuffs became a concern alongside the traditional one of providing for the communal needs and limited trading surpluses. To meet these needs, the institutional structure of resource management became more complex as the role of the colonial state became less benign and more interventionist in order to achieve its objectives. Western science was harnessed in government research stations to the solving of problems related to the production of export crops, whilst food crops were largely ignored.'

Resource surveys and planning were similarly directed. In Africa, colonisation by European powers significantly affected the setting and character of development efforts. In particular, the approaches to resource assessment and land use planning differed significantly between British and French colonies, and these differences persist today. The concepts and terminology of the French school of soil science are distinct from those in English. Buringh (1968) noted that almost half of the important literature on tropical soils is in French, and there is some in Spanish and Portuguese. The French literature is published mainly by ORSTOM, the overseas scientific and technical research organisation based in Bondy, France, and by INEAC (the National Institute for Agronomic Studies in the Congo, now Zaire) based in Brussels.

Gaitskell (1964) described the priorities for development in the colonial period as:

'surveys to find the best places for resource development, research to find the best methods, pilot schemes to find the best social forms for using them, and contacts to find markets for the products.'

Whilst the colonial era broke the isolation of Africa and saw a start made towards achieving many of these priorities, its impact was varied and limited because it occurred 'in an age in world history when colonialism itself began to lose its prestige' (Gaitskell *op cit.*). Development was left to expatriate private enterprise and only after 1945 did colonial policy actively encourage local development.

Herskovits (1962, quoted in Paden and Soja 1970, p269) has outlined three major phases of agricultural development in colonial Africa:

'the early period of conquest and concessions, during which the money economy was extended on a large scale and European establishments and settlements were introduced; an intermediate period of agricultural development schemes, conceived of on a large scale, generally remote from the masses and resulting in little cultural change; and lastly, a period when new agricultural methods were introduced and greater emphasis placed on land reform.'

The result, at independence, was a dual economy:

'one segment composed of relatively advanced, commercial farmers (such as cocoa farmers in Ghana) highly specialized in the production of cash crops for export; the other consisting of the majority of the population who remained basically subsistence farmers with, perhaps, a small surplus for sale.'

One of the major problems facing agricultural planning has been the difficulty in accommodating traditional systems geared towards producing food for local consumption with modern systems of cash crop production for local and overseas markets. The two sectors remain poorly connected, even today.

Where European settlement was unattractive, the policy was to rule through the local tribal chiefs and active, planned development was discouraged, even up to the outbreak of the Second World War, e.g. in The Sudan. Where the land attracted European immigration and settlement was encouraged, e.g. Algeria, Tunisia, Kenya, Southern Rhodesia, and South Africa, much of the best land was expropriated for European ownership and resource surveys and land use planning were concentrated on these areas.

The demand for surveys of resources increased in the 1930s, when the colonial administrations sought information to identify land suitable for settlement and development by Europeans, particularly for farming and plantations, and also for the needs of the indigenous populations. The *mapping out* procedure developed in Sri Lanka from 1935 marked a beginning of land use planning with the needs of the local population in mind (Dent and Goonewardene 1993). Information was also needed to deal with issues such as soil erosion, to identify areas free of tsetse fly, and to set aside forest reservations and hunting areas (later parks). At this time, there was very little information on the natural resources. Even topographic surveys were mostly involved with plans for registration of title, although triangulation of several territories was completed in the 1930s.

Some of the earliest exercises in national development planning began in the period 1943-45. In 1943, the Government of Kenya put forward a plan for soil conservation, water supply and housing, with plans foreshadowed for afforestation and silviculture, for education and construction. The Governor described the broad outlines of the plan as:

'Land, water, forests and roads are necessarily the key words in any development plans which are formulated for Kenya; progress and development in other directions must inevitably depend to a large extent upon the development of the chief natural assets of the Colony - land, water and forests - and an improved road system is necessary before these resources can be developed and exploited.' (File 38557, Kenya 1943, (CO/533/530) item 10, Despatch No. 112).

In 1944, the Governor of Uganda submitted an aggregate of departmental proposals for a six-year period which included measures for the conservation of natural resources, the control of pests and reclamation of rural areas. In Jamaica, a sketch plan of development schemes was prepared in 1945, based on reports of expert committees. By comparison, the 1944 proposals of the Government of Nigeria concentrated on capital works and the extension of various government services.

In 1945, a despatch to the colonial administrations from the British government required the preparation of development plans. Attention was drawn to the advantages of regional schemes, particularly for communications and water supply. A proper balance between development and welfare was stated to be fundamental to a wise development policy, according to Morgan (1980). Plans were also drawn up to provide central organisations to undertake geodetic, topographic and geological work throughout the Colonies, with aerial photography to be carried out by the RAF. Aerial survey was to open new horizons for natural resources surveys, but most of these belong to the next period.

3.1.1 Early Resource Surveys

During the early decades of this century, most survey work, particularly soil survey, was confined to temperate areas. Schantz and Marbut (1923) published the earliest known soil map of Africa at a scale of 1:25 million, based on less than 30 soil profile analyses scattered over the entire continent. They tried to show the probable location and trend of the great soil belts and stated that it was 'not a real soil map but merely a statement of the possible distribution of soils'. An advance on this was a 1:20 million scale coloured soil map of Africa, with an explanation in Russian by Z.J. Shokalskaia (date unknown). The map (key in English) distinguishes 22 soil types and seven more in mountain regions. Stamp (1964) reports that the text was translated by Mr. V.P. Sokoloff of the School of Geography of Johns Hopkins University.

According to Young (1976), soil maps of tropical areas from before the 1930s are rare. He notes a few:

'There is a soil map of Cuba at 1:800 000 by H.H. Bennett and R.V. Allison of the US Department of Agriculture of 1928; a survey of the island of Tobago published in 1929 by the Imperial College of Tropical Agriculture; and a map of 1930 on 1:30 000 scale by R.L. Pendleton of the La Carlota area of the Philippines. This last shows 30 mapping units consisting of soil types, e.g. Guimbalaon clay loam.

'In the library of the Royal Tropical Institute, Amsterdam, there is a survey of Sumatra at 1:800 000, published in 1920, and two undated maps of parts of Java (one at 1:10 000) believed to date from about 1910. The earliest [from Sumatra], however, is the *Groondsoortenkart van eengedeelte van Deli* by J.J. Hissink, published at Buitenzorg in 1910.'

In the period 1930-45, several notable reconnaissance soil surveys were undertaken on limited budgets and with few staff. Amongst these are the reconnaissance survey of the Belgian Congo (Baeyans 1938); the eleven *grey books* covering the British West Indies, produced by the Imperial College of Tropical Agriculture (see Hardy and Ahmad 1974); and a map of the central part of Nyasaland (Hornby 1938). Young (1976, p329) has commented that Hornby's map is astonishingly accurate considering the poor topographic base maps then available and the lack of air photos. Several surveys were conducted by R.L. Pendleton in Thailand.

The Provisional Soil Map of East Africa (Milne 1935/6) is regarded by many as the outstanding survey of this period. It introduced the concept of the soil catena as a mapping unit and this was taken up by Vine (1941) in Nigeria and became the basis of reconnaissance surveys after 1945.

The earliest and some of the best examples of integrated survey were the vegetation-soil surveys of Northern Rhodesia by Trapnell and co-workers (1937, 1943 and 1948). Their map legends incorporated landform features in addition to vegetation-soil units, and the reports contained much relevant detail on the farming systems. As Dent and Young (1981, p110) point out, 'natural vegetation is a sensitive integrator of the total environment' and Trapnell's work was helped by the fact that much of the country still carried semi-natural vegetation little altered by the low intensity of cultivation.

3.2 The Late-Colonial Period After 1945

The period 1945-55 witnessed rapid growth in the economies of most European colonies. Many former soldiers sought land to farm in the colonial territories, and native people who had also joined the forces returned more sophisticated and seeking land as a route to wealth and betterment. Surveys and planning were required and, in British colonies, soil survey was established as a branch (usually small) of many government Departments of Agriculture. The post-war period saw the production of the first soil maps of many countries (e.g. Ceylon in 1953, Thailand in 1949). In 1949, C.F. Charter published a paper on the methods of soil survey used in the Gold Coast.

In general, soil surveys followed one of two routes. The first followed the methods developed by the US Department of Agriculture, first published as the Soil Survey Manual (Kellogg 1937) and expanded to the definitive edition of 1952. This school was based on detailed field survey and laboratory analysis, using the Soil Series as the mapping unit. The other school developed reconnaissance surveys using air photo interpretation and the catena or land system as the mapping unit (Chapter Four).

Chisholm (1982) has described how the emphasis on technology transfer, which characterised the colonial period, continued in the years following the end of the Second World War:

'Western industrial civilisation apparently was available neatly packaged for export, the export drive led by hosts of advisers who were mostly European or American. Any notion that the standard package might not suit all customers was dismissed - as much by would-be recipients as by willing sellers.'

It is difficult to judge how well the technology travelled, but a number of large projects in the late colonial period either failed completely or performed below expectations. The relatively successful Gezira Scheme in Sudan and the ill-fated Tanganyika Groundnut Scheme represent two extremes. The latter is perhaps the classic example of a large agricultural scheme that introduced new methods and was implemented without undertaking adequate resource surveys. There were faults of many kinds in the planning of this scheme which resulted in its failure (Box 3). Amongst these was the fact that the environmental conditions in two of the three areas selected were not suitable.

Stamp (1964) described the scheme as an index both of continued ignorance of tropical soils and of the costliness of that continued ignorance. However, the spectacular failure of the scheme brought a wide recognition of the need for soil and other natural resource surveys prior to land development, and guaranteed their place in project planning thereafter.

During the colonial period, improved security and health brought multiplication of human populations and livestock, needing land for subsistence. At the same time, the opportunities of trade demanded land for cashcrops. Overcrowding brought serious consequences for the land and for societies which Gaitskell (1964) described as a *dead end picture*:

Box 3: The Tanganyika Groundnut Scheme

In 1946, following a visit to Tanganyika, Frank Samuel, Managing Director of the United Africa Company (UAC), suggested to the British Minister of Food a scheme to grow groundnuts over 2.5 million acres in the 'empty spaces' of East Africa to satisfy Britain's acute shortage of oils and fats. The Minister accepted the general idea but a host of questions remained, including (a) whether the soil was suitable, (b) whether there were insuperable objections from the point of view of native land tenure, (c) how the finance was to be provided, and (d) whether the necessary agricultural machinery could be procured quickly (Morgan 1980).

A three man investigating team spent 9 weeks in the field and their report (the Wakefield report) proposed a substantially larger project than originally envisaged. It recommended mechanised clearance of 3.2 million acres over 6 years to secure an annual production of 600 000 tons of groundnuts on farm units of 30 000 acres. Advisers raised a number of technical doubts, recommended chemical analyses of the soil, and cautioned *inter alia* that rainfall distribution in the areas proposed was unsuitable and that Rosette disease would be a problem. Even prior to the mission, advisers had warned that half of the area being considered was arid, that half comprised soils unsuitable for groundnuts and that soil surveys were needed. But these risks were dismissed and the government approved the scheme in its entirety. It was implemented to be at 'full speed' under the responsibility of the Ministry of Food, with the UAC as Managing Agents until a new government corporation, the Overseas Food Corporation (OFC) took over in March-April 1948.

The areas chosen in Tanganyika (see Figure 3) were:

Central Province (Kongwa)	450 000 acres
Western Province (Urambo)	300 000 acres
Southern Province (Nanchingwea)	1 650 000 acres

In addition, 300 000 and 510 000 acres were to be cleared in Kenya and Northern Rhodesia, respectively. As part of the scheme, a new railway link was to be built in Southern Province from the new deep water port of Mtwara near Mikindani. The scheme envisaged several long-term benefits to Tanganyika:

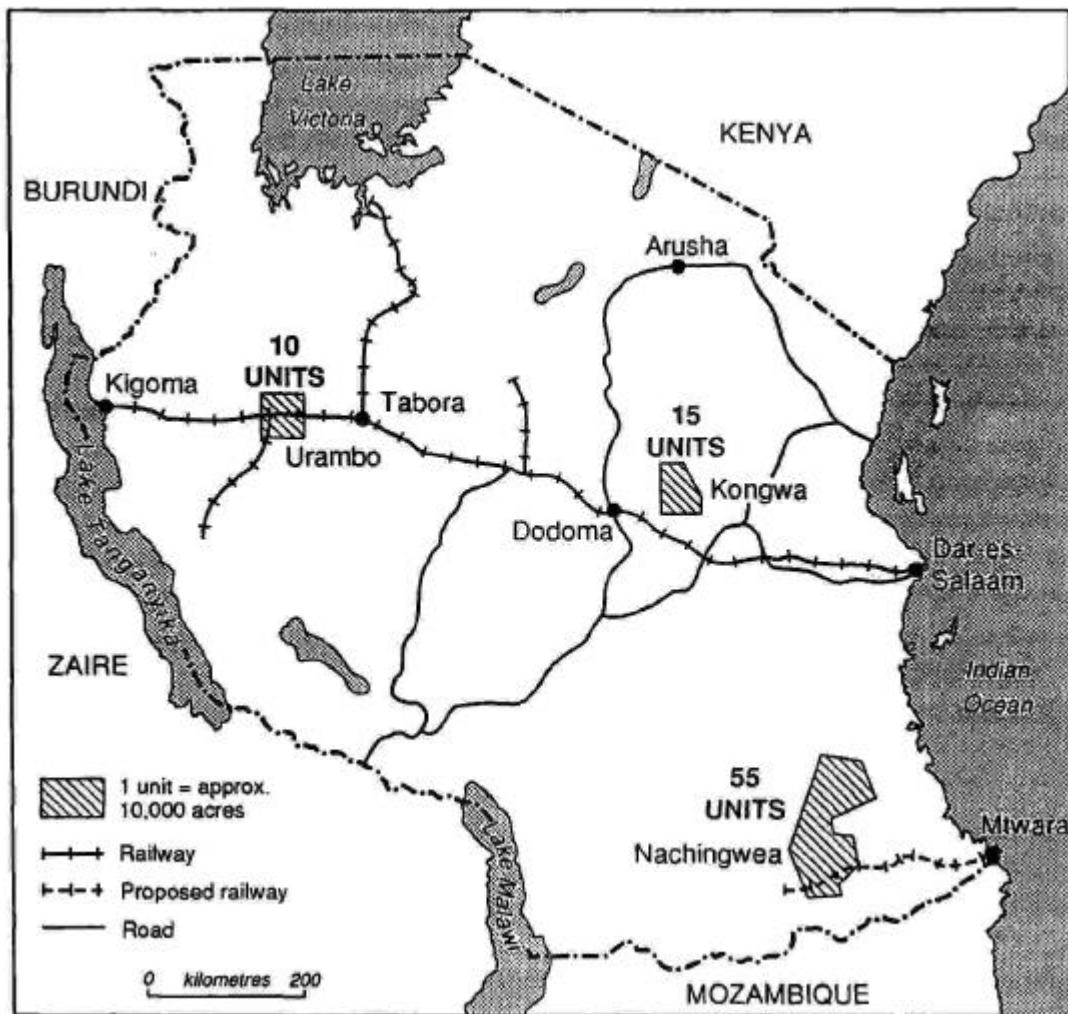
- The new port and railway;
- Development of large areas which would otherwise remain undeveloped for a long time to come;
- Other industries might be established in connection with the Corporation's activities - e.g. timber and fertilizers;
- The creation of a new African agricultural economy on co-operative lines.

Morgan (1980) reports a memorandum on progress to 31 January 1947 by UAC stating: 'the urgent need for progress, dictated by the desire to have a crop in the Spring of 1948, has rendered it impossible to enter the scheme on a fully planned basis'.

Second-hand, heavy bush-clearing machinery was procured, especially bulldozers (modified tanks) from American army surplus in the Philippines, and Canadian tractors. Bush clearing commenced on April 30 1947 following the arrival of the first of the European personnel, but the rate of progress was slow. Up to 75% of the heavy machines broke down. In addition, difficulty was encountered in extracting the very long roots of the vegetation to ready the land for ploughing. The machinery compacted the topsoil, making it unfit for groundnuts, and the disc ploughs were defeated by the abrasive nature of the soil. Also, there were considerable weed problems.

Stamp (1964) pointed out that millions of pounds might have been saved had the implications of the work of Cecil Charter in the Gold Coast (now Ghana) been understood earlier. In 1950, Charter had

Figure 3: Tanganyika Territory. Proposed Areas for Groundnuts Production Scheme



Source: Adapted from map planned by A.E. Kelleway, Historical Section, Cabinet Office, London, in Morgan (1980).

Box 3: Continued

demonstrated the importance of the sharply angular sand grains in ancient African soils which packed under the weight of heavy machines to form a macadam surface and which quickly rasped plough discs. Also, the vagaries of the rainfall were not sufficiently appreciated.

The first crops [at Kongwa] are said to have been less than the seed put in the ground (Stamp 1964). By September 1949, it was acknowledged that the objectives could not be reached and a revised plan for a total of 600 000 acres by 1954 was introduced, concentrating on a rotation of crops rather than groundnuts. Even this plan could not be fulfilled in the time or within the capital provision. The British government was faced with a choice: to abandon the whole scheme or to introduce radical changes. A working party, appointed by OFC in March 1950 to recommend the long-term and short-term agricultural policies at Kongwa, recommended that 24 000 acres should be set aside for four farms to crop groundnuts and sorghum, with the remaining 70 000 acres to be used for grazing store cattle.

In January 1951, the cabinet wrote off a loss of £36 millions, and decided to change the emphasis completely. No further land clearing was to take place at Kongwa or Urambo. The land already cleared was to be used for experimental crop farming: four farms totalling 24 000 acres at Kongwa and 13 farms totalling 60 000 acres at Urambo in 1951. Clearing in the Southern Province was to be restricted to 60 000 acres by 1954. Experience in the Southern Province had demonstrated that the high cost of fully mechanised land clearing could be reduced by substituting hand labour, and suggested that cropping with groundnuts, maize and millet should be combined with cattle ranching. The proposals for Northern Rhodesia and Kenya were abandoned but the port at Mtwara was completed. Thus, the continuing project was rationalised by the government as 'a scheme of large-scale experimental development to establish the economics of clearing and mechanised, or partly mechanised, agriculture under tropical conditions' (Cmd 8125, 1951, quoted in Morgan 1980). OFC found it necessary to economise on general agricultural research expenditure, and soil survey work at Urambo and pedological studies in all regions were transferred to the East African Agricultural and Forestry Research Organisation (EAAFRO). OFC retained responsibility for agronomic studies.

In 1952, further drastic revisions of the plans slowed down further the tempo of operations and introduced the idea of using some areas for European and African tenant farming. As a salvage operation, the Tanganyika Agricultural Corporation (TAC) was established in 1954 by the Government of Tanganyika and the scheme assets transferred from the OFC to TAC in 1955. Activities at Kongwa were concentrated on cattle and pasture improvement with one arable farm to continue the experiment of mechanised agriculture under dry farming conditions.

By 1957, large scale arable production at Kongwa had been discontinued. With the exception of an African Tenant scheme and an experimental station engaged in research in pasture improvement, the whole of the cleared land was used for ranching. The Urambo area became a tenant farming and settlement scheme, depending largely on the production of flue-cured tobacco, with some maize and cattle. The farms at Nachingwea in Southern Province remained production farms based on large-scale mechanised farming of soya beans, groundnuts, maize, and some cashew. At Independence in 1961, the TAC became responsible for agricultural development projects for the government as its managing agents. It was merged with the Tanzania Development Corporation to form the National Development Corporation in 1964.

By 1992, the Nachingwea arable scheme was completely abandoned. Most of the land was left unutilised, with a small area being used for subsistence farming. In Kongwa, most of the area is still a cattle ranch managed by the National Ranching Company with a small area managed by the Ministry of Agriculture, Livestock and Cooperatives as the Kongwa Pasture Research Station. At Urambo, the land has been taken by villagers for subsistence farming.

Sources: Stamp (1964), Morgan (1980), Kauzeni *et al.* (1993)

'In the first place, the bush rotation can no longer be preserved and land which ought to be lying fallow to regain fertility has to be allocated to someone to use. The yield naturally falls. As the pressure gets more extreme there can be no fallow. The land is then under continuous cultivation which, in sloping country, presents a great erosion hazard. The animals have no bush to graze in and climb the hills, destroying the tree and grass cover and increasing the erosion. In the next stage not only are the yields low but the family holding itself begins to be fragmented, so that after a while a typical holding is no longer in one place but a series of small patches scattered over quite a distance. It ceases to be a manageable farm at all. Finally some families have no land at all in a continent where land is the only security against starvation. It may well be imagined that before this stage is reached every individual will be desperate to hold on to his bit of land and may well lose it by litigation.

'Something of a similar deteriorating nature has also been happening in the great pastoral areas of Africa since the advent of colonialism. Under the colonial shield and with improved veterinary control, herds have increased and the pressure of humans and animals has begun to have the same devastating effect on land as in the cultivation areas. Indeed in many parts of Africa the destructive effect of excess herds in the drier pastoral country has been more dangerous, for the disappearance of grass and tree cover has changed perennial streams to intermittent torrents and turned many a pastoral landscape to desiccation.'

The colonial administrations realised the seriousness of the situation and took steps to combat the problem including land use planning. A good example in the British sphere was the Swynnerton Plan, in Kenya, which still provides many useful lessons. Its aim was to change a deteriorating region (that of the Kikuyu tribe) into individual, consolidated holdings with legal titles. On these, stock, subsistence and cashcrops were to be integrated to enhance family income. The crops might be tree crops like coffee and tea; or field crops like pyrethrum and pineapples; or livestock, dairy products, grain or vegetables; or combinations of these according to location. The essential points were registration of title, a sound rotational unit, insistence on high cultural standards through a quadrupled extension service and farm institutes, credit loans, and marketing organizations. The scheme acquired a momentum and was extended to other parts of Kenya. A similar scheme was introduced by the Belgians in the overcrowded territory of Ruanda-Urundi both in cultivated and pastoral areas. The *native land units* established in Southern Rhodesia and the *paysannet* initiated in French colonial countries were comparable attempts at new land use systems.

The Gezira irrigation scheme in the Sudan, with its standard unit holdings, planned rotation, and packaged services to farmers, became a model for large irrigated development.

3.3 Independence Imperatives

As colonies became independent, their first drive was to establish industry but they maintained much of the colonial infrastructure and services, including those dealing with resource surveys and land use planning. Many colonial civil servants continued to serve the independent governments. The needs for resource information remained essentially similar to those in the late colonial period, with a continuing emphasis on agricultural development and settlement schemes. As a consequence, the methods of resource assessment and planning remained largely unaltered.

The failure of the East African Groundnut Scheme in Tanganyika brought recognition that soil and other natural resource surveys should precede land development. In the words of C.F. Charter (1957):

'by far the most important function of soil surveying is to recognise, describe and map the soils occurring in any territory so that their capabilities for enduring land use can be properly assessed.'

Notable contributions to soil survey in Africa during the late colonial and independence period were

made by Charter (1949, 1957, 1958) working in Ghana and Tanganyika; Brammer (1962) in Ghana; Maignen (1959, 1961, 1966) in French African territories; Sys (1960, 1961, 1967) in the Belgian Congo; Vine (1941, 1954) in Nigeria; and Young and Brown (1962, 1965) in Malawi.

Gradually, the experienced staff retired or departed and were replaced by relatively inexperienced nationals. Gleave (1987) has observed bluntly that many of the latter were members of local elites who were no better informed than their colonial predecessors about indigenous rural resources systems and their potential for future development. The new bureaucrats in the independent countries were well educated in western ways but appeared to have little concern for the problems of rural areas and management of natural resources.

Despite disappointing results from large development schemes, independent governments continued to plan and implement them. For example, many large settlement schemes were planned and implemented to exploit supposedly under-utilised resources. As Chambers (1969) has noted, these were sometimes based on different models from those of the colonial period. In western and eastern Nigeria, for example, settlement schemes were modelled on the Israeli *moshav* (Roider 1971), whilst in Tanzania a radical approach of villagisation was instituted with the creation of *Ujamaa* villages (the experiment was finally abandoned in 1990).

Economies increasingly faltered, and survey and planning institutions were run down.

3.4 The International Aid Era

The 1970s saw the expansion of support to developing countries by aid agencies. Some of these emerged from colonial administrative departments: in Britain, the Department of Overseas Survey and the Land Resources Division (LRD) mounted substantial professional teams undertaking aerial photography, topographic and natural resources survey, mainly but not exclusively in Commonwealth countries. Other agencies were newly created (e.g. NORAD, SIDA, DANIDA). Specialist agencies of the United Nations Organisation, (especially FAO) provided natural resources survey support.

Published works include land systems atlases of Lesotho (Bawden and Carrol 1968), Swaziland (Murdoch *et al.* 1971); part of Kenya (Scott *et al.* 1971); Uganda (Ollier *et al.* 1969) by the Military Engineering Experimental Unit; and Indonesia (NRI 1990). Other land resources studies that adopted the land systems approach included Ethiopia (King and Birchall 1975), N.E. Nigeria (Bawden *et al.* 1972), western states of Nigeria (Murdoch *et al.* 1976), central Nigeria (Hill 1978/9), and Zambia (Mansfield *et al.* 1975/76). Land resource inventories by consultant companies funded by multilateral aid include those by Hunting in Sri Lanka (Hunting Survey Corporation 1954) and Sudan (Hunting Technical Services 1974, 1976, 1977).

It has to be recorded that little development seemed to result from these inventories. An exception is the Mahaweli power and irrigation project in Sri Lanka that can be traced back to the surveys carried out by the Hunting surveys (*op.cit.*) under the Colombo Plan. More developments were directly associated with surveys for irrigation which universally adopted a conventional hydrological appraisal, soil survey, and financial appraisal according to the procedure of the United States Bureau of Reclamation (1953).

Assistance was provided in some countries to revamp run-down survey and planning organisations or to establish and develop new institutions (e.g. NORAD support for the Zambia Soil Survey Unit -Box 4 - and Dutch support for the Kenya Soil Survey). The expatriate professionals employed through the aid agencies introduced new methods which included: air photo interpretation, satellite imagery,

Box 4: The Zambia Soil Survey Unit

A national soil survey unit to undertake land evaluation for agricultural development projects was proposed in 1971 by FAO expert Hugh Brammer. At that time, there was one soil surveyor in government service. NORAD agreed to fund expatriate surveyors who began to arrive in 1973. Then, from 1977 to 1982, NORAD supported the development of a Soil Survey Unit within the Land Use Branch of the Department of Agriculture with three objectives:

- Systematic survey for a national soil map;
- *Ad hoc* surveys for agricultural development projects as requested by the government;
- Training of counterpart staff.

Due to the pressure of development projects, *ad hoc* surveys were given priority and hardly any systematic survey was carried out.

A five-year project extension to 1987 gave priority to training and to completing an Exploratory Soil Map of Zambia at a scale of 1:1 million. Specialist staff recruited included a soil correlator, land evaluation specialist, a national mapper, and a training officer. In addition to the HQ near Lusaka, nine provincial soil survey units were set up each with an expatriate soil surveyor, a Zambian counterpart, a technical officer and field staff. Each unit carried out its own field program, agreed annually according to provincial and national priorities, and here the conflict of interest arose again between *ad hoc* surveys for provincial settlement or crop production schemes and the national scientific priority of systematic surveys of selected quarter degree sheets at a scale of 1:100 000, later revised to become district surveys at 1:250 000.

It was never clear who requested the systematic survey for a national soil map, or who would use it. It was a requirement of the Zambia-NORAD agreement and satisfied the scientific interests of the professional staff. The location and methods adopted for systematic survey work were determined largely by the professional staff themselves. A Steering Committee - on which the government and NORAD were represented - was intended to guide the development of the project. In practice, it was ineffectual and internally divided in setting priorities. Also, there were few people in the Department of Agriculture who understood the nature of the work. As a consequence, the Steering Committee acted mainly as a rubber stamp for proposals tabled by the Soil Survey Unit itself.

During the NORAD years, the Soil Survey Unit became one of the most active survey organisations in Africa. Adequate financial support in foreign exchange enabled it to import a fleet of four-wheel drive vehicles, establish a good laboratory, send counterparts for overseas training, attend international meetings and undertake an extensive field program. Several Zambian counterparts were sent abroad for training at BSc or MSc level and, on returning, assumed senior posts. During a final extension of NORAD funding, 1987-1992, all expatriate posts were phased out.

No attempt was made to assess national, regional or district requirements in relation to the national mapping program, nor to determine the nature of the soil survey products that were needed, nor to identify those which could be used effectively in planning and decision-making. As a consequence, much of the output of the Unit was highly technical reports and incomprehensible soil maps classified in terms of Soil Taxonomy or the FAO-Unesco Legend. Several hundred survey reports and numerous special subject bulletins and technical guides were published. A Land Evaluation System was developed on the principles of the FAO Framework for Land Evaluation (1974). However, the land use planning officers considered it to be too cumbersome and continued to use the older Land Capability system (Woode 1981).

Box 4: Continued

Project agreements specified a Zambian contribution to funding, gradually increasing throughout the life of the project, but the Government of Zambia never met its funding commitments to the unit and, when NORAD funding finally ceased at the end of 1991, the Soil Survey Unit suffered a dramatic fall in income. The only survey work now undertaken is commissioned on a commercial basis; staff trained overseas are unable to practise their skills and have become demoralised; some have left the unit, others have not returned after training.

The SSU never promoted its findings. Few planning decisions were based on the data supplied by the Soil Survey Unit. Costly printed maps lay in the SSU offices unused although one SSU office messenger used them to cover the wall of his hut to keep the breeze out!¹

The parallel with the Dutch-supported Kenya Soil Survey is almost exact, except that the Dutch did manage to complete the Exploratory Soil Map of Kenya at 1:1 million (Sombroek *et al.* 1982) and their support for the organization continues.

Sources: Dalal Clayton 1984, P.Commissaris (pers.comm.)

1. George Murdoch (pers.comm.) cites an identical use of large colour-printed land suitability maps in Swaziland.

statistical methods, international soil classification systems such as the Soil Taxonomy and the FAO-Unesco Soil Legend, the application of FAO techniques of land evaluation and, most recently, computerised databases and geographic information systems. In addition, counterpart staff were sent to Europe and North America to be inducted in those new approaches and technologies which they applied on their return if the required facilities were available.

Apart from the regular programs and activities of survey and planning organisations in developing countries, there was an almost exponential growth in rural development projects funded by aid agencies. Donors required that many of these projects be preceded by resource assessments as a basis for planning and implementation. These surveys have been mostly undertaken by consultancy companies or external organisations under commission to the aid agencies. The survey methods used and the reporting procedures have usually been prescribed by the aid agency or, sometimes, the methods have been those recommended by the consultancy companies concerned. As far as soil surveys are concerned, they have been based on established international systems of classification and land evaluation put forward by the same small group of professionals. There is little evidence of much consultation with the developing country governments concerned about the methods and products (some observers would argue that such consultation would not have helped much!), or prior consultation with in-country potential users of the information generated and, as far as planning aspects are concerned, almost no indication of involvement of project beneficiaries.

Important developments pioneered by the consultancy companies, initially in surveys for irrigation, were evaluations of land by financial and other measures for a specific development; and the involvement of land resources professionals in this evaluation, and in engineering design - at least to the extent of avoiding geotechnically unsuitable areas. Previously, natural resources surveys and institutions responsible for them had typically been free-standing. Interpretation of the data was seen as someone else's job.

Developments since the early 1970s include procedures for interpretation of the basic data beyond the almost mechanical application of land capability classification or the USBR payment capacity criterion. The FAO Framework for Land Evaluation (1974) recognised that land cannot be graded from best to worst regardless of the purpose. Involved procedures were developed for characterisation of land use types and land evaluation for these specified land use types (FAO 1983, 1984, 1985, 1990). The FAO procedure, in turn, has often been applied ritually to survey data with no perceptible increase in the utility of the information to farmers or policy-makers. Two notable innovations from the UK-based Land Resources Development Centre were the presentation of information from the huge land systems survey of central Nigeria (Hill 1979) in terms of crop options and agricultural development possibilities; and the focussing of data from the land resources study of Tabora Region, Tanzania, through algorithms to calculate human- and stock-carrying capacity to identify specific areas which were over-populated or had quantified opportunities for resettlement (Corker 1982).

Hills (1981) drew attention to the weakness of natural resources data that cannot be applied in the economic models that planners and policy-makers use. Since then, quantitative land evaluation and dynamic, quantitative crop modelling have come of age (FAO 1978, Beek *et al.* 1987, Kassam *et al.* 1991, Driessen and Konijn 1992). The data demands of the most recent simulation models can only be satisfied by instrumented benchmark sites, which are rare, and the methods are still the province of a few specialists and their computers. However, the obvious advantage of being able to make quantitative predictions about crop production is that these data can be fed into cost:benefit models, e.g. Querner and Feddes (1989).

3.4.1 Integrated Rural Development Projects

The 1970s also saw moves to provide more focus for rural development efforts through *integrated rural development projects/programs* (IRDPs). The concept of the IRDP was to address rural development priorities and needs through a set of mutually-supportive components, e.g. a combination of agronomic packages with credit, development of infrastructure like roads and water supply, commonly with baseline natural resources survey, sometimes even clarification of land tenure. Many of the ideas now captured within the philosophy of *sustainable development* were embodied within the concept of the IRDP.

Approaches to IRDPs varied as a result of different local conditions and donor philosophies. Many were planned and implemented through an autonomous project body, although initially they may have intended to work with and through local institutions, and many encountered problems of donor dependency.

Without doubt some IRDPs have had some success in building institutional capacity to undertake planning. For example, under the Serenje, Mpika and Chinsali Districts IRDP in Zambia, 'planning, co-ordination and implementation systems were evolved by the district institutions themselves, with the IRDP acting as a catalyst in a flexible *learning-by-doing*, evolutionary approach' which was regarded in the country as 'a model for institutionally sustainable development' (Mellors 1988).

However, most IRDPs have been integrated in name only. Their component elements have often been little more than a shopping list of essentially independent sub-projects, each of which could have been (and usually were) undertaken separately by responsible government agencies, and simply subsidised by the IRDP's external funds. Whilst IRDP staff responsible for each component may have executed their responsibilities professionally and effectively, management of these diverse activities has proved difficult. IRDP staff have rarely functioned as an integrated team, working on each component collectively so as to bring together their combined skills and engage in an interdisciplinary approach to solve problems and achieve objectives.

In several cases known to us, withdrawal of external funding has led to cessation of activity. No perceptible impact remains in terms of land use patterns or practices. The projects have sunk without a ripple leaving a ripple.

3.4.2 Environmental Assessment

During this period, several techniques have been developed for the environmental assessment of projects, programs and policies. They include various procedures such as environmental impact assessment (EIA), risk assessment, social impact assessment, and the routine desk-screening of proposals for development.

Since its introduction in 1969 in the USA under the National Environmental Protection Act, EIA has become widely used for project analysis. Clark (1989) has defined EIA broadly as:

'a procedure for encouraging decision-makers to take account of the possible effects of development investments on environmental quality and natural resources productivity and a tool for collecting and assembling the data planners need to make development projects more sustainable and environmentally sound.'

More and more countries are introducing legislation which requires EIAs for certain categories of development. In line with this trend, donors have introduced procedures, manuals and guidelines for the environmental assessment of projects. EIA has been applied mainly at the project level as a formal process of analysis (Box 5) to predict the environmental consequences of major developments (e.g. power stations, hydroelectric dams, irrigation schemes, ports). EIA predicts the likely environmental impacts, identifies ways to reduce or mitigate unacceptable impacts, and presents these predictions and options to decision-makers. Mostly, EIA has been essentially reactive, often conducted after the design phase of projects and, sometimes even, after implementation (e.g. the Victoria dam in Sri Lanka).

In the main, current EIA practice deals with environmental impacts in biophysical terms. But there is a widening recognition of the need for EIA to foster sustainable development by integrating equally the consideration of social and economic and biophysical aspects, and by introducing participatory approaches (Dala-Clayton 1993). Social Impact Assessment examines family and community processes, employment and work effects, distribution and consumption of goods and services, and psychological factors.

There is increasing recognition of the value for environmental management of introducing environmental considerations at earlier stages of the decision-making process. However, it should be obvious that any approach must be tailored to the institutional context of decision-making in individual countries. EIA has rarely been attempted at policy level. The recent development of Strategic Environmental Assessment and work on the concept of Sustainability Analysis (Dala-Clayton 1993) are attempts to address this issue. The consideration of cumulative impacts, public participation, post-evaluation procedures and the adoption of sustainable environmental planning options are likely to be key issues in applying environmental assessment to policy-making.

Partidário (1992) has suggested a procedure to integrate environmental assessment in land use planning. It uses the basic elements of EIA in an iterative, learning-by-doing approach involving multiple loops (Figure 4).

Box 5: The Main Steps in Environmental Impact Assessment

A full EIA process is not necessary for every kind of development project. For major projects, an EIA may consume considerable resources, expertise and time, so a stepwise approach is usually followed:

- 1 **Screening** to clear types of projects which past experience indicates are unlikely to cause serious environmental problems. It may take several forms: measuring against simple criteria (e.g. size, location); checking against lists of projects which either rarely need an EIA (e.g. schools) or which always do require one (e.g. large dams); estimating general impacts (e.g. increased infrastructure needed) and comparing these against set thresholds.
- 2 **Preliminary assessment** is undertaken when screening fails to clear a project. It seeks to identify key environmental impacts and briefly evaluate their significance for decision-makers. This step can eliminate unsuitable sites and provide early warning of serious environmental problems.
- 3 **Organisation:** If preliminary assessment indicates the need for a full EIA, then organisation can include: commissioning, assembling and briefing an independent co-ordinator and team comprising the necessary disciplinary expertise; identifying key legislation, regulations and decision-makers; determining how the findings and report will be presented, etc.
- 4 **Scoping** aims to ensure that all the important issues are addressed. It involves discussions with the project developers/promoters, decision-makers, regulatory agencies, scientific institutions, NGOs, leaders and other members of local communities - particularly the target group, and others, to identify all possible issues and concerns. Primary concerns and potential impacts are selected for specific attention.
- 5 Detailed assessment (the **full EIA study**) may include the following steps:

Identification: The preceding steps should have indicated the main likely impacts and issues of primary concern to decision-makers. The full EIA first identifies those impacts needing to be assessed in detail. Various approaches can be used, for example: compiling a candidate list of key impacts (e.g. air or water quality changes, increased noise levels, loss of or changes in habitats or species diversity, displacement of communities); using checklists or questionnaires to pinpoint sources of impacts (e.g. smoke emissions, construction, water consumption) and then using surveys and consultation with interested parties to catalogue receptors of impacts (e.g. crops, communities drinking the same water, migrant labourers). One or more of the following techniques may be used to identify the impacts:

Checklists of features which may be affected by a project. There are several formats: *simple lists* of potentially affected factors; *descriptive checklists* which include measurements and indicate predictive techniques for each factor as guidance; *scaling checklists* which incorporate criteria for evaluation, usually in the form of a subjective rating - usually as a worksheet with space to indicate the relative significance of each impact, along with critical values which represent a threshold of concern for each factor; and *multi-attribute utility theory* - an extension of scaling checklists in which a subjective measure of relative merit is derived for each environmental parameter listed. Some of the widely-used checklist variants have been described by Canter (1983) and Hyman and Stiftel (1988).

Box 5: Continued

Matrices with separate sets of factors on the horizontal and vertical axes. Interactions between components are recorded in the cells common to both axes, either using symbols or numerical codes, or using algebraic functions. The best known is that developed by Leopold *et al.* (1971).

Overlays in which transparent sheets summarizing environmental features according to value classes, connoting high (dark shading), medium (light shading) or low (no shading) quality for that particular environmental element, are superimposed on a base map. Impacts are shown through the building up of density of shading. Computer-based geographic information systems have removed some of the technical constraints to overlay mapping and have facilitated the mathematical analysis of data.

Networks - directional diagrams which link secondary and tertiary impacts to primary impacts. They are rarely used because of lack of knowledge.

Simulation models. Where reliable quantitative data are available, an array of mathematical, natural system and economic models may be used.

Prediction: The causes and extent of possible changes, and their consequences for the environment and local communities, are predicted as far as is practicable. This step draws on data and analytical techniques from physical, biological, socio-economic, anthropological and other disciplines. However, few of these procedures are unique to impact assessment. Ortolano (1984) and Westman (1985) have reviewed physical scientific techniques used in EIA, whilst social-science methods have been outlined by Finsterbusch (1983).

Evaluation: To determine whether mitigation is warranted, the significance of predicted adverse impacts can be evaluated by comparison with laws, regulations or accepted standards; consultation with relevant decision-makers; reference to pre-set criteria (e.g. protected sites or species); consistency with government policy objectives; or acceptability to the local community or general public.

Mitigation: Measures are proposed to prevent, reduce, remedy or compensate for significant adverse impacts. These might include: (a) changing project sites, routes, processes, raw materials, operating methods, disposal routes or locations, timing, or engineering designs; (b) introducing pollution controls, waste treatment, phased implementation, landscaping, personnel training, special social services or public education; (c) offering (as compensation) restoration of damaged resources, money to affected persons, concessions on other issues, or off-site programs to enhance some other aspect of the environment or quality of life for the community. Costs of measures are quantified, comparisons made and trade-offs weighed, and one or more *action plans* may be proposed. The implications of adopting different options can be analysed using various techniques including cost-benefit analysis.

6 ***EIA Report:*** To be effective, the report needs to be aimed at identified audience(s) and shaped to meet their specific needs

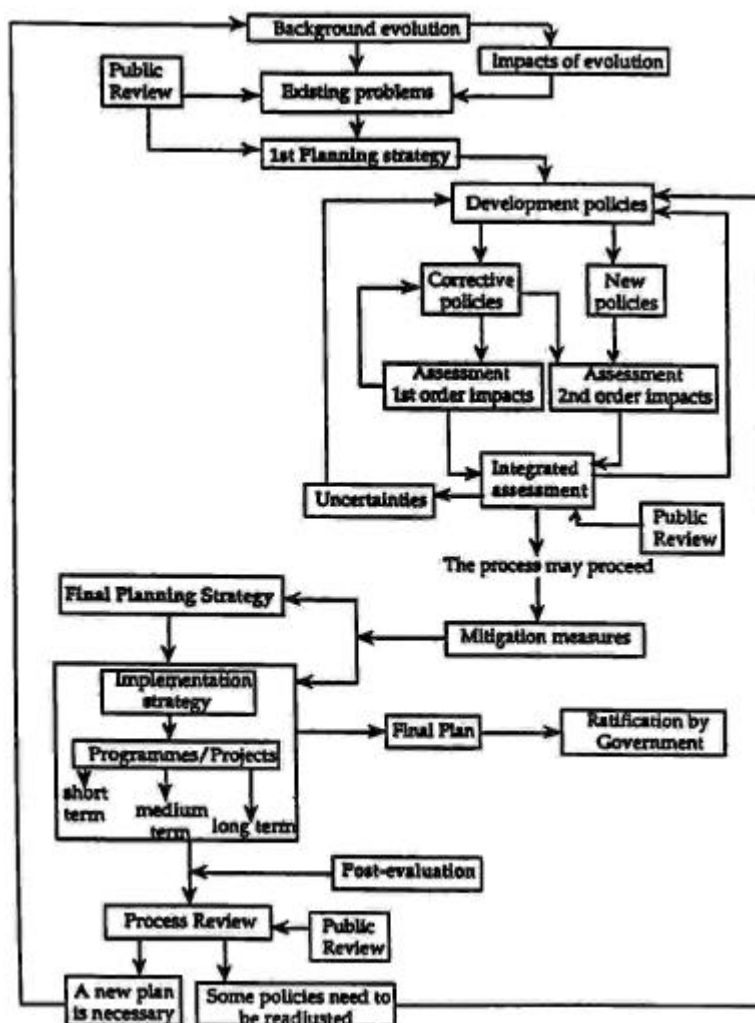
Box 5: Continued

- 7 **Review of EIA Report:** Before the competent authority makes its decision on a project, the report may be assessed independently to determine its adequacy and quality, and to identify further questions and studies needed.
- 8 A program of **monitoring and evaluation** may be recommended by the EIA and/or included in the project to check that mitigation measures are implemented,
9. Sometimes, a post-project **audit** is undertaken to determine how close the predictions made by the EIA were to the real impacts.

Sources: UNEP (1988) and Smith (1993)

Figure 4: Environmental Assessment and Review (EAR) Process

(Source: Partidário 1992)



3.5 The Post-Brundtland Era

Development has turned out to be not so simple as we once thought. Some of the goals of development now seem illusory; the constraints more and more intractable; and the contribution of natural resources information disappointing in the absence of ways and means of using it.

The colonial and central planning strategy of large projects dependent on transfer of technology from the developed world, called the *big push* idea by Gleave (1987), has been re-appraised. There is a move towards a strategy of incremental change based on the adaptation and improvement of indigenous technology, combined with the transfer of *intermediate* technology. But such a change is dependent, *inter alia*, on the capacity of traditional systems to adapt under the pressure of the increasing demands made upon them. In most cases, this capacity is very limited (see Gleave 1987 p5). Subsistence farmers have little real flexibility, and government structures also appear to be inflexible.

The Report of the World Commission on Environment and Development (WCED 1987) - widely known as the Brundtland Commission - gave impetus to the concept of sustainable development and the links between environment and development. It emphasised that sustainable development could not be achieved without the participation of local communities in the development process, including the management of natural resources. This led to a recognition of the need to move away from simple physical planning to integrate social, economic and environmental aspects. It has also highlighted the need for community participation in planning.

The traditional top down, physically-based approaches have been shown to be wanting. More attention is now being given to bottom up approaches and many innovative participatory techniques have been developed drawing on methods first used in social analysis (see Chapter Six and Appendix). Yet the means to link planning at national level and local participation have been slow to develop.

The publication of the World Conservation Strategy (IUCN/WWF/UNEP 1980) stimulated many countries to prepare cross-sectoral National Conservation Strategies (NCSs) in order to integrate environmental concerns into the development process (Box 6). National Environmental Action Plans (NEAPs), initiated by the World Bank in 1987, also involve reviews of the natural resource base and environmental problems (Box 4). Both NCSs and NEAPs have been drawn up on the presumption that governments are dominant throughout the development process.

On a sectoral basis, many countries have prepared National Forestry Action Plans as promoted by the Tropical Forestry Action Programme (TFAP). These plans have also highlighted priority projects for financing. The TFAP process has been the subject of some criticism (see Box 7). Water masterplans have also been developed in many countries, whilst others have initiated action plans concerned with water management. International response to catastrophic flooding in Bangladesh in 1987 and 1988 led to the Bangladesh Flood Action Plan, funded by a wide range of donors and coordinated by the World Bank. It was launched in 1990 as a series of regional and supporting studies aimed at identifying appropriate action. Despite its promotion as a comprehensive exercise, the regional planning studies which are now emerging are focussed mainly on flood control. They have not dealt with inter-regional issues (and vast amounts of water move through Bangladesh !); have not captured the wealth of historical experience in Bangladesh concerning water management; have involved very little effective participation of the people the plan aims to protect; and have suffered from a lack of reliable baseline data (Dala-Clayton 1990, Hughes 1993, Hughes *et al.* 1994).

Box 6: National Conservation Strategies and National Environmental Action Plans

National Conservation Strategies (NCSs) provide broad policy frameworks. They have been prepared, or are in preparation, in over fifty countries, mostly in the tropics although the earliest were in New Zealand and Canada.

Most have involved a consultative process and the preparation of national natural resource reviews, usually on a low budget (approximately \$100 000 to \$300 000), over periods from seven months to seven years. Partly because most were country-driven and with no deadline or other obligation to meet, many have stalled - not being backed up with adequate resources and consolidation of effort. Those that have been completed have succeeded in bringing indigenous capacities to bear on sustainable development issues, and many important policy changes have been made through them.

The formulation of NCSs has generally been overseen by a high-level policy steering committee, one or more technical groups, and a secretariat which also coordinated the public participation process. The organisational structures have usually stayed on to monitor implementation. Alternatively, new coordinating organisations have been put in place by the NCS. Where outsiders have been employed, these have tended to be long-term consultants for process design and management, plus for some skills which were not locally available e.g. environmental economics.

Early examples, e.g. Zambia and Nepal, have been criticised for focusing too much on ecological issues and for being weak on social and economic considerations. More recent NCSs, e.g. Botswana and Pakistan, were much better in this regard.

National Environmental Action Plans (NEAPs), are nowadays associated with a World Bank initiative, begun in 1987. Whilst also involving reviews of the natural resource base and environmental problems, most NEAPs have been designed to generate a suite of *environmental* projects for funding. The early NEAPs, notably Lesotho and Mauritius, have been criticised for being driven too much by World Bank influences and by the imperative to deliver a basket of bankable projects for presentation at donor conferences. However, NEAPs have addressed the vital need for major environmentally-related investment. More recent NEAPs, notably Seychelles and Ghana, have been much improved, being largely country-driven and focusing not solely on end-product projects for financing but, also, on defining issues and needs, consulting widely with government and society, and on trying to reach consensus.

The World Bank Operational Directive 4.02 of 1992 stated that NEAPs should be completed or well advanced by June 1993 for all countries seeking to borrow from the International Development Agency and be initiated in all countries receiving support from the International Bank for Reconstruction and Development. This tight deadline has caused problems and there has been confusion in many countries with existing NCSs and similar plans that might be said to meet NEAP criteria.

The government of the borrowing country is responsible for preparing the NEAP. Usually, this has been done by a three-tier structure similar to that used by many NCSs: a policy-level steering committee, a secretariat, and task forces for selected environmental issues. Limited public participation has been incorporated in some. However, far more outside consultants have been associated with this structure than with NCSs. There has often been significant technical and/or financial assistance from the World Bank, various international organisations, NGOs and other donors. The World Bank's Multi-Donor Secretariat handles many of the international coordination concerns.

Box 7: National Forestry Action Plans

These have been coordinated by FAO since 1986 and promoted under the Tropical Forestry Action Program (TFAP) developed by FAO, UNDP, the World Bank and the World Resources Institute. The TFAP evolved to address the causes of deforestation at political, macro-economic and local levels. It defined five areas of activity: the relationship between forestry and other demands on the land; the appropriate management of forests for economic purposes; energy and fuelwood needs; conservation; and institutional strengthening.

National TFAP exercises are undertaken by the country concerned, starting with a multisectoral review of forest-related issues, and leading to policy and strategy plans. They are followed by an implementation phase for policy measures, programs and projects. The plan seeks to produce informed decisions and action with explicit national targets on policies and practices, afforestation and forest management, forest conservation and restoration, and integration with other sectors. Round table discussions involving government bodies, NGOs, donor agencies, and international organisations are held during planning and implementation.

The TFAP process has been criticised for not dealing adequately with the socio-economic activities leading towards deforestation, and for not involving sufficiently those whose livelihoods and culture are at stake. Since 1990, the TFAP has been under review. There have been calls to strengthen cross-sectoral government and non-government capacities, and to change the focus of TFAP so that it is a planning and implementing process; not simply an opportunity for the flow of project funds between donor and acceptor (Sargent 1990/1).

Many of these national and sectoral plans overlap in subject and geographical scope, and some have been duplicated in the same country. An analysis of the documents from any one country which has undertaken more than one of the different processes reveals that they have all used essentially the same data. Old, inaccurate or suspect information has often been recycled without validation or updating. The fact is that gathering new data requires time (particularly when long-term trends are involved) and is costly. Rarely has sufficient time been allowed or funding made available to support such work.

Public consultation, rather than participation, has been a feature of the development of most NCSs and NEAPs and of some sectoral plans and strategies, but rarely have the results of such consultations been included in a clear or obvious way in the final documents. The preparation of national surveys, plans or strategies has frequently involved (foreign) consultants talking to the same people in the governments who, in turn, have had to meet conflicting demands. A notable advance is the current work on a National Forestry and Conservation Action Plan (NFCAP) in Papua New Guinea. The extensive consultation of all types of NGOs in this TFAP process has resulted in an equal sharing of responsibilities for NFCAP planning and implementation between NGOs and government. It has also stimulated NGOs to form a coordinating organization.

On occasion, an element of 'green conditionality' has been involved, as the preparation of a plan or a strategy document has been linked to the release of aid funds. Agenda 21, one of the main accords agreed at the 1992 UN Conference on Environment and Development urges all nations to develop a National Sustainable Development Strategy (NSDS) to implement, at the national level, its priorities and recommendations. There is little doubt that those countries with a completed NSDS will stand at a comparative advantage in terms of securing investment and aid. Such plans are likely to become a major focus of aid agency attention as they move away from funding piecemeal projects and demand that development projects fit into national frameworks for sustainable development.

A handbook on preparing and implementing National Sustainable Development Strategies (IIED/IUCN 1994) defines an NSDS as a participatory and cyclical process of planning and action to achieve economic, ecological and social objectives in a balanced and integrated manner. The handbook epitomises the participatory approach to planning that has emerged in the 1990s. It is not prescriptive. Rather, it presents flexible options. The handbook also discusses the need to develop a 'tool kit' of methods and techniques that can be applied during the NSDS process. These tools would include:

- Participatory methodologies
- Environmental economics
- Sustainable development indicators
- Natural resources surveys
- Environmental assessment
- Expert identification and registration
- Policy and institutional analysis

There are many dilemmas in the NSDS approach (Dala-Clayton 1993):

- How to ensure that it is not just another document that is not read, not used and not acted upon. To put it bluntly, how to ensure that it is not just another fashionable and easy way to spin money ?
- How to ensure that it is about capacity-building and behavioural change, and not just about planning ?
- How and by whom should the strategy be prepared ? What is its relationship to the democratic process - should it bypass, accelerate or supplement it ? Just how much participation is feasible in a country's particular circumstances ?
- What is the key objective ? Is the NSDS a process, plan or report, and is the process open or closed, forward- or backward-looking ?
- How to ensure that economic imperatives are central to the process - otherwise it becomes irrelevant to government ?
- To what extent can or should an NSDS process be concerned only with national or sovereign issues ? Should it also take account of dependency on and impact of external resources or the nation's overall impact on the global environment ?
- How to counter the tendency for plans and strategies to centralise and become top-heavy and top-down ?

The dilemmas are common to land use planning in its widest sense and every country will need to address the issues in its own way and to suit its own circumstances. Every NSDS (and every land use plan) is something of an experiment. The problems and dilemmas need to be addressed frankly to avoid setting expectations which are too high.

The NSDS process will require both modifications to existing techniques of natural resources survey and land use planning and the development of new approaches. This will require training, e.g. in the use of FAO Guidelines for Land Use Planning, as opposed to routine application of standard methods of resource survey and interpretation. The concept of the multi-disciplinary team of specialist engineers, economists, and natural resources and social scientists, is also being reassessed in the light of the difficulties of management and interpretation of their outputs.

CHAPTER FOUR

METHODS OF RESOURCE ASSESSMENT

4.1 Introduction

Few systems of resource survey and interpretation have matured to win widespread acceptance. A similar pattern of methodological development can be seen in various parts of the world and most institutions in developing countries have adopted standard methods that originated in quite different physical and social circumstances.

Early surveys were casual, though often perceptive, descriptions by amateurs. For example, Packer's charts of East Kent, published in 1743 at a scale of 1:42 240 and prepared over nine years from accurate field observations, delineated landforms and distinguished coastal sands, stony land and woods.

When a clearly-defined need for information arose, funds were made available by business interests or the responsible public authority, and appropriately-qualified professionals were engaged to carry out the survey. At this stage, there were no standard methods. The surveyors applied their professional skills and common sense way to the task and presented their information in a way judged to be acceptable. Once methods have become standard, however, they acquire momentum of their own. In the public sector, methods become not only standardised but institutionalised and their evolution is cramped.

There are many cases of inappropriate methods borrowed from elsewhere being applied without modification. This situation may be seen in topographic survey, geological survey, the collection and analysis of hydrological data and, especially, in soil survey, land evaluation and environmental impact assessment.

4.2 Soil Survey

Soil survey poses peculiar difficulties: there are many soil attributes that determine the performance of the land; these vary spatially and with depth at different scales, often in complex patterns; they are largely hidden below the land surface, so we have to dig for data; and some critical characteristics can be profoundly changed by management. Before the general availability of powerful computers, the data had to be depicted and stored mainly as two-dimensional mapping units on a topographic base map. Manual retrieval and interpretation demanded complex, hierarchical classifications. Most soil information is still in this form.

Two of the earliest surviving soil maps are Young's maps of Suffolk (1797) and Norfolk (1804). Young was Secretary to the Board of Agriculture at a time of huge investment in agricultural improvement in England which promoted keen interest by both landowners and the government of the day. On the basis of a systematic reconnaissance, Young distinguished mapping units according to soil texture, drainage and workability or responsiveness to the best farming practices of the time. His reports fleshed out details of variations within the mapping units, parish by parish. There is a remarkable correspondence between his map of Norfolk (Figure 5) and the map of soil landscapes at a similar level of generalization based on detailed modern soil survey (Figure 6). The pragmatic

Figure 5: Arthur Young's Soil Map of Norfolk, 1804

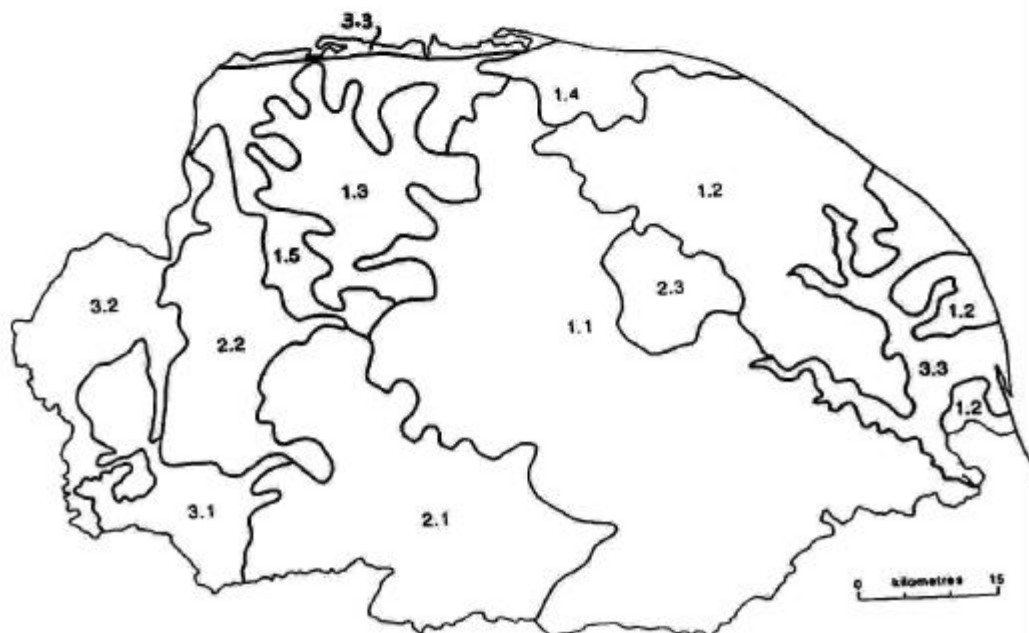


Figure 6: Soil Landscape of Norfolk
(Corbet and Dent 1993)
(See Box 8 for legend)

Box 8: Legend to Figure 6

1 High Norfolk

1.1 Boulderclay plateau Gently undulating upland of stiff clayey till with chalk stones, overlain by windblown sand. Sandy loam to sandy clay loam topsoils on chalky clay subsoil with a perched watertable.

1.2 Rich loams Undulating upland mantled in loamy loess on till or glacial outwash. Well drained, almost stoneless loam, about 0.5 m thick on interfluves and 1 m or more thick downslope.

1.3 Good sands Rolling upland mantled in coversand on red, strongly-weathered subsoil, on chalky till. Well drained sandy loam on clay loam.

1.4 Cromer ridge High ground falling steeply to the north but gently to the south. Podzols on cobbly gravels on the ridge crest, well-drained brown sands on spurs.

1.5 Chalk scarp Rendzinas with dark brown, sandy loam, plough layer directly on chalk rubble. Deep topsoil on gentler slopes.

2 Low Norfolk

2.1 Breckland Low chalk plateau covered by windblown sand. Sand about 1 m thick on plateau top but striped pattern of chalky drift and sand on slopes. Podzols in deep, sandy colluvium in bottomlands.

2.2 West Norfolk Very mixed landscape with well-drained swells and wet hollows including sandy glacial outwash, sands on Carstone and clayey soils on till.

2.3 Wensum Sands Glacial outwash forming rolling land with well-drained soils, or subdued relief with a high watertable giving gleys and gley podzols.

3 Fens and Marshes

3.1 Black Fens Peat, now wasted to below sea level giving complex patterns of residual peat in hollows between exhumed sandy, clayey and marly substrata.

3.2 Marshland Calcareous alluvium reclaimed by embankment and drainage. Deep, stoneless, coarse silty to clayey.

3.3 Broadland and North Coast Floodplains with silty to clayey marine alluvium in their lower reaches and peat inland. Coastal saltings, dunes and shingle bars.

classification of land according to soil texture and drainage class, which are closely related to workability, is still the farmers' classification and was used by most practical soil surveys until the 1930s.

Two schools of survey now dominate the scene although they are by no means mutually exclusive. Conventional soil surveys build up a picture of the soil pattern from systematic field observations of soil profiles. This is arduous and, therefore, costly. By contrast, land systems surveys (see Section 4.3) proceed by analysis of the landscape on air photos or satellite imagery, followed by characterisation of the land mapping units by field observations, still relying heavily on relationships between the unseen soils and visible landforms and vegetation. Land systems survey is much faster than conventional soil survey and more cost-effective for work at small scales over large areas (Beckett 1971).

4.2.1 Survey Scales

There is no universal system of nomenclature for natural resources surveys according to scale or intensity. Most survey organisations have their own definitions but practically all use the same terms. For instance, the US Bureau of Reclamation uses *semi-detailed* for surveys at a scale of 1:12 000 (USBR 1953) while the UK Land Resources Development Centre applied the same term to surveys at scales from 1:50 000 to 1:100 000 (Murdoch 1972). Table 1 summarises the scales of soil survey, their different applications and approximate rates of progress, but it should be noted that there is a considerable overlap in scales and purposes. It is more useful to consider the intensity of inspection sites on which the mapping units are based, rather than the scale of the map on which they happen to be plotted.

4.2.2 Mapping Units

Hall and Russell (1911) in their survey of the soils and agriculture of Kent, Surrey and Sussex, distinguished Chalk Soils, Wealden Soils, Gault Soils and so on, picking out the local relationships between soil parent material and many other soil attributes. They extended their point observations of soil profiles by using existing geological maps but appreciated that their system could not be extended universally.

The mapping unit that combines soil parent material and soil profile morphology ultimately emerged from mapping by the United States Soil Conservation Service as the *soil series*. This is defined as a group of soils showing the same succession of horizons in the profile and developed from similar parent materials, and is named after the place where it is first established, e.g. Miami Series. Variations in the texture of the topsoil that are of importance to management are recognised within the series as *soil types*, e.g. Miami silt loam. Other land characteristics important for management may be mapped as *soil phases*, outside the soil classification, e.g. Miami silt loam, gently rolling phase.

Conventional soil survey is based on field observations of soil profiles, sampled either on a systematic grid or by *free survey* in which the surveyor uses knowledge of the field relationships between soil profiles and landforms, vegetation or land use, and air photo interpretation to locate each observation site where it will yield the most useful information. Mapping units are delineated in the field (Dent and Young 1981).

Table 1: Scales and Time Requirements of Soil Survey

						TIME NEEDED FOR DIFFERENT ACTIVITIES (days per 22-day month)					RATE OF MAPPING PER MONTH
EXAMPLES OF PURPOSES	TYPE OF SURVEY	SMALLEST MAP SCALE	OBSERVATION INTENSITY (at 1 per cm ² map)	MAPPING UNITS	METHOD OF SURVEY	IMAGE INTERPRETATION	FIELD MAPPING	PROFILE DESCRIPTION	FIELD AND LAB. TESTS	DATA MANAGEMENT, OFFICE	
Resource inventory, Pre-feasibility, Project location	Reconnaissance	1:250 000	1 per 13.5 km ²	Physiographic soil associations, Soil landscapes	Image interpretation with free survey by sample traverses	8	8	3	-	3	150-500 km ²
Project feasibility	Semi-detailed	1:50 000	1 per 50 ha	Soil series with some associations and complexes, Soil landscapes	Free survey with air photo interpretation in the field	4	12	3	-	3	30-100 km ²
Project planning, Irrigation, Management support, Urban fringe planning	Detailed	1:25 000	1 per 12.5 ha	Soil series, Phases of series	Statistically stratified or grid survey	3	9	2	5	3	1000-1500 ha
		1:10 000	1 per 2 ha	Individual parameters		0	8	2	8	4	450-800 ha

Source: Dent & Young (1981)

The amount of data gathered at each observation site varies greatly between different organisations. Most soil survey organisations have their own field handbooks detailing the observations to be made and defining the terms to be used. These show a clear family relationship with the USDA Soil Survey Manual (Kellogg 1937, Soil Survey Staff 1951). In the field, these procedures are applied with varying degrees of rigour.

At the lowest level of detail, the site may simply be allocated to a category of a pre-determined classification, whether a soil series or some soil genetic group. At the next level of detail, the minimum data recorded for each horizon to a depth of about 1 m, include its colour, texture and stoniness and, for the profile as a whole, the parent material and drainage class. At representative sites, the soil series is further characterised by additional field tests, soil profile pits are dug and described in more detail and samples collected for laboratory analysis.

Table 2 summarises the levels of information gathered, the time needed and the kinds of interpretations that may, subsequently, be made of the data. Most surveys have collected large amounts of level A and level B data, most of which are subsumed in the mapping units and not recoverable as point data. Rarely has the range of quantitative data been extended by quick field and field laboratory tests, as suggested under Extended Level B in Table 2. Few organisations have devoted significant resources to collection of detailed (level C) data. Level D data are rare, anywhere in the world, although they are necessary to run simulation models. Realistic representations of soil and land processes can be achieved with level C and extended level B data, but little effort has gone into developing such models or into developing more efficient procedures for gathering these data.

The soil series has stood the test of time as a carrier of practical information but is costly to map. At scales smaller than 1:25 000 to 1:63 360 (one inch to one mile), it is difficult to separate individual series, so compound units of two or more series have to be used (associations or complexes). This can lead to a serious loss of information where the scale of publication is much smaller than the scale of field survey. This loss of information can be avoided by mapping *soil landscapes* that specify the field relationships between soil profiles and landforms. Northcote (1984) gives the example of a dune landscape which, on examination, shows soil profiles are brownish sands. The soil landscape *dunes of brownish sands* may be mapped individually at a scale of 1:10 000. At smaller scales, more complex soil landscapes have to be mapped so that, at 1:25 000 to 1:50 000, a landscape may be described as *dunes and swales - dunes of brownish sands with intervening swales of highly calcareous earths*; and so on to the more complex soil landscapes depicted in the 1:2 million scale Atlas of Australia Soils (Northcote 1960). By this means, the map user can identify the individual components of a landscape in the field, appreciate their inter-relationships and easily make a soil map or interpretation at a larger scale if this is needed.

Since the pioneering work of Milne (1935, 1935/6) in East Africa, many survey reports have used topographic cross-sections with brief soil descriptions to depict the main soils in each component of the landscape. Soil landscapes are the basis of the legend to the national 1:200 000 soil map of The Netherlands (Stiboka 1961, de Bakker 1979) although the mapping units are associations of, mainly, soil textural groups. The soil associations used by the Soil Survey of England and Wales (1983) for the 1:250 000 national map are, essentially, soil landscapes (Figure 7). All soil mapping units are built up from field observations of soil profiles. Members of compound mapping units are individually defined and their relationships can be shown, e.g. by a block diagram, and a key to soil units provided, so that map users can make their own more detailed soil map on air photos or large-scale plans.

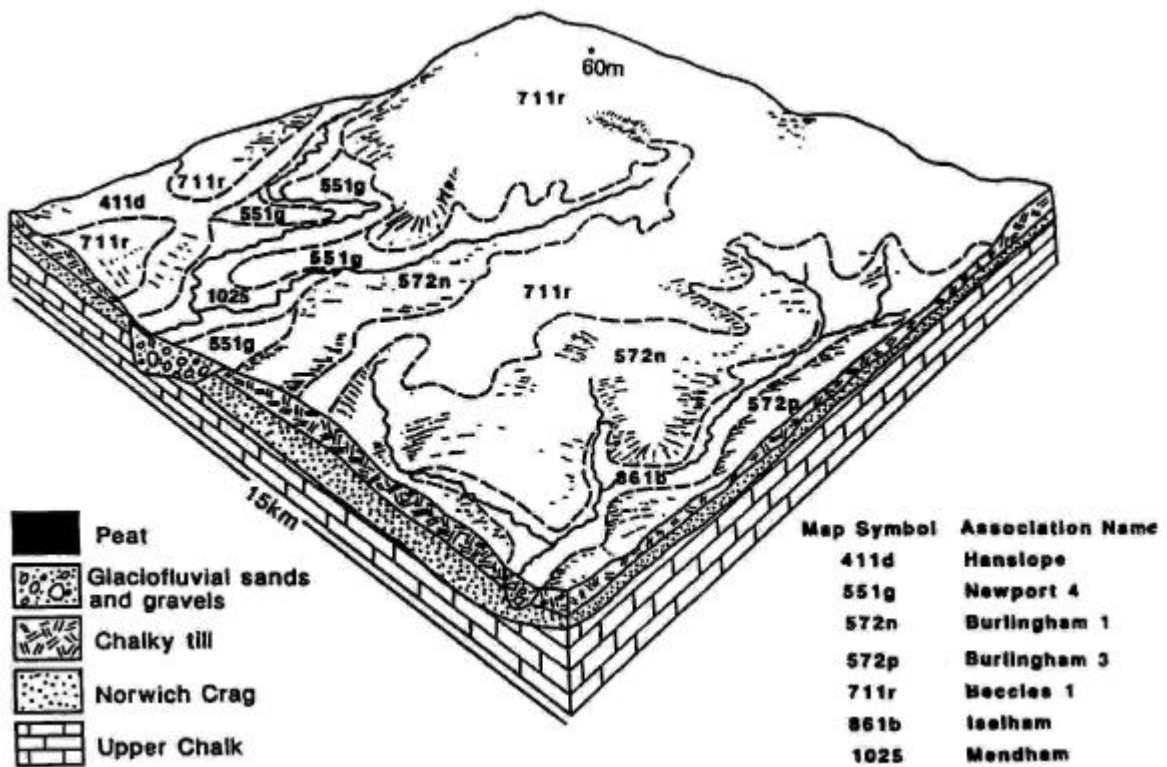
Table 2: Levels of Detail in Soil Observations and Interpretations

(Adapted from McKenzie 1991, after Hackett 1988)

LEVEL	NUMBER OF CHARACTERISTICS	TIME NEEDED	TYPES OF DATA	EXAMPLES	INTERPRETATIONS
A	1	1 - 30 mins	Soil name	Reddish brown earth	General statement of suitability for major types of land use
B	15-30	15 - 60 mins	Profile description. Can be detailed but qualitative; includes texture, structure, stoniness, layersimpeding roots and drainage.	Hardsetting loamy topsoil, strong textural contrast over heavy clay. Well drained. Kimbo Series	Specific statements on some capabilities and limitations. Empirical water balance relationships. Value greatly increased by level C characterisation of the Soil Series at representative sites
Extended B	50-200	30 mins - 2 hrs	Profile description augmented by quick quantitative field and field lab. tests	As B with additional standard data: pH, lime requirement, shear strength, bulk density, depth to watertable, salinity, slope angle	As B, plus simple water balance models. Hand calculations
C	80-400	2 - 20 days	Profile description plus rigorous field and lab. characterisation. Detailed, quantitative but static	As B with wide range of standard data, eg, infiltration rate, particle size, clay minerals, cation exchange characteristics	Specific statements on most capabilities and limitations. Simple models of water, nutrient and geotechnical behaviour. Value greatly increased by statistically valid sampling and good field mapping
D	100-500	10 - 30 days	Direct measurement of parameters controlling soil processes, including those external to the soil profile	As C with data on fluxes of nutrients, solutes, hydraulic conductivity, probability values of rainfall and evaporation	Dynamic, probabalistic predictions of processes. Input for computer models

Figure 7: An Example of a Soil Landscapes in Eastern England

(Extract from Soil Survey of England and Wales, Bull. 13. Soils and their Use in Eastern England (Hodge *et al.* 1984)



Key to component soil series, Beccles 1 Association

Soils prominently mottled or greyish above 40 cm 1
 Subsoils faintly mottled above 60 cm or distinctly mottled between 40 and 80 cm²

- | | |
|--|----------|
| 1 Fine loamy over clayey | Beccles |
| Coarse loamy over clayey | Aldeby |
| Clayey | Ragdale |
| 2 Fine loamy over clayey | Ashley |
| Clayey, subsoil calcareous above 40 cm | Hanslope |

In the memoir, description of series is morphological with standard laboratory data for mean particle size, organic matter, pH, bulk density and available water capacity. This is backed up by a computer database holding fuller physical and chemical characteristics of each soil series, often for 30 or more sample sites.

4.2.3 Soil Map Legends

Most of the information about the mapping units is presented in accompanying memoirs, but these are scarcely used by agronomists, planners and other professionals who seek a quick insight into the soil pattern and a short description of features that can be recognised in the field. Therefore, map users turn immediately to the map legend, which they usually find to be uninformative or unintelligible. This is partly because of the complex nature of the mapping units which cannot be illustrated in a few words but needs cross-sections or block diagrams; and partly because of the complex, technical soil classifications that have been used. Many map legends now include some less technical descriptions as well as the technical classification, e.g. Table 3.

Table 3: Extract from Legend to Soil Map of Rajkot Area, Gujarat

(Source: 1:250 000 national map of India, NBSS and LUP 1992)

MAP UNIT	DESCRIPTION	SOIL TAXONOMY
1	Moderately shallow to shallow, moderately well drained clayey soils, slightly eroded	Vertic Ustochrept Lithic Ustochrept
2	Shallow, well drained clayey soils, severely eroded	Lithic Ustochrept Lithic Ustorthent
3	Very shallow, well drained clayey soils, severely eroded	Typic Chromustert Vertic Ustochrept
4	Moderately deep, well drained clayey soils, slightly eroded	Typic Chromustert Vertic Ustochrept
7	Deep, poorly drained clayey soils, very severe salinity	Typic Halaquept

Sombroek and van de Weg (1983) argue that the needs of non-specialist map users are best served by legends that show the relationships of soils with other landscape features and soil parent materials and that, also, include short, non-technical descriptions of the soil. See, for example, Table 4.

It is surprising that the Extended Soil Legend developed by the FAO soil survey project in Pakistan (e.g. Ali *et al.* 1968) and the New Zealand Soil Bureau, which includes all this and, also, a range of interpretations for practical use (e.g. in booklet form, Campbell (1978); and as a wall chart, Vucitich *et al.* (1978)), has not been adopted elsewhere.

Table 4: Example of Legend Construction (map scale 1:100 000)

U	UPLANDS (major rivers deeply incised, slopes 2-16 %)
UF	Soils developed on gneisses rich in ferromagnesian minerals
UFr	Well drained, deep, dark reddish brown, friable sandy clay (Rhodic Ferralsol)
UT	Soils developed on shales
UTbP	Imperfectly drained, moderately deep, dark brown, firm to very firm clay, in places saline (Eutric Cambisols)

4.2.4 Coverage

A lot of work goes into a detailed or semi-detailed soil map. Time and cost have restricted the area covered at soil series level and few countries have achieved substantial coverage. The USA has almost completed its county sheets at 1:20 000. Belgium and The Netherlands also have complete semi-detailed coverage. In England and Wales, national coverage at 1:250 000 was achieved by a five-year program of systematic extrapolation from representative 1:25 000 sheets, after 50 years of survey had covered just 10 percent of the country at six inches to the mile. Scotland, which also had a strong soil survey tradition, had achieved coverage of one-third of the country at 2½ inches to the mile between 1947 and 1978, but abandoned the soil series to complete national mapping at 1:250 000 using landscape units defined by landforms, lithological soil associations and genetic soil group (Soil Survey of Scotland 1984).

Systematic soil survey programs in developing countries have concentrated on reconnaissance surveys. For example, Zambia began systematic soil surveys of the country in 1982, at first based on quarter degree sheets at 1:100 000 scale and then by district at 1:250 000 scale, but only limited coverage was achieved and the program effectively ceased in 1991 with the withdrawal of Norwegian support to the Zambia Soil Survey Unit (see Box 4).

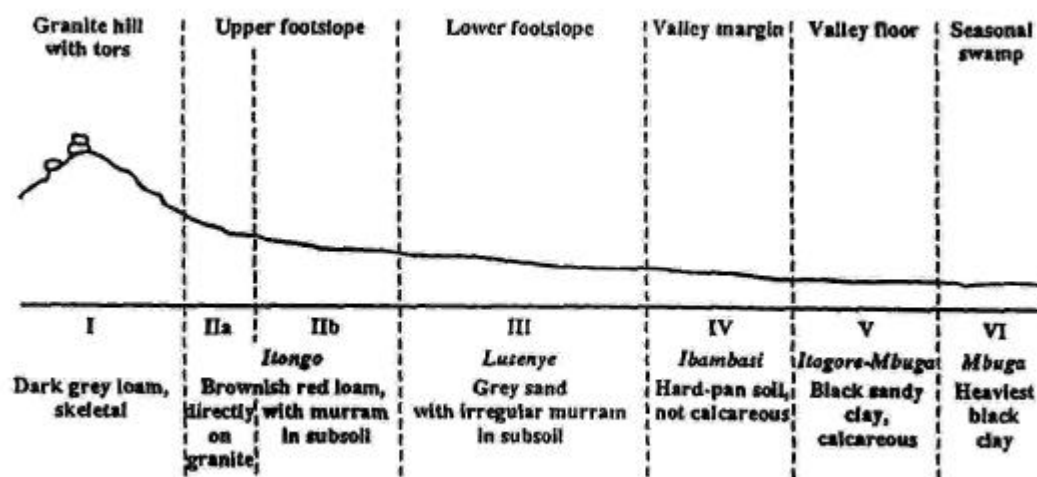
Many attempts at systematic mapping of soil series have become bogged down without achieving significant coverage, without maintaining essential correlation or useful characterisation of mapping units, and without maintaining the data base (see Chapter Five). Continuity of effort, very highly-skilled and motivated professional staff, and institutional stability are prerequisites of a successful soil survey - one that completes the job and continues to service and update its product. The prerequisites cannot be provided by short-term expatriate input and this has limited the usefulness of one-off soil surveys by visiting teams.

4.3 Land Systems Survey

A quite different school of survey arose from the demand for rapid overviews of the land resources of large areas, chiefly in the tropics and sub-tropics, for which little formal information was available. In his Provisional Soil Map of East Africa, Milne (1935/36) recognised that particular landforms were

associated with particular sequences of soils which were related to their situation along the slope (Figure 8). He defined the *catena* as a regular repetition of a certain sequence of soil profiles in association with a certain topography. Continuity of slope from the crest to the foot of the catena allows water and soil material to move laterally downslope so processes occurring in particular parts of the landscape may be predicted (e.g. Dalrymple *et al.* 1968, Conacher and Dalrymple 1977, Hugett 1975, 1976) and so can the soils.

Figure 8: Soils of an East African Catena (After Milne 1935/6)



Explanation of Symbols (after Gerrard 1992)

'A shallow dark grey loam (I) formed by weathering of the granite surfaces has worked downhill by creep and slow erosion to act, on the footslope, as the parent material on which a deeper soil (IIa) of the red earth group has developed. At the base of the red earth profile, where a temporary accumulation of seepage occurs in the wet season, a horizon of coarse granitic grit (IIb) in a black rusty ferruginous cement has formed. Occasional storm water running over the surface has gradually pared off the topsoil and the material has travelled differentially according to particle size, so that by a cumulative effect a zone of washed sand (III) has covered the footslope, with silty or clayey sand (IV, V) beyond it, and clay has accumulated on the level bottomlands (VI). At all stages the erosion has been slow and non-catastrophic and the soils have borne their appropriate vegetation and been developing towards maturity'.

As a mapping unit in small scale surveys, the catena has been used in two ways: either the map shows the most extensive component of the catena, usually a well-drained upper member; or the catena as a whole is the mapping unit with its components and their extent indicated in the legend and accompanying memoir. Some workers have restricted the term to soil sequences on a single parent material (e.g. Watson 1965), many others have used it for any topographic sequence (mixed catena).

The value of the catena concept is that it facilitates prediction of soil distribution based on position in the landscape. This is of particular value in reconnaissance surveys where extrapolation of a few observations over large areas is required. Perhaps because Milne's original work in East Africa was based on transects across the grain of the country, the catena seems to have remained a linear concept.

Some surveys failed to produce soil maps, even though the catenas were described in some detail (e.g. Hunting Survey Corp. 1962). Stereographic interpretation of air photos was the key technique enabling the analysis of landscapes in three dimensions and the development of the land systems approach as a mature system of survey. It was initially applied: (i) to the reconnaissance of largely empty areas of Australia by CSIRO Division of Land Use Research (Christian and Stewart 1952, 1968, Christian 1983); (ii) by the National Institute of Road Research, South Africa, concerned with engineering properties for the design of road systems (Brink and Williams 1964); and (iii) by the Military Engineering Experimental Establishment of the British Army who wanted to know whether their tanks would sink into the mud and other military questions (Beckett and Webster 1962, Webster and Beckett 1970).

Christian and Stewart (1952) defined a **land system** as an *area, or groups of areas, throughout which there is a recurring pattern of topography, soils and vegetation* and it is identified by this pattern on air photos or satellite imagery. Each land system is unique and is identified by a code number or local name. Within a land system, smaller areas, known as **land facets** or **land units**, are distinguished, as the smallest area that can be recognized and delineated on the air photo and within which environmental conditions that are uniform for most practical purposes. The land facets within a land system are genetically linked by geomorphological origin or groundwater flow (i.e. they are members of a catena) rather than merely being contiguous areas. The overall approach of land systems mapping was systematised and nomenclature established by Brink *et al.* (1966). Accounts of the technique are given in Mitchell (1973), and Dent and Young (1981), amongst others.

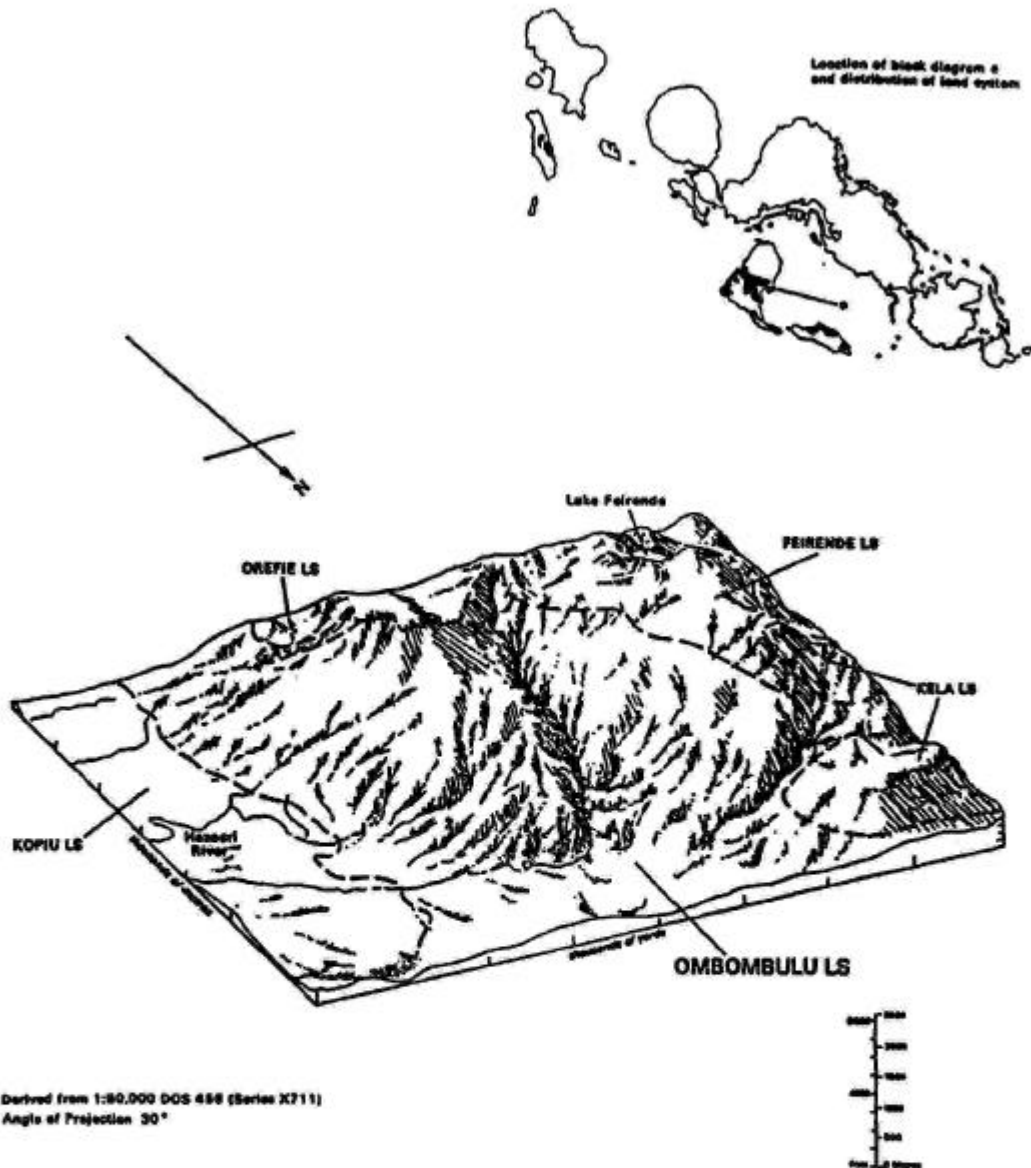
Land systems survey differs from soil survey in that mapping units are identified and defined in terms of landforms and (sometimes) vegetation by remote sensing - usually in qualitative terms, e.g. moderately sloping with closely-spaced, narrow valley floors. Fieldwork differs substantially from soil survey. It is carried out by vehicle traverses, planned to visit all or most of the provisional mapping units identified by remote sensing. A convoy of landrovers sets off carrying, besides tents and supplies, a team of one or more geomorphologists, soil surveyors, ecologists and, possibly, hydrologists and land use/farm systems experts. At each stop, survey is based on catenary traverses by which facets are described in terms of landform, geology, hydrology, soil, vegetation and land use.

Map scales between 1:1 million and 1:100 000 have been most widely used. Usually, only land systems have been mapped, the relationships of facets being shown by catenary transects, block diagrams (Figure 9), or annotated photographs of the landscape (e.g. Scott *et al.* 1985). However, Murdoch *et al.* (1976) mapped facets directly at 1:125 000 in Western State, Nigeria; Galloway *et al.* (1974) mapped comparable *landunits* in Queensland, Australia; and work in virgin rainforest in Guyana (Hawkes and Wall 1992) and has demonstrated the practicability of detailed land systems mapping.

Land systems survey was born of the need for speed and, also, integration of a variety of natural resources information. Both depend on the relationships between landforms, which are visible on imagery and on the ground, and other features of interest, some of which are not so easily determined. The method relies on personal judgement in recognising patterns, and in progressive, hierarchical subdivision of the landscape. This is, at the same time, the weakness of the method: there is no consistent basis for identification of mapping units (land systems range in size from 10 km² to 1 000 km²) while the scope and detail of information provided varies according to the scale of operation, the team composition and the house style of the organisation concerned - apart from the

Figure 9: An Example of a Land System from the Solomon Islands

(Source: Wall & Hansell 1975)



Land Unit	Area (km ² -%)	Landform	Soil	Vegetation and land use
1	58 48%	Ridges: broad to very broad, even profile, moderate to moderately steep crestal slopes	Deep to moderately deep, brown, dark brown or dark yellowish brown clay with weathered rock fragments (Humitropepts)	Lowland Forest with <i>Pometia pinnata</i> as the most common large tree. Other large trees include <i>Ficus benjamina</i> , <i>Celtis latifolia</i> , <i>Vitex cofasus</i> and <i>Alseodaphnophyllum</i> . Other common small trees include <i>Marsfieldia irya</i> and <i>Neoscorechinia forbesii</i>
2	42 32%	Ridges: very narrow to narrow, even to uneven profile, moderately steep to steep crestal slopes	Yellowish red to red clay in places with weathered rock fragments (Haploorthox)	
3	27 21%	Gorges: narrow, slopes very short to medium, steep to precipitous, straight to irregular	Shallow to moderately deep, dark brown or dark yellowish brown clay over limestone (Troporthents)	
4	3 2%	Valley bottoms: incised stream bed, narrow channel with many large transported boulders	Rock outcrops and large displaced boulders common. Small areas of stony siltation	

inherent complexity of the landscape. For the 1:250 000 scale mapping of land systems of Indonesia for transmigration planning (Land Resources Dept./Bina Program 1980), land systems were delineated on small-scale air photos on the basis of landforms and existing geological maps, then characterised in terms of physical properties using the best available secondary information. Because of the limited time and budget, no systematic field surveys were undertaken but, for each mapping unit, an assessment was made of the reliability of the data used. Subsequent rapid field testing of the land systems by Brinn (1993) showed that, of the four systems tested, three did not conform even to the defining characteristics of landform, rock type or altitude. Discrepancies arose from inaccurate original geological data; inaccurate identification of landforms on air photos where the land surface was concealed by vegetation of uneven height and age or where the pattern of landforms was too intricate to map at 1:250 000; and from the difficulty of assessing the depth of peat from air photos, especially in areas of sporadic cultivation. In the case of assessments of land suitability made for the land systems, none of the original predictions was confirmed. As Brinn points out, the test involved a very small sample and the land system mapping was quite effective in identifying areas with severe constraints like steepland, swamps and flood plains. Arguably, this was the most useful outcome of the program.

The hazards of the procedure are clear enough, especially the use of unverified secondary data, not only in characterising the mapping units but in defining them and assessing their land suitability. A better but more costly procedure is to define mapping units only in terms of data that are mapped directly and, for land evaluation, first establish the critical land qualities and then map these, or acceptable surrogates, by field survey.

Several studies have demonstrated correlation between measured, individual parameters and land systems or facets (Ollier 1969, King 1975, Gardiner 1976, Gerrard 1992); but it can be argued, as Northcote (1984) and Beckett and Bie (1978) do, that *the same effort could have produced better soils and vegetation maps separately*. Inasmuch as mapping units are delineated as patterns on remotely-sensed imagery, it is difficult to provide precise information on land suitability for specific places or for specific land use options. Land systems surveys have rarely provided much interpretative information applicable to land use planning or management, but this criticism can be levelled at any general purpose natural resources survey. Obviously unsuitable areas can be eliminated quickly and attention concentrated on more promising areas, and this should justify the very modest outlay of a land systems survey.

Moss (1968, 1969) has argued that land systems emphasise static relationships within landscapes rather than the dynamic ones between soils, climate and vegetation. He advocated an *ecological* approach in which agriculture is viewed as part of the biological system on which it takes place. While his ideas were demonstrated in a research area in south-western Nigeria, his approach has not been widely adopted because its translation into practical survey procedures and relatively unknown areas has not been well defined (Dent and Young 1981). This last point is significant. The methods of survey that have been adopted widely are not necessarily those best suited to provide the information needed, but are those that have been applicable without much further investment in research and development. Only those methods backed-up by national and international institutions have evolved into mature systems.

4.4 Geomorphological Survey

While land systems survey adopts a reductionist approach, some geomorphologists have argued for the opposite approach of building up mapping units - either by combination of single parameter maps (Speight 1976, 1977) or by combination of geomorphologically related sites into larger groupings (Wright 1972, 1979, Viktorov 1973).

The systematic approach summarised by Wright (1993) involves preliminary air photo interpretation to identify a network of sample traverses representative of different terrain types identified by their air photo pattern, as in land systems survey. Then, by field measurement, the slope profiles of individual slope elements (*sites*) are recognised by their internal uniformity, not by abrupt breaks in slope because delimiting discontinuities may be very slight. The positions of the identified sites in relation to local elements on the air photographs are marked in the field and the sites characterised by slope orientation, surface materials and soil profile observations. Similar sites in various localities are grouped into *site types*, and areas dominated by one, or two or more closely interspersed site types are delimited in the field on air photos as *site assemblages*. Plotting can then be extended quickly along the field traverses outwards from the sample areas.

Mapping units built up in this way are consistent in their degree of internal variability. Site assemblages have an internal unity of ground climate, hydrology, soil characteristics and plant habitats - greater than mapping units produced by subdivision. The painstaking initial work of slope measurement is comparable to the research phase of soil survey (Dent and Young 1981) in which the surveyor must build and test his models of field relationships before extending these to the mapping phase.

Diverse techniques are available for mapping and spatial analysis in geomorphology (Savigear 1965, Goudie 1990, Cooke and Doornkamp 1990) but geomorphological maps in their own right have found only limited applications in land use planning (Tricart 1966, Shroder 1976, Demek 1972, Breyer 1982). In the absence of soil maps, pre-feasibility studies for the Maheweli irrigation development in Sri Lanka (FAO 1965) relied on topographic maps and landform analysis (Hunting Survey Corporation 1962). In the early 1970s, IRAT (Institut de Recherches Agronomiques Tropicales et des Cultures Vivieres) France, introduced Cartes Morpho-Pédologiques in some African countries. These maps combine geomorphological and soil information, separating units on the basis of lithology, landform, soil genesis and classification (Tricart 1978) but, for a non-specialist, the maps are very difficult to read.

The value of geomorphological interpretation of a landscape for soil mapping is, however, well proven. In Zambia, a national geomorphic legend was developed for soil survey purposes (Dala-Clayton *et al.* 1985, Dala-Clayton 1988). It provided a classification of geomorphic units grouped within geomorphic orders at specified scales (1:5 million; 1:2.5 million; 1:1 million; 1:100 000 and 1:50 000). The scheme was tested in a pilot reconnaissance survey (scale 1:100 000) in Eastern Zambia. Third order geomorphic units (1:100 000 scale) were initially delineated (eg, gently undulating plateau, dissected plateau) and soils subsequently mapped within these. The map combined both geomorphic unit and soil class boundaries (Dala-Clayton 1987).

4.5 Parametric Mapping and Interpolation Techniques

Soil survey and land systems survey first identify discrete, individual mapping units. These individuals are delineated by boundaries drawn where several land characteristics change more or less simultaneously over a relatively short distance - usually at breaks in slope or changes in drainage and vegetation. These individuals are then characterised by a wide range of measurements at representative points. The mean values of these data are assumed to apply equally to the whole mapping unit, the variation within the mapping unit is assumed to be random and normally distributed about the mean. This is an effective way of extending point data from few sites over a relatively large area.

However, the use of complex mapping units for storage, organisation and retrieval of data requires complex, hierarchical systems of classification, and data are inevitably lost at each stage of generalisation - from site observations to the individual delineation in the field, from delineation to mapping unit, and so on at each higher level of classification. By the time a genetic soil group like *reddish brown earths* is arrived at, there is little precise information left. The attempt to maintain some

continuity of quantitative information through several levels of classification reached its zenith in the Soil Taxonomy (Soil Survey Staff 1975) - the soil classification system developed in the USA. The system is explained in a large memoir which weighs 2.2 kg, is supplemented by regularly revised keys (Soil Survey Staff 1990), and is accessible only to specialists.

Where compound mapping units containing more than one taxonomic unit are mapped, prediction of soil characteristics for any point within the compound unit becomes even more problematic.

These constraints have been removed by the advent of powerful, cheap electronic computers and data base management systems that can store and retrieve an infinite amount of point data in a disaggregated way. The still more recent development of *geographic information systems* enables these data to be displayed instantly in a variety of ways, as single parameter maps or in any desired combination. The profound implications of these developments for natural resources surveys and their applications have yet to be realised. Lack of imagination on behalf of both practitioners and customers has channeled most research into using computers to do what can already be done manually at a fraction of the cost, and the skills needed to operate these computer systems remain very scarce and expensive.

Two developments of importance in land use planning are knowledge-based systems to support decision-making (e.g. Dent 1993, Bouma *et al.* 1993 in press) which do not have to be computer-based (e.g. Dent and Murtland 1990), and dynamic simulation modelling of land processes and performance (e.g. van Keulen and Wolf 1986, Rapoldt 1986, Jones 1990). To a greater or lesser extent, these require quantitative data for individual parameters like solar radiation, temperature, crop water demand, water supply and nutrient supply. These topics are discussed at more length in Chapter Five (Section 5.3).

Spatial interpolation techniques are needed to predict the values of parameters of interest for any place from measured values at sample points. For the relatively simple case of climatic variables, common techniques include Thiessen polygons and the use of regression equations to establish relationships between the variables of interest and mapped features, e.g. between rainfall and elevation (see Box 13).

For parameters that do not change regularly or which do not have obvious relationships with surface features, geostatistics (originally developed to estimate gold content in South African goldfields) have recently been applied to other natural resources surveys. Methods are reviewed by Trangmer *et al.* (1985) and Webster and Oliver (1990). Their principle is that the value of a variable at any point can be predicted from the value at the nearest sample point and the distance from that point. The weighting given to the distance is calculated by comparing values of pairs of points according to their distance apart plotted on a semi-variogram. In the simple example shown in Figure 10, the *nugget variance* is the amount of variation at distances smaller than the smallest sample interval and cannot be predicted. The *structural variance* in the variance related to distance between points, which commonly levels off at a *sill value*. A suitable mathematical function has to be fitted to the structural variance and a distance-dependent weighting calculated by which values at unknown points can be predicted from the scatter of sample points by a technique known as *kriging*. An increasing range of computer software is available to perform these operations.

Figure 10: Semi-Variogram of Depth to Sulphidic Material, Conoco, Kalimantan

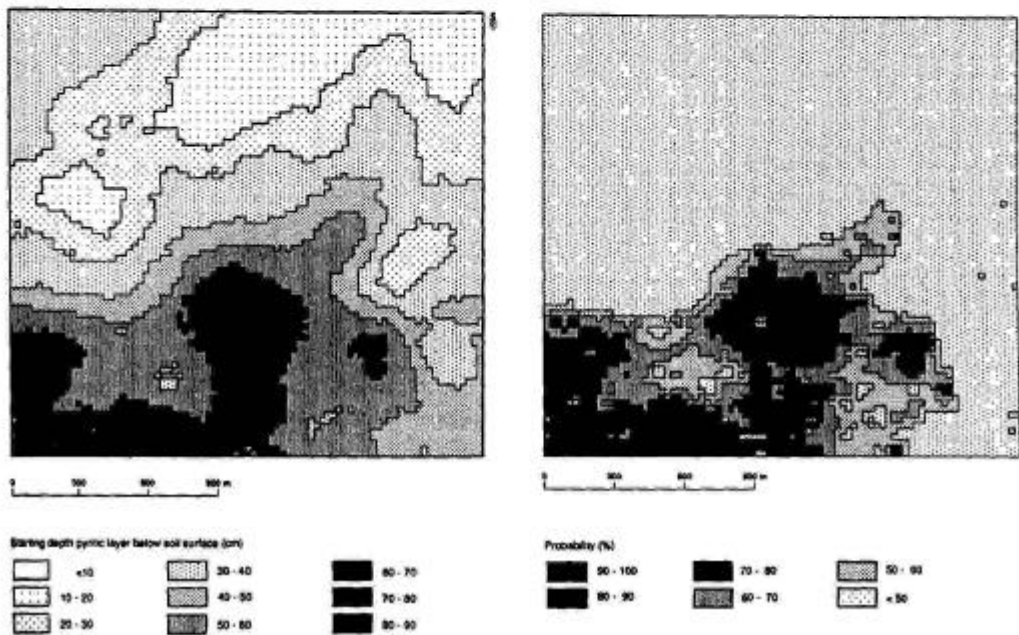
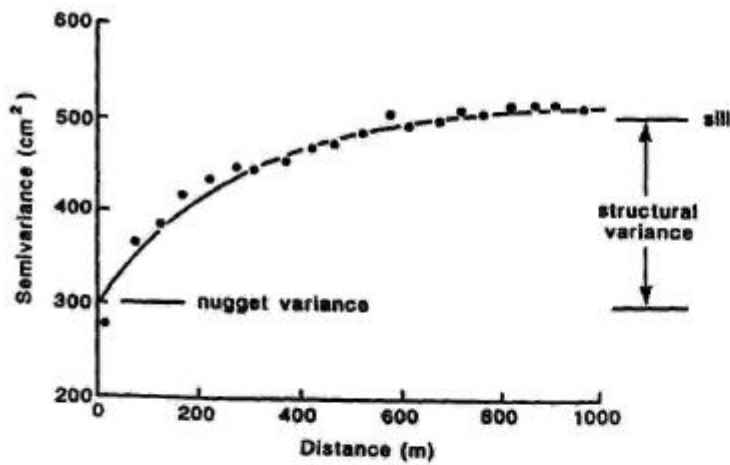


Figure 11: Geostatistical Mapping, Pulau Petak, Kalimantan

Notes

a) depth to potential acid sulphate soil, cm based on kriging; b) probability of depth > 50 cm based on predictions by the inverse distance method and the standard deviation of the prediction errors.

Calculations involved data from 790 auger borings and chemical tests for potential acidity at six depths for each (193 samples per km² x 6 tests)! No studies using commercially practicable sampling intensities have been reported.

Source: Bregt *et al.* 1992.

Immediate applications to natural resources survey include the use of semi-variograms to judge the sampling intensity needed to determine the distribution of any property of interest, and the direct use of interpolation techniques to produce single parameter maps with associated confidence limits (Figure 11). Sampling to build the semi-variogram is, however, a major exercise in its own right and properly belongs to the research phase of a soil survey.

Geostatistical maps appear to offer no advantage over conventional soil survey at scales smaller than 1:5 000 where the properties of interest have some direct relationship to the landscape (Kuilenburg *et al.* 1962, Bregt *et al.* 1987) but geostatistical techniques applied within individual map units do provide good information that is not obtainable by means other than digging for it.

4.6 Forest Inventory

Quantified forest inventories date from the 19th century and, in developing countries, were mainly to determine how much marketable timber there would be when forests were cleared for agriculture or plantations.

Resources (time, manpower, transport) commonly dictate the procedures that are feasible. Experienced inventory staff may make reasonable subjective estimates of standing timber volume and productivity from the ground or the air but objective sampling is, obviously, essential if bias is to be avoided. **Systematic sampling** of plots on a regular grid is particularly good for detection (e.g. stratifying into forest types) but less appropriate for quantifying the resource. **Stratified random sampling** first uses air photo interpretation, satellite image interpretation, or data from earlier surveys to partition the forest into a number of strata within which sampling plots may be randomly located, e.g. Johnson (1978), working in the Gambia, divided the mangrove forests into height classes and species by measurement on 1:20 000 air photos prior to sampling within each class. Unrestricted random sampling is rarely used except for small forests.

Commonly, the statistical limitations of an option are outweighed by practical matters such as time, cost, and user confidence. The main points are that the data are reliable and that the inventory is completed. More mistakes have been made when staff have found the procedure confusing (Box 9).

Forest management and planning require information on stocking levels, basal area, log lengths and/or volume:

- by tree species, size (diameter or length) and/or commercial characteristics;
- by individual inventory plots, user-selected strata, and/or regional averages.

There is also a need for forecasts for management and planning of timber production. As Vanclay (1990b) points out, managers and planners may need to know:

- What is the maximum sustainable harvest ?
- If the present harvest exceeds this, for how long can it be continued without permanent detriment to the forest ?
- What is the nature of future harvests (average stem size, species composition, yield per hectare) ?

These are minimum information requirements. Analogous information for non-timber products may also be required. The information can be compiled from three sources:

Box 9: Systematic Forest Inventory in Myanmar

Myanmar (Burma) has been undertaking a national forest inventory by systematic sampling, using a three kilometre grid over all national forest land. Every fourth plot was to be a remeasured permanent plot to provide data for growth and yield estimation. While the scheme looked good on paper, there have been many difficulties in implementation.

Myanmar has a lot of forest and few roads (or other infrastructure). Consequently, access to many of the plot locations was difficult and time consuming. Military and insurgent activity meant that many areas could not be inventoried. The few existing maps dated from before the war and were of doubtful accuracy. Thus, inventory crews could never be sure that plot locations were correct, and often had difficulty in relocating the permanent plots for remeasuring.

Ambitious plans for completing the inventory required many inventory teams, some of which had little training or experience. Low wages made it difficult to recruit good field staff. The inventory has taken longer, cost more and delivered less than was envisaged. It is still not complete after ten years, and many of the data are of doubtful accuracy. Some forest areas are under considerable human pressure and much of the information will be outdated before the inventory is completed.

A simple and more efficient inventory would have satisfied the objectives and could have provided a timely result.

Source: J.Vanclay, personal communication

- Area data indicating the extent and kind of the existing forest;
- Stand-level inventory, indicating the characteristics of the present forest;
- Growth models enabling forecasts of the future forest to be prepared.

Area data are usually obtained by analysis of air photos or satellite imagery from the visible and near-infra-red spectrum. This is not possible in areas with persistent cloud cover or dust haze. The potential of radar imagery for all-weather, cloud-penetrating survey is obvious and extensive use was made of Sideways Looking Airborne Radar (SLAR) during the 1970s, notably in the RADAM project over the Brazilian Amazon and for national land use mapping in Nigeria, both at 1:250 000 scale (Parry and Trevett 1979, Trevett 1986). There was little repeat business because of the cost of mounting airborne surveys and processing the data. Geometric rectification is difficult and ground control always difficult to achieve in inaccessible areas.

Synthetic Aperture Radar (SAR) has successfully been used in numerous forest surveys, notably in Indonesia and Costa Rica. Developments of SAR with increased definition and low energy requirements are well-suited to satellite-mounted sensors. The European Radar Satellite ERS-1, launched in 1991, is now sending a stream of data of special interest to foresters and other natural resources specialists.

During 1992, the European Space Agency (ESA), arranged a radar campaign to test the latest Canadian Technology over sites in South America. This project (SAREX-92) served as a prelude to the land resource information which is now available from the European Radar Satellite (ERS-1) launched in 1991. This satellite is now providing a stream of radar imagery which will be of special interest to foresters and land resource scientists in tropical regions. An ERS-2 satellite is planned for 1994 to ensure continuity of data and Canada will also launch a radar satellite in 1994. At present, satellite-mounted radar is in the research phase. Limitations to its use in developing countries in the near future are the cost and high level of technology needed to process the data; and the common feature of all

systems of remote sensing - the need for skilled interpretation based on extensive fieldwork. Few resource interpreters are familiar with radar imagery or radar sensing systems.

Characteristics of the present forest can be gauged from stand-level inventory, with enumeration and measurement of trees on temporary plots. If the area of the plot is known (or the angle gauge used for point samples), tree diameters are measured and the species and merchantability of each tree on the plot are recorded, this will provide many of the data needed.

The presence and abundance of other plants on the plot may be required to satisfy non-timber information needs, and may be useful in gauging site productivity. Such additional data can usually be gathered from inventory plots without difficulty and without much additional cost.

Growth models, coupled with area and inventory data, provide the best way to estimate sustainable harvests and to investigate the impacts of alternative harvesting strategies (Vanclay and Preston 1989). However, such models demand several years of data on permanent plots, the placement and management of which require careful thought (Vanclay 1991a, Beetsen *et al.* 1992).

Without a growth model, a more or less subjective estimate of the sustainable harvest can still be made. One way is to estimate the volume production (per unit area) and multiply by the net area, but there is a tendency to overestimate. A more intuitive method is to quantify the potential harvest from some typical forest areas and to estimate the time before a second harvest would be viable, both silviculturally and economically. Dividing the potential harvest by the time to the next harvest gives $\text{m}^3/\text{ha}/\text{yr}$. This figure, multiplied by the net productive area, gives an indication of a reasonable allowable cut. An estimate prepared in this way more clearly indicates how it has been derived and may, therefore, give more confidence.

Stands for which the potential yields are estimated should be carefully selected, preferably objectively (e.g. stratified random sampling). The volume realized in harvesting depends on the nature of the initial stand, the size and number of trees removed, the skills of the individuals involved, and the damage to harvested stems in felling and handling. These may be estimated subjectively or determined through logging studies. The time until the next viable harvest depends on the nature of residual stand (influenced by the initial stand, removals and damage), its growth rate, and on damage and other losses during the intervening years. Growth data (and ring counts where applicable) may give an indication, but only growth modelling can avoid a subjective estimate.

Inventory techniques have evolved to accommodate changes in technology and skills, as illustrated by some examples from the Queensland Forest Service (Box 10). In some cases, forest inventory is undertaken as an independent exercise whilst in others it may be part of a broader land use planning exercise (see Box 11). When the design of an inventory does not suit local capabilities and conditions, problems may arise, cost may increase and the inventory may take much longer to complete. The use of existing data can reduce inventory costs and can be very effective, particularly for forests in which tree growth is slow and where data may remain valid for many years. This last approach is being used in Australia which has recently decided to compile its first national forest inventory making use of satellite imagery to extrapolate existing data to unsurveyed regions. Geographic information systems are being used to collate and manipulate numerical and graphical data from various sources.

Since 1946, FAO has undertaken periodic assessments of the world's forest resources. The latest, the 1990 Global Forest Resources Assessment, has three components assessing industrialised countries (UN-ECE/FAO 1993), non-tropical developing countries (FAO 1994, in press) and tropical countries (FAO 1993). The latter report provides comprehensive information on the current state of tropical

Box 10: Evolution of Forest Inventory Technique in Queensland, Australia

Initial inventory was hampered by poor access and the lack of prior information (e.g. maps or air photos). Survey teams spent months measuring systematic strip samples. To reduce the task of measurement and computation (these data were summarized by hand), only commercial trees over 40 cm diameter were measured and recorded. The surveys were labour-intensive and expensive. They provided good coverage, but rather general data (forest type and standing volume maps), and the commercial emphasis limited the use of these data for other objectives such as conservation planning. The data provided no indication of the sub-merchantable stand, and were soon out of date.

By the 1960s, these strip surveys had become too costly, and a two-stage approach was introduced. A systematic sample (a 1-km grid of sample points) was measured on stereo air photo pairs. These data formed the basis of a computerized area information system in which each grid intersection represented 100 ha. A random sample of these points was visited and temporary plots were measured. This approach offered some cost savings and provided more detailed data than were previously available.

In the 1970s, the efficiency of point (angle gauge) sampling was recognized. This technique samples with probability proportional to size, thus providing a reasonable sample of all size classes, avoiding the disproportionate sampling of small trees common with fixed-area plots in uneven-aged forest. Optical wedges were convenient and gauges were chosen to suit the forest (basal area factor 10 m²/ha in rainforest, 2 m²/ha in open woodland). Clusters of these points were often used to provide a better sample. These clusters of point samples continued to be established within the two-stage systematic grid, but additional details were recorded. The availability of each tree for harvesting was indicated, and stream buffers, steep slopes, seed trees, etc., were explicitly recorded. A *netting factor* allowed an accurate reduction from gross area to net area available for harvesting, and eliminated a bias present in many previous yield estimates.

A further change in technique was introduced in the 1980s to take advantage of the increased capability and availability of computers, data management systems, satellite remote sensing and geographic information systems. Landsat Thematic Mapper data were used to revise maps of the forest, and estimates of the gross forest area were updated. A digital elevation model provided slope maps and estimated the extent of steep slopes not available for harvesting. Digitized forest type and administrative boundaries facilitated the compilation of strata within the geographic information system, and stratified random sampling was used for new inventory requirements. These data were used to prepare detailed yield forecasts and to examine the sustainability of the timber harvest (Vanclay and Preston 1989).

These forests are increasingly being managed for recreation and conservation, as well as for timber production. These changing objectives will require additional information based on field inventory and monitoring.

Source: Vanclay 1992b

forests in 90 countries including deforestation, management, conservation and development of the resource, with information on rates of change during the period 1981-1990. It addresses issues related to forest degradation, loss of biomass and biodiversity. The methodology used to estimate changes was based on the analysis of forest resource data in the form of time series. Inevitably, the data are of mixed reliability: both statistics which were available from individual countries and new data obtained from satellite imagery were used, combined in a geographic information system.

Box 11: Forest Inventory for Land Use Planning in Vanuatu

Vanuatu, in the south-west Pacific, comprises many islands. Most inventories have addressed commercial aspects over restricted areas. Only recently has national forest inventory been attempted - as part of a land use planning database. The land systems approach was used to delineate *resource mapping units*, homogeneous with respect to vegetation, land use and other characteristics (relief, geology, slope, altitude and rainfall). These were prepared from recent aerial photography (1:30 000) and existing geological maps. Ground and aerial checks were made to verify the air photo interpretation.

Time and funds did not permit each mapping unit to be sampled, so they were aggregated by forest type and land use to form strata for sampling. The inventory was based on two-stage sampling. One resource mapping unit was selected from each stratum, and several plots were established within that mapping unit.

Supplementary sampling helped to reduce the variance in strata where the basic sample failed to meet targets.

Plots comprised clusters of ten point samples using a 10 m²/ha optical wedge. This comparatively wide angle gauge was chosen to minimize difficulties in sighting trees in the dense thickets common on these islands.

These plot clusters provided a good indication of the vegetation type and species present, as well as the timber volume within the mapping unit.

Source: Baldwin *et al.* 1992

4.8 Vegetation Mapping

Vegetation maps may be used in conjunction with topographic maps, geological and soil maps to build up a complete picture of the landscape (e.g. Biophysical Land Classifications in Canada). Most recent vegetation maps are derived from interpretations of air photos or satellite imagery, with limited field checking of boundaries and the species composition of map units. This approach has to rely mainly on structural features of the vegetation, although it is usually assumed that these coincide with changes in species composition.

In spite of useful reviews (e.g. Kuchler 1967, Kuchler & Zonneveld 1986) and attempts by the International Biological Program (Fosberg 1967, also in Nicholson 1970) and UNESCO (Ellenberg and Mueller-Dombois 1967), there is no universally-accepted system of classifying vegetation (Goldsmith 1974). Vegetation map units are usually described according to physiognomy (appearance of the vegetation or a combination of vertical and horizontal structure) or species composition. Physiognomic systems may characterise the life-forms of the plants present (e.g. the systems of du Rietz 1931, Raunkiaer 1934 and Dansereau 1961) and/or the structure of the vegetation, e.g. floodplain grassland with scattered trees. Botanical descriptions of plant communities often indicate one or more dominant genera, e.g. *Acacia-Combretum* woodland, *Hyparrhenia* grassland or, in most phytosociological studies, the co-occurrence of indicator species.

A range of methods of vegetation analysis has been developed. In Europe, Braun-Blanquet (various dates from 1932 to 1964) developed a system of phytosociology based on the concept of certain plant species being faithful to certain vegetation communities. These communities can be arranged in a hierarchy of units which parallels the Linnean system of taxonomy. It was hoped that this system would enable the functional and causal reasons for the spatial distribution of plant-types to be found. The system was widely used in France, some other European countries and former French colonies (Long 1974). There is a similar Scandinavian school. However, American, Australian and English workers

have criticised its subjectivity, favouring a more numerical approach based on dominant species or, more often, groups of indicator species derived from computer analyses of chi-squared values between species (Association Analysis) or ordination techniques such as Reciprocal Averaging (Hill 1979, Goldsmith *et al.* 1986). The latter is the basis of TWINSpan which is used for the National Vegetation Classification of British vegetation (Rodwell 1991). In developing countries, the indicator species that are usually generated by these techniques have considerable potential for allocating new samples to vegetation classes and indicating sensitivity of the vegetation to drought, salinity, drainage or overgrazing; or the nutrient status of the vegetation. However, they require a high level of expertise for both the collection and analysis of data.

Structural or physiognomic classifications are simpler to use and may be better suited to rapid and more extensive surveys. The basic information can usually be obtained by remote sensing. The main information presented is:

- canopy open or closed;
- diameter of tree canopies;
- position of the perennating bud;
- periodicity (e.g. deciduous/evergreen/ephemeral);
- type of leaf (macrophyll/mesophyll/sclerophyll/orthophyll/microphyll);
- thorniness;
- evidence of fire tolerance (e.g. thick, corky bark);
- life strategy, e.g. competitors, stress tolerators, ruderals (see Grime *et al.* 1987).

Vegetation maps have been most used in western Europe where they have mostly been phytosociological (Long 1974, Ellenberg 1968) and in North America and Australia where they have been of various types - but cover type or biophysical have predominated (e.g. Zoltai and Pettapiece 1973, ECTF c.1973).

Vegetation mapping in developing countries has been undertaken using air photos and satellite imagery. Examples include: in East Africa, especially in association with game management and national park planning (e.g. Astle 1989, Edington & Edington 1977); Madagascar (based on bioclimatic and physiognomic information); South America (Beard 1944, 1967, 1978) and especially the Amazon Basin (sometimes to document forest loss); India (based on physiognomy using satellite imagery but with secondary floristic information); and the Middle East (Poore & Robertson 1964). An extensive list is given by Kuchler (1980) in a useful four volume bibliography of vegetation maps.

Since 1975, the Global Environmental Monitoring System (GEMS) - a part of the United Nations Environment Program based in Nairobi - has included the monitoring of terrestrial renewable resources by vegetation. It aims to do this globally but, in practice, more attention may have been focussed on priority areas such as the Sahel. Geographical information systems (GIS) permit computerised calculations of area, assessment of changes between surveys and statistical analyses of data.

While the emphasis of research funding is increasingly based on satellite imagery and GIS, the most appropriate approach to vegetation mapping depends upon the objectives of the exercise. Vegetation maps are used in wildlife management, the designation of wilderness areas, selection of protected areas, forest inventory, game ranching, environmental impact analysis, airport siting, planning of new highways, location of industrial areas, and oil terminals (Goldsmith 1991a, Spellerberg 1992).

Vegetation integrates the effects of climate, geology and soils and is relatively easy to see. The question arises, therefore, as to why vegetation maps have not been used more extensively. There may be a number of reasons which apply in different combinations to different projects, objectives, methods and countries. The problems are:

- species identification;
- identifying boundaries in what is essentially a gradient;
- the dynamic nature of vegetation (seasonal differences and longer term changes);
- conceptual difficulties - Is vegetation a continuum or discrete classes ?
- assessing productivity/sensitivity/carrying capacity;
- the difference between actual and potential vegetation;
- analysis of imagery;
- data processing;
- training;
- cost (satellite imagery, GIS, skilled interpreters, field surveyors as well as the cost of producing large, usually coloured, sheets).

In spite of these difficulties, there is an increasing demand for vegetation classification and mapping, related to the growing interest in conservation. Nearly all countries are currently preparing Biodiversity Strategies (following the June 1992 UN Conference on Environment and Development in Rio de Janeiro) and an inventory of their present vegetation cover would provide a useful baseline.

4.8 Wildlife Resources

Surveys of wildlife resources are undertaken for two main reasons. First, to identify priority areas for conservation, when information is needed about wildlife population ranges, population densities of individual species, areas having the greatest biodiversity and centres of endemism. Secondly, where land use is already determined, information needed for management of wildlife resources includes population density, diversity and trends of individual species, potential threats such as domestic herds, and relationships with weather and changes in habitat.

There are some obvious differences between wildlife (and livestock) resources and other natural resources that affect the way surveys have to be conducted and how often they are conducted. Animal populations may crash or erupt very quickly, e.g. wildebeest in the Serengeti National Park in Tanzania increased from 0.25 to 1.5 million in ten years, and wildebeest in Botswana decreased from 0.8 to < 0.1 million in ten years. And populations are mobile, often using vast areas at low overall densities. Therefore, surveys need to be extensive and frequent if they are to be useful. They must also encompass key elements of the habitat and weather over the preceding period if some understanding is to be gained of how wildlife systems work.

Until the 1950s, most information on wildlife in tropical countries was gleaned from natural history and hunting notes, was qualitative, species-oriented, and often anecdotal. National parks, game reserves and wildlife sanctuaries were created without the benefit of many surveys to establish ecological or social criteria.

Over the savannas, where game can be counted from the air, survey methods have been revolutionised by the use of light aircraft. One of the first surveys using aircraft was by Ionides who mapped elephant concentrations over the Nachingwea Block of the Tanganyika Groundnut Scheme (Box 3) in 1947/48. Quantitative aerial surveys and statistical techniques were pioneered at the Serengeti Research Institute in Tanzania. Systematic reconnaissance flights (SRFs) began in the 1970s and enabled quantitative, spatial assessment of natural resources over large areas (Box 12). Norton Griffiths (1979) describes modern survey methods, and Jolly (1969) and Krebs (1989) give details of the statistical theory. SRFs rely on precise navigation, speed and flying height to control sampling

Box 12: Systematic Aerial Reconnaissance Flights. An Example from Tabora Region, Tanzania

The survey of 94 000 km² used a 3 per cent sampling grid based on transects 10 km apart. The high wing monoplane was flown at 300 ft above the ground at 90-100 mph; vertical air photographs were taken at 10 km intervals and the film scale of 1:5 000 could be projected to a x10 enlargement.

Three crew and the pilot maintained continual observations into individual, synchronised recorders, assessing in abundance classes or quantified vegetation cover type, canopy closure, ground cover and greenness, topography, soil colour, erosion, water, infrastructure, settlement types, crops, logging or hunting camps and cattle. Wildlife was analysed by species and number, using camera counts for large herds.

Computer analysis of data produced 10 km grid cell maps of different resource densities, and correlation showed relationships between, for example, cattle density and erosion, or wildlife species with habitat types.

Repetition during different seasons and at three-year intervals gave information on seasonal variations and changing patterns of resource use.

Source: A. Rodgers, personal communication. See also Stocking (1983) for more detailed analysis of land resources in the S.E. Shinyanga Land Use Study.

along transects. The method has been extended using interpretation of low-level colour air photos and simultaneous recording of in-flight observations to assess soils and soil erosion, crops and their stage of growth and field success. Correlation with secondary sources of data on topography, infrastructure and human population gives a range of useful information very quickly and this is greatly enhanced by supporting field survey (e.g. Stocking 1983).

The SRF method has been continually improved with better-equipped aircraft, trained crews and more user-friendly computer programs to provide raster (grid square) maps of wildlife, cattle and soil erosion. Repetitions of surveys at different seasons and at regular intervals enables an analysis of changing patterns of resource use, within and outside wildlife areas. The Kenya Rangeland Ecological Monitoring Unit (KREMU) routinely surveys the whole country at a variety of scales using SRF. Botswana and Tanzania have permanent aerial monitoring teams in their wildlife agencies.

Aerial census is not without problems. It needs costly equipment and trained manpower (although costs per km² covered are relatively low). Data typically have high variances so use of these data for calculating offtake is risky (for example, a fall in animal density of 25 per cent will not be detectable with confidence limits of 30 per cent) but attainment of lower variances requires a great increase in sample density and, therefore, cost. When animal densities are low and herds scattered, the method becomes less effective. Rodgers (1992) comments on this for Botswana:

It is of importance to examine wildlife response to management activities. Several important questions can be asked: Does protected area status lead to higher densities ? Does providing dry season water lead to higher density ?

Unfortunately, there are no hard, objective, quantitative data to answer these. Density estimates come from low-sample-intensity aerial counts over large areas. Sample levels for smaller internal areas are very low, giving low precision, often with confidence limits $\pm 100\%$. There is, thus, little ability to compare before and after data for one area, or area-to-area data. There is no cost-effective way to census very low

density ($< 2 \text{ km}^2$) mobile animals. The clumped nature of the populations into herds and then in selected localities plays havoc with precision.'

Aerial survey works well over large areas ($> 1\,000 \text{ km}^2$) where trees don't get in the way. Ground survey methods are needed in forested land and for smaller areas such as ranches and tribal areas. These are described by Clarke (1986) and in locally published technical manuals, e.g. Rodgers (1991).

Survey objectives in tropical forests are usually related to mapping or monitoring areas of high diversity or endemism. Indicator groups are often used and the literature includes many references, e.g. for primates (Marsh & Mittermeier 1987), for birds (ICBP 1992), for mammals (Rodgers 1992).

The monitoring of small wildlife populations at risk from wildland fragmentation and loss of habitat is a common feature of wildlife surveys in industrialised countries. Goldsmith (1991) gives a good overview of methods. Increasing attention is being given to the importance of viable populations and minimum viable areas to ensure the survival of species or communities.

4.9 Surveys for Range Management

There are three elements in range surveys: counting livestock, mapping the kind and condition of the pastures, and locating and assessing water supplies. Large areas are involved and the extensive use of the land does not justify detailed survey. Therefore, most work has been done at a small scale (1:50 000 to 1:1 million), relying heavily on visual interpretation of satellite imagery and air photos to identify landform/vegetation units, followed by SRF or windscreen survey (Box 13).

Touber (1991) in N.E. Kenya, used 1:500 000 Thematic Mapper imagery and the 1:1 million reconnaissance soil map (Sombroek *et al.* 1982) to identify and describe land mapping units. Field observations, plotted on 1:250 000 topographic sheets, were qualitative ratings of soil water holding capacity, soil nutrient status, soil erosion status, accessibility for livestock and flooding hazard. Full details of methods are given in Touber (1988). Two local informants, employed to give the local names and local herdsman's appreciation of the land, distinguished about half as many kinds of land as the image interpretation. These assessments were combined with the physical assessment. Examples of the combined land mapping units are:

Acham. Sandy alluvial soils along river courses. These areas have agricultural potential and are productive of fodder. Acham is always preserved for dry season cattle grazing, because of large amounts of standing hay. Goat herding is avoided in the wet season because of too high density of the vegetation; also there is a tsetse problem for cattle during the rains.

[Mapping units 10 FS (sub-recent alluvium from metamorphic rocks, regular, long gentle slopes 2-5%) and 17 AA (recent alluvial deposits, almost flat).]

Koruron. Red, strongly-weathered soils on older footslopes, mainly strongly degraded by sheet erosion so the B horizon forms a hard, sealed surface. Koruron are known as *the soils where grass will not grow*. It produces good browse but little or no grazing. No problems of access in the wet season.

[Mapping unit 9 FU (colluvium derived from metamorphic rocks; regular, long, gentle slopes 3-8%)]

Box 13: Rangeland Mapping in the Kimberleys, Western Australia

Extensively-grazed native rangeland occupies 940 000 km² of semi-arid land in Western Australia, divided into 540 pastoral leasehold stations grazing sheep and cattle. Rangeland mapping is undertaken to assist management, specifically to identify areas of overuse or degradation and help formulate specific rehabilitation procedures.

Multispectral satellite imagery is used to identify land systems. On station, an up-to-date map of infrastructure is made in collaboration with the pastoralist, marking fences and gates, tracks, bores, mills and buildings. Then land units (facets) are mapped on 1:50 000 air photos. Descriptions of lithology, landform, vegetation and soils are made along station tracks. A standard scoring system is used for pasture type and condition and the procedure is designed to operate at 40 km hr⁻¹ with the ratings assessed over a 50-mile radius of the vehicle. Air photo interpretation is used for areas that are difficult to get to.

Landform and vegetation are the most significant predictors of rangeland quality, with soils a poor third.

Station maps are produced at 1:100 000 on a geographic information system. Permanent sample sites are then set up and re-photographed at regular intervals to assess changes in rangeland condition.

Source: Cotching (1990)

None of these surveys gives quantitative data on the productivity of the rangeland. Interpretation and use of the information has mostly been in terms of estimated *carrying capacity*, which is a central concept in rangeland and pasture management. The conventional concept, developed in the United States over the period 1930 to 1960, was based on research on plant succession. Range management attempts to balance the grazing pressure against the natural regenerative power of the pastures and to maintain a stable, sub-climax vegetation. The concept of carrying capacity dictated the stocking densities needed to achieve this balance. Skilled range managers are able to judge range conditions by observations of indicator species (*increasers*, *decreasers*), perennial:annual ratios and bush *encroachment*, and can adjust stocking density or grazing regime accordingly. Range management has long been associated with beef ranching and many of the standard botanical indicators have been derived implicitly to assess 'economic' carrying capacity for beef ranching systems.

A variety of other concepts of carrying capacity has developed in other contexts: *ecological* carrying capacity, *genetic* carrying capacity, *maximum sustainable yield* and *optimum* carrying capacity or *optimum sustainable yield* (Larkin 1977, Caughley 1979, Brooks and MacDonald 1983, Bell 1985 - all reviewed by Behnke and Scoones (1991). Bell (1985) has argued that the only realistic definition is:

'that density of animals and plants that allows the manager to get what he wants out of the system. Thus, any specific definition of carrying capacity must be expressed in relation to a particular objective, and it must be defined very precisely since there are no natural stability points in such interactive systems that act as foci for self-defining concepts'.

Bartels *et al.* (1990) argue that estimates of carrying capacity are not a useful tool for planning and, at least in Africa, of questionable validity. Recommending stocking rates is a waste of time because:

'Though there have been numerous attempts, we know of no case in which a government has successfully persuaded householders, or a pastoral group, in Africa, to voluntarily limit livestock numbers to an estimated carrying capacity.'

4.10 Agroclimate and Hydrology

Agroclimate and hydrology are characterised by extreme variability over both the long and short term and spatially. Spot measurements are therefore of little value. Useful data have to be accumulated by regular or continuous monitoring from relatively few, well-instrumented stations over a period of at least 10 and up to 30 years. Long-term stations and secure maintenance of the data base require institutions that are adequately funded and staffed, which is costly. The value of meteorological data to a wide range of military and civil activities greatly augments the funding available for data collection, but land use planners in developing countries often have to work with fragmentary data of questionable reliability or with data from distant stations. Bernard (1975) and Hills (1981) discuss the cost and structure of meteorological services in developing countries.

Interpolation of data, at least in respect of rainfall, is greatly assisted by interpretation of Meteosat imagery that is now available from low-cost ground receiving stations and these are becoming common in semi-arid Africa, particularly as a component of drought early warning systems (Box 14).

Box 14: Low-Cost Ground Receiving Stations for Meteosat

The UK-based Natural Resources Institute (NRI) and three British university groups have collaborated to develop low-cost systems for direct reception of satellite remote sensing data in developing countries. This initiative is called Local Applications of Remote Sensing Techniques (LARST). Using LARST systems, local resource managers can receive and process quickly key environmental information from Meteosat and NOAA satellites. A LARST Meteosat system costs little more than a Landrover.

By 1993, systems were in place in a dozen developing countries, mainly in Africa. They are used locally to estimate rainfall and to monitor vegetation condition in support of drought and famine early-warning systems. Local users of LARST include hydrologists and managers of forests, rangelands and wildlife parks. In Ethiopia and Namibia, LARST is used to assess the state of each growing season. Meteosat systems are used to estimate rainfall and weather conditions over large areas. In many data-sparse countries, such information is not available to local meteorologists and hydrologists from any other source. With NRI support, several small African meteorological services are using Meteosat images and global weather model outputs to improve national weather forecasts and to improve local dissemination of environmental information to the public in farming communities, via the media.

Source: Sear *et al.* (1993)

Land use planners and managers need climatic information to understand how to protect crops, to reschedule crops during the year for better production or to reduce risks, or to introduce new crops or varieties in the production system and for the use of growth regulators for convenient harvesting. Information is needed on the relationship between climatic variables and periodic phenomena in crops - germination, flowering, fruiting - and crop quality, and any likely damage by frost, hail, wind, snow or intense rainfall. The length of the growing season depends on the balance between water demand (through evapotranspiration) and supply (from rain, irrigation and soil water storage) and, also, on temperature and day length. Growth rate may depend, in addition, on light intensity. Harvest may need

a long enough dry period. Data on variability of these parameters are most commonly lacking in natural resources reports.

4.10.1 Climatic Data

The climatic data needed for land use planning are:

Precipitation - at least mean monthly totals. Standard week, pentade or ten-day periods provide a much better guide to the length and reliability of the growing season, e.g. Mitchell *et al.* (1984) provide a drought analysis for Tabora Region, Tanzania, using pentade data. Probability estimates based on long series of data are needed to determine the risks of drought, flood, suitability of new crops or management practices and for crop simulation models. But, even here, the analyst must watch out for cyclical trends of climate and, perhaps, the effects of global climatic change. Rainfall intensity over short periods (< 1 day) is needed to estimate the hazard of flooding, soil erosion and landslips.

Temperature: Average daily temperature, mean maximum and mean minimum temperatures are usually recorded. Mean day and mean night temperatures are needed in crop modelling for calculations of gross and net photosynthesis, at least on a monthly basis. Where there is a frost hazard, the grass minimum temperature indicates the minimum leaf temperatures that may occur.

Vapour pressure. This is needed to estimate evapotranspiration and is calculated from simultaneous measurements of air temperature and relative humidity.

Wind speed at 2 m. Average wind speed at 2 m above ground level is used to calculate evapotranspiration. Strength and frequency of strong gusts is needed to assess the risk of wind damage.

Total radiation. This is measured at few stations. Generally it is calculated from sunshine duration and tables.

Evapotranspiration. Potential evapotranspiration may be calculated according to the Penman method, or, where data are inadequate for this, using only radiation values or evaporation pan measurements. Standard procedures are detailed by Doorenbos and Pruitt (1977) and Jensen *et al.* (1990). Revised procedures (Penman-Monteith) for calculating crop water requirements, detailed by Smith (1992), estimate potential evapotranspiration values 20% lower than the earlier procedure.

FAO (1984, 1987) provide invaluable generally-available reference climatic data for Africa and Asia, respectively. Interpretation of standard data for field conditions is not straightforward. Nevertheless, many natural resources reports have simply presented basic data without information about what they mean, e.g. early Land Resources Studies by LRDC, although later ones provide some useful analysis, e.g. Mitchell *et al.* (1984). Use is now being made of agroclimatic data in crop production and economic modelling, e.g. Querner and Feddes (1989). Euroconsult (1989) provides a digest of agroclimatic calculations, including interpolation procedures (Box 15).

4.10.2 Hydrological Data

Reliable estimates of streamflow are needed to assess water supply for irrigation, hydropower generation, urban and industrial use, and to assess flood hazard. Long runs of data from river gauging stations are often not available and, if they are, should be checked for reliability ! Checking procedures are summarised by Euroconsult (1989).

In the absence of adequate, or even any, gauging station data, hydrographs are constructed from rainfall data using empirical formulae. Some of these make hair-raising assumptions, yet they are often used without testing under local conditions. Rainfall/runoff models should be checked visually by simple graphical plots of simulated and measured hydrographs, or by scatter diagrams. A poor model simulation can be identified quickly and easily. More rigorous and objective checks based on linear regression, e.g. coefficient of efficiency (Nash and Sutcliffe 1970) are used less commonly. The choice of appropriate checks is important and depends on the use to which the streamflow estimates are to be put: peak flows for flood forecasting; low flows for environmental protection, medium flows for reservoir storage calculations (Aitken 1973).

Studies for reservoir storage should also take account of soil erosion in the catchment and consequent sedimentation that diminishes the capacity and life of reservoirs. Where this has been done at all, engineers have usually applied the Universal Soil Loss Equation (Wischmeir and Smith 1965), even though local data for ground cover, erodibility of the soil and erosivity of the rainfall are not often available !

Groundwater resources may be usefully divided into shallow groundwater that can be tapped by hand-dug wells and manually-operated pumps, and that is recharged annually; and deep groundwater that is recharged over a longer cycle. Methods of groundwater survey are also summarised by Euroconsult (1989). The possible existence of useful groundwater resources can be inferred from geological maps and landform position (Table 5) and, hence, by interpretation of air photos and satellite imagery. Quantitative data on aquifer yield have to be collected by pumping tests. Reserves can then be estimated by extrapolation based on topographic and geological maps.

Data networks for hydrological measurement need long-term institutional support. The wide range of measurements can be grouped in the *continuity equation*:

$$\text{INFLOW} = \text{OUTFLOW} \pm \text{STORAGE}$$

<u>Inflow</u>	<u>Outflow</u>	<u>Storage</u>
Precipitation	Runoff	Soil water
Surface water flowing across boundary	Evapotranspiration	Aquifer contents*
Piped or canal transfers	Irrigation losses	Reservoirs
Groundwater flowing under boundary*	Power station evaporation losses	
	Surface abstraction (not returned to system)	
	Groundwater abstraction	

* Not measurable directly: have to be inferred

Table 5: Occurrence of Aquifers and Aquicludes

TYPE OF GEOLOGICAL FORMATION	AQUIFERS	AQUICLUDES
<u>Unlithified sediment</u>		
River valley deposits	Stream channel deposits: gravel and sand	Flood plain deposits: silt and clay
Fan deposits	Material deposited in the upper and middle parts	Finer material deposited further from the fan's apex
Delta deposits	Foreset beds	Bottom-set beds
Coastal plains	Near-shore sand deposits, dunes and beach ridges	Offshore silt and clay, backswamp deposits
Lacustrine plains	Old delta and lake shore sediments	Lake bottom deposits
Loess plains	Well-sorted loess	Clayey alluvial material in depressions
<u>Sedimentary rocks</u>	Partly-cemented sandstone, fractured hard sediments	Mudstones, shales, siltstones, dense sandstone
	Karstic limestone	Dense unfractured limestone
<u>Igneous and metamorphic rocks</u>		
Plutonic and metamorphic rocks	Faults, heterogenous weathered rock zones, joints, porous zones	Unaltered rocks
Volcanic rocks	Lava flows, buried alluvial deposits, dykes when fractured and contact zones	Volcanic ash, tuffs and dykes
<u>Geological structures</u>		
Faults	Faults in hard rock	Faults in soft rocks due to presence of clay and precipitated minerals
Joints	Joints in tensile zones	Joints closed in compressed zones, generally deep below the surface

Source: Euroconsult (1989)

To assess how rainfall is transformed into river flow and aquifer recharge, calculations are made for river basins or representative smaller catchments. A basin-wide data network of measuring devices may include more-intensively instrumented areas. Where terrain or manpower is limited, it may be easier to instrument only one area intensively and extrapolate results to surrounding areas.

There is a trade-off between the accuracy of the estimate of areal rainfall from the network of a particular density and the cost of maintaining the networks, so the density required and the frequency of reading depends on the problems under review: compare Table 6, giving WMO recommendations for minimum needs for precipitation networks, with gauge densities of 2 to 160 per km² used in important reservoir areas in the UK. Useful references include Hutchinson (1969) and Reich (1963) for areas with sparse data; Rodriguez-Iturbe (1974) for interpolation; and Rodriguez-Iturbe *et al.* (1979) and United Nations (1968) for hydrological networks.

Various methods may be used to assess the areal distribution of rainfall and some other parameters from the often sparse networks of recording stations (see Box 15).

Table 6: WMO Recommendations on Minimum Densities for Precipitation Networks

TYPE OF REGION	RANGE OF NORMS FOR MINIMUM NETWORK (km ² per gauge)	RANGE OF PROVISIONAL NORMS TOLERATED IN DIFFICULT CONDITIONS
Flat regions of temperate mediterranean and tropical zones	600-250	250-1000
Mountainous areas of temperate mediterranean and tropical zones	100-250	250-1000
Small mountainous islands with very irregular precipitation	25	
Arid and polar zones	1500-10 000	

4.10.3 Water quality

Water quality data are needed to assess the suitability of water for domestic, industrial and irrigation use and for choosing suitable materials for pumps, well screens and pipelines - some waters are very corrosive. Water quality has to be determined by chemical analysis, which only provides a snapshot at the time of sampling. A sampling regime must cover the full range of conditions likely to be experienced. As in the case of hydrological networks, a permanent network of sampling stations is needed to monitor the longer-term changes that result from changes in land use and the use of water for irrigation, industrial and domestic use.

The information usually provided is for total dissolved solids (for which electrical conductivity is

Box 15: Methods of Assessing Areal Distribution of Rainfall and other Parameters (Source: Linden Vincent, pers.comm.).

Arithmetic mean of stations within a catchment. This simple method may give adequate results if gauges are equally distributed, or if the area is fairly flat. The results are likely to be particularly unrepresentative in mountainous areas.

Isohyetal method - Contours of equal rainfall (isohyets) are sketched in relation to rain gauge measurements, topography, etc.

$$\text{Mean rainfall} = \frac{\sum (\text{area between isohyets A \& B} \times \text{mean value of A and B})}{\text{catchment area}}$$

A more accurate, but more tedious method, is the equation:

$$R = \frac{x+i}{3} \frac{(2a+b)}{a+b}$$

R = mean depth of rainfall between isohyets A and B
a = length of isohyet of higher value
b = length of isohyet of lower value
i = isohyet interval A - B
x = value of lower isohyet

Each R value then has to be multiplied by the area between isohyets. This is the most accurate method as factors like relief, aspect and storm direction should have been carefully considered in drawing the isohyet map.

The isohyetal technique is appropriate if the network is dense enough to give reasonably accurate results.

Isomeric method - In this method, precipitation over any length of time at a point is expressed as a percentage of the long period mean annual precipitation at that station, to give the isomeric value. These values are then averaged for gauges over the catchment and the mean percentage then applied to the long-period mean annual precipitation for the catchment to give the areal value.

Thiessen polygons make allowance for uneven distribution of gauges. In addition, data from adjacent areas are incorporated into the mean. The method is based on the assumption that a station best represents the area which is closest to it (this may not be so if precipitation is controlled by topography or results from intense convection). Polygons are constructed around each gauge by drawing perpendicular bisectors through the straight lines joining adjacent gauges. The area of each polygon is then multiplied by the associated rainfall. The results are totalled and divided by the catchment area to give the estimated mean rainfall depth over the catchment.

Height-balanced polygons allow for effects of altitude as well as gauge distribution. Perpendiculars are drawn through the midpoint in terms of altitude between adjacent gauges rather than distance.

Spatial correlation between rain gauges can be undertaken by Kriging or co-Kriging techniques (the latter particularly with elevation as the co-variable) as in soil mapping (see section 4.5).

Other methods that can be used where there are few or no records include the use of vegetation mapping, especially using satellite imagery for different seasons.

a useful surrogate) pH, cations (Na^+ , Mg^{2+} , Ca^{2+}) and anions (Cl^- , SO_4^{2-} , HCO_3^- , NO_3^-) and borate. Even tiny amounts of toxic elements are, obviously, critical for potable water and food processing, and wider-ranging analysis is needed for these purposes.

In extrapolating spot analytical data over wider areas, relationships may be drawn with geomorphology, soil and rock type. Water in upland areas, in the vicinity of recharge areas, is generally of good quality - except in ultrabasic areas. Quality deteriorates downstream and in aquifers towards discharge areas. The rock type in contact may affect quality: some marl or evaporite deposits are salty. Saltwater intrusion occurs in tidewater and in coastal aquifers. Use and re-use of irrigation water raises the salt content.

Pollution from point sources like industrial and sewage outfalls is easy to trace but diffuse sources like fertilizer leaching are more difficult to trace, and both vary enormously over short periods.

4.11 Present Land Use

Reliable objective information about present land use is essential for policy-making and land use planning. Rarely is such information available. Many governments have administrative procedures for gathering land use information through reports by district field staff. In the absence of systematic survey, these reports can only be guesstimates and, sometimes, they are fiction

Field-by-field survey like that achieved by Stamp (1931-34) and Coleman (1960-61) in Britain is too slow and costly for large areas. Air photo interpretations can provide detail and accuracy if the interpreters do enough fieldwork to build up a good photographic key. Examples are the land use atlas of Tanga Region, Tanzania (TIRDP 1985) and the Sri Lanka-Swiss remote sensing project that published maps for Sri Lanka at scales of 1:50 000 to 1:100 000 (e.g. Survey Dept. 1983). Shultz (1974) prepared a national land use map for Zambia (2 sheets at scale 1:1 million with explanatory memoir) on the basis of airphoto interpretation, but the amount of fieldwork undertaken is unclear. More-detailed land use maps covering the country are not available, and Schultz' maps have been used extensively as base maps for rural development planning in Zambia.

Aerial survey is costly, so it cannot be updated often, and cover may be at widely different dates or for different seasons. Persistent cloud cover and dust haze are problems in some areas and, for these, airborne radar imaging has been used (Trevett 1986). Satellite imaging has the advantage of regular, repetitive coverage, at least in principle. False colour composites available at scales of 1:50 000 or smaller can be interpreted visually to distinguish broad features of land use like grassland, forest, cultivated and fallow land. Considerable research investment has gone into more automated interpretation of the original digital data, but the kaleidoscopic patterns produced by sophisticated manipulation of those data cannot be interpreted without rigorous fieldwork; and few developing countries have the facilities and skilled staff for sophisticated computer enhancement of imagery and manipulation of the digital data.

Land use surveys are *ad hoc* affairs. There is no widely-applicable, consistent set of descriptors for land use and no generally-accepted land use classification.

CHAPTER FIVE

METHODS OF LAND EVALUATION AND LAND USE PLANNING

The demands for natural resources information have widened - from emphasis on specialist data; to land evaluation, predicting the potential of land for one or more uses; to land use planning involving consideration of land use problems and opportunities, generation of a range of land use options, and making choices between these options (Dent 1991, FAO 1993 in press). Early impetus for this direction came from soil conservation issues and from land settlement and irrigation schemes. Most interpretations of natural resources data have been physical ones - either predicted physical response to various land uses or in terms of constraints on such uses. Where financial appraisal has been demanded, this has been tacked on without much change in procedure, either from natural resources specialists or economists.

The step from land evaluation to land use planning is a big one and goes beyond the physical and financial assessment of natural resources. Where conflicts of interest arise, conventional methods have been found wanting, and possible future directions are largely untried. In this chapter, the logic and assumptions of conventional methods of land evaluation and land use planning are reviewed according to their principles - from trial-and-error, to the transfer of experience by analogy, to simulation models (McKenzie 1991, Dreissen and Konijn 1991). Chapter Six deals with what now seems to be the stumbling block to more effective use of natural resources information and rational land use planning - the need for participation in the process by all the stakeholders.

5.1 Trial and Error

This is the oldest way of adapting land use to changing circumstances; the only way in the absence of a scientifically-based program of resource survey and evaluation; and still the usual way. However, the economic, social and environmental costs can be very high and it is difficult to develop a rational strategy for new areas, new problems and new opportunities.

Usually, the experience gained is not recorded and most is lost when managers change.

5.2 Transfer of Experience by Analogy

The results of a land use trial, be it a farmer's experience, a field experiment or a catchment study, are strictly applicable only to that site and, may be, only to that time. The assumption that underlies soil survey, land systems survey, and most methods of land evaluation is that this experience can be transferred to other sites by analogy - by assuming that all occurrences of a particular class of land (the land analogue) will respond in the same way to the same treatments.

Transfer by analogy needs a classification of land that permits the prediction of performance or behaviour over a wide range of land uses. The analogues have to be identified in the field even though the attributes of the land that determine performance may not be known or not visible in the field.

Analogues may be defined by classifications of soil, e.g. Soil Series, or land, e.g. Land Systems. For example, if trials are carried out on Mondha Series, a Typic Chromustert (NBSS & LUP 1987), we assume that these results apply to all soils of Mondha Series and, to some extent, all Usterts. The method

relies on detailed characterisation of the trial sites and tightly-defined analogues that are rigorously correlated in the field, across the country and within the higher levels of the taxonomy. This is a substantial and demanding task that has been achieved by only a few survey organisations.

It is possible to improve a system of classification in the light of experience. The present amendments to Soil Taxonomy (Soil Survey Staff 1990) are the fifth published amendments since the definitive version of 1975. However, the combinations and values of land characteristics that determine the performance of one crop (or system of management) in one environment are not the same for other crops and/or other environments (Gibbons 1961), so it becomes difficult to define a manageable number of land analogues (about 10 000 Soil Series are established in the USA). For precision in the transfer of experience, we are forced to adopt narrowly-defined mapping units (e.g. phases of Soil Series) that can only be mapped at large scales. National soil survey coverage at this level has proved not to be a practicable proposition for poor countries, and for most rich ones too.

5.3 Empirical Land Evaluation Using Expert Knowledge

Expert knowledge of land response to management can be used to interpret natural resources data to provide information that is, at once, more accessible and more focussed on land management than the basic data. Four approaches have been widely adopted: Land Capability Classification, FAO Framework for Land Evaluation, USBR (United States Bureau of Reclamation) land classification system for irrigation schemes, and Parametric Indices. More recently, decision trees have been advocated as a more transparent way of using expert knowledge so that it can be built upon by the manager or decision-maker in the field.

5.3.1 Land Capability Classification

The best known and most widely used method is Land Capability Classification, originally developed by the United States Soil Conservation Service in the 1930s to interpret conventional 1:20 000 soil maps for farm planning (Hockensmith and Steele 1949). The definitive account of the system is given by Klingebiel and Montgomery (1961). It has been adopted and, sometimes, modified by survey organisations in many developing countries.

Land is classified according to the degree of its limitations for sustained use and the soil conservation measures necessary to maintain it in productive use (Table 7). The limitations to use that are considered are those not feasible for the farmer to correct (e.g. climate, slope, soil depth, liability to flooding) and these are recognized at subclass level. A third level of classification, within the subclass, is the capability unit which groups soils that require similar management and are suitable for similar crops. Land allocated to a particular class has capability for the defined land use (e.g. Class I: arable, no restrictions) and all uses allowed for lower classes (so Class I is also suitable for grazing, forestry and wildlife). This does not necessarily indicate which use is most productive or profitable.

The classification assumes the technical means, capital resources and skills of the better farmers under local conditions and a favourable ratio of outputs to inputs. Access to markets, shape and size of land parcels and land ownership are not considered.

Expert judgement and field testing are needed to specify the criteria for classes and subclasses, and the strength and wide application of the system lies in this flexibility - criteria appropriate to local conditions should be specified. Table 8 shows the conversion table drawn up for Malawi by Shaxson *et al.* (1977), who also prescribe the soil conservation practices to be followed in each subclass. Astonishingly, the original USDA criteria have sometimes been adopted without change in quite different technological and physical environments.

Land capability classification is relatively easy to do and easy to use. Shaxson (1981) shows how class and subclass can be mapped quickly and directly, without bothering with time-consuming soil survey. Users are much more comfortable with land capability maps than soil maps or other complex land resource surveys (e.g. Woode 1981). After all, class I is obviously the best, class III is less good and class VI is rubbish, isn't it? Well, no, but the assumptions and shortcomings of the system are not immediately obvious.

The most obvious shortcoming is that land cannot be graded from best to worst irrespective of the kind of management. Some kinds of use have special requirements and tolerances that others do not have, for example:

- Rice requires a soil with a high available water content and tolerates prolonged flooding; other cereals will not tolerate waterlogging during their period of active growth;
- Tea, sugar cane and oil palm need efficient transport to processing plants and so have a minimum area requirement; grain grown for subsistence does not;
- For mechanised operations, stones and rock outcrops are limiting, but with oxen or hand hoeing you can work round them.

The arable bias of Land Capability Classification and the very generalised nature of the information does not help choice between alternative uses, except to eliminate the grossly unsuitable. Land use, productivity and profitability are often poorly correlated with land capability class (Smit *et al.* 1984, Burnham *et al.* 1987). No one-shot land evaluation can provide the information needed to choose between two or several land use options and, thus, match land use closely with land suitability. These objections were addressed in the FAO Framework for Land Evaluation (1976).

5.3.2 FAO Framework for Land Evaluation

The first principle of the Framework is that evaluation is for a *specified land use type*, relevant to local conditions in terms of the physical environment and social acceptability. The first step is, thus, to identify and define promising land use types and establish their land requirements (and also requirements for labour, capital and infrastructure - so this becomes a substantial, inter-disciplinary task).

The structure of the Framework is outlined in Box 16. The various land suitability classes are arrived at by matching the requirements of the land use type with the qualities of the land. The Framework separates *land characteristics* - attributes of land that can be measured, like slope angle; and *land qualities* - complex clusters of land characteristics that act in concert to determine the performance of a land use type. Sufficiency of water is a land quality. It is a dynamic attribute of land resulting from the interaction of several demand-side and supply-side characteristics (Figure 12) so it cannot be measured directly, though it can be modelled.

Table 8: The Malawi System of Land Classification (Source: Shaxson *et al.* 1977)

		Limitation															
Worst permissible value symbol in each class	1	slope (degrees)	1	2½	4½	6½	11	11	any	any	any						
	2	past erosion	nil	moderate	moderate	severe	moderate	severe	severe	any	any						
	3	wetness	nil	nil	short periods	considerable periods	nil	considerable periods	considerable periods	considerable periods	any	any				all or most of season	
	4	surface hindrances (%)	10	10	25	50	10	50	50	any	any						
	5	unfavourable surface conditions	porous	liable to capping	any	any	porous	liable to capping	any	any	any						
Range of permissible values	6	slope (degrees)	1	2½	2½	6½	6½	11	6½	11	11	any	any	any	any	any	
	6	texture of top 20 cm	SCL-C	SL-HC	SCL-HC	any	SCL-HC	any	SL-HC	SCL-HC	SL-HC	SL-HC	any	any	any	any	
	7	combinations of effective depth (cm)	90	50	90	50	25	50	25	25	25	50	50	90	25	50	any
-----and-----																	
	8	upper subsoil texture	CL-C	SL-HC	SCL-HC	any SL-HC	SCL-HC	CL-HC	any	SCL-HC	SCL-HC	SL-HC	SL-HC	any	any	any	any
	9	permeability within the profile	good	good-rapid	restricted-rapid	restricted-rapid	good	restricted-good	very restricted-rapid	any	any	any	any	any	any	any	
Land capability class		A-Arable (AA)	B-Arable (BA)	C-Arable (CA)	D-Arable (DA)	Special Arable (SA)*	A-Non-arable (AN)	B-Non-arable (BN)	C-Non-arable (CN)	Wet (W)							
USDA equivalent		I	II	III	IV	no equivalent	VI	VII	VIII	Vw							

The Special Arable class is restricted to areas with more than 1150 mm mean annual rainfall

Box 16: Structure of the FAO Framework for Land Evaluation

The target set by the FAO Framework is a four category evaluation:

- ◆ Land suitability orders. The first categorization is into SUITABLE/NOT SUITABLE for a specified land use type - dubbed land suitability orders.

Suitable means that sustained use of the kind under consideration will yield benefits which justify the inputs without unacceptable risk of damage to land resources.

Not suitable means that the kind of land use is technically impracticable, or would cause unacceptable degradation of land resources, or that the value of expected benefits does not justify the expected costs of needed inputs.

- ◆ Land suitability classes. These reflect degrees of suitability. Experience of testing land suitability evaluations against crop performance is very limited. Such experience as there is does not support a detailed sub-division. Two classes may be enough; FAO recommends not more than three, as follow:

Class S1 land having no significant limitations to sustained use, or with only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level;

Class S2 land having limitations that, in aggregate, will reduce productivity or benefits and will increase required inputs so that the advantage to be gained from the land use - though still attractive - will be less than that expected on Class S1 land;

Class S3 land having limitations that, in aggregate, are so severe that expenditure on the land use will be only marginally justified.

Within the order Not Suitable, there are two classes:

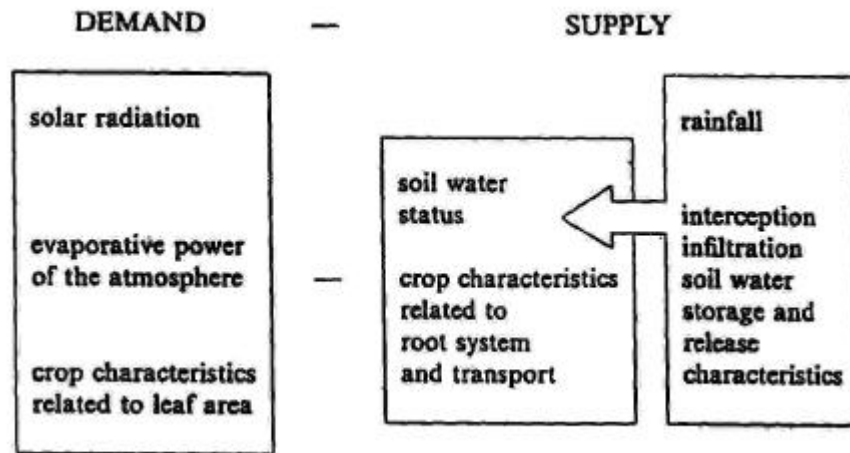
Class N1 Currently not suitable. This land could be used for the purpose under consideration but the social or economic cost is, at present, unjustified;

Class N2 Permanently not suitable. Land having limitations that appear so severe that sustained use is not possible.

- ◆ Land suitability subclasses. These reflect the kinds of limitations, e.g. water deficiency, erosion hazard - S2w, S3e. There are no subclasses within S1.

- ◆ Land suitability units. These are subdivisions of a subclass which differ in their response to management. Units are significant at the farm level. They are distinguished by arabic numbers, e.g. S2e - 1, S2e - 2.

Figure 12: Schematic Model for the Land Quality *Sufficiency of Water*



The clarity of thinking behind the FAO Framework has had a profound influence on land evaluation, paving the way for quantitative modelling. But early applications were qualitative and used the same kind of matching technique between land and land use requirements as in Land Capability. Typically, one or more diagnostic land characteristics have been used as surrogates for land qualities (e.g. Table 9).

A refinement is to begin with a cropping calendar for the land use type and, from this, establish critical periods of the year for different qualities, e.g. trafficability at sowing and harvest, a dry spell for ripening and so forth (see Hackett 1988 who also outlines the expert procedure for judging the severity of individual limitations on crop performance).

In the absence of short cuts that can be taken only by an experienced 'old hand', the procedures recommended by the series of FAO Guidelines for land evaluation (for rainfed agriculture, FAO 1984a; forestry 1984b; irrigated agriculture 1985; and extensive grazing 1991) are time-consuming and opaque. The end product of a qualitative evaluation - that a parcel of land is, say, suitability class S2s for sorghum but class S3s for cotton - is not a lot more interesting to a farmer or a policy maker than news that it is in land capability class IIIs.

Another principle of the FAO Framework is the comparison between land use and land in terms of *benefits* yielded with *inputs* needed. If this comparison is to be made in financial or economic terms, then suitability classes have to be calibrated in terms of yield or other outputs and the inputs needed. This has not been done often. The magnitude of the task is illustrated by the recent agroecological land resource assessment for agricultural development planning for Kenya (Kassam *et al.* 1991, Box 17). Even though the scale of mapping was only 1:1 million, the study involved a GIS with some 91 000 unique records (in terms of the land and climatic characteristics considered), five principal computer programs, and a nine volume final report weighing 3.3.kg !

Table 9: Qualitative Application of the FAO Framework for Land Evaluation: Example of Land Requirements for Bunded Rice, Sri Lanka

(Source: Dent & Ridgway 1986)

LAND QUALITIES	DIAGNOSTIC LAND CHARACTERISTICS	LIMITING VALUES FOR LAND CHARACTERISTICS			
		S1	S2	S3	N
Sufficiency of energy	Mean annual temp, °C	>24	21 - 24	18 -21	< 18
	Elevation, m*	0 - 600	600 - 1200	1200 - 1800	> 1800
Sufficiency of water	75% probability rainfall, mm	> 1300	900 -1300	500 - 900	< 500
	Soil drainage class	Poorly drained	Imperfectly drained	Well drained, Moderately well drained	Excessively drained
	Soil texture	C,SC,SCL,L	SC,SCL,SL	SL	S,LS
	Soil depth, cm	> 80	60 -80	40 - 60	< 40
Sufficiency of nutrients	pH of flooded soils	6 - 7	5 - 6	4.5 - 5	< 4.5
			7 - 8	8 - 8.5	> 8.5
Salinity hazard	EC _e , mS cm ⁻¹	< 3	3 - 5	5 - 7	> 7
Ease of water control	Slope angle, degrees	< 1	1 - 2	2 - 6	> 6
Ease of cultivation	Stones and rock outcrops, %	nil	1 - 5	5 - 10	> 10

* Elevation is used to assess sufficiency of energy where temperature data are not available.

Box 17: Semi-Quantitative Land Evaluation for Kenya

Computer databases for agroclimate and soils were established. Then for 64 crop types, pastures and two types of fuelwood at high, middle and low levels of inputs, yields were estimated using the FAO agroecological zones method (Kassam 1977, FAO 1978) as follows:

- (i) Maximum attainable yield was modelled using data for photosynthetically active radiation, crop life cycle, and the crop's photosynthetic efficiency less its respiration requirements. Total biomass production was partitioned between harvested and non-harvested parts. References to the derivation and testing of the models are not presented, so values for maximum attainable yield have to be taken on trust.
- (ii) The maximum attainable yields were then de-rated according to the extent to which the thermal and growing period requirements of the crop are met. Length of growing season was calculated as the period during which rainfall is \geq half evapotranspiration calculated by the Penman method.
- (iii) The climatically-attainable yields were further de-rated according to soil constraints that affect sufficiency of aeration, water and nutrients; salinity/sodicity; and slope.
- (iv) Hazard of soil erosion was modelled for each crop management/soil combination and further de-rating of yields applied according to the forecast effect on nutrient and water supply.

For each de-rating step, constraints were allocated by expert judgement into five classes:

S1	yield reduction < 20%
S2	20-40%
S3	40-60%
S4	60-80%
N	yield reduction of > 86%

For livestock production, further assumptions were made about conversion of pasture production to livestock products.

The interpretations of the soil data are problematic in two ways. First, the soil mapping units of the Exploratory Soil Map of Kenya, scale 1:1 million (Sombroek *et al.* 1982) are associations of several contrasting kinds of soil. For each of the 392 mapping units, the percentage composition of each component was estimated (van der Pouw 1983) but this proportion has to be applied equally to every part of that unit. Secondly, the soils were defined and mapped according to their morphology, not according to water-supplying and nutrient-supplying capacity. The key land qualities were estimated from derived information on soil, texture, stoniness, depth, salinity/sodicity and slope.

No evidence of local calibration of crop, fuelwood and livestock production is presented. The study appears to be a desk exercise. However, the production estimates for each land/crop/management combination have been made on a consistent basis and do permit a crude economic evaluation of land use options over the whole country. Storage of the data in a GIS facilitates recombination of different elements of the information and any part of the computer programs and corresponding data sets can, in principle, be modified in the light of new knowledge and/or new objectives.

Source: Kassam *et al.* 1991

Unavoidable problems of economic evaluations are that costs and prices are themselves ephemeral, and that performance depends on management as well as land qualities. The effectiveness of management is difficult to forecast and its ability to cope with problems - physical, social and economic - is not assessed in land evaluation.

These problems can be overcome to an extent if the data about land qualities is stored in a GIS and computer software is written to recalculate physical and economic suitability from updated information. A simple and readily-available example is the ALES computer program (Rossiter and van Wambeke 1993) that can perform the computation of physical and financial suitability from decision rules entered by the investigator. By this means, any new or revised parameter can be taken account of and the re-evaluation undertaken quickly. Similarly, evaluations can be performed for a range of possible future scenarios.

5.3.3 The USBR System

The Land Classification System of the Bureau of Reclamation of the US Department of the Interior (USBR 1953) was developed for planning irrigation projects. It classifies land in terms of its payment capacity - the money remaining for the farmer after all costs except water charges are met and after making an allowance for family living costs. This was an early attempt to integrate physical and financial criteria of land suitability and was the standard method of evaluation for irrigation projects for more than 30 years.

Once again, expert judgement is brought to bear to identify specific limits of land, soil and water characteristics that determine the payment capacity. This has to be done separately for each individual irrigation scheme, according to the technical and economic setting (Table 10).

Classes 1 to 3 have progressively lower positive payment capacities; class 4 designates restricted land use or special engineering needs; class 5 is a holding class pending further investigation; and class 6 is not suitable for irrigation, as it doesn't pay. Classification proceeds directly by survey of the relevant land characteristics and USBR prescribe the scale, accuracy and survey intensity for different purposes. Mapping units are identified by a compound symbol (Figure 13). The USBR system works only for a single use within a specific scheme. The parameters change from scheme to scheme and, also, as costs and farm gate prices change with time.

Figure 13: USBR Compound Mapping Symbol

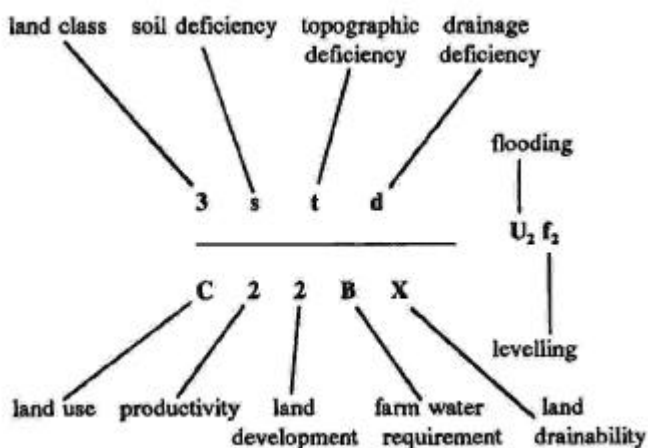


Table 10: USBR Land Class General Specifications

(Source: Landon 1984)

Land characteristics	Class 1 - arable	Class 2 - arable	Class 3 - arable
<u>Soils</u>			
Texture	Sand loam to friable clay loam	Loamy sand to very permeable clay	Loamy sand to permeable clay
Depth (measurements in cm): To sand, gravel or cobble	90 plus - good free working soil of fine sandy loam or finer; or 105 of sandy loam	80 plus - good free working soil of fine sandy loam or finer; or 75-90 of sandy loam to loamy sand	45 plus - good free working soil of fine sandy loam or finer; or 60 to 75 of coarser-textured soil
To shale, raw soil from shale or similar material (15 less in each to rock and similar material)	150 plus; or 135 with minimum of 15 of gravel overlying impervious material or sandy loam throughout	120 plus; or 105 with minimum of 15 of gravel overlying impervious material or loamy sand throughout	105 plus; or 90 with minimum of 15 of gravel overlying impervious material or loamy sand throughout
To penetrable lime zone	45 with 150 penetrable	35 with 120 penetrable	25 with 90 penetrable
Alkalinity	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent	pH 9.0 or less, unless soil is calcareous, total salts are low and evidence of black alkali is absent
Salinity	Total salts not to exceed 0.2%. May be higher in open permeable soils and under good drainage conditions	Total salts not to exceed 0.5%. May be higher in open permeable soils and under good drainage conditions	Total salts not to exceed 0.5%. May be higher in open permeable soils and under drainage conditions
<u>Topography</u>			
Slopes	Smooth slopes up to 4% in general gradient in reasonably large-size bodies sloping in the same plane	Smooth slopes up to 8% in general gradient in reasonably large-size bodies sloping in the same plane; or rougher slopes which are < 4% in general gradient	Smooth slopes up to 12% in general gradient in reasonably large-size bodies sloping in the same plane; or rougher slopes which are < 8% in general gradient
Surface	Even enough to require only small amount of levelling and no heavy grading	Moderate grading required but in amounts found feasible at reasonable cost in comparable irrigated area	Heavy and expensive grading required in spots but in amounts found feasible in comparable irrigated areas
Cover (loose rocks and vegetation)	Insufficient to modify productivity or cultural practices, or clearing cost small	Sufficient to reduce productivity and interfere with cultural practices. Clearing required but at moderate cost	Present in sufficient amounts to require expensive but feasible clearing
<u>Drainage</u>			
Soil and topography	Soil and topographic conditions such that no specific farm drainage requirement is anticipated	Soil and topographic conditions such that some farm drainage will probably be required but with reclamation by artificial means appearing feasible at reasonable cost	Soil and topographic conditions such that significant farm drainage will probably be required but with reclamation by artificial means appearing expensive but feasible
<u>Class 4 - limited arable</u>			
Include lands having excessive deficiencies and restricted utility but which special economic and engineering studies have shown to be irrigable			
<u>Class 5 - non-arable</u>			
Includes lands which will require additional economic and engineering studies to determine their irrigability and lands classified as temporarily non-productive pending construction of corrective works and reclamation			
<u>Class 6 - non-arable</u>			
Includes lands which do not meet the minimum requirements of the next higher class mapped in a particular survey and small areas of arable land lying within larger bodies of non-arable land			

5.3.4 Parametric Indices

Parametric methods of land suitability assessment consider just a few key properties of the land and assign to each property a numerical value. The valuations of individual factors are then combined in a mathematical equation that produces a single numerical expression of performance or a relative index. The criteria for selection of key properties, their valuation and combination are, again, defined by experts.

The underlying assumption is that land suitability or performance is determined by only a few *significant* factors. The effect of each individual significant factor is expressed as a response function. Driessen and Konijn (1992) give the example of the single land characteristic *depth of soil* which is positively correlated with production, strongly so when the soil is shallow and tending to an asymptote when the depth approaches the unrestricted rooting depth of the crop. An index which expresses the sufficiency of depth of soil on a scale of 0 to 1 could be:

$$SDI = (1 - \exp(-t \cdot SD))$$

where SDI is soil depth index,
t is a crop-specific coefficient (cm^{-1}),
and SD is depth of soil (cm).

All relations and the values of all coefficients have to be established by experiment or field calibration. Once each significant factor has been evaluated, all the single factor indices are combined, either by multiplication or some more complex mathematical function to produce a single expression of system performance.

The best known parametric system is the Storie Index (Storie 1933, 1978) (Box 18), but there is a host of systems and many have provided locally useful results. The Bonitierungskala (Fackler 1924) was established to rate land for taxation purposes, originally in Bavaria, later throughout Germany. The Storie Index classifying land for irrigated citrus in California has been revised locally many times and there are versions for, e.g. Columbian and Spanish orchards.

Subjective, even arbitrary, decisions are taken by the expert at several stages: the selection of properties to be used, the valuations of each factor, the formulation of the equation and, not least, the translation of the final numerical value into planning or operational terms. The Storie Index illustrates common shortcomings of these methods: it uses compound factors, such as character of soil, which include factors that are used again and are not independent variables. Above all, the functions are developed and tested for one application, in one area and at one time. They do not travel well. Tests must be done anew before each application but, often, they are not.

From the point of view of the land use planner, the system is easy to apply by a non-specialist. But the final numbers appear as if by magic; the assumptions are hidden; the logic is difficult to retrace. If performance really is dependent on just a few characteristics, surely it is better to say so explicitly ?

Probably, parametric indices represent an evolutionary dead end in land evaluation, although they represent the beginnings of calculation. Future developments lie in, on the one hand, more transparent expert systems and, on the other hand, quantitative modelling of physiological processes.

Box 18: The Storie Index

The Storie Index Rating is given by:

$$\text{SIR} = A \times B \times C \times X$$

Character of soil profile Texture of surface soil Slope Miscellaneous factors

Each factor is scored as a percentage but multiplied as a decimal. The final index is expressed as a percentage. Where more than one property is considered, as in factor X, each is also scored as a percentage, then all are multiplied together as decimals and expressed as the combined percentage for that factor.

Examples of ratings from the most recent revision (Storie 1978) follow:

FACTOR A - Rating on character or physical profile

		Percent
I	Soils on recent alluvial fans, flood plains, or other secondary deposits having undeveloped profiles	100
	x shallow phases (on consolidated materials) 60 cm deep	50 - 60
	x shallow phases (on consolidated materials) 90 cm deep	80
	g extremely gravelly subsoils	80 - 90
	s stratified clay subsoils	80 - 95
II	Soils on young alluvial fans, floodplains, or other secondary deposits having slightly developed profiles	95 - 100
	x shallow phases (on consolidated material) 60 cm deep	50 - 60
	x shallow phases (on consolidated material) 90 cm deep	70
	g extremely gravelly subsoils	80 - 95
	s stratified clay subsoils	80 - 95
III	Soils on older alluvial fans, alluvial plains or terraces having moderately developed profiles (moderately dense subsoils)	80 - 95
	x shallow phases (on consolidated material) 60 cm deep	40 - 65
	x shallow phases (on consolidated material) 90 cm deep	60 - 75
	g extremely gravelly subsoils	60 - 90
IV	Soils on older plains or terraces having strongly developed profiles (dense clay subsoils)	40 - 80
V	Soils on older plains or terraces having hardpan subsoil layers	
	at less than 30 cm	5 - 20
	at 30 to 60 cm	20 - 30
	at 60 to 90 cm	30 - 40
	at 90 - 120 cm	40 - 50
at 120 - to 180 cm	50 - 80	
VI	Soils on older terraces and upland areas having dense clay subsoils resting on moderately consolidated or consolidated material	40 - 80

Box 18: Continued.

<p>VII/ VIII</p> <p>IX</p>	<p>Soils on upland areas underlain by hard igneous bedrock/consolidated sedimentary rocks</p> <p>at less than 30 cm</p> <p>at 30 to 60 cm</p> <p>at 60 to 90 cm</p> <p>at 90 to 120 cm</p> <p>at 120 to 180 cm</p> <p>at more than 180 cm</p> <p>Soils on upland areas underlain by softly consolidated material</p> <p>at less than 30 cm</p> <p>at 30 to 60 cm</p> <p>at 60 to 90 cm</p> <p>at 90 to 120 cm</p> <p>at 120 to 180 cm</p> <p>at more than 180 cm</p>	<p>10 - 30</p> <p>30 - 50</p> <p>50 - 70</p> <p>70 - 80</p> <p>80 - 100</p> <p>100</p> <p>20 - 40</p> <p>40 - 60</p> <p>60 - 80</p> <p>80 - 90</p> <p>90 - 100</p> <p>100</p>
	<p>FACTOR X: EXAMPLES:</p> <p><u>Alkali</u>: according to degree</p> <p><u>Nutrient (fertility level)</u>: according to degree</p> <p><u>Acidity</u>: according to degree</p> <p><u>Erosion</u>: according to degree</p>	<p>5 - 100</p> <p>60 - 100</p> <p>80 - 95</p> <p>30 - 100</p>
<p>An example of the calculation of the SIR for the Altamount soil map unit in California is:</p>		
<p>FACTOR A</p> <p>FACTOR B</p> <p>FACTOR C</p> <p>FACTOR X</p>	<p>Altamount series brown upland soil, shale parent material, bedrock at 90 cm. Profile group VIII.</p> <p>Clay loam texture.</p> <p>Rolling topography.</p> <p>Moderate sheet erosion with shallow gullies.</p>	<p>70 %</p> <p>85%</p> <p>90%</p> <p>70%</p>
<p>Index rating = 0.70 x 0.85 x 0.90 x 0.70 = 0.37, reported as 37%</p>		
<p>A soil map can be annotated with SIRs, if necessary weighted according to the areal proportion of different soils within compound map units. SIR ratings can also be converted to ranked categories.</p> <p>Source: McRae and Burnham 1981</p>		

5.3.5 Knowledge-based Systems

Dent (1993) and Bouma *et al.* (in press) have argued that more transparent knowledge-based or *expert systems* should be built to answer specific land use questions. Each step in the decision-making process is flagged, the rules for making the decision are laid down explicitly, and the evidence on which the current decision is based is also presented. Then, by using the system, it is expected that the user will become more expert and can change the rules and bring in additional land evidence to reach better decisions than the expert who originally devised the system.

While computing power greatly enhances the scope of expert systems, it is not a prerequisite. Figure 14 illustrates a manual system to provide a practical guide to afforestation in North Yemen. PLANTGRO (Hackett 1991) is an example of a computer-based system.

5.4 Process Models

The Penman-Monteith formula is an expression of a physically-based process model that relates evaporation from short grass to solar radiation, wind and relative humidity. Many other physical models find application in the various specialist disciplines of natural resources science. More recently, process models have been developed to predict crop production, risk, hazards of use or inputs needed for a land use type by combining a large number of individual sub-models like the Penman-Monteith model. Models with a sound physical basis have a wider potential application than analogue models or empirical (expert) knowledge. In particular, they are quantitative and dynamic. They can, in principle, provide probabilistic predictions of, say, crop yield or profit under a range of management practices (Jones 1990). For example, Huygen *et al.* (1990) have used the WOFOST (Centre for World Food Studies) simulation model (Box 19) to assess the riskiness of improved technology maize production in Zambia.

At present, simulation models are complex; their data requirements exorbitant. Their development and maintenance consume scores of man years of research time in well-founded institutions. A great deal of work is needed to develop and validate the models, and their thirst for quantitative data on specific land qualities cannot yet be matched by data available from natural resources surveys or knowledge of farming systems. However, these are not good reasons to dismiss their relevance to decision-support systems in developing countries with limited data bases and cash-starved scientific institutions. If the data are not available for simulation models, they are not available either for empirical models, hybrid methods like the FAO Agro-ecological zones approach (FAO 1978), or expert judgement.

There is a need for innovative research into simpler yet realistic models. There is also need for surveys to provide quantitative data on the spatial distribution of relevant individual soil characteristics (like texture and soil depth) rather than taxonomic units; topographic characteristics (like slope angle, roughness and length of slope) rather than land systems or landform units; specific agrometeorological and hydrological characteristics, and so on.

The present state of the art in simulation modelling is comparable to that in geographic information systems. They are active and exciting research fields needing scarce and costly staff and equipment. Linking them will greatly increase their applications in land use planning - data can be re-analysed and presented anew almost instantly when conditions change, or to meet specific client needs, and to incorporate estimates of risk into assessments (e.g. for cropping in areas with marked climatic variability). Oh, brave new world!

Figure 14: Key to Forest Planting Sites in the Central Highlands, Montane Plains of North Yemen

(Source: Dent & Murtland 1990)

		Q1. SOIL DEPTH 60cm OR MORE, SLOPE TERRACED? (on hillsides)																			
		YES										NO									
		Q2. SLOPE 6° to 11° WITH STONE TERRACE WALLS OR REMNANTS?										Q1(a) Rainfall <400mm?									
		YES					NO					YES		NO							
		Q2(a) Rainfall <400mm?		Q3. SLOPE 2° TO 6°?																	
		YES	NO	YES			NO														
				Q4. FROST FREE: 'Qat' GROWN EXTENSIVELY?			Q.5 SLOPE 2° OR LESS, CALCIC HORIZON PROMOUNCED & WITHIN 50cm SURFACE?														
				YES	NO		YES	NO		YES	NO		YES	NO							
				Q4(a) Rainfall <400mm?		Q6 Frost slight, 'Qat' grown with protection in cold season?		Q5(a) Frost free?		Q5(b) Frost free?											
				YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO						
				Q6(a) Rainfall <400mm?		Q7. Frost mod. to severe?		Rainfall <400mm?	Rainfall <400mm?	Rainfall <400mm?	Rainfall <400mm?										
				YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO						
						Q7(a) R.fall <400mm	Q7(b) R.fall <400mm														
				YES	NO	YES	NO														
Qualifying remarks		Steep terrd. hillside, frost free		Mod. to steep hillside, earth bunds		Hilly, subject to some frost		Ridges & hills on edge of frosty plain		Frost-free		Frost-free plains & wadies to west		High Montane Plains		Frost-free plains & wadies to west		Ridges and hills on edge of frosty plain		Hillside too steep (slope >11°) and costly to prepare for planting	
Site Classification		1	2	1	2	3	4	5	6	1	2	7	8	9	10	1	2	5	6	11	12

See explanatory notes

Explanatory notes to Figure 14

a	mean annual rainfall <400 mm
fs	slight frost
fms	mod/severe frost
c	continuous calcic horizon
vs	steep (slope > 11°)

1	S1	Most suitable. Frost free, rainfall over 400 mm
2	S1a	Suitable with limitations due to rainfall (less than 400 mm). Frost free
3	S2 fs	Suitable with limitations due to slight frost. Rainfall over 400 mm
4	S2 a fs	Suitable with limitations due to slight frost and rainfall (less than 400 mm)
5	S3 fms	Limited suitability due to frost (moderate to severe). Rainfall over 400 mm
6	S3 a fms	Limited suitability due to frost (moderate to severe) and rainfall (less than 400 mm)
7	N1 c	Currently not suitable due to calcic horizon. Rainfall over 400 mm, frost free
8	N1 a c	Currently not suitable due to calcic horizon and rainfall (less than 400 mm); frost free
9	N2 c fms	Not suitable due to calcic horizon and frost (moderate to severe). Rainfall over 400 mm
10	N2 c fms	Not suitable due to calcic horizon, frost (moderate to severe) and rainfall (less than 400 mm)
11	N2 vs	Not suitable due to steep slope and lack of soil. Rainfall over 400mm
12	N2 a vs	Not suitable. Rainfall less than 400 mm, steep slope and lack of soil

Data from several years of species trials were correlated with site characteristics. Key site characteristics such as frost incidence and severity and sufficiency of water were established; then locally-observable surrogates were identified - qat cultivation for frost hazard, indications of former terracing and landform for sufficiency of water.

Sites can be keyed out by local technical staff. Suitable species and their planting and management recommendations are provided for each of the site classes.

Box 19: The WOFOST Crop Simulation Model

WOFOST simulates the production of annual crops by modelling their growth from emergence to maturity. Three situations are defined:

- (1) potential production under optimum water and nutrient supply under a given temperature regime;
- (2) water-limited production under that temperature regime and optimum nutrient supply;
- (3) nutrient-limited production or, alternatively, fertilizer requirement for optimum production.

For potential production, the net daily increase in dry matter as a result of assimilation and respiration is calculated according to agroclimatic conditions, green leaf area, biomass and stage of phenological development.

Water-limited production is calculated through models of water sufficiency, according to the crop's tolerance of drought.

For both of these situations, calculations are performed on a daily basis throughout the growing season. Allowance for nutrient limitation is empirical and made for the growing season as a whole.

The data requirements, in summary, are:

Crop species, climatic and soil type (the package comes with data from representative weather stations, soils and crops);

Site information, e.g. initial water status, depth to groundwater, nature of soil surface and soil nutrient status;

Agroclimatic data converted to daily values of minimum and maximum temperature, potential evaporation, rainfall;

Soil physical data including soil water retention and unsaturated hydraulic conductivity;

Nutrient data, for example uptake rates of N, P and K from unfertilized soils;

Crop data, especially properties determining assimilation and respiration rates and rate of phenological development.

Further assumptions have to be made to translate the modelled yield into a realistic estimate of production, for example incidence of disease, losses to pests, water losses or gains by runoff and runoff.

Sources: Rappoldt *et al.* (1986), van Diepen *et al.* (1989)

5.5 From Land Evaluation to Land Use Planning

Land users have always made land use plans, whether formally or informally. There is also a long history of sectoral planning. All this has been *ad hoc*, for individual farms, plantations, forests or parks, or narrow sectoral purposes - water resources development, roads, etc. While no clearly-defined planning methodology is discernable, conventional approaches have developed within individual sectors. For instance, meeting objectives for both wildlife conservation and development has been greatly assisted through designating particular management categories. Most countries follow the categories defined by IUCN (1982):

- I Scientific reserve/strict nature reserve
- II National park
- III Natural monument/natural landmark
- IV Managed nature reserve/wildlife sanctuary
- V Protected landscape or seascape
- VI Resource reserve
- VII Natural biotic area/anthropological reserve
- VIII Multiple use management area/managed resource area
- IX Biosphere reserve
- X Natural world heritage site

It is usual to prepare management plans for protected areas designated within these categories. These tend to adopt a standard approach providing baseline information (e.g. on landscapes, fauna, flora) and including prescriptions for use and development covering, for example, zoning, visitor management, resource management (e.g. fire control, game cropping, hunting quotas), research, infrastructure, education, etc. The master plans for national parks and wildlife management in Malawi are an excellent example (Clarke 1983).

In the forestry sector, many countries have designated areas in various categories (e.g. protected forest areas, forest reserves, plantations) and have prepared management plans for such areas. Recently, legal categories have been defined for forests and forest lands by functions and by conditions (ITTO 1993):

- 1 Protection forests
 - 1.1 Protection forests on fragile land
 - 1.2 Forests set aside for plant and animal species and ecosystem preservation
 - 1.3 Totally protected areas
- 2 Production forests
- 3 Conversion forests

Frequently, protected forests are also designated as protected areas under the IUCN protected area categories. There are no universally agreed criteria for preparing management plans for these and other forest categories. Usually, plans describe the forest types and percentage cover, the standing stock, management objectives, logging quotas, controls and plans for regeneration/replanting.

Such planning is often effective within its own narrow terms of reference, so long as the planning agency is also the executive agency and has some freedom of action; and so long as there are few conflicts of interest. Land use planning has been most effective and, sometimes, successful in settlement of empty land and in new plantation and irrigation developments. In these cases, administrative or engineering concerns have been paramount. Limited natural resources information has been used to guide the physical layout of farms, roads and the water distribution system and in the choice of crops. A good example is the work by Hunting Technical Services (1980/81) for the Mahaweli irrigation development in Sri Lanka (Dent and Goonewardene 1993). Social aspects have received generally less attention, in some cases leading to conflict, e.g. the case of Barabaig pastoralists affected by the Tanzania-Canada wheat production scheme in Hanang District, Tanzania (Box 20).

Management of natural resources is much more difficult when there are many independent decision-makers and management units, several sectoral and administrative authorities, and conflicts of interest between the various stakeholders. This situation is typical of local-level land use plans undertaken by district or provincial teams within the Department of Agriculture or an Integrated Rural Development Plan.

The techniques have been adapted from farm planning and small-scale engineering development for settler farms, often based on a soil or land capability survey. Several national or departmental manuals have been drawn up and these show strong family relationships. For example, the manuals of the Land Use Services Division (1970) - later the Land Use Branch (Zambia Dept.Agric. 1977) in Zambia, and by Shaxon *et.al.* (1977) in Malawi, evolved out of earlier manuals prepared by the Department of Conservation and Extension (CONEX) of the Federation of Rhodesia and Nyasaland. In Zambia, for example, land use plans follow a conventional format covering description of area, history, physical conditions, resources, population, communications, present land use, assessment of agricultural potential, proposals for land use, plot demarcation, bush clearing, extension program, roads, water supplies, soil conservation, staff and housing, economic appraisal, etc. Good examples are the North Nyamphande Settlement Scheme (Wilson and Bourne 1971) and the Msandile Catchment Plan (Wilson and Priestley, 1974).

The difficulties of implementing land use plans in settled areas that have inherited many and complex problems of land use have already been mentioned in Chapter Three. These difficulties stem from conflicts of interest within local communities, between government and local people and, not least, the failure of professional planners and administrators to comprehend and respect these different goals. These various problems are exemplified by the case of the Barabaig in Tanzania (Box 20). There have also been difficulties in getting several agencies to work together and, often, a lack of technical solutions to land use problems that are practicable, profitable and easily-incorporated into existing farming systems.

Box 20: The Case of the Barabaig

In 1970, in response to an expected increase in demand for wheat in Tanzania, and with financial and technical support from Canada, the government - through the National Agricultural and Food Corporation - initiated a wheat production project which covers 100 000 acres of the volcanic Basotu plains, 12% of Hanang district (see Figure 15). The scheme is highly mechanised and based on the mono-cropping of hybrid wheat varieties along the lines of prairie wheat farming in Canada.

The areas of land appropriated by the scheme are also used for dry season communal grazing by the Barabaig, a tribe of semi-nomadic pastoralists who number more than 30 000 in Hanang district. Each household manages its herd to maximise production of milk, meat and occasionally blood. But they do not exist on a purely pastoral diet and maize is obtained through exchange or sale of livestock, and from shifting cultivation by households with the help of communal labour provided by relatives and neighbours.

The Basotu plains are characterised by drought and lack of permanent water supplies. Therefore, the use of these plains by the Barabaig involves trade-offs between the productivity and stability of grassland production in different areas and by constraints of water availability and the incidence of tsetse flies. The sustainability of the pastoral system is critically dependent on a flexible response to changing patterns of resource availability; opportunistic natural resource use that allows for the exploitation of key resource patches (e.g. wet depressions, river and lake margins) at particular periods. The Barabaig have developed their own natural resource management strategy which includes: traditional seasonal grazing rotation; grazing management; tsetse control measures (e.g. burning bushland); controlling resource access (common property management); and customary regulations to control degradation (e.g. banning settlements in certain areas).

However, there are limits to the ability of traditional Barabaig practices to cope with changing circumstances. The removal of access to *muhajega* grazing resources (depressions on the plains which provide important dry season fodder) through the appropriation of land for the wheat project has increased pressure on other resources, resulting in land degradation. Despite the fact that some Barabaig were resident in the area appropriated, and that the *muhajega* were a vital forage resource, this land was described as "idle" during the project assessment (Young 1983).

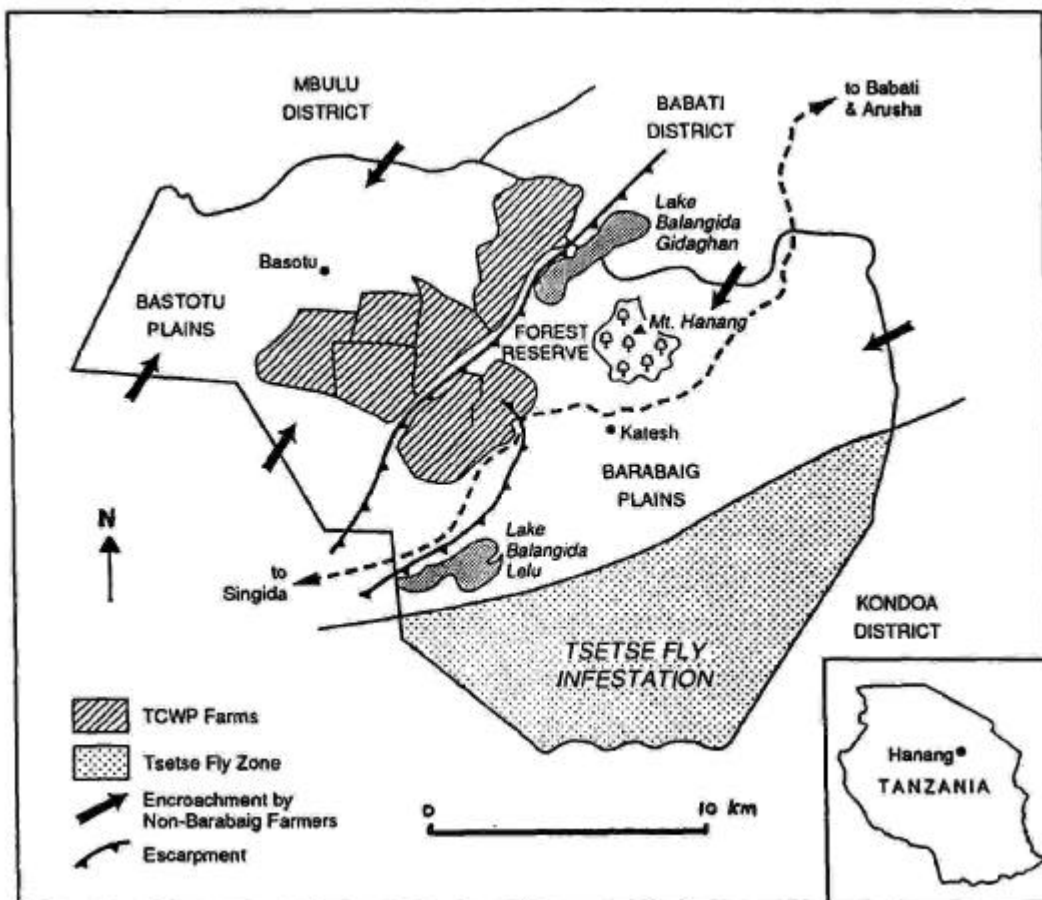
According to the Barabaig, cattle populations in areas adjacent to the wheat farms have declined by about 30% over the past seven years, whilst productivity of the remaining herds has declined due to the loss of land. Traditional burial sites have been ploughed up, causing considerable cultural discontent.

The loss of *muhajega* has forced the Barabaig to adopt a new grazing pattern and to rely more heavily on the remaining forage areas, particularly in times when they would otherwise be rested from grazing. As a result, they are more intensively used during the critical regeneration period. There is increasing pressure to utilise more intensively those areas which have low resource potential, e.g. the rift escarpment which has shallow soils on steep slopes, and the tsetse infested bushland. This will inevitably result in further soil erosion and reduced production.

The mechanised wheat farming, with no provision made for soil conservation measures, has also caused considerable soil erosion and siltation of water courses.

The wheat project assessment was inadequate on two important counts. Firstly, it overestimated the potential economic returns of the scheme. Secondly, the assessment ignored the opportunity costs of reductions in land to the pastoral system.

Figure 15: Map of Hanang District, Tanzania, Showing Major Land Use Features



Box 20: Continued.

The changes in pastoral land use induced by the establishment of the wheat scheme have resulted in a range of environmental impacts:

RESOURCE TYPE

IMPACT

Upland Range Resources

Plains
Hills/mountains
Bushland

Decreased perennials
Soil loss
Bush clearance

Bottomland Key Resources

Muhajega (depressions or plains)
River and lake margins

Gully erosion in cultivated land
Heavy grazing and soil erosion, puddling

Source: Lane & Scoones (1991)

5.5.1 FAO Guidelines for Land Use Planning

Guidelines for Land Use Planning (FAO 1993 in press) lays out a planning procedure that can be applied at field or global level, and drawing on the often painful experience of formal land use planning over the last 25 years (Dent 1988, 1991a & b). It lays out how to define goals, identify opportunities and constraints; integrate diverse strands of physical and socio-economic information to devise a range of land use options and to choose between these. Box 21 outlines the steps involved. The diagram implies steady progress from one step to another but, in practice we often have to retrace over steps to take account of new information, changing conditions or new goals. Figure 16 may be nearer to the truth.

The crucial question remains, who shall be responsible for each step? As Brinkman (1993) has pointed out, there has to be a platform for negotiation between the different interest groups where goals can be agreed, problems prioritized and responsibilities for action allocated by consensus. And this requires democracy of information, including information about natural resources (Dent *et al.* 1993).

5.5.2 Integrated Land Use Models

The technical difficulties of handling and combining large amounts of diverse data have severely limited the use made of natural resources information. If decisions are to be taken on rational grounds, decision-makers must weigh the natural resources information along with economic and social imperatives. Usually, the balance is struck intuitively according to the information available to, and understood by, the decision-maker at the time.

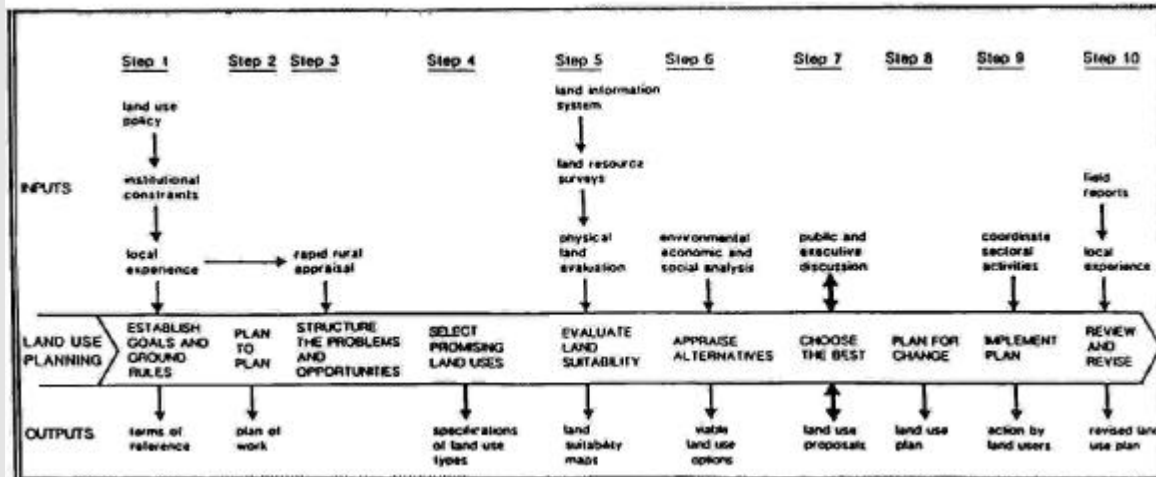
The power of economics in decision-making lies in its reduction of many variables to a single measure - money - and the general acceptance of a limited range of measures of project worth (net present value, benefit-cost ratio, internal rate of return). Natural resources information has not been fully used by decision-makers in government and international aid institutions because it is not easily condensed into single financial terms. Air, water and soil, for example, are often treated as free resources in economic planning. This problem has quite recently been addressed by the growing discipline of environmental economics which seeks to develop economic measures of environmental resources and ways of incorporating these measures into decision-making. For accessible introductions, see Pearce *et al.* (1990), Pearce (1991), Turner (1985) and Turner *et al.* (1993).

The problem of dealing with a welter of detailed land resource information has been addressed through mathematical programming techniques that can be carried out by computers and can be linked to geographic information systems. The LUPLAN package, developed in Australia, has three components (Ive and Cocks 1983, 1988; Ive *et al.* 1985; Kessel 1990). First, the area is divided into mapping units or planning areas and information is assembled on these. Secondly, mapping units are rated in terms of their attractiveness for a range of land uses on the basis of different policy guidelines. These ratings express the relative contribution that each mapping unit can make to the achievement of each specified policy. Third, the relative importance of different policy guidelines is assessed. This means that the more important (preferred) policies are given greater weight.

LUPLAN can hold individual characteristics of each mapping unit, provide attractiveness ratings for each potential land use, determine the most attractive land use for each mapping unit, and allocate land use on this basis. Output is in the form of percentages which express the extent to which individual land use plans achieve a given policy. Results can be reviewed and votes assigned to

Box 21: Steps in Land Use Planning

(Source: Dent 1988)



DEFINE PROBLEMS

Step 1: Decide what you want to achieve. Establish the present land use situation; find out the needs of the people; agree and specify the goals.

Step 2: Plan to plan. Organise the work needed.

Step 3: Structure the problems and opportunities. Socio-economic and bio-physical considerations should be given equal weight.

MODEL SOLUTIONS

Step 4: Devise alternative solutions. Identify or design alternative land use types that might achieve the goals.

Step 5: Evaluate land suitability. For each promising land use type, establish its land requirements and match these with the qualities of the land.

Step 6: Appraise alternatives. For each well matched combination of land use and land, assess its environmental, economic and social impact.

DECISION

Step 7: Choose the best achievable land use.

Step 8: Draw up a land use plan, allocating land to land use and making provision for appropriate management.

TEST SOLUTIONS

Step 9: Implement the plan. Action by decision-maker, implementing agencies and land users.

Step 10: Learn from the plan. Monitor progress. Revise the plan in the light of experience and to accommodate new goals.

Figure 16: An Experienced Practitioner's View of the Steps in Land Use Planning

Source: Dent (1988)



different policies may be changed. Further runs of LUPLAN can be made until broadly acceptable results are achieved.

Another approach developed by the Canadian group of University of Guelph and Agriculture Canada (e.g. Smit *et al.* 1984, Brklacich *et al.* 1989, Smit *et al.* 1991) also starts with land mapping units and sets of policy objectives or *land use scenarios*. Objectives are quantitatively specified as production targets. Scenarios specify supply-side conditions such as land availability, quality and productivity. The relationships between production potential and needs can be expressed in terms of resource use feasibility, flexibility and sensitivity. Where an area's potential for agricultural

Box 22: Canadian Integral Land Evaluation Procedure: Example of the Use of Quadratic Programming to Appraise Flexibility and Criticality of Land Use

A set of simultaneous functions represent:

- (1) *Constraints* Limitations on resource availability and use. For example availability of land, fuel, fertilizer; goals or targets of production. These are set out first.
- (2) *An objective function* The example chosen simultaneously minimises the proportional allocation of each land use type to each land unit and also the differences between these allocations. If it were found that a large proportion of a land unit must be used in some particular way, this would indicate a very narrow range of feasible alternatives, given the constraints and production targets. Conversely, if only a small proportion of the land unit need be allocated, this would indicate a high degree of flexibility of use.

A general model can be specified in mathematical notation for a planning unit comprising **m** land units in which each land unit may be devoted to one or more of **n** land use types.

For x_{ij} = amount of land unit *j* allocated to use *i*;
 P_{ij} = productivity of land unit *j* for use *i*;
 X_i = supply (or availability) of land unit *i*;
 P_i = goal (or target or requirement) for activity *i*.

The variables x_{ij} are subject to certain constraints:

a) x_{ij} cannot be less than zero: $x_{ij} \geq 0 (1 \leq i \leq n; 1 \leq j \leq m)$

b) Availability constraints, since the amount of land unit *j* utilized cannot exceed the supply:

$$\sum_{i=1}^n x_{ij} \leq X_j (1 \leq j \leq m)$$

c) Goal constraints, which mean that targets must be met for the total output of each land use type:

$$\sum_{j=1}^m P_{ij} x_{ij} \geq P_i (1 \leq i \leq n)$$

d) The objective function, which selects one solution from the feasible set and measures overall flexibility:

$$\text{Min } Z = \sum_{i=1}^n \sum_{j=1}^m x_{ij}^2 / X_i$$

Box 22: Continued

A measure of the *critical importance* of a land unit for a land use type is derived from the solution variables:

$$a_{ij} = x_i/X_j$$

Any a_{ij} approaching zero means that the production targets could be attained without a large proportion of the land unit being needed for a particular land use. Any a_{ij} approaching 1.0 means that it would be very important to have most of that land unit devoted to a particular use to meet the production targets. In the simplified example below, land unit 1 is already critical for agricultural production; land unit 2 becomes critical for agriculture under a substantial growth scenario, and unit 3 under modest growth and substantial-growth scenarios.

LAND UNIT	LAND USE	INDEX OF CRITICAL IMPORTANCE		
		Scenario 1 (base scenario)	Scenario 2 (modest growth in demand)	Scenario 3 (substantial growth in demand)
1	grains	0.55	0.48	0.18
	forage	0.33	0.34	0.76
	fruit, vegetable	0.12	0.18	0.06
	total agriculture	1.00	1.00	1.00
2	grains	0.00	0.00	0.00
	forage	0.06	0.42	1.00
	fruit, vegetable	0.00	0.00	0.00
	total agriculture	0.06	0.42	1.00
3	grains	0.16	0.41	0.46
	forage	0.17	0.58	0.54
	fruit, vegetable	0.00	0.01	0.00
	total agriculture	0.33	1.00	1.00

(Source: Smit *et al.* (1986))

production surpasses projected needs (feasibility), the magnitude of the excess provides a measure of the options for production (flexibility). Should the productive capacity be only a little greater than the need, then there would be little flexibility but to use all resources efficiently. However, if there is considerable excess capacity in the production system, there would be many options (much flexibility). If the capacity for production is less than the need, it is important to estimate the magnitude of the shortfall, so that policies can be developed to make it good.

Neither production potential nor needs are static. The degree of flexibility of a system depends on the conditions and targets specified. Sensitivity refers here to the degree to which flexibility is changed given a change in some variable that influences production potential, needs, or both.

The major characteristics of a production system are specified in the form of constraints and an *objective function* (Box 22). A general model can be specified of a production system comprising resource or land units of different type or quality, where each land unit can be used for one or more activities or land uses

to attain specified levels of production. The solutions or *allocation variables* are subject to constraints on resource availability and product demands and the *objective function* selects from a feasible set a solution that maximises or minimises some function of land allocation. To predict or prescribe the allocation of land use to land, the objective function is set to simulate the dominant allocation process, e.g. maximising profit or minimising outlay.

The procedure has also been used to assess the possible impact of soil erosion (Smit *et al.* 1988), acid rain (Ludlow and Smit 1987), land drainage (Brklacich *et al.* 1987), and climatic change (Brklacich *et al.* 1989).

5.5.3 Local Evolution of Practicable Procedures in Developing Countries

Land use planning procedures range from the sophisticated, as described in the preceding section, to the summary, even arbitrary. Examples of both have been tried in Tanzania, where land use problems arose both from pressure on the land and resettlement of people in new villages located by administrative fiat. The problems were addressed first by an externally-funded resource inventory of Tabora Region. Subsequently, a rigorous village land use planning procedure was developed based on algorithms of carrying capacity, economic viability, livestock carrying capacity and fuelwood availability (Corker 1982). The procedure proved too ambitious in terms of the time and expertise demanded (at least 45 days by an interdisciplinary team per village plan) and also in terms of the resources available to implement desired developments. With the benefit of this experience, a simplified procedure has been evolved (Wheeler *et al.* 1989) involving a much reduced professional input to produce a framework plan that can be fleshed out and implemented by the local Village Council (Box 23).

A problem of this approach is that the villagers themselves are not involved from the outset - the initiative is external - nor in the active gathering and appraisal of data. Furthermore, Village Councils in Tanzania are essentially organs of government and Village Chairmen are political appointees. As a consequence, Council decisions do not necessarily reflect the needs, wishes or aspirations of the village community as a whole.

In Tabora, the planning teams bring in considerable expertise in land resources and planning built up by the externally-funded land use project. Extension of the simplified procedure to other areas without this benefit is unproven. In the absence of external funding, the cost of SPOT imagery has proved prohibitive.

Here we see two continuing problems of local level land use planning:

- 1) an acute shortage of both professional expertise and of resources for both planning and implementation;
- 2) a growing awareness of the need for people's participation in planning without grasping the far-reaching implications of this for political development and professional procedures.

Box 23: Procedure for Framework Village Plans in Tanzania

I Quick appraisal

- i Using air photos or 1:50 000 enlargements of SPOT imagery, delineate village boundaries and measure areas suitable for cultivation and areas actually cultivated.
- ii Collect basic data on population and farming systems.
- iii Discuss local land use problems with village leaders to arrive at a crude appraisal of the match between village land resources and village needs.

This takes a three-man team about four days working in the village. On the basis of such appraisals, priority villages for the next stage of planning can be identified at district level.

II Framework plan

- i Sketch landforms, land use, soils, eroded areas, water sources and tracks on 1:50 000 imagery.
- ii Field check, especially of soils and water sources.
- iii Survey village and sample households to determine population distribution and growth, land holdings, livestock ownership, levels of production and other economic activities.
- iv Assess land suitability and draw up an indicative land use plan. Discuss its implications with the people concerned.

The whole procedure, including the production of a framework plan, involves a three-man planning team over about two weeks, living in the village.







Implementation relies on devolution of authority to the Village Council which resolves conflicts and determines the priorities for development. The resulting framework plan (Figure 17) is its responsibility. It can allocate land according to customary law, lay out individual farm plots, and manage communal land uses such as woodlots and grazing reserves. Locally-developed plans can be implemented because they do not rely on major external inputs.

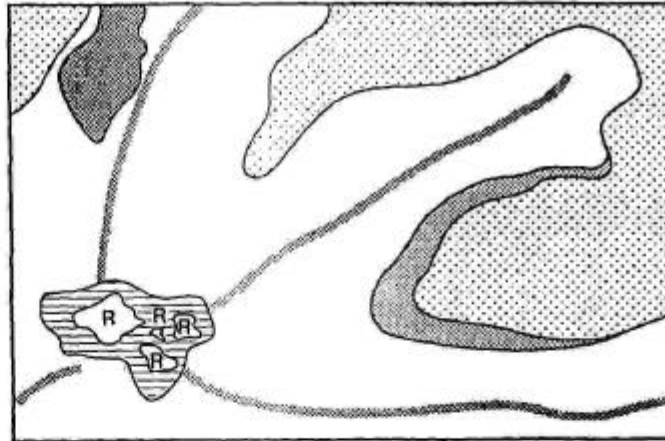
Source: Wheeler *et al.* (1989)

Figure 17: Land Suitability, Present Land Use and Framework Plan for a Village in Tanzania





(After Wheeler *et al.* (1989))

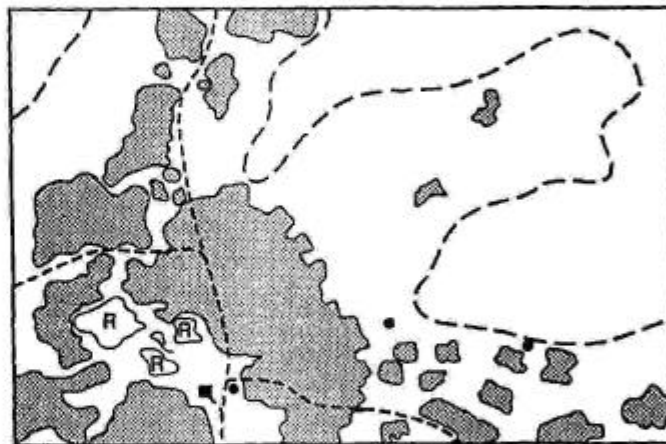
LAND SUITABILITY

-  Upland suitable for cultivation
-  Mbuga
-  Ipwesi (seepage) not suitable for cultivation
-  Hardpan, not suitable for cultivation
-  Steep and rocky
-  Crest line



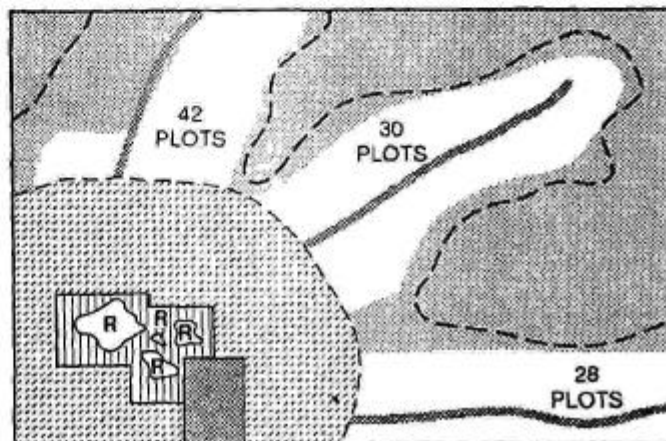
PRESENT LAND USE

-  Cultivation
-  Well
-  School
-  Track



FRAMEWORK PLAN

-  Central cultivated area to remain
-  Proposed clusters and number of plots
-  Grazing reserve
-  Afforestation
-  Service centre
-  Crest line



CHAPTER SIX

PARTICIPATORY PLANNING

6.1 Introduction

People's participation, like sustainability, has become part of the language of development agencies. It is to be found in the public statements and stances of even those agencies which have little to do with people or participation. Adnan *et al.* (1992) observe:

'the meaning of the phrase has become even more elusive after its professed adoption by the most unexpected quarters. It is often difficult to understand whether those talking about people's participation mean the same thing or simply use the phrase as a kind of magical incantation.'

Clearly, participation means different things to different people; and whilst people may mean the same thing, they may actually practise it quite differently. Even more confusingly, people can both mean and practise different things in the name of people's participation. The use of participation for very different purposes has generated widespread confusion. According to Pretty (1993):

'The term *participation* has been used to justify the extension of control of the state and to build local capacity and self-reliance; it has been used to justify external decisions and to devolve power and decision-making away from external agencies; it has been used for data collection and for interactive analysis. In conventional rural and urban development, participation has often centred on encouraging local people to sell their labour in return for food, cash or materials. Yet these incentives distort perceptions, create dependencies, and give the misleading impression that local people are supportive. This paternalism then undermines sustainability goals and produces results which do not persist once the project ceases. As little effort is made to build local skills, interests and capacity, local people have no stake in maintaining structures or practices when the flow of incentives stops.'

Table 11 lists seven types of participation. Care is necessary in both using and interpreting the term which should always be qualified by reference to the type of participation. Clearly, consultation and participation are not the same thing. Top-down consultation by which people are asked to provide facts or opinions, usually about proposals or initiatives drawn up by others, tends to be disillusioning and rarely reveals the full range of information available. Participation means individuals and groups being actively involved in drawing up proposals, identifying needs, and in implementing and monitoring projects.

Both consultation and participation have employed a variety of routes: the formal structures of national and local government; village and traditional communities and groups; round tables, specialist group meetings and non-governmental organisations. Box 24 illustrates several elements of participation by village communities in the defining of priorities for action.

6.2 Participatory Inquiry

Participatory techniques for diagnostic analysis, planning, implementation, monitoring and evaluating development activities (Table 12) are now being used by an array of governmental and non-governmental organisations operating at local level. They are part of a widespread shift of professional attitudes towards the sharing of experience, mutual learning, and flexible yet structured

Table 11: A Typology of Participation

(Source: Pretty 1993, adapted from Adnan *et al.* 1992, Biggs 1989, Eyben & Ladbury 1992 and Paul 1987)

Type	Components
1 <i>Passive Participation</i>	People participate by being told what is going to happen or has already happened. It is a unilateral announcement by an administration or project management without any listening to people's responses. The information being shared belongs only to external professionals.
2 <i>Participation in Information Gathering</i>	People participate by answering questions posed by researchers using questionnaire surveys or similar approaches. People do not have the opportunity to influence proceedings, as the findings of the research are neither shared nor checked for accuracy.
3 <i>Participation by Consultation</i>	People participate by being consulted. External agents define both problems and solutions, listen to views, and may introduce modifications in the light of people's responses. Such a consultative process does not concede any share in decision-making, and professionals are under no obligation to take on board people's views.
4 <i>Participation for Material Incentives</i>	People participate by providing resources, for example labour, in return for food, cash or other material incentives. Much on-farm research falls into this category, as farmers provide the fields but are not involved in the experimentation or the process of learning and have no stake in prolonging activities when the incentives end.
5 <i>Functional Participation</i>	People participate by forming groups to meet predetermined objectives related to the project, which can involve the development or promotion of externally-initiated social organization. Such involvement does not tend to be at early stages of project cycles or planning, but rather after major decisions have been made. These institutions tend to be dependent on external initiators and facilitators, but may become self-dependent.
6 <i>Interactive participation</i>	People participate in joint analysis, which leads to action plans and the formation of new local institutions or the strengthening of existing ones. It tends to involve interdisciplinary methodologies that seek multiple perspectives and make use of systematic and structured learning processes. These groups take control over local decisions, and so people have a stake in maintaining structures or practices.
7 <i>Self-Mobilization</i>	People participate by taking initiatives independent of external institutions. Such self-initiated mobilization and collective action may or may not challenge existing distributions of wealth and power.

analyses. It is not simply the methods themselves, but the combination and sequence in which they are used that make participatory approaches particularly useful. They are designed to generate quickly new information and hypotheses about local conditions and livelihoods, and to elucidate the complexity of local situations.

The participatory approach involves the investigators in self-critical awareness of their own attitudes and behaviour towards the people with whom they work. Rapport, open dialogue and mutual sharing

Box 24: Interactive Participatory Planning in Mali

In Mali, ACORD (A UK-based NGO) attempted to reinforce the participation of non-governmental structures in local planning through a variety of support to informal and formal groups. One approach adopted has been that of *auto-evaluation*. ACORD teams adopted an *animation* methodology developed by the Groupe de Recherche et d'Appui pour l'Autopromotion Paysanne (GRAAP) based on pictures by a local artist depicting activities and situations in ACORD's program areas. This phase is described by Roche (1991):

'The teams visit villages to begin an animation phase and to collect information on the conditions of that group or village, e.g. population, calendar of activities, environmental, economic and social conditions. This constitutes a group 'fiche' or file for baseline information. The group or village then divides into sub-groups according to age and sex to discuss their problems. With the assistance of an animator, a full village meeting then listens to the problems of each sub-group and tries to agree on a common priority to all. This discussion leads to an idea for a project they wish to initiate. Another 'fiche' is drawn up with details of the activity, and the support needed from ACORD. This takes the form of a contract, where ACORD and the group agree on certain commitments. At this stage the group is asked how they will evaluate the proposed activity. The team helps the group to discuss various indicators: social, economic, technical and organisational. These indicators are combined with ACORD's criteria to form an overall evaluation framework. A permanent record of the expected results, criteria and indicators is left with the group. A 'fiche de suivi' is then created and any visit by ACORD or local government service is recorded with details of the activity, advice or further commitment.

An evaluation is carried out by the community and ACORD at the completion of a particular activity. The monitoring and evaluation at the group and ACORD level is undertaken with the assistance of a local research institute [Institut Malien de Recherche Appliquees au Developpement - IMRAD]. This process is finally supplemented by a third level of external evaluation by local technical services, Local Development Committees, or donors. This would be carried out at the end of a programme funding period'.

An example of insights into community priorities revealed by the process concerns a project of riverine fodder-crop (*Panicum bourgou*) regeneration along the Niger river. It had been assumed by most people (particularly the technical services working in the area and external aid agencies) that the primary reason groups were interested in this activity was in order to ensure adequate fodder for their animals during the dry season. Whilst this was true for many individuals, discussions with women established that they would judge the success of this activity on the amount of *Kundou* (a sweet drink made from this grass) that their children would drink during the year. This was a single indicator that allowed rapid appraisal of several aspects of the project, since, if the *Kundou* had been available to the children, there had been enough grass to satisfy the needs of the animals.

Different priorities were revealed between men (whose evaluation criterion was 'if we can offer you some milk in March when you return, then the activity will have been successful') and women, and between women who owned livestock and those who did not. The auto-evaluation also revealed differences in household relations, particularly between pastoral groups, depending on levels of sedentarisation and the social origins of households.

Table 12: Techniques of Participatory Inquiry

Source: Pretty 1993

<i>Group and Team Dynamics</i>	<i>Sampling</i>	<i>Interviewing and Dialogue</i>	<i>Visualisation and Diagramming</i>
<ul style="list-style-type: none"> ■ Team contracts ■ Team reviews and discussions ■ Interview guides and checklists ■ Rapid report writing ■ Energisers ■ Work sharing (taking part in local activities) ■ Villager and shared presentations ■ Process notes and personal diaries 	<ul style="list-style-type: none"> ■ Transect walks ■ Wealth ranking and well-being ranking ■ Social maps ■ Interview maps 	<ul style="list-style-type: none"> ■ Semi-structured interviewing ■ Direct observation ■ Focus groups ■ Key informants ■ Ethnohistories and biographies ■ Oral histories ■ Local stories, portraits and case studies 	<ul style="list-style-type: none"> ■ Mapping and modelling ■ Social maps and wealth rankings ■ Transects ■ Mobility maps ■ Seasonal calendars ■ Daily routines and activity profiles ■ Historical profiles ■ Trend analyses and time lines ■ Matrix scoring ■ Preference or pairwise ranking ■ Venn diagrams ■ Network diagrams ■ Systems diagrams ■ Flow diagrams ■ Pie diagrams

* Brief descriptions of some of these techniques are given in Appendix 1.

make the methods effective. Furthermore, beyond their value for learning, some of the methods are also a means of establishing rapport; they help to sustain and strengthen the participatory process of which they are a part (Mascarenhas *et al.* 1991, Chambers 1992).

Many of the techniques employ diagrammatic and visual work. By creating and discussing a map, model or diagram, all who are present - both insider and outsider - can see, point to, discuss, modify and refine conceptual diagrams or representations, sharing in their creation and analysis. Non-literates are not excluded; everyone has visual literacy which allows them to participate actively in the process.

Early approaches (notably rapid rural appraisal) emphasised speed, and the label 'quick and dirty' has sometimes been applied. As the approach has evolved, the stress has moved from exploitation of local people's labour or knowledge (to push through projects or facilitate research) to a sharing approach with contributions from both sides and patient iteration. This avoids some of the biases of rapid rural appraisal: spatial (tarmac), personal (leaders, entrepreneurs, professionals, English-speakers, males, living), dry-season, politeness/timidity (outsiders not shown the worst conditions and will not ask searching questions).

6.3 Participatory Planning

Clearly, there are development matters that are national in scope, for example development of a major catchment for hydro-electric power or the establishment of a national park, where decisions have to be taken in the national interest. There are other matters where the initiative rests with local communities.

But in either case, planning agencies need to be sensitive to the experiences, priorities, needs and aspirations of local communities.

At the same time, in order for local communities to assume greater responsibility for managing and planning the use of their own local resources, they will need to have better ways of drawing on the technical and financial support of government services. One of the challenges of development planning is to bring closer the poles of *top-down* and *bottom-up* or participatory planning so that they are mutually supporting (Box 25).

Participatory planning is now promoted as an alternative model to conventional top-down planning, but it faces similar or greater problems of inflexible and hierarchical institutions, undefined lines of authority and responsibility, and a weak information base. Appropriate methods of planning and methods of survey to deliver the data that are needed have yet to evolve. Progress in this field is most likely to occur where there is an equal and long-standing partnership between decision-makers, planners and natural resources specialists.

Box 23 in Chapter Five illustrates a step in the direction of participatory planning in Tanzania developed over more than ten years involvement of the British Land Resource Development Centre in resource assessment and land use planning in Tabora Region. Box 26 illustrates how a superficially similar procedure, also in Tanzania, can fail completely in the absence of participation and adequate natural resources data.

6.4 Linking Bottom-Up and Top-Down Planning

Participatory approaches have been confined mainly to community and local level development but there are some examples of initiatives which show potential for scaling up the approach to involve more people and larger areas, linking local initiatives with policy and planning processes and public institutions. In India, the Kribhco¹ Rainfed Farming Project, initiated in 1989 in the drought-prone states of Gujarat, Madhya Pradesh and Rajasthan, is attempting to develop a participatory approach which is flexible, builds on local knowledge, and involves the joint formulation of local renewable natural resource strategies by villagers and project staff. Jones *et al.* (1993) report:

'It starts with participatory rural appraisals but goes on to community problem analysis, awareness raising (e.g. by visits to government and NGO projects in the region), skill development and support to village organisations. The process involves joint learning by local communities and the project, and the development of the people's capacities in planning and problem solving.'

In Kenya, the Ministry of Agriculture adopted an interdisciplinary *catchment approach* to soil and water conservation in 1988, seeking to involve all interested parties at local level, both resource users and external government and non-government agents, in planning, decision-making, implementation and maintenance (Box 27).

¹ Kribhco: Krishak Bharati Cooperative Ltd. A national cooperative organisation involved in fertilizer production and marketing, but with a mandate to undertake general farmer development activities.

Box 25: Bottom Up and Top-Down Planning

Bottom-up planning describes planning that is initiated at village or other local level and involves the active participation of the local community. The pooled experience and local knowledge of the land users and local technical staff are mobilized to identify development priorities, draw up plans and implement them. The advantages are:

- ◆ a strengthening of the community's sense of responsibility and confidence in land resource management, and strengthening local institutions to take on responsibilities;
- ◆ building of more popular awareness of land use problems and opportunities;
- ◆ people will be more enthusiastic about a plan felt to be their own, and more willing to join in its implementation;
- ◆ plans can pay closer attention to local goals and local constraints, whether related to natural resources or socio-economic issues;
- ◆ better information is fed upwards to higher levels of planning, educating upper levels of management to the realities at village level.

The disadvantages are that:

- ◆ limited technical knowledge at local level means that technical agencies need a big investment in time and manpower in widely-scattered places;
- ◆ difficulties occur in integrating local plans within a wider framework;
- ◆ local efforts may collapse through lack of higher level support (or even obstruction);
- ◆ the local community's interests may not be well represented, i.e. village leaders, elders or businessmen may dominate decision-making and local planning.

Top-down planning describes the classical procedure of systematic, technical surveys on the basis of which plans are devised centrally and worked out in detail by professional staff to meet goals that are also decided centrally. Implementation is, again, typically the responsibility of line ministries or other government agencies.

Examples include sectoral plans (forestry, fisheries, agriculture departmental plans); watershed management planning; town and country planning; individual land development projects (e.g. Accelerated Mahaweli Project in Sri Lanka, the Tanganyika Groundnut Scheme, the Gezira irrigation project).

Top-down and bottom-up planning may be in conflict because local interests are not necessarily the same as regional or national interests.

Box 26: Different Perceptions of Participation. An Example from Tanzania

Under the Town and Country Planning Ordinance, villages can only receive legal title to their land on completion of a land use plan by government officials, showing what land is to be used for residence, agriculture, grazing, etc. This is then gazetted and becomes legally binding. Following the official planning of Dirma village in Arusha Province, an independent rapid rural appraisal (RRA) assessed the effectiveness of the planning procedure.

The official surveyors had invited village leaders from neighbouring villages to discuss and agree the boundaries, which were mapped accordingly. Some conflicts were resolved by voting in the Ward Development Committee. Some village leaders had also been consulted to help identify where settlement, farming and grazing should take place, so this was considered to have been participatory planning.

Villagers told the RRA team that, whilst they had checked the boundaries thoroughly, they left the land use plan to the experts and thought it was merely a formality for securing title. The RRA revealed that the village leaders represented mainly the permanently-settled villagers whereas the majority registered in the village are semi-nomadic pastoralists who do not participate in Party or village affairs, who had not been told of the plan to privatize grazing land, and who were afraid that they would lose their right to move in and out of the village in search of water and pastures.

Water is the limiting natural resource. Its availability determines land tenure, settlement, land use and migration yet the land use plan merely stated that each settlement should have water without specifying ways and means. Unrealistic proposals included zero grazing and grade cattle based on 30 acres of pasture per household and a maximum of 18 livestock units (but no proposals for destocking); irrigated agriculture without adequate water supplies, and tree planting (regarded as bizarre given the 20 000 acres of *miombo* forest in the village area). Settlements were shown where no one lived and the area under cultivation was estimated at three times the actual area.

This kind of prescriptive replacement of all existing agricultural and pastoral practices by modern, methods does not build on local people's knowledge of their resources; it could not be implemented without force; and forcing it on the villages would damage both their economy and the environment, and confidence in their own government.

Source: Johanssen and Hoben (1992)

In Sahelian West Africa, the *Gestion des Terroir* approach has developed over the last 5 to 8 years to address environmental degradation. It involves the transfer of control over the management and use of natural resources from government to local people and includes programs to support increasing and more reliable yields within crop, livestock, and forestry production (Box 28). A few projects have reached the stage of implementing an agreed management plan: most are at the stage of establishing the issues to be addressed and priorities to be set, so evidence of success or otherwise is, as yet, patchy.

The World Resources Institute has studied several cases in Latin America where, first, local priorities were identified by local communities with assistance from NGOs, and local authorities were able to respond and encourage participatory rural appraisal in other areas (Thrupp, personal communication). Pooling of community priorities at regional level enabled them to link with the development of policy. State representatives participated in the discussion of local plans, reacted to ideas emerging from

Box 27: The Catchment Approach to Soil and Water Conservation, Kenya

In Kenya, soil conservation is the responsibility of the Soil and Water Conservation Branch (SWCB) of the Ministry of Agriculture which operates in 222 divisions in all 47 districts of the country. The *catchment approach* to soil and water conservation was adopted in 1988 as a response to a realisation that conventional approaches (through farmers being advised, lectured, paid and forced to adopt new measures and practices) were not effective. In this new approach, the term catchment is closely associated with a specific community of people known to each other, rather than a strict physical watershed.

Local communities are purposefully involved in the analysis of their own farming and conservation problems, and decisions and recommendations made with their active participation. Community mobilisation is achieved by interdisciplinary planning teams, the formation of catchment conservation committees by farmers themselves, and intensified publicity and training through field days, public meetings, demonstrations and tours. This process enables information to flow to the community, the development of better understanding of the conservation problems specific to each area by the SWCB, and closer collaboration between farmers, the SWCB and other agencies.

Each Divisional Planning Team typically works in 3 or 4 catchments each year. Priority is given to catchments where local people or administrations have requested support, where soil erosion is serious, or where the SWCB has not worked before.

Multidisciplinary teams drawn from various government departments work for about a week in the catchment: beginning with a day of orientation and introduction to the methods, followed by 2-3 days building up a picture of local skills, knowledge and perspectives on problems and concerns using a variety of participatory inquiry methods (see Table 12), with a public meeting on the final day to present the findings in visual form.

Following the dialogue, a catchment conservation committee (CCC) of farmers is elected to coordinate action within the catchment (typically 8-15 people with the local Technical Assistant as an ex-officio member). The divisional team then prepares a catchment report to serve as a baseline document for planning, implementation, monitoring and evaluation, and for the coordinated action by extension professionals based at Divisional and District level. The District Planning Team makes a detailed map of the catchment, and plans the soil and water conservation measures for each farm, working with the catchment committee. The CCCs receive support in the form of basic tools, equipment and technical training and advice from Ministry staff. In return, committee members assist fellow farmers in planning and implementing various individual and group soil and water conservation activities, and support the District Planning Teams in laying out and implementing plans for each farm.

The success of the approach is, in part, due to the ownership of the plan and commitment that has been achieved by active CCCs working with District Planning Teams. Lines of communication have been established and farming communities can exert a pull on the services of extension agents.

The SWCB is aiming to extend the catchment approach to some 600 catchments a year. This will obviously bring new professional and institutional challenges, particularly with respect to the desire to maintain interactive participation.

Source: Pretty *et al.* 1994

Box 28: Gestion de Terroir

Two terms, Gestion de Terroir (GT) and Aménagement de Terroir, are commonly used, often synonymously, to describe the range of community-focussed projects being undertaken in Sahelian West Africa. Gestion de Terroir refers to the management (gestion) of natural resources within a given area (terroir) describing actions which involve using the resources in a particular way, allocating land to certain uses, limiting access at certain times, and controlling levels of resource use. Aménagement de Terroir refers to the improvement (aménagement) of resources within a given area, involving a variety of investments to raise productivity, reduce crop risk, and conserve soil and water. Terroir refers to a socially defined space containing resources and associated rights, within which a particular community is assumed to satisfy most of their needs.

GT focusses on the management of natural resources at the level of the village or camp, and operates in three inter-related systems:

- ◆ The technical system related to the physical environment - optimizing nutrient cycling, management of natural forests, control of erosion;
- ◆ The socio-economic system related to the organisational structures within which people live, and including the allocation of power between people and groups, economic incentives to manage, and returns from the use of resources;
- ◆ The legal system and its administration which determines rights of access to natural resources and the means by which these rights are enforced.

GT projects explicitly address the weaknesses identified in past development strategies - e.g. lack of clarity regarding rights, the poor performance of large single-sector or integrated rural development projects, over-extended state administration, adverse trends in natural resources management - by clarifying rules of tenure, redefining the responsibilities and rights of local communities to manage their resources, and by pursuing a participatory diagnosis of the problems of the community. This diagnosis is then followed by the establishment of a plan within which the outside agency and local people agree what is to be done, by whom, how, and over what time scale.

This approach has been widely adopted by governments, donors, and NGOs throughout the Sahel. Two routes have been adopted: informal and systematic. The first route is typified by Burkina Faso where many established rural development projects have been brought within a national program to encourage exchange of information and experience. Similar national programs are being established in other Sahelian countries under the auspices of the Natural Resources Management program of the World Bank.

A more systematic route, aiming to shorten the process of trial and error, comprises (PNGTV 1990):

- i Initiation of discussion and diagnosis, in collaboration with local people, to identify current and potential problems associated with resource use and management;
- ii Election of a committee at village level (la Commission Villageoise de Gestion des Terroirs) to represent local people and liase between them and the administration;
- iii Establishment of boundaries to the village territory;
- iv Elaboration of a management plan, specifying zones and the uses to which these will be put. The plan is jointly agreed with the village committee which specifies the responsibilities of the various parties involved - local people, GT project, technical services;
- v Implementation of planned activities;
- vi Monitoring and evaluation.

Source: Toulmin (1993)

communities and provided information and ideas about means of carrying out the plans and about potential constraints. Considerable negotiation may be needed to reach agreement among the different interests involved and consensus is not always possible, but dialogue can lead to effective collaboration at local level and political empowerment of local people, and can be extended into national fora to involve high level policy-makers. Of course, this linkage depends on willingness to empower local institutions and the building of a planning and institutional framework in which it can occur.

Another example of local-level resource planning can be found in Zimbabwe, where the Communal Areas Management Program for Indigenous Resources (CAMPFIRE) is devolving power and decision-making over wildlife and other resources to local people. The program was initiated by the Department of National Parks and Wildlife Management and originally focussed on wildlife utilization (Martin 1984)). The success of the project has been attributed to the tangible benefits from wildlife that now accrue to the local community. These benefits generated increased local support which enabled the project to be broadened to cover other communal resources such as grazing, water and woodlands (Murphree 1993). The CAMPFIRE program parallels two experiments in community-based wildlife planning and management in Zambia: the Luangwa Integrated Resource Development Project, which is intended as a multi-sectoral program for economic development in which local leadership committees have control over revenue from wildlife management and decide on their disbursement for development priorities (Dala-Clayton 1988b, 1991, Lungu 1990) and the Administrative Design for Game Management Areas (ADMADE) which is concerned strictly with the wildlife sector but which also involves use of wildlife revenues (Mwenya *et al.* 1988, Lungu 1990).

The Aga Khan Rural Support Program has also used community level analysis of problems, determining of priorities, and investment of both local and external resources to support planned activities in Gujarat, India and in Northern Pakistan. Again, the program has concentrated on strengthening existing village institutions or establishing new ones as a vehicle for its work (Conway *et al.* 1988).

Probably the largest community-based approach is LANDCARE in Australia, initiated in 1989 by the Australian Farmer's Union and the conservation movement. It brings together elements of community and environmental education, research and participative planning to deal with a range of issues concerning the environmental and production in a very diverse range of settings. There has been a phenomenal growth in LANDCARE groups, from 350 in 1989 to 1400 in June 1992 (Campbell 1992). These groups are voluntary associations of rural people who work together and in collaboration with long-established state agencies to develop sustainable resource management practices in their neighbourhoods. Their varied activities, which are almost identical with those of farmer groups in *conservation districts* in the USA, include:

- Development of a catchment or district plan, identifying major problem areas, and proposals for dealing with them;
- Active involvement in natural resource monitoring, often in conjunction with schools, state agencies and professionals;
- Documenting local knowledge about land and its management;
- Study tours of their own and other regions;
- Joint research with universities, research bodies, and state agencies;
- Production of educational materials, and videos.

LANDCARE pays particular attention to *land literacy*. This involves activities which assist people to read the land, and make visible conditions and trends in degradation, e.g. overflights for farmers to see

their land and the extent of degradation, publications and kits to assist land users in recognising emerging problems such as soil salinity.

The examples of participatory approaches to natural resource management and planning discussed above are part of a new development paradigm (Toulmin 1993):

- Decentralisation of power and decision-making to the level of user groups, particularly over common property resources;
- Recognition of indigenous knowledge and practices as a basis on which to develop resource management systems;
- Attention paid to institutions, their effectiveness, governance, and the role of land tenure;
- The role of government limited to provision of an *enabling environment* that provides incentives to manage resources, rather than through policing and sanctions.

Community initiatives like LANDCARE and social guarantees like security of tenure cannot, in themselves, bring about sustainable land use although they may be prerequisites. They must be supported by technical knowledge, land resource information, finance (if this cannot be generated locally), good management and leadership.

There will always be development issues that are national in scope where decisions have to be taken in the national interest. There are other matters where the initiative should rest with local communities. The centralised, top-down methods of land use planning that have typified the past and the participatory approaches described in this chapter are not alternatives. Clearly, links need to be forged between the two approaches so that are mutually supporting.

CHAPTER SEVEN

CONCLUSIONS

We rarely publicise our mistakes. It is unusual even to document the stages of learning in the course of a natural resources survey or planning project. Valentine (1986) notes that:

'The very things that are obvious after the fact (and, therefore, rarely written down) were often far less obvious before the fact (and, therefore, should be written down).'

Consequently, the conclusions reached below rely on our own experience, on informal sources and reading between the lines of published work. Some have been put forward before and many resources specialists will recognise here their own, sometimes uncomfortable, gut feelings.

7.1 Developing Country Imperatives

Present land use is not sustainable throughout much of the Third World. Escalating pressures on the land, and systems of land use characterised by low levels of technology, low inputs and low outputs have created a vicious circle of degradation of land, water, forest and wildlife resources. Recurrent crises of production, falling living standards, conflict between landed and landless or between urban and rural populations or ethnic groups may be triggered by drought, pestilence or some external cause. But the underlying force is increasing pressure on natural resources; degradation bringing about a permanent loss of productive capacity; leading to lack of margins in the production system. One goal of development policy and land use planning is to break free from this cycle.

It is characteristic of poor countries that capital and expertise for investment in both people and land are quite inadequate. To direct investment where it will generate the most benefit, decision-makers need sound principles, good information about land resources and the capability to use this information in support of their decisions. Policy-makers are involved in seeking opportunities for development. They also need criteria for judging and ranking these opportunities. They need to know the benefits that may accrue, the costs involved, environmental, social and economic problems associated with each development option, and possible solutions for these problems.

Problems of land use involve both land and people. They involve physical, biological, social and economic issues, so decision-makers need information on each of these aspects. Integrating this diverse information is difficult, and is usually done intuitively, the decision-maker placing greatest reliance on the information that is best understood and perceived to be important.

The decision-making process may be represented as a series of 'What if ?' questions, the answer to each determining the next question. This means that decision-makers need dynamic interpretations of data on natural resources that keep pace with the changing nature of the questions asked of them. The decision-makers' question is not simply 'What is the depth to groundwater ?' but a sequence: 'Is there groundwater at reachable depth (if so, what depth) and will there still be groundwater at reachable depths if we install wells every km and pump at 10 000 gallons a day ?' Answers need to be area-specific, so that particular areas, people and projects can be identified and, usually, answers need to be quantitative.

Throughout the cycle of a development project, from conception to feasibility study, to bidding for funding, to detailed design and implementation, to monitoring and evaluation, the need for information changes. A different mix of political, social, economic and biophysical information and a different level of detail or generalisation is needed for sequences of decisions that have to be made at different stages of the cycle. And if the project extends over many years, new needs appear and old data require updating (see Box 29).

Box 29: The Accelerated Mahaweli Project, Sri Lanka

Confirmation that there was enough water and enough land for very big hydro-power and irrigation developments in the Mahaweli basin came from reconnaissance scale land resources surveys, especially Hunting (1962) and a good topographic base map at one inch to one mile. An order of magnitude more analysis (and eighteen volumes instead of one) was needed to devise a *master plan* for basin development (FAO 1969), although little more systematic resources survey was undertaken. Decisions by international donors to fund the Polgolla Diversion and, later, the elements of the Accelerated Mahaweli Project, were taken mainly on political grounds, although the economic case for the hydro-power component alone justified these decisions.

Feasibility studies undertaken to terms of reference laid down by the donors *followed* the decision to fund, which was taken on trust. In the event, these feasibility surveys served as design and implementation surveys of the land development component which went ahead without any more detailed information, other than topographic surveys. Sophisticated models of land use recommended by the consultants have not been adopted. Neither the administrative and planning capacity nor the natural resources data base are adequate. Farmers in the Mahaweli area grow rice, and a lot of water seeps through permeable soils whose distribution or permeability is not known. Neither soil permeability, available water capacity nor even soil texture are diagnostic characteristics of the soil classification used in the soil survey.

A new phase of investment with detailed attention to market opportunities, product processing, infrastructure, hydrology, soil permeability and nutrient status, agronomic development and extension will be needed to upgrade the farming system to meet the social and economic challenges of the next few decades. Equivalent effort, again needing better land use, soil, hydrology, and farming systems information will be needed to arrest land degradation in the catchment and protection of water supplies which were not seriously considered in the original development.

Source: Dent and Goonewardene (1993)

Ideally, policy-makers and managers need to use the data iteratively in the course of the evolution of projects, planning exercises or development programs. A static, one-shot survey cannot fulfill this need. Unfortunately, poor countries in general lack the capability for re-interpreting, updating and upgrading their natural resources data base.

7.2 Common Limitations of Natural Resources Surveys

7.2.1 Terms of Reference

The most important part of any natural resources survey is a clear statement of purpose. Explicit objectives are needed to avoid, on the one hand, the danger of collecting irrelevant data and, on the other hand, omitting something important. Terms of reference for natural resources surveys have usually failed this test. The objectives of the whole exercise have been vague while the operational procedures have often been laid down in some detail. Thus, they have imposed standard recording of standard characteristics, standard intensities of survey and standard interpretations.

This criticism applies to donor organisations supporting resource surveys for development projects or supporting survey organizations (e.g. Box 4) and to indigenous survey organizations that simply follow established, scientifically-respectable methods. Sometimes the procedures are modified but, essentially, no new thinking is involved. As a result, in feasibility surveys, excessive time is spent fulfilling the terms of reference and early data are not available to other team members when they are framing their own concepts. Soils data, in particular, are all too often placed in appendices - collated long after the recommendations have been made - and remain largely unused. In systematic national surveys, the responsible organization often runs itself into the ground with little areal coverage to show for many years of effort. Thus, when a question is asked about a particular area, the answer is likely to be 'We have no information for that area'.

In fact, terms of reference and surveys tend to be the product of the same, quite small group of people. There is an incestuous cycle that breeds overweight surveys that serve the scientific and professional interests of the instigators but are ill-adjusted to the needs of decision-makers. Ive *et al.* (1983) noted that in the South Coast Project in New South Wales (Austin and Cocks 1978), 150 data items were collected against 5 300 mapping units, but only 20 data items were used in the subsequent land allocation phase.

For a resource inventory of the Gambia (Dunsmore *et al.* 1976), LRDC expended more than 20 man years of effort, the greatest component of which was in establishing soil series characterised by detailed laboratory data, only to publish the soil information as 1:100 000 maps of soil associations that could have been completed in a tenth of the time. Subsequently, consultants to the Gambia Barrage Project (Coode and Partners 1979) found key data lacking on the soils of the tidal flood plain (which had resisted soil series characterisation), and no information on contours, river discharge, land use or mangrove timber resources. A rapid appraisal, which discovered 13 000 ha of potential acid sulphate soils in the project area, and dynamic modelling based on approximate data, killed the project in three man months. These results were then confirmed by a further three man years of conventional survey and laboratory analysis (Thomas *et al.* 1979). LRDC surveys in The Gambia, classics of their kind, simultaneously achieved overkill of superfluous data and missed crucial information needed for development.

Dent and Goonewardene (1993) describe the collection of exhaustive data on market opportunities, farm economics, and regional socio-economic evaluation by an FAO team in Sri Lanka. More than six metres of shelf space, some documents costing more than £ 1 000 a page at today's prices, assembled as the basis for a land rehabilitation and settlement project, still lies unused by the project management. The natural resources data, though collected and analysed by state-of-the-art methods, is incomprehensible to the decision-makers; the planning recommendations are too complex; the recommended farming system is unpopular; and the market economics data are now out of date.

7.2.2 Comprehension

Natural resources data are under-utilised because planners, planners and other professionals, let alone policy-makers, do not appreciate their utility. There are several reasons for this. The two most commonly complained about, though not necessarily the most fundamental, are:

First, they are simply not understood by anyone except the specialists who produce them. Jargon and the intimidating welter of data are obvious reasons for this. Natural resources reports are, quite clearly, written for the benefit of natural resources specialists and not for anyone else. Reports should be addressed to the users and presented in a way that they can clearly understand, which means that the users should be known in the first place.

Secondly, the information does not tie in with the experience of the potential users. Apart from the language, the level of detail or generalization of the information is not the same, and the resource mapping units may not be recognised by the decision-maker. Information must coincide with the effective management unit, generalized at national level but detailed and precise at field level, if its applications are to be recognized (Figure 1).

7.2.3 Usefulness

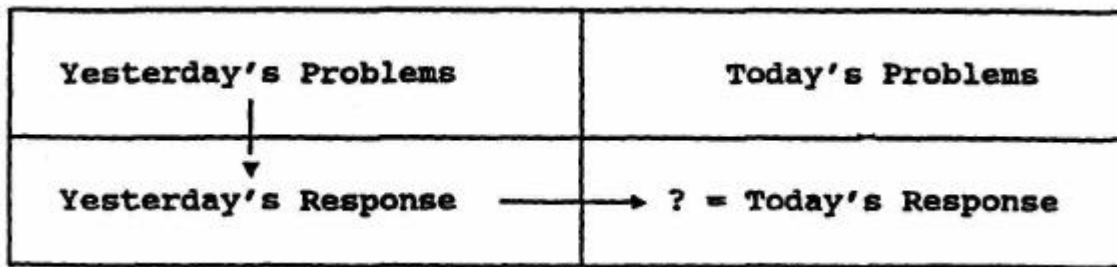
Natural resources information of all kinds is very interesting to natural resources professionals. It helps them build up their model of the world. But much is irrelevant to the kinds of decisions actually being taken about land use. Box 28 draws attention to the use in irrigation projects in Sri Lanka of a pedological soil classification that ignores permeability and available water capacity.

That there is a problem of comprehension is well understood. In response, survey interpretations have been provided both to simplify the data and to integrate them. Examples include the Storie Index, Land Capability Classification and others discussed in Chapter Three. Each of the well known interpretations was originally designed for a specific, practical purpose which it fulfills very well. However, it has since been adopted as a stock interpretation, offered off-the-peg by survey organizations or demanded by clients simply because it is less intimidating than, for example, a sheaf of soil maps.

In truth, the usefulness of an off-the-peg interpretation is extremely limited and this is especially so in poor countries that are already densely settled and farmed to the limits, or beyond the limits, of the present capacity of the land. We are not starting with a clean sheet. Decisions already taken and acted upon severely limit our room for manoeuvre and it is not helpful to a subsistence farmer to tell him that his land is suitability class S3 or even class S2 for millet! If all that comes out at the end of an exhaustive natural resources survey is a ranking of S1 to S3 or N, essentially on the basis of slope angle, the cost-effective procedure would have been simply to measure the slope angles. In recent national studies in Kenya (FAO/IIASA 1991, Box 17) and Botswana (in progress), quantitative estimates of production for specified levels of input are provided, either for land suitability classes or individual mapping units. The use made of these data has not yet been assessed.

Relatively few mature systems of resource survey and evaluation have developed. There appears to be little or no consultation between land resources professionals and any of the supposed beneficiaries of development or supposed users of information. Natural resources professionals, rather than users, drive the methods used. Henry Ford had an expression for it: 'The customer can have any colour he likes, so long as it's black.' As a consequence, natural resources surveys and land evaluation are usually addressing yesterday's problems. At best, they are addressing a perspective of the future perceived yesterday (Figure 18).

Figure 18: Problems and Responses



The syndrome is exaggerated in developing countries where scientific and technical staff are few and very inadequately resourced. Their natural resources professionals do not have the benefit of frequent exposure to a wide range of approaches and methods. They work in an institutional environment where skills and information are hoarded rather than shared, and they find it safer to continue the status quo or defer to outside consultants than to strike an independent course. Short-term consultants are also constrained by inappropriate terms of reference and unwillingness of their clients to allow any change of these, suspecting attempts to cut corners for some commercial advantage.

7.3 Inappropriate Planning Methods and Inappropriate Data: A Failure of Institutions

Sustainable development cannot be achieved without the integration of several discrete sets of information:

- ◆ If the development is not physically and biologically viable, it will degrade and possibly destroy the resources on which it depends. Information about natural resources is, therefore, needed. However, static information about the situation today is only the starting point. We need dynamic interpretations of the interactions between resources and their use.
- ◆ Unless the development under consideration meets the need for production and profit, it is unlikely to be adopted. Data on demand, production, markets, costs and returns are essential. The difficulty of forecasting future costs and prices is evaded to some extent by discounting but this gives a distorted, essentially short-term perspective. This is especially so in the case of natural resources like water and soil that are not indefinitely substitutable by other resources.
- ◆ Any development brings an element of risk, which must be assessed and judged to be acceptable by the parties concerned if a plan is to be implemented. Risks lie in both biophysical factors like the reliability of rainfall and the biological margins within the production system, and in the uncertainties of markets and availability of essential inputs.
- ◆ Proposals must marry with the social structure and mores of the area. In particular, unless they are widely perceived to be equitable they will not command widespread support. Information is needed about the motivation of the people, their perceptions and aspirations. Rights of land tenure and water use are often key issues that are difficult and dangerous to tackle but which are often constraints upon the sustainable use of resources.

No one set of data is all important. The failure of so many development plans that have emphasised just one physical, economic or social component demonstrates that little benefit and no sustainable development is likely to be achieved unless all relevant aspects are considered. This is a big task and

cannot be achieved without better planning procedures and a revolution in the attitude and training of planners and decision-makers.

Failure of land use planning has been much more a failure in working with people than a failure of natural resources data. Land use planning has been a centralised and top-down activity. This is well illustrated by the *Zambian land use planning guide* (Zambia Dept.Agric. 1977):

'The aim of [catchment conservation] planning would be to **direct the people** to cultivate suitable land, to use the best methods applicable to the area and to make sure that **controls to land use** are implemented in both the mechanical and cultural spheres.'

Land use planning has failed because governments are not omniscient or omnipotent. The loads they impose on themselves in attempting to plan, implement and administer land use soon exceed their administrative and logistic capabilities, and outstrip both the abilities of their professionals to supply natural resources information and their own capability of using it. Governments must learn the limits of their own capacity. Yet they hanker after the tried and tested and failed procedures of physical planning - in which experts prepare maps that indicate in considerable detail how land should be used. The supposed beneficiaries of development have little opportunity to articulate their needs in terms of development, technology or information. Nor do they have the opportunity to contribute their own local knowledge. Box 30 highlights some principles that might bring planning and people closer together.

7.4 Meeting the Need for Natural Resources Information at Local Level

If local community institutions are to take on wider responsibility for management of land resources, they will need support, including information about their land resources. The established procedures cannot match the needs. There just aren't enough natural resources specialists to go round, so the grassroots planners will have to fend for themselves.

A village-based ecosystem approach has been advocated for India by Agarwal and Narain (1990, 1992) in which common resources are brought under the control of the community. This requires the establishment of a village-level institution which can work with a high degree of democracy in decision-making and can enforce discipline amongst group members. Agarwal and Narain suggest that thought should be given to training *barefoot village ecosystem planners*, able to work with local people in a collaborative manner, provide them with information regarding sources of technology, build on local knowledge and skills, and encourage village institutions to set their own agenda and priorities.

A research and development program is needed to support the step-by-step evolution and testing of locally-developed, do-it-yourself natural resource survey and interpretation tool kits for use by local communities and farmer groups.

Box 30: Principles of Land Use Planning

1. Planning should not be an external exercise by planners in offices remote from the area concerned. To be successful, a plan needs to be developed and implemented by the stakeholders. All those with a legitimate interest in a land use plan should first be identified, particularly residents of the area and those whose livelihoods are dependent on its resources. At the earliest possible stage, a mechanism should be established for participation and a platform for negotiation between all the stakeholders, including the supposed beneficiaries.
2. Acknowledge the existence of potentially conflicting interests in developing, implementing and benefiting from land use plans, and develop processes to deal with this. To the extent possible, try to reach consensus, taking particular care to ensure the inclusion of marginalised groups (e.g. women) and minority interests (e.g. hunters and gatherers).
3. The needs and goals of all the interest groups should be clarified against the aims of the plan stated by the initiating organisation or individual.
4. Consensus-building and negotiation requires wide and public access to information about the issues, problems and development options.
5. Deliberate, voluntary change is likely to occur where there is:
 - knowledge
 - the capacity to change
 - the motivation to change

Knowledge. Information about natural resources (their nature, distribution, current and potential use) is essential at all levels of decision-making so that emerging problems can be recognised quickly. Good information is needed not only about land resources and the interactions between climate, landscape, soils, water, ecology and land use; but also about the social and economic consequences of change, or not changing.

There is no single way to achieve effective communication of this information to all interested groups. A range of approaches will need to be tried, modified and repeated. Knowledge and understanding of information and about interactions and their consequences will probably differ amongst interest groups.

Capacity to change. Lack of time, people, management skills, appropriate institutional structures (tenure, laws or decision-making systems), equipment and money are all constraints. Financial and managerial resources are needed for activities that do not give a quick return and, often, benefit urban people more than those in rural areas (e.g. safeguarding water resources). Money and managerial skills are not available easily in poor rural areas. It is hard for the poor to invest in costly interventions to effect environmental change. But, not all environmental changes are expensive and cheaper interventions may be more cost-effective in the long-term.

Motivation to change. Education, information and persuasion will be effective only if the change interests and benefits the people for whom change is deemed desirable and where such change is socially acceptable.

Practical, profitable solutions to land use problems are needed that can be incorporated easily into farming systems, but are not available in many instances. Attractive (e.g. affordable) technical solutions may be readily accepted - although some may have the potential to be

Box 30: Continued

environmentally damaging (e.g. pesticides); unattractive ones are not likely to be accepted (e.g. many mechanical soil conservation practices).

6. Build on:
 - indigenous, existing systems of local knowledge, land use and planning, taking care to retain their diversity and flexibility, i.e. mobility within common property resource systems;
 - the experience and expertise of other sectors and NGOs;
 - government and local support.
7. Build and support local institutions that can manage common property resources such as land, water, pastures, wildlife, forest products and infrastructure.
8. Address social issues, especially land tenure and access to resources, as well as physical or environmental issues.
9. 'Free' (or unpriced) resources such as land, water and wildlife have important economic values and are not infinitely substitutable. Both an accounting system to assess depreciation of these natural resources and a mechanism to ensure their sustainable management are needed, otherwise they are likely to be exploited to the point where the system is destroyed.

Local research is needed to establish the kinds of decisions to be taken, the capability of the decision-makers to implement change and the specific information they need and can use. Dent and Goonewardene (1993), developing the idea in the Sri Lankan context, identify village water management groups and the management of newly-privatised tea estates as potential users. To be useful, the kits must be tailored to the local situation but the idea should have general application.

Local community planners will also need the means of access to relevant information already held by public bodies. A first step, however, should be to find out what approaches to resource assessment and planning procedures are already used by specific communities and to determine what can be learned from these methods, whether they can be built upon and transferred, and to see what assistance can be given to enable these communities to teach others to use the methods.

Based on the growing experience of participatory approaches to land use planning, a set of basic questions can be derived to guide us in determining how to assist local communities to plan their own resource management (Box 2, Chapter One). We should not assume that only experts have the answers. We will be able to learn much from what communities already do.

7.5 Natural Resources Support for Higher Level Decision-Making

Most external assistance and the whole of national efforts at gathering and synthesising natural resources data has gone into providing information for higher level policy making and centrally- or regionally-organised development projects. Yet, review of many institutions and projects in developing countries reveals that there has rarely been much communication between policy-makers and project management and their resources specialists. Exceptions are in commercial companies in the estate sector that employ natural resources and agronomy expertise to identify and specify their information needs, and in the

more successful large development projects where a long-term professional relationship has built up between the project management and natural resources consultant companies.

In general, neither policy-makers nor project managers are natural resources specialists. This review has confirmed the original proposition that they do not know what information to ask for in any detail and do not have a clearly-defined place for natural resources information in their decision-making procedure. Equally, since the natural resources specialists usually do not know the criteria on which decisions are to be based, or even what decisions are to be made, they cannot supply really useful information. Instead, they have adopted set approaches to the collection and presentation of their data and data collection *per se* has become the goal. Box 1 (Chapter One) lists questions that should be asked by people who are commissioning new surveys.

A major effort must go into developing awareness of natural resources, the possibilities and benefits of sustainable land and resource use, ways of managing resources in a sustainable way, and the kinds of information needed to do so. Support is needed for institutions that can build and maintain this awareness and maintain useful, accessible data bases and the expertise to make use of them. A bridge must be built between natural resources institutions and users of data so that natural resources specialists can carry through their information to the point of decision. It is unrealistic to expect generalists to do this. Synthesis and generalisation from factual detail, to answer specific questions or identify opportunities and problems, must be done by a master of the information.

At the same time a range of land literacy initiatives is needed, most immediately amongst policy-makers and task managers in both governments and aid agencies. Without the appreciation of natural resources at the highest level, funds will not be made available for natural resource survey and the political will needed to bring about coordination of effort between different institutions will not be there.

Institutions supporting decision-making need to pay attention to the following technical points:

- ◆ Information is not of consistent quality and detail and quality control is often lacking. This limits the use that can be made of the better data. For example, soil profile data gathered during land systems surveys is sometimes alarmingly slight (e.g. reddish brown earth); so little interpretation is possible.
- ◆ There is a gap between the scale at which information is needed and the scale at which it can be provided quickly. Survey coverage and recording networks are incomplete at any level of detail, and there is no strategy for completion. There is no continuity of planning on survey effort and no continuity of staff. As a result, methods are not compatible, a good level of expertise is not built up, and institutional memory is short.
- ◆ Procedures for survey and planning are needed that can be implemented by imperfect and modestly-funded in-country institutions.
- ◆ There is little co-ordination of activities between institutions. Duplication of effort is common, e.g. new surveys are carried out in ignorance of earlier surveys and development is attempted without learning the lessons of the past. This is also related to poor financial support to institutions and inadequate archival services.
- ◆ The output of scientific institutions remains incomprehensible even to specialists in closely allied fields. Where summaries or interpretations are provided, they tend to be standard and mechanically applied. Reports are targetted at fellow professionals. To a large degree this has been imposed by manual filing and retrieval through complex hierarchical classifications. The advent of computerised storage and retrieval, manipulation and display of data has the potential

to change all this. At present, however, computerised systems are costly, need specialist staff and become an end in themselves. Public sector institutions are unable to compete with the private sector for these staff, so computer-assisted developments tend to be associated with international funding. The withdrawal of overseas support at the end of the short-term project has commonly lead to the collapse of high-technology systems.

Modelling, GIS and knowledge-based decision-support systems have unlimited potential but still need basic data of good quality, and the funding of basic survey remains inadequate to supply these data.

- ◆ There is a critical shortage of competent land resources specialists able to provide a service to policy-makers, managers and land users, both in specialist institutions and to provide in-house support, e.g. to engineering agencies or in public administration. While information gaps can be plugged by overseas-funded and managed survey programs, these do not provide follow-up or update the data base for iterative use. Participation by local partners in overseas mounted surveys has been limited. Counterpart staff receive a good technical training when attached to expatriate teams, but we have not been able to follow up the use they make of this training.
- ◆ The lack of in-country career structure in land use planning is a major constraint. The secondment of staff from established institutions is universally unsatisfactory.

Land resources specialists can make their greatest contribution by de-mystifying technical issues, making the problems of sustainable management of natural resources more visible, and by de-fusing the 'export syndrome' that pervades land use planning. There is no excuse for being incomprehensible. People need information if they are to take on responsibility for management of the land, and it is the responsibility of analysts, surveyors and planners to make this information available to and accessible to everybody.

This responsibility is not one-sided. People involved in land use policy-making and management at all levels owe it to the land to demand better information.

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APPENDIX 1

BRIEF DESCRIPTIONS OF TECHNIQUES OF PARTICIPATORY INQUIRY

[Based on Mascarenhas *et al.* 1991; J. Thompson 1993 pers.comm.]

1. Group and Team Dynamics and Methods

Team Contracts

A formal written contract in which the team members set out their norms, roles and responsibilities, and what they see as appropriate behaviour and attitudes towards one another and towards local people. The contract is seen as a working agreement between all team members. It can include such rules as, 'We shall only speak the local language in front of the villagers'; 'We shall be punctual'; 'We shall dress plainly and simply', 'We shall review each day's activities and critically evaluate our performance before preparing the next day's programme'; 'We shall not interrupt or contradict anyone'; and 'We shall thank the local people after each discussion and say goodbye'.

Team Reviews and Discussions

Periodic meetings of team members to review their findings, cross-check (triangulate) key information, discuss methodological and procedural achievements or difficulties, revise their checklists (below) and assign new roles and responsibilities. Typically, these discussions take place informally in the field and formally at the end of every working day.

Interview Checklists

Informal lists of issues to investigate, possible methods that could be used to investigate them, and the roles and responsibilities of the team members (principal interviewer, recorder, observer/facilitator). Checklists are designed to guide semi-structured interviews, and are meant to be used in place of formal survey instruments or questionnaires. The checklists are modified daily, as information is gathered, data are cross-checked, and new issues and hypotheses arise.

Rapid Report Writing

A process by which a summary report is produced during and immediately after the fieldwork is completed. The report is written in the same way that the fieldwork is conducted - by the interdisciplinary team. Each team member is assigned a different part of the report to write and various diagrams to prepare and analyse. Sometimes two or three team members work together on a section of the report. The report includes not only a description of the local situation, but a detailed analysis of the findings and a lengthy summary of the process (roles and responsibilities, unforeseen problems and opportunities, serendipitous discoveries, etc). The aim is to produce a final draft report of the fieldwork before the team members return to their respective duties.

Energisers

Games and exercises designed to enliven participants of training workshops and planning events. They are intended to animate and energise the group, while helping to break down barriers to communication and free exchange such as differences in seniority, gender, discipline and so on.

Role Reversals/Work-Sharing

Attempts by an external team to learn about the complexities of local life and the capacities of local people by having the villagers show the team members how to do certain tasks, such as thatching, ploughing, planting, food processing and so on. Through these role reversals, the local people become the 'teachers' or 'experts' and the team members become the 'students'. The objective is to make parties aware that they both have a great deal of knowledge and skills to offer. This work-sharing often occurs at the beginning of the interactions between the insiders and outsiders to help reduce anxieties and create more equitable and open dynamic relationships.

Villager and Shared Presentations

Meetings in which findings are presented back to the local people (e.g. villagers) and outsiders - best done by villagers themselves, providing a further opportunity for cross-checking and feedback. Outsiders should avoid lecturing and concentrate on listening and facilitating.

Process Notes and Personal Diaries

A private diary or series of notes kept by each team member to focus on where he/she, as an outsider, would desire things to go better next time; recording where the problems were, what could have been done to avoid them, who might be able to provide some solutions, what errors to embrace, and what lessons can be learned.

2. Sampling Methods

Transect Walks

Systematic walks with **key informants** through the area of interest to study natural resources, topography, indigenous technology, soils and vegetation, farming practices, etc. A transect walk involves observing, asking, listening, looking, identifying different zones, seeking problems and possible solutions. The findings can be mapped on a transect diagram. Walks may take many forms, e.g. following a particular course (e.g. along a nullah), cross country, in loops, or covering the area in a combing or sweeping motion.

Wealth Ranking and Well-Being Analysis

The process by which one person or a group of local people assess relative well-being (wealth and poverty) in their own community using their own criteria (eg., amount of arable land, access to off-farm non-agricultural income, membership in farmers organisation, number of children, etc). The informants will stratify part or all of their community on the basis of these criteria, thus assigning various households or farm families to different categories (from best off to worst off). This may be done in the open or in private using social mapping or other diagramming techniques, or different pile-sorting techniques (in which the names of all of the households are written on a set of cards - one household per

card - which are then placed into different piles). This procedure is normally done several times to cross-check and verify the results.

Social Maps

Maps which indicate the village or community layout, infrastructure, population distribution, chronic health cases, handicapped people, malnourished children, family planning cases, vaccinations, widows, destitutes, etc. Social maps can, like pile-sorting techniques, be used to stratify a community using local people's own categories and criteria.

Interview Maps

Social maps from which different households or informants may be selected either randomly or purposefully. These groups or individuals may be identified for further consultation or interviewing.

3. Interviewing and Dialogue

Semi-Structured Interviewing

Guided interviewing and listening in which only some of the questions and topics are pre-determined, and questions arise during the interview. The interviews appear informal and conversational, but are actually carefully controlled and structured. The team may use a guide or checklist to pose open-ended questions and to probe topics as they arise. New avenues of questioning can be pursued as the interview develops. The output is usually in the form of hypotheses and propositions, but can also be in quantitative form.

Direct Observation

The inquirer looks at situations for himself/herself asking questions directly related to what he/she sees.

Focus Groups

Groups convened to discuss a particular topic (e.g. farmers growing a similar crop or all with fields in a particular catchment).

Key Informants

Local experts who can provide critical information (e.g. men on ploughing, women on transplanting and weeding, shopkeepers for credit and inputs, etc.).

Ethnohistories and Biographies

Histories that outline import local events, trends and changes as told by elders or knowledgeable individuals in a community. These are generally oral and may be related in the form of a narrative or story. These individuals may also describe their own experiences and life events in the form of oral biographies.

Local Stories, Portraits and Case Studies

Brief summaries of a household's history, a farm coping with crisis, how a conflict was resolved, etc; short, colourful descriptions of situations encountered by the team; or stories recounted by local people.

4. Visualisation and Diagramming Methods

Mapping and Modelling

The preparation of maps and models through marking, drawing and colouring (using local materials such as sticks, leaves, stones, grass, coloured sands, cigarette packets, etc.), usually on the ground, by local people with the minimum of interference and instruction by outsiders. This can be a sequential activity with one map leading to another and another as more and more people want to get involved. As maps and models take shape, more people become involved, contributing and suggesting changes. Sometimes map preparation is interrupted to enable more focussed discussions to take place or for a **transect walk**.

A range of maps and models can be produced, e.g.:

- Resource maps of catchments, villages, forests, fields, farms, home gardens, etc.
- Social maps of residential areas
- Health maps (e.g. with the health and welfare status of family members marked on each house)
- Topical maps (e.g. aquifer, soil, irrigation maps)
- Impact and action orientation maps (e.g. recording pest incidence, input usage, weeds distribution, erosion rates, etc.)

Mobility Maps

Maps of people's movements to other towns and cities from their community. These can reveal valuable information about seasonal migration patterns, trends and changes in rural-urban migration, transportation difficulties and so on.

Seasonal Calendars

These explore seasonal constraints and opportunities by depicting monthly changes throughout the year. The timing of ceremonies can be used to cross-check the correct use of month names. Participants draw histograms using chalk or pieces of stick in the dust, or may use piles of stones, seeds or powders to represent relative quantities and patterns of rainfall, soil moisture, crops, livestock activities, agricultural and non-agricultural labour, diet, food consumption, illnesses, prices, animal fodder, fuel, migration, pests, income, expenditure, debt, childrens games, school terms, and so on. Seasonal calendars can be drawn linearly with 12 months to show a typical year or 18 months to illustrate changes between years; or can be drawn in a circle.

Daily Routines and Activity Profiles

Daily patterns of activity are recorded for each hour of the day; charting typical activities, amount of effort, time taken, location of work, etc. Comparisons are usually made between different groups of people (e.g. men, women, old, young) and during different seasons.

Historical Profiles

Detailed accounts (often as pictorial/graphic representations) of the area at different points in time, focussing particularly on relationships and evolutionary trends. These can include histories and reviews of technology, land use, crops, livestock breeds, labour availability, trees and forest, education and population change. Folklore, songs and poems are valuable resources for exploring history.

Trend Analyses and Time Lines

Time lines provide a history of major recollected events in a community with approximate dates, and discussion of which changes have occurred and why (cause and effect).

Matrix Scoring

Matrices are useful for ordering and structuring information gathering and planning. Matrix scoring takes criteria for the rows in a matrix and items for columns, and local people fill in the boxes for each row. The items may be ordered for each of the criteria (e.g. for 6 trees, which is best to worst for fuelwood, fodder, erosion control, fruit supply, etc.); or participants may use piles of stones, seeds, or berries to score relative values.

Preference or Pairwise Ranking

A method which can be used to confirm local people's categories, criteria, choices and priorities. For pairwise ranking, items of interest are compared pair by pair, informants being asked which is preferred of the two, and why, and what is good or bad about each.

Venn Diagrams

The use of circles of different sizes (and sometimes different colours) to represent people, groups and institutions. Local people arrange these to represent the degree of real overlap. The relationship between the village circle and other circles can be represented by drawing lines between the circles, with the thickness of each line representing strength of relationship, or by representing strength by distance from the centre.

Network Diagrams

Diagrams showing linkages between people and/or institutions in different places. These may indicate resource (e.g. remittances) flows and sources, information flows and sources, and the flows of people (migration). The diagrams may look similar to Venn Diagrams but with more emphasis placed on revealing internal and external 'networks'.

Flow Diagrams

Flow diagrams are used to show the cycling of nutrients, information, capital, inputs/outputs, and so on through a farm, catchment, community, region, etc. There are many variations on these, from **systems diagrams** to **impact diagrams**, all of which reveal relationships between different flows and fluxes in a social, economic or environmental system.

Pie Diagrams

Simple circles representing relative proportions or percentages of, for example, principal crops, major pests and diseases, sources of income/expenditure, etc. These diagrams are sometimes referred to as

chapati diagrams in South Asia. The purpose is to get a sense of relative amounts of various items and their changes over time. Thus, for instance, one can explore trends and changes in major land use patterns by asking local people to produce three separate pie diagrams, one of the past (e.g. 10 years ago), one of the present, and one of the future (e.g. 10 years from now).