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AN ENVIRONMENTAL DATA BASE FOR AGROFORESTRY

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AN ENVIRONMENTAL DATA BASE FOR AGROFORESTRY

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A B S T R A C T

An environmental data base has the function of relating different kinds of information in agroforestry research to a common basis of environmental information. The paper outlines the principles and structure of the data base, the information contained within it, and its potential uses. Information is included on geology, landforms, climate, hydrology, soils, vegetation, fauna and disease, and land use, including agroforestry practices. There are three levels of detail: a Summary Level, an Intermediate Level 1, and Level 2 containing detailed information. Data are transferred from an input form to computerized storage, using the Knowledgeman data base management system. Potential uses of the data base include, first, the collection, storage and selective retrieval of information on individual aspects of agroforestry: multipurpose trees, agricultural crops, agroforestry systems, and agroforestry experimental work. Secondly, it may be used for synthesis of these different kinds of information, as in land evaluation, diagnostic and design studies, and advisory work.

Supplement (June 1985). The information structure described above is now referred to as the sites file. A second file, the requirements file, has been added, which records the environmental requirements of components of agroforestry. The new structure of the data base is shown in Figure 2.

CHAPTER 1

THE NEED FOR AN ENVIRONMENTAL DATA BASE

1.1 GENERAL

Agroforestry is based on plants: trees, crops and grasses. Plant growth is dependent on the physical environment; different crops are suited to particular environmental conditions, and multi-purpose tree species will respond in different ways to variations in climatic conditions, soils and drainage. The choice of plant species suited to the environmental conditions of an area is fundamental to the success of any agroforestry practice. Equally there are environmental influences upon agroforestry practices which involve livestock, acting both directly on the animals and indirectly through effects on the growth of pastures.

There is a second, equally important, aspect: the effects of agroforestry practices upon the environment. Such effects can be either positive (i.e. beneficial) or negative. Frequently, they involve interaction between two or more components of an agroforestry system, e.g. trees and crops. Such interactions do not take place directly, but through the medium of climate and soil, modifying, for example, the microclimate and the soil moisture, organic matter and nutrient content.

Hence many types of information in the science of agroforestry are environment-specific: what grows well, or interacts effectively, under one set of physical conditions may not do so under another. This applies very obviously at the broad scale of major climatic zones, e.g. the humid tropics or rain forest zone, the subhumid tropics or savannas, and the semi-arid lands. At more detailed scales also there will be differences between efficient agroforestry designs on, for example, sandy soils as compared with clays, or on steeply-sloping lands as compared with gentle slopes.

Various past and present ICRAF activities have collected environmental data, or require it to be collected, as part of a methodology. These activities include:

- the crop sheets manual (Nair, 1980);
- the agroforestry systems inventory;
- the multipurpose tree dta bank;
- the manual for research on fast-growing nitrogen-fixing trees

- the guidelines for agroforestry diagnosis and design, together with the practical application of this methodology in collaborative projects;
- land evaluation;
- computerized indexing of library holdings.

These different activities can be linked through the use of a common basis for environmental information. Such a basis would serve, first, to ensure that the same kinds of information are collected (or at least sought) by all activities; for example, that studies of trees, crops, and land use systems are linked by a basic minimum of information, e.g. on length of dry season, slope angle, and soil reaction. Secondly, it would assist such collection by providing a common set of descriptors and classification systems for environmental data, in particular, classifications of rock type, climate, soils and vegetation.

The common base for environmental information could be used in two ways: transfer and synthesis. On the one hand, it would assist in transfer of information from one activity to another;for example, much information relevant to the multipurpose tree inventory has been collected by the agroforestry systems inventory. Secondly, where the objective is to assemble information of different kinds relevant to a specific area, the common data base would assist in initial retrieval; this applies to work in the collaborative programme, for designing agroforestry research projects for selected sites, and will certainly be required in future advisory work.

These potential applications of the environmental data base are discussed in more detail in Chapter 5.

1.2 OBJECTIVES

This Working Paper is written at a time when the framework for the environmental data base has been established, but before any substantial amounts of data have been put into it. The present objectives are, therefore:

i. To outline and justify the nature and content of the data base.
ii. To provide an introduction on how to use it at the initial stage, that of collection of data.
iii. To indicate its potential applications.

The Paper is intended primarily for those working permanently or temporarily with ICRAF, that is, the scientific staff together with research fellows, trainees, and others who join the organization for short periods. It may also assist individuals and organizations who make use of the results of ICRAF studies by providing an explanation of the basis and terminology employed for environmental information.

CHAPTER 2

PRINCIPLES AND NATURE

2.1 PRINCIPLES

The following principles, discussed in more detail in succeeding sections, underlie the construction of the data base:

1. It should be relevant to the needs of agroforestry (Section 2.2.3)

2. At least in its highest category it should be simple. As far as possible, the terminology used should be comprehensible to the non-specialists in environmental sciences. There should, however, be the potential for more detailed data, as called for by the needs of particular purposes (Section 2.3).

3. Although generalized, that is, employing broad classes, the class boundaries should be precisely defined. For example, the generalized landform class 'steeply sloping' is defined as having dominant slopes over 18^o.

4. The form in which data is recorded and stored should be standardized. There should also, however, be a measure of flexibility, including provision for acquiring data of diverse types from different sources.

5. It should make provision for data of varying degrees of reliability, and for missing data (Section 2.4).

6. It should be computer-compatible, i.e. have the potential for machine storage and retrieval (Section 2.6).

2.2 TYPES OF DATA

2.2.1 Factors of the physical environment

The physical environment can be described in terms of eight major factors: geology, landforms, climate, hydrology, soils, vegetation, fauna and disease. As the distinction between the last two is blurred, it is often convenient to treat fauna with disease as a single factor.

Selection of factors to be included, and the relative degree of detail, is governed by three considerations: utility as a general reference base on the environment, specific relevance to the needs of agroforestry, and compatibility with data used by research organizations with which ICRAF cooperates.

2.2.2 Utility as reference base on the environment

There are many strong interactions between the major factors, taking place over different time scales. Among the strongest of these interactions are:

Influence of:	Upon:
Geology	Landforms, and, as parent material, soils
Landforms	Climate, hydrology, soils, vegetation, fauna and disease
Hydrology	Soils, vegetation, fauna and disease
Soils	Vegetation
Vegetation	Soils, fauna and disease
Fauna	Vegetation

Although some of these effects are in part mutual interactions (e.g. landforms<--->climate, soils<--->vegetation) there is some element of direction downwards in the order in which the factors are listed. In particular, geology and climate are relatively independent variables at the start of the causal chain, whilst vegetation, fauna and disease are relatively dependent end-members. Vegetation possesses a special value in that it responds to, or indicates, all other factors of the environment; however, as it is also highly responsive to disturbance by human influences, such indications may require skilled interpretation.

There are two consequences of this situation. First, no major factor can be entirely left out of the data base, for to do so would cause an element in the causal network to be missing. Secondly, and more specifically, although geology is not directly relevant to agroforestry, it needs to be included as a basic element in the environmental setting. For example, in Kenya, the distinction between areas of Basement Complex rocks and volcanic rocks is fundamental to soils, vegetation and agriculture.

A further component, land use, is not of itself environmental information, but is usefully included in the data base for two reasons. First, the broad type of land use is a necessary background for interpreting elements of the environment, notably vegetation and fauna. Secondly, land use specifically interacts with some environmental characteristics; for example, soil organic matter is normally lower under cultivation than under natural vegetation. To describe land use in detail would go beyond the scope of the data base, so a broad classification is adequate.

Thus the environmental data base should include, in greater or lesser degree of detail, the following major components: geology, climate, landforms, hydrology, soils, vegetation, fauna and disease, and land use.

2.2.3 Relevance to the needs of agroforestry

Relevance to agroforestry was initially assessed by listing the environmental data included in five ICRAF projects current or completed in early 1983: the crop sheets manual, agroforestry systems inventory, multipurpose tree inventory, nitrogen-fixing tree manual, and diagnostic and design methodology. All included, or called for, elements of both climate and soils; four made some mention of landforms, and three of hydrology and of fauna and disease. Vegetation was included in two as the object of study, and two as environmental setting. Geology only received mention for its role as soil parent material.

A request for comments by ICRAF staff on a draft list of data resulted in added emphasis being given to hydrology and to fauna and disease. Since that enquiry, hydrology and landforms have acquired added significance in relation to the watershed approach now being incorporated in the diagnostic and design methodology, whilst landforms are clearly significant in forthcoming work on soil conservation aspects of agroforestry.

Hence all but one of the major environmental factors had been independently identified as relevant to agroforestry, the exception being geology. Climate and soils have received the greatest emphasis in ICRAF work to date, whilst vegetation and the pests and diseases which may affect it are direct objects of study.

On this basis, therefore, the data base should contain information in greatest detail on climate and soils; in moderate detail on landforms, hydrology, vegetation, and fauna and disease; but need only cover basic elements of geology and of land use.

A further aspect relevant to the needs of agroforestry, that of dynamic change, is discussed in Section 2.5.

2.2.4 Compatibility with data used by other organizations

Of its nature, agroforestry interacts with a particularly wide range of organizations, self-evidently including those in agriculture, forestry, and in the environment itself. Besides major national research centres in agriculture and forestry, ICRAF has had contacts with numerous international organizations, among those with close connections to date, being FAO (Agriculture and Forestry Department), Unesco, WMO (Commission for Agricultural

Meteorology), the International Society of Soil Science, research centres such as CATIE (Costa Rica), the East-West Centre (Hawaii), the Commonwealth Forestry Institute (U.K.), and, among CGIAR centres, particularly CIAT (Colombia), CIMMYT (Mexico) and IITA (Nigeria). If it had been found that many of these organizations employed the same standardized methods to record environmental data, there would clearly be good reason to adopt such standards.

The actual situation, however, is that on the one hand, there is a considerable measure of standardization of methods for recording details of environmental data; but on the other, there is little common agreement on systems of classification. Thus methods and units for collection of climatic data are well standardized, evapotranspiration excepted, as are methods of soil profile description. But there is, for example, no one climatic classification system recognized as standard by the World Meteorological Organization, nor soil classification system by the International Society of Soil Science.

Certain elements of the environmental data base have been identified from methods used by related research organizations. Among significant aspects taken into consideration (although not all incorporated) are:

- Much available information on climatic crop suitabilities is based on the FAO agro-ecological zones methodology (FAO, 1978, 1981).
- The FAO-Unesco Soil map of the world incorporates a classification system which is in quite widespread use for purposes of international comparison (FAO, 1974); equally, however, the US soil taxonomy is used in many countries (Soil Survey Staff, 1975).
- The Commonwealth Forestry Institute makes use of a simple but efficient characterization of soils, in terms of texture, reaction and drainage (Webb, Wood and Smith, 1980).
- There is fairly wide recognition of the Unesco system of vegetation classification (Unesco, 1973).

However, set against such elements of common use is the need for flexibility, to permit interaction with countries and organizations which employ classification systems different from those used in the ICRAF data base. For this reason, basic descriptive detail is included in addition to classifications. Thus to meet the joint requirements of uniformity and flexibility, the data base should include information of the following kinds:

- standardized classifications, e.g. climatic zones, soil types;
- individual characteristics, e.g. mean annual rainfall, soil texture;
- verbal information in free format.

2.3 LEVELS OF DETAIL

Any classification system is open to attack from two opposite directions: that it is too simplified, or too complex. Simplified systems may be held to be inadequate for scientific purposes. Complex systems may be regarded as unsatisfactory for either of two reasons: that information of the degree of detail required will rarely be available, or that non-specialist users will be put off by the technical terms or concepts used.

There is no easy way around this dilemma. For some users, and some purposes, broad descriptions are both desireable and sufficient; to know, for example, that an area is in the lowland rain forest climatic zone, and that the soil texture is sandy. For other purposes, greater precision is essential: to know whether the rain forest climate does or does not have a short dry season and whether the soil texture is a sand, loamy sand or sandy loam.

In an attempt partially to meet this incompatibility, the data base employs three levels of detail:

<u>Summary level</u> Giving classifications only.

<u>Level 1</u> This is for uses, and users, requiring a simple basic framework. It employs relatively simple terms, and the classifications employed contain few and broad divisions (in most cases eight classes or less). Understanding and use of this level should be open to most scientists.

<u>Level 2</u> This is for uses, and users, requiring more specific environmental information. Some specialized terminology is employed, and classifications are subdivided into more numerous classes. There may be a need for specialized environmental scientists to obtain or interpret data.

Level 1 provides a broad setting to items of information. It tells the user, for example, whether an item relates to acid clay soils in the lowland rain forest zone, or to calcareous sandy soils in the sahel. Level 2 narrows down the environment to a more limited range of conditions. If the data base is regarded as a selective environmental net to filter out relevant items of information, the mesh of the net is very coarse at Level 1, somewhat finer at Level 2.

The data contained in Level 2, however, will certainly be insufficient for detailed analysis, as for example in a design exercise. In such circumstances there will nearly always be a need for such items as monthly temperatures and rainfall, observed or calculated evapotranspiration, representative soil profile descriptions and analyses, and for some purposes, detailed information on vegetation physiognomy and species. Such further information can conceptually be thought of as "Level 3" in the data base, but it would be wasteful of effort to require that it should be standardized, i.e. the same data collected for all circumstances, and there is no need for storage in computerized form. What is important is to emphasize that substantial data over and above that of Level 2 of the data base will be needed for most exercises in detailed analysis and design, for example, in the determination of specific cropping patterns.

For purposes of output only there is also a summary level, 'Level 0', which prints out only the main classifications of each factor, thus providing a compact but highly generalized summary of the environmental setting.

2.4 RELIABILITY OF INFORMATION

Data for the store is going to be derived from sources of diverse kinds and reliability, including direct field observation, questionnaire surveys, publications, and maps ranging from world or national reconnaissance to detailed scales. In using the data base, it will become necessary to compare information on the same subject from different sources: for example, several different estimates of the rainfall range of a tree species. In such situations, one record of high reliability may outweigh several that are more questionable.

To meet this circumstance, the data base employs three levels of reliability, coded 1-3, together with a return of 'no data', computer-coded as 9:

1	Confident	The site can confidently be assigned to the climatic, soil, etc. class indicated. (The term 'certain' is avoided, as cautious scientists would rarely be willing to commit themselves to it.)
2	Probable	Whilst there is some doubt, evidence is such that the user is moderately confident about the class indicated.
3	Guess	The evidence is clearly inadequate, and reasoned guess has been made from inference, small-scale maps, or broad knowledge of the area.
9	No data	No data is given, and there is not even the basis for a reasoned guess. This return is also used to cover circumstances of 'not relevant'.

The alternatives were open of assigning a reliability class to the whole of the data about an environmental factor, or to the main class for that factor; for example, to information on soils as a whole, or to the soil class. It is felt that often some data items on a particular factor will be much less reliable than others, making the former course impracticable. For the most part, therefore, the reliability is attached to the classification of the environmental factor. An exception is fauna and disease where there is no overall classification, and reliability refers to data on this factor as a whole.

2.5 DYNAMIC ASPECTS: ENVIRONMENTAL DEGRADATION

For general natural resource survey purposes, it has long been recognized that many characteristics of the environment are dynamic, or subject to change in time. Such changes are frequently for the worse, as in soil erosion or vegetation degradation. The distinction between the static approach of environmental mapping, as in many land systems studies, and the dynamic or functional relationships approach is a classic item of debate among resource surveyors (e.g. Young, 1976, p. 387).

The dynamic element is of special significance for agroforestry. There are clear grounds for supposing that the introduction of trees of land use systems can be of particular benefit in areas which have suffered some form of environmental degradation. Agroforestry systems themselves are frequently intended to halt or reverse such degradation.

It is difficult to describe degradation in a standardized manner, and in particular to obtain reliable information. However, the data base at Level 2 contains items for recording degradation for each of the relevant environmental factors: hydrology (degradation of rive flow regime or siltation), soils (erosion, fertility decline, and other forms) and vegetation (degradation of pasture or tree cover). In each case there is a record of the type of degradation, together with its severity on a qualitative scale of absent, present, or severe.

A problem that arises is what is to be taken as the basis for assessing degradation, i.e. the non-degraded state: is it to be the natural state before any form of use by man, possibly in the distant past, or the state at some more recent date prior to clearly adverse effects on the resource base through over-intensive use? For practical purposes, the latter basis is selected, as purely natural conditions are rarely found outside of nature reserves, and furthermore it is a specialist study to judge what in fact constituted such natural conditions. Thus montane grassland which is believed to have replaced montane forest through clearance and burning, should not be classed as degraded; nor should soils under apparently stable agricultural use, even though their organic matter content is lower than that found in soils under natural vegetation.

A useful guidelines is that degradation should be recorded where the adverse change in the resource is either severe or progressive (FAO, 1976, p.39). Severe degradation is that in which the resources are substantially lowered in productive potential, or destroyed. Progressive degradation refers to a condition in which the resource is being continously depleted by a land use practice, without having attained a steady state. In the case of vegetation, a possible criterion of severe degradation is where the power of regeneration has been reduced.

2.6 COMPUTERIZATION

The number of agroforestry systems recorded by the systems inventory is likely to run into hundreds, the number of multipurpose tree species possibly into thousands. If not yet the case, it may be only a few years before several hundred experimental stations are operating agroforestry trials. It is not simply the nature of agroforestry that leads to the collection and synthesis of information from numerous sources, but ICRAF's role as a world coordinating organization.

It is no longer necessary to argue for the superiority of computerized handling for certain purposes involving large quantities of data. In the past, such data sets were handled by card indexing with cross-classification, or by the vast and apparently limitless storage and retrieval capacities of (some) human brains. But where there are large and relatively standardized sets of data, computers can achieve a virtually limitless amount of storage, a repeated and uniform retrieval of data, together with output in convenient printed form; thus leaving the human brain free for more refined tasks of analysis that are equally necessary but which, at least without excessively lengthy programming, the computer cannot achieve.

Hence the environmental data base must be capable of storage in computerized form. For convenience, a microcomputer with storage on discette has been employed in the first instance. There is some additional trouble for the user, particularly with respect to items of data that are zero in value, not relevant, or missing. Set against this is a considerable facility for selective retrieval and output. The computer program which incorporates the environmental data base is called AFENV (AgroForestry ENVironment), and is outlined in Section 4.3.

CHAPTER 3

INFORMATION INCLUDED

3.1 GENERAL

Based on the discussion in Chapter 2, the information contained in the environmental data base is guided by the following:

1. Information is included on all seven major factors of the physical environment, (treating fauna and disease as a single factor), together with land use. Climatic and soils information are recorded in greatest detail, geology and land use in outline only.

2. There are three levels of detail: Summary, Level 1 (intermediate) and Level 2 (detailed).

3. For each factor, information of four types is included where relevant:

   - classifications;
   - individual characteristics, mainly numerical;
   - short verbal descriptions;
   - dynamic aspects.

The remainder of this chapter is an introduction to the information included for each environmental factor. In particular, it gives reasons for the classifications selected. The chapter should be read in conjunction with the check lists and legend sheets (Appendix 1).

3.2 FACTORS OF THE ENVIRONMENT

3.2.1 Geology

Information on geology is required in outline only, as a broad setting and with particular respect to its influence as a soil parent material. It is thus rock type (lithology), not geological age, which is important.

Classification

Igneous and metamorphic rocks are grouped together as crystalline rocks; this will include most areas of Precambrian Basement Complex rocks widespread in the tropics, particularly African and South America. Basic rocks (those rich in ferromagnesian minerals, and dark in colour), which give rise to such highly distinctive and often fertile soils, are separated from felsic rocks (those rich in feldspers and free silica, sometimes called 'acidic'). The two classes of crystalline rocks are distinguished from sedimentary rocks, separated into siliceous (non-calcareous, e.g. sandstones and shales) and calcareous (limestones). There is a fifth group covering all forms of superficial deposits ---river and marine alluvium, blown sand, etc. As with each of the classifications, the reliability is recorded.

Other data

There are no suitable numerical values for rock type. The Level 1 set of data is completed by a verbal description of rock type, permittting more detail to be given as wished. At Level 2, rock grain size is classified, together with more specific verbal information.

3.2.2 Landforms

Classification. The most important element of geomorphology affecting agroforestry is slope angle, so the classification must be based primarily on this. Of the available classifications of slope angle, that employed in the FAO Soil map of the world is selected for Level 1. This contains three slope classes, separated at 30% and 8% (17^{o} and 5^{o}), corresponding to a subjective appraisal of 'steep, moderate, and gentle' slopes. Depositional landforms (alluvium, coastal plains) are separated from gently-sloping landforms of erosional origin, with a further class of swamps. The resulting five classes are each subdivided at Level 2.

Other data. A verbal description of landforms is given, e.g. 'gently undulating plain with broad concave valley floors'. The most important numerical value is slope angle (entered as either degrees or percent, and output as both), given as a single value where the item refers to a point or small area, or otherwise as a range. At Level 2, three further descriptors are added: relative relief (local height difference, e.g. between interfluve crest and valley), slope curvature, and position on the slope, this last being relevant to the soil catena.

3.2.3 Climate

Classification. Climate is the first of two factors for which a considerable number of classification systems are in existence, with none having predominant recognition or authority. These include the well-established systems of Köppen and Thornthwaite; the life zones of Holdridge, used particularly in Central America; Emberger's classification of Mediterranean and related climates; the major climates and growing periods employed in the FAO agro-ecological zones project; and the system of moisture availability and altitude/temperature zones used in Kenya.

The relative strengths and weaknesses of these systems, and equivalence between them, will be discussed in a separate publication (Darnhofer, in preparation). For the present purposes it is essential to have a system, the class of which can be calculated from widely available data; it must also be both known and proven on a world scale. On these two grounds, the Köppen system was selected as superior. As it contains many levels of detail, a simplification was prepared with the needs of agroforestry in developing countries in mind; this has 16 classes, mostly two-or three-letter, of which two are broad groupings of cool to cold climates. The distinction between one-and two-wet season savanna climates, the latter shown by the sign ", was retained as being very significant to plant growth.

There are occasions, particularly with data derived from publications, in which the Köppen class cannot be reliably estimated, but nevertheless the user is clear about the broad nature of the climate. To meet this circumstance, a set of 'generalized climatic types' is included in addition to the Köppen system. These consist of the very distinctive 'four worlds of the tropics': the permanently-humid (rain forest) lands, the subhumid lands (savannas), the semi-arid zone, and the arid zone or deserts. There are also the summer-rainfall or Mediterranean climatic type, the humid subtropical zone found on continental east coasts, plus classes for temperate maritime climates (as western Europe) and cold climates. The resulting 8 classes are defined by the Köppen classes included within them; but assignment of an area to a generalized climatic type may often be possible where the Köppen class is not known , so guidelines of annual rainfall, and length of dry season, applicable to the tropics, are given.

Other data. At Level 1, altitude, rainfall regime, mean annual temperature and rainfall, and number of dry months are included; a dry month is defined following Köppen as one with less than 60 mm rainfall (tropics) or 30 mm (extra-tropical); even if monthly rainfall values are not available, as may be the case in data abstracted from published articles, it may be possible to estimate the number of dry months approximately. These five characteristics alone convey much information on the climatic setting.

At Level 2, mean monthly values of rainfall are included, as these permit the subsequent user to calculate a variety of values relevant to particular purposes. Values for the hottest and coldest months are added, as these permit precise calculation of the Koppen class. There is provision for other somewhat more sophisticated data of particular relevance to agroforestry: data on observed or calculated evaporation, the rainfall/evaporation ratio r/E_o (as employed in the Kenya system of moisture availability zones), and the growing period, calculated by the FAO agro-ecological zones method. Rainfall confidence limits are not included as they will frequently not be available, or not in a standardized form; where known, they may be added as user-defined additional data (Section 3.2.9).

3.2.4 Hydrology

Classification. The major item of significance for plant growth is degree of surface waterlogging, and this is taken as the basis for a simple threefold classification, into areas which are wet permanently, seasonally, or not at all.

Other data. Linked to the classification is depth to groundwater, significant for tree growth.

A second and distinct type of hydrological information is that on flow. The flow regime---perennial, seasonal, intermittent or none---may not be directly significant to agroforestry, but is useful as a broad setting to the analysis of farming systems. However, this is an element of the environment often subject to degradation through land use either by adverse effects on the flow regime through deforestation, or by siltation through soil erosion. These effects are potentially reversible through agroforestry practices. The severity of river flow degradation is therefore recorded at Level 2.

3.2.5 Soils

Classification. The classification problem is perhaps even more difficult with respect to soils than to climate (for a review, see Young, 1976, pp. 235-258). Besides the multiplicity of systems in use, national as well as international, there are the added problems: that most modern systems employ a terminology unfamiliar to the non-specialist; whereas the older and more widely known terms lack precise definitions. Even the simplest of standard modern classifications is too complex and jargon-filled for understanding by most non-soil scientists.

To meet this problem, a broad grouping, called 'generalized soil types' has been devised, which is used together with a widely recognized international system, that of the FAO/UNESCO Soil map of the world. In addition, provision is made for including the soil class or name on any other system for which it is known.

The set of generalized soil types is designed with the intention that they can be identified by the non-specialist. All of the 'red and yellow' soils of the humid tropics, acid in reaction, are grouped together as a single class, the latosols; this includes both the strongly leached soils of the rainforest zone and the moderately leached, but still acid, soils typical of the savanna zone, together with the distinctive red soils which form on basic rocks,* Soils of the semi-arid zone, neutral to alkaline in reaction and in which free calcium carbonate is present, are similarly grouped as a single class, calcimorphic soils. There are then classes for a number of soils which are both distinctive and well recognized: vertisols ('cracking clays, black cotton soils'), desert soils (sand and rock), saline and alkaline soils, the shallow or stony soils common on steep slopes, and a class which combines alluvial soils with the poorly drained soils of valley floors (gleys), together with peats. Finally, temperate soils are combined as a single group.

The user at Level 1 can then add the soil class or name on any other system for which it is known, specifying the classification system; this could be an international or national system.

For use at Level 2, a more detailed classification is necessary. On grounds of widespread recognition, the choice lay between the CCTA, French/ORSTOM, US, and FAO systems. That of the CCTA Soil map of Africa, although having many merits, including a comprehensible terminology, has not been

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* In terms of the FAO/CCTA/US classifications, respectively, the broad group of latosols covers the ferralsols/ferrallitic soils/oxisols and ultisols, the luvisols/ferruginous soils/alfisols, and the nitosols/ - / -.

widely applied outside the African continent, whilst the ORSTOM system is mainly used in francophone countries. The US soil taxonomy, initially devised for use in the United States but employed in a number of countries, has merits and defects; it has very precisely defined class boundaries, and a seven-category system of subdivisions; but its extreme complexity coupled with the unfamiliar and sometimes self-parodying nature of its terminology arouse strong feelings and make it unsuitable for many intended users of the data base.

The system selected is that of the FAO/UNESCO Soil map of the world (FAO, 1974). This combines a moderate degree of precision in definitions with a terminology that is not too unfriendly. Although originally devised as a map legend, it is, in fact, and is commonly used as, a classification system, with 26 soil classes in the higher category and 106 subdivisions. There are the added advantages that world maps are available, to give a first approximation of the soil types to be expected in any area, and that many soil survey reports contain equivalence tables to the system.

Other data. For soil properties, Level 1 makes use of a simplified method of description devised by the Commonwealth Forestry Institute (Webb, Wood and Smith, 1980), which gives substantial information in terms that are widely understood. In its original form there are three classes of texture, reaction and drainage, plus a fourth descriptor for stating whether the soil is shallow, saline, or possesses any other distinctive features. In the version used here, a fourth reaction class, 'strongly acid', has been added, to separate soils in which phosphate fixation and aluminium toxicity are severe problems. These four descriptors constitute in effect a form of classification, with classes such as 'well drained, sandy, acid soil'. At Level 2, information on the same profile features, texture, reaction and drainage, is given in standard pedological terms.

For soi degradation, the six types recognized in the FAO methodology are adopted: water and wind erosion, salinization, and chemical, physical, and biological degradation (FAO, 1979). A seventh class of 'fertility decline' is added, to cover situations in which the cause of such decline cannot be more precisely identified. As with other factors, degradation is rated as absent, present, or severe.

3.2.6 Vegetation

Vegetation differs from the other environmental factors in that the natural vegetation may have been totally removed from the actual site described, as when it is under crops or forest plantations. It is therefore described in two stages. First, the natural vegetation of the area as a whole, which may or may not be found on the site; secondly, the vegetation present on the site itself, whether predominantly natural or planted by man. For the vegetation of the area, 'natural' does not necessarily mean climax, but refers to any form of predominantly self-sown vegetation.

Classification. In choosing between classification systems, the same compromise was adopted as in the case of soils: a system of 'generalized vegetation types', few in number and widely understood, at Level 1, coupled with a standard and more technical system at Level 2. For tropical latitudes, the basis of the generalized system is the distinction between rain forest, deciduous broadleaved vegetation, xeromorphic communities dominated by thorny trees, semi-desert vegetation, and desert; the broad-leaved types are divided into woodland, with a relatively continuous crown cover, and savanna. Other distinctive communities are separated: grassland, coniferous woodland, temperate deciduous woodland, montane vegetation and swamp. At Level 2, the Unesco (1973) system is adopted, with five main groups and 19 classes; a class of 'planted vegetation' is added.

Other data. At a generalized level, vegetation is better described verbally than by numerical descriptors. One-line descriptions are requested for physiognomy and for botanical composition. At Level 2 apparent (visual) degradation of vegetation is rated as absent, present or severe; there are no established classes for types of degradation, so this is verbally described (e.g. 'lack of tree regeneration owing to fire', 'pasture dominated by unpalatable species').

3.2.7 Fauna and disease

A classification system is not appropriate for this factor. Space is given to list whatever fauna, pests or diseases are believed to affect plants (e.g. animal or bird pests, termites, locusts, damaging soil fauna, or plant diseases), and animals (insect carriers and livestock diseases, including tsetse fly/trypanosomiasis). Disease may usefully be described as endemic or epidemic, or in terms of their severity.

The description of fauna is not intended to cover livestock, i.e. cattle, sheep, goats, etc. In the absence of a classification, the reliability statement refers to information on fauna and disease as a whole.

3.2.8 Land use

Classification. Agroforestry research frequently requires a detailed description and analysis of present land use, as set out in the diagnostic and design methodology. This, however, goes beyond the purposes of the environmental data base, in which land use is included to give background to, and for its effects upon, other environmental factors. A simple broad classification is sufficient for this purpose.

For such a broad description, the concept of major kinds of land use, originally devised for land evaluation, is suitable (FAO, 1976, p.9). Major kinds of land use are more easily described by examples than by a formal definition: annual crops (arable agricultural), tree and shrub crops (perennials), irrigated agriculture; two forms of livestock production, based respectively, on natural pastures (free range grazing, including both nomadic grazing and ranching) and improved pastures; two forms of forestry, based on natural and on planted forests; and specialized uses such as recreation/tourism, wildlife conservation, and water catchments. Two distinctive forms of crop production are separated from annual and perennial cropping as a whole, namely swamp rice cultivation and gardens (intensive cultivation on small plots, whether subsistence or commerical). Field perennial crops are separated, as being intermediate in characteristics between annual cropping and tree and shrub crops. In many cases the land use will cover two or more of these classes, and computer provision is made to enter up to three codes. The classification is supplemented by a brief verbal description of land use.

Any existing agroforestry practises should clearly receive mention. As there is not yet any classification system adopted for common use by ICRAF, space is given for the user to enter a class name on any system he wishes. A system of coded agroforestry classes may be entered under 'user-defined additional data' (see below).

3.2.9 User-defined additional data and general notes

For some data stores, there may be items of environmental information that are essential, but not included in the standard data bace. Provision is made for the user to define such additional data, and enter values. Up to three coded items (classes), three numerical values, and three one-line verbal descriptions may be entered. In allocating class code numbers, no.9 should always be allotted to 'no data/not relevant'.

It is frequently helpful to enter a summary of the environmental features of the site, which can serve as a reminder to users familiar with similar environments. Any of three aspects may be mentioned:

i Ways in which the site is typical of a well-known environment, e.g. 'a typical African plateau landscape, gently undulating with broad valley floors, one-wet-season subhumid climate and *Brachystegia* savanna'.

ii Ways in which the site is distinctive or unusual, e.g. ' a high altitude plateau remnant, cooler and wetter than the surrounding region and with more strongly leached soils; montane grassland, with montane forest remnants in valleys'.

iii Elements of synthesis, including mention of dominant environmental problems, e.g. 'this site lies towards the drier margin of savanna zone, with the drought hazard accentuated by the low water availability of the soils'.

3.2.10 More detailed information

For many purposes, the data base will need to be supplemented by considerably more detailed environmental information. This will differ from one purpose, and one area, to another. For example, data for drought hazard will be essential in a semi-arid area, whereas information relating to leaching of soils will be more relevant in the rain forest zone. Such information can be thought of as a 'Level 3' to the data base, but will not be stored in standardized form. Certain data, however, will commonly be included, and should be obtained for any studies involving diagnosis of problems and/or design of agroforestry systems. These data include:

- monthly values of temperature;
- observed or calculated monthly values of evaporation or potential evapotranspiration;
- representative soil profile descriptions and analytical data;
- more detailed descriptions of vegetation, including species lists and phytosociological records.

Such more detailed investigations should also include a list of sources of environmental information: maps, reports, articles, research stations, individuals, etc.

CHAPTER 4

FORMAT

4.1 DATE SETS AND SITES

Information is collected and stored on the basis of data set, stores of information of a similar kind. Examples are 'sites of recorded agroforestry systems' or 'experiment stations conducting agroforestry trials'. Each data set is given a reference number or letters and title, plus a description. Subsequent reference is by the user's initials and the reference number or letters, e.g. EF/1 or EF/AFSYS.

Within any data set, information is collected and stored for a number of sites. These can be of varying extent, e.g. one specific point at which a tree is found growing; the area of a single farm, or the whole environmental range observed for a specified tree, or farming system. Each site entered in the data set must be allocated a sequential reference number, 1, 2, 3,..... If there is already some other form of reference, this is stored separately as the user's reference number, which can be of any form, e.g. KEN/32. The site is given a short title. The sequential reference number is the basis for all computer storage and retrieval and must never be altered.

For each site, basic identification data is recorded on source of data, country, location, latitude and longitude, and altitude, with reliability of position and altitude.

Environmental information, at Level 1 or 2 as preferred, is then entered for each site within each data set (Table 1). The full reference for any site is of this form: data set - sequential number of site, e.g. EF/1 - 25, the twenty-fifth site in data set EF/1.

4.2 INPUT FORM AND LEGEND SHEET

Data are initially recorded on an input form, one form for each site. The same input form serves for all levels, the data included in each being indicated on the form.

A legend sheet provides instructions for completing the input forms. It gives instructions for each item of data, together with details of classifications used.

In many cases, data will be spread over a range of numberical values, e.g. altitude 600 - 850 m, or will include more than one verbal class, e.g. ferralsols and acrisols. There are spaces for two such numeric values, one being left blank where necessary; verbal combinations are simply entered as such.

For geology, landforms, soils, vegetation and land use, classifications are supplemented by verbal descriptions. This allows information to be entered in whatever form the user prefers, including expansions or qualifications of the classes. For example, rock type might be given as a coded class, 'superficial deposits', supplemented by a description, such as 'river alluvium of variable texture including swamps'.

4.3 COMPUTERIZED STORAGE

The data base is stored by means of the KnowledgeMan data base management system, using the IBM Personal Computer. This has a large capacity, including for number of fields, length of record and number of records.

There are procedures to input, edit and selectively output data. In the input procedure, a form identical to the input form appears on the screen, and values are entered. The edit procedure is nearly identical, except that existing values appear on the screen, and can be edited.

The standard output procedure asks the user:

i. At which Level is output required?
ii. For which site number is output required?

The selected site is then output at the level of detail required.

Selective output i. achieved by the standard commands of the KnowledgeMan System; for example, a request could be entered for all sites with rainfall 400-700 mm and altitude over 1200 m, or for all sites with ferralsols or acrisols.

CHAPTER 5

USING THE ENVIRONMENTAL DATA BASE

5.1 BUILDING UP DATA BANKS

The data base is of no use on its own; it only becomes useful when environmental information has been put into it. That is, the environmental data base, regarded as a framework, must be used as the means to build up environmental data banks.

As at late 1983, the data base exists only as a framework, together with a few examples of data stored for purposes of testing and demonstration. The steps in building up the data store may include the following:

- Multipurpose trees. Questionnaire forms for the multipurpose tree data bank, currently in progress, include environmental information compatible with Level 1.
- Agroforestry systems. Proforms for the agroforestry systems inventory include a simplified version of Level 1 as the basis for environmental data.
- Field sites in the collaborative programme. Work is in hand to give record level 2 environmental data for sites in ICRAF's Collaborative and Special Projects Programme (COSPRO).
- Crop requirements. The existence and whereabouts of much data on crop environmental requirements is known. This needs to be systematized as part of the Land Evaluation project.
- Experimental sites. Whilst recognized as desirable, no steps have yet been taken by ICRAF to conduct a systematic inventory of stations undertaking agroforestry experimental work.

5.2 RELATION OF THE DATA BASE TO LIBRARY INDEXING

It would be unrealistic to consider indexing of ICRAF's library holdings at even Level 1 of the data base. Quite apart from the work involved, the required data would rarely be available. Moreover, computer indexing of publications is a specialized task with its own requirements.

What has been done, however, is to include some of the classes in the environmental data base as descriptors in the library indexing systems. This applies particularly to the generalized classifications of climate and of soils. This will allow selective searches for published material environmentally related to a given area to be made through these descriptors. The data base can also be used in a negative way, to reject, or treat with caution, publications initially retrieved as related to a problem in hand, but which, on further inspection, prove to be based on environments substantially different from that under consideration.

5.3 POTENTIAL USES

Once the necessary data bank has been built up, potential applications include the following:

I. Applications involving one data set

MULTIPURPOSE TREES:

- Storing environmental conditions under which trees are found
- Storing environmental requirements of trees
- Retrieving tree species suited to a given environment

AGRICULTURAL CROPS:

- Storing environmental requirements of crops
- Retrieving crops suited to a given environment

AGROFORESTRY SYSTEMS:

- Storing environments under which systems have been recorded
- Retrieving systems recorded under similar conditions to a given environment

AGROFORESTRY EXPERIMENTAL WORK

- Storing environmental data for sites on which research trials are being carried out
- Retrieving experimental sites which have similar conditions to a given environment.

II. Applications involving comparison or synthesis of information from different data sets

LAND EVALUATION

- Collecting information about land units
- Retrieving environmental requirements of trees, crops, etc.
- Combining information for evaluation of agroforestry land use

systems on specified land units

DIAGNOSTIC AND DESIGN STUDIES

- Collecting information from a study area
- Retrieving information (trees, crops, systems, publications) relevant to the environment of that area.

ADVISORY WORK

- Similar purposes to those of diagnostic and design studies.

5.4 A FUTURE SCENARIO

It will be some years before the necessary data banks are assembled. Looking into the future, however, the following idealized situation may be possible to achieve (Fig. 2).

It is wished to design an agroforestry system suited to a given area. This could be as part of the design of a research project in the Collaborative Programme, or in advisory work; when the state of the art permits, it could be also for drawing up recommendations for extension purposes.

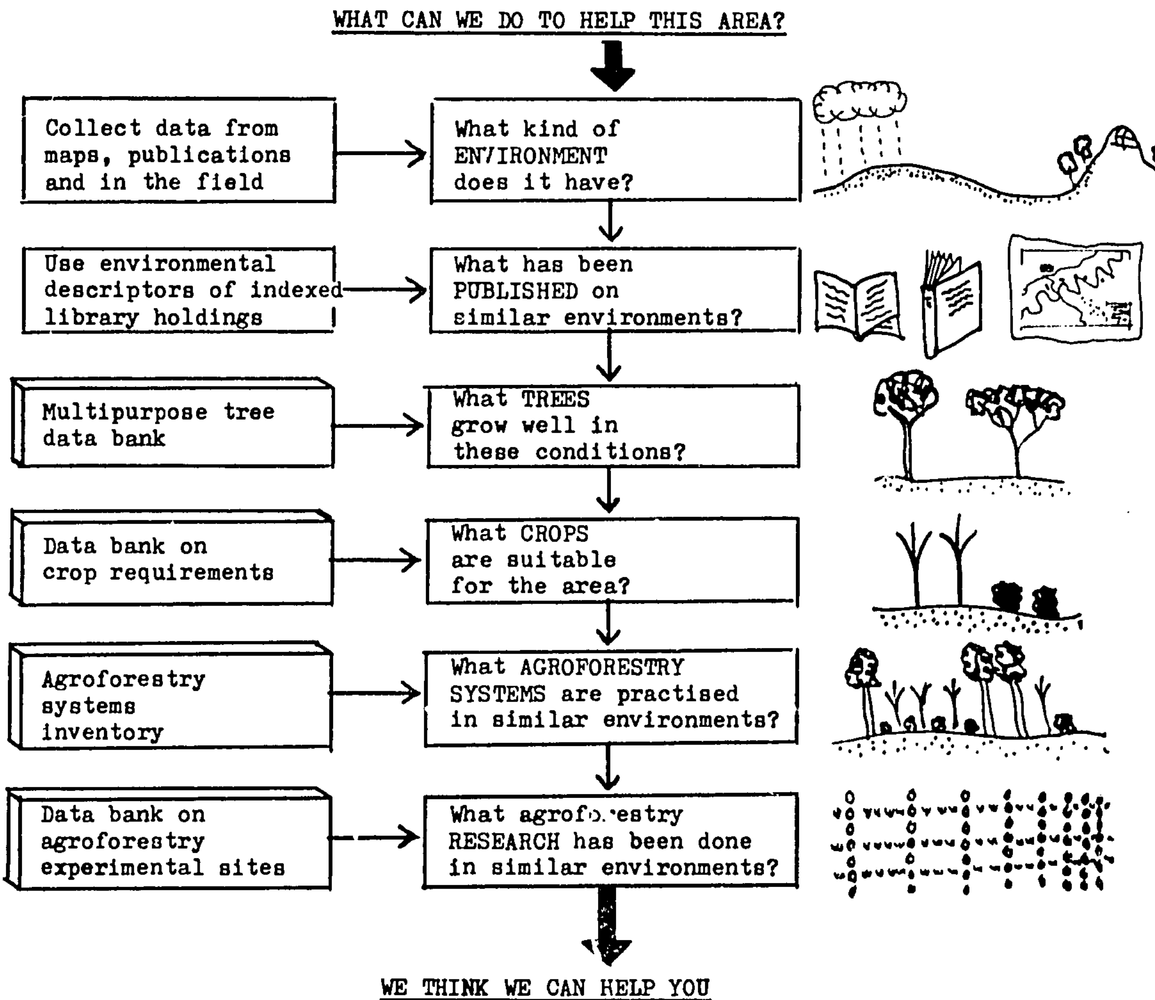
The first step would be to collect information on the environment of the study area. This would be in the format of the environmental data base, Level 2, together with supplementary information. The collection could be done in the first instance from published sources, later supplemented by field observation.

A library search of indexed publications is then conducted, using descriptors from the climatic, soil and possibly other classifications. This may reveal a range of papers and reports which refer to similar environments. The Level 2 check list can also be used be used to test the relevance of published data obtained in other ways.

The order of the next four steps is immaterial. A search is made for multipurpose tree species which are expected to grow well in the environment of the study area. A parallel search is made for crops (and possibly grasses or leguminous pasture species) suited to the environment, comparing various reported ranges of suitability.

Parallel with the above, a search is made for agroforestry systems observed in similar environments. Since the environmental data base will retrieve

Figure 1. Using the environmental data base: a future scenario.



irrespective of continent or of economic or social conditions, some interesting possibilities for (modified) transfer of land use systems may be revealed. Could it be, for example, that some of the rather intensive systems found in the subhumid climates of peninsular India, under climates of monsoonal origin but with a single rainy season and a long dry season, might be relevant for consideration in some of the one-wet-season savanna climates of Africa or South America?

One further search, either of positive retrieval or negative vetting, might be made for experimental sites where there have been agroforestry trials. It would be appropriate for ICRAF to compile such an inventory, and if carried out, essential to make results specific to environment.

From the above searches there could therefore emerge, for the described environment of the study area, the following:

- publications concerned with similar environments;
- trees expected to grow well;
- crops believed to be suitable;
- agroforestry systems which have been observed;
- relevant experimental results.

These are elements on which could be based the design of an agroforestry research programme, or, in the course of time, a practical system for extension.

It is important to end on a note of caution. The retrieval exercise described above should be treated very much as a first approximation. It is a net with a coarse mesh, which will let through many items which, on closer inspection, are found to be unsuitable. It would be madness to rush into, say, 'an alley cropping system based on trees X and Y with crop Z, as successfully demonstrated at Somewhat Agricultural Research Station and described by Bloggs (1982)' simply on the basis that thse components were retrieved from similar environments. From environmental considerations alone, there are three reasons why such initial identifications could prove to be unsuitable:

- Errors of description. Some of the initial records may have been inadequately or erroneously described; this is particularly likely to apply to soil type.
- Differences in detail. Even Level 2 is still based on broad classes.

A substantial range of variation can occur within any one class, and some such variations will be significant to plant growth.

- Interactions between factors. Of its nature the environmental data base does not take account of environmental interactions. Examples include interactions of climate, with soil in affecting moisture availability; or of landforms, climate and soils in affecting soil/ erosion hazard. The approach of land qualities, as employed in land evaluation, is designed to take account of such interactions.

Finally, it goes without saying that agroforestry systems should never be designed with suitability to the physical environment alone in mind. To do so would be retrogressive, reverting to an earlier and crude approach which, on occasion, could lead to disastrous consequences. The procedures of search, analysis and synthesis described above with reference to environmental data need, of course, to be paralleled by economic and social analysis. To debate whether the physical or human input to design it 'more important' is unproductive. Both are essential to any form of land use design.

AN ENVIRONMENTAL DATA BASE FOR AGROFORESTRY
ICRAF WORKING PAPER 5

SUPPLEMENT: JUNE 1985

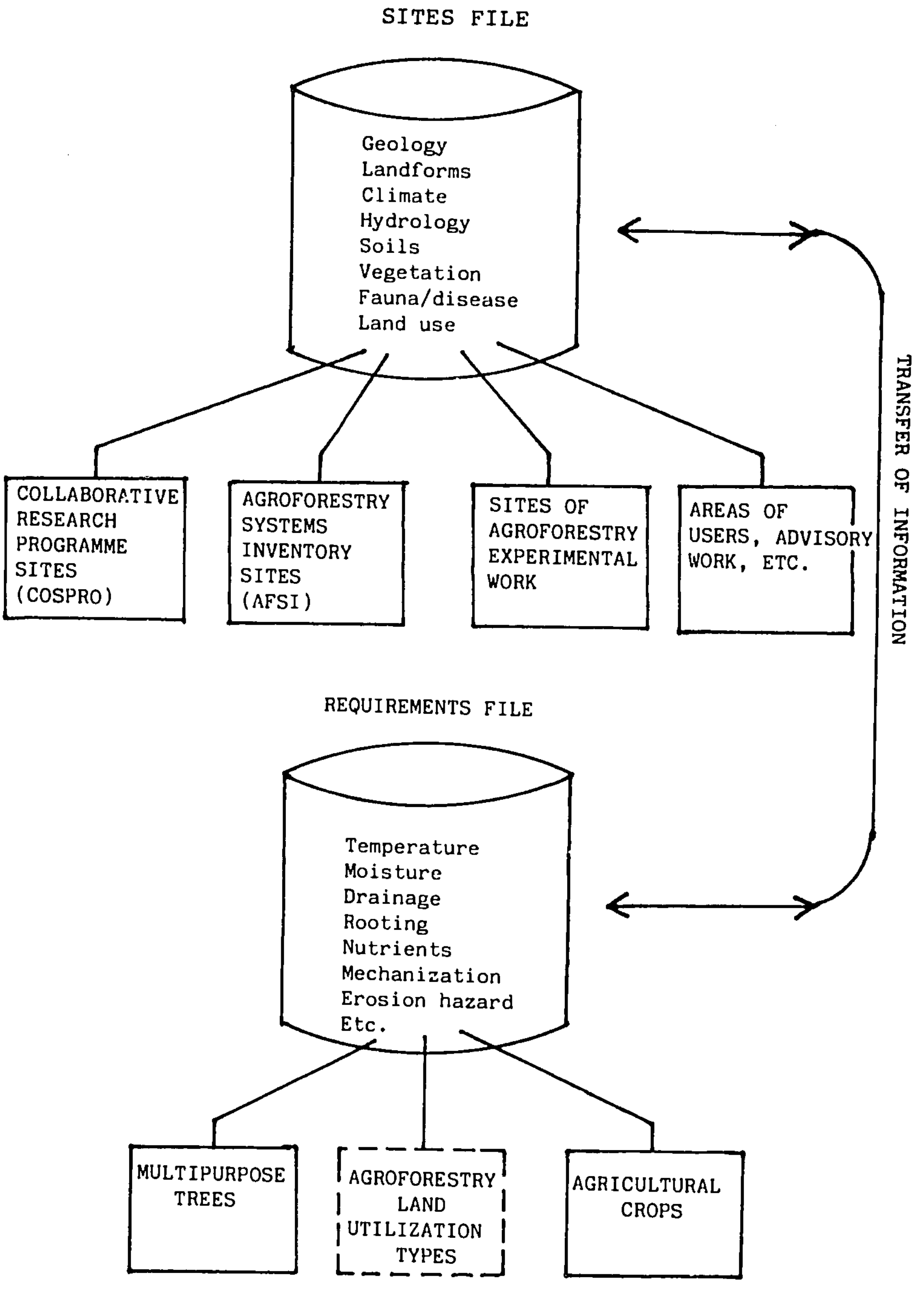
Since publication of the above Working Paper, amendments and additions have been made to the ICRAF environmental data base. Pending production of a revised version, the principal changes are here summarized. These are as follows:

1. The information structure described in Working Paper 5 is now referred to as the sites file, or AFSITES. It records the total physical environment of a location (point or area). A second file has been added to the data base, the requirements file, or AFNEEDS. This records specific environmental requirements of components of agroforestry: multipurpose trees, crops, and in time it is hoped, technologies. Requirements are arranged according to the land qualities of the FAO system of land evaluation, e.g. requirements for temperatures, moisture, nutrients, drainage, rooting conditions. The requirements file will be described in detail in a subsequent publication. The relation between the two files is illustrated in the attached diagram.

2. The AFENV computer program has been abandoned in favour of storage of information on the KnowledgeMan data base management system, operated on the IBM-PC microcomputer. As a result of KnowledgeMan's large capacity for field length, the numeric codes described in the Working Paper have become superfluous. Thus, for example, the landform class "1. Steeply sloping" is now recorded as "Steeply sloping". This modification does not affect the nature of the information recorded.

As a consequence, the input form and legend sheet have been simplified, omitting code numbers. Revised versions are given in Appendix A.

Figure 2: SIMPLIFIED STRUCTURE OF THE ICRAF ENVIRONMENTAL DATA BASE



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APPENDIX 1

SITES FILE, INPUT FORM AND LEGEND SHEET

The same input form serves to input data at all levels. The items included in the Summary level are indicated by an 'S', and the division between Levels 1 and 2 by subheadings.

The legend sheet contains instructions for entering data on the input forms, including details of classifications used. There are two Attachments to the legend sheet:

- the Köppen climatic classification
- guidelines to the FAO soil classification system

The computerized system contains a programme for interactive determination of Köppen climatic class.

ICRAF ENVIRONMENTAL DATA BASE: SITES FILE, INPUT FORM

S Type of data ....

Title ....

Subtitle ....

Reference: Letters ...... Number ...... Input by ..... Date: D.... M .... Y ....

Source .... Suitability level ....

LOCATION

Country .... Location ....

Latitude ...... - ... NS Longitude ...... - ...... EW Rel.......

S Altitude ...... - .... m Rel.......

GEOLOGY

S Class .... Rel......

Description ....

Level 2 data

Grain size .... Formation ....

Age .... Lithology ....

LANDFORMS

S Class .... Rel.......

Description ....

Slope angle ...... - ...... degrees or ...... - ...... %

Relative relief ...... - ...... m

Level 2 data

Slope shape......................... Slope Position ....

CLIMATE

S Class: gen. .... Rel.......

S Köppen: code ...... class .... Rel.......

Alt. zone ..... - ..... m Rainfall regime ....

Ann. temp ..... - C

Ann. rainfall ....- .... mm with ...... - ...... dry months

Level 2 data

Mean temp.: Hottest month ...... - ...... C Coldest month ...... - C

Driest month ...... mm Occurrence of Frost ....

Mean annual Eo ..... - .... mm By which method? ....

Humidity index r/Eo = ... - ...... Growing period ...... - ...... days

Mean Monthly Rainfall, mm

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
....	....	....	....	....	....	....	....	....	....	....	....	....

Climatic details for ...... Distance from site ..... km Altitude ....

S Summary level data

HYDROLOGY

S Class .... Rel.......

Groundwater .... Depth: Average ...... - ...... m

Level 2 data Groundwater depth: lowest ...... - ...... highest ...... - ...... m

River regime .... Degradation ....

Flooding ....

Soils

S Class: gen. ....Rel.......

S FAO Code ...... Class ....Rel.......

Other .... on .... classification

Properties: Texture .... Reaction ....

Drainage .... Other ....

Level 2 data

Texture class: topsoil ...... - ...... subsoil ...... - ......

Reaction (pH): topsoil ...... - ...... subsoil ...... - ......

Drainage .... Lim.horizon ......- ......

Degradation: Severity .... Type ....

Vegetation

S Class: gen. Area ....Rel......

Site ....

Unesco ....Rel......

Description ....

Association ....

Level 2 data Degradation: Severity ....

Type ....

FAUNA AND DISEASE

Affecting plants ....Rel......

Affecting animals ....

LAND USE

S Class ....Rel......

S AF class ....Rel......

Description ....

....

NOTES ....

....

....

....

ADDITIONAL DATA

	Name of variable	Value
1:		
2:		
3:		
4:		

ICRAF ENVIRONMENTAL DATA BASE:
SITES FILE, LEGEND SHEET FOR DATA INPUT

INTRODUCTION

This sheet gives instructions for the input of data to the sites file of the ICRAF Environmental Data Base. It is used in conjunction with an input form on which the data values are recorded. The input form is reproduced on the screen of the microcomputer for transfer to the data base.

An explanatory description of the sites file, with reasons for selection of data items and choice of classifications, is given in A. Young (1983), "An environmental data base for agroforestry" (ICRAF Working Paper 5).

Sites

A site recorded in the data base may be:

i. A point or small area, e.g. where a single multipurpose tree is observed to be growing.

ii. A larger but contiguous area, e.g. the area covered by a diagnostic and design survey or advisory study.

iii. A non-contiguous set of areas, e.g. all sites on which a multipurpose tree is known to grow, or on which an agroforestry system is practised.

Data

A data item may be given as a single value or a range; e.g. mean annual rainfall may be recorded as 1250 mm or 1100-1300 mm. If a single value is recorded, the space for the second value is left blank.

With a few exceptions, data are recorded as character strings, that is, numbers and/or letters and symbols may be used. This allows use of the c. (=circa) or ? to indicate approximate or doubtful data, e.g.:

Slope angle c.12 degrees	Approximately 12 degrees
Soil class vertisols?	Probably vertisols, but unsure

Levels of detail

Data may be input and stored at any of three levels of detail:

Level 0	Summary level
Level 1	Semi-detailed
Level 2	Detailed

The same input form and legend sheet are used for input at all levels, ommitting values as necessary. Items in the summary level are marked on the input form with an S in the left margin. The division between Level 1 and Level 2 is shown by subheadings "Level 2 data".

Recording of classes

Each environmental factor (geology, climate, etc.) commences with one or more classifications, intended for retrieval of data in broad groups, e.g. all sites on steep slopes, in Mediterranean climates, etc.. For the purpose of computerized retrieval, the code word for the class should be written in full, correctly spelt, e.g.

Sedimentary	Sedimentary rocks other than calcareous e.g. sandstone, shale

should be recorded as Sedimentary, not Sed. or Sdry. Where there are words in brackets, however, these are for clarification and should be omitted, e.g. Crystalline (non-basic) should be recorded as Crystalline.

Reliability codes

Each of the classifications is assigned a reliability code, as follows:

1 Confident
2 Probable
3 Guess
9 No data

IDENTIFICATION DATA (All items included in Summary level)

Type of data The following types of data, recorded by abbreviations, are currently recognized:

COSPRO	Sites of ICRAF Collaborative Programme
AFSI	Sites of ICRAF Agroforestry Systems Inventory
EXPT	Sites of agroforestry experimental work
MPT	Sites of multipurpose trees
ADV	Sites of agroforestry advisory work
OTHER	Sites not included in the above

Title The main title, sometimes a location, e.g.

(for a COSPRO site)	Kakuyuni
(for an AFSI site)	Chagga home gardens
(for an experimental site)	Bunda College, Malawi
(for a multipurpose tree)	Leucaena leucocephala

Subtitle Amplification of the title. For trees, use Subtitle to give variety or provenance. May also be used as a continuation of the title.

Reference:

Letters	E.g. AFSI
Number	The sequential number under the preceding reference letters, e.g. AFSI/15. Need not be given until transfer to computer storage.

Input by	Initials of person completing input form.
Date	Day Month Year, e.g. 22.8.84
Source	Source(s) from which data derived. If a publication, enter author and year here, e.g. Laidlaw (1979), and give bibliographic details below as references (computerized in the source file).
Suitability Level	This is to assist transfer to the requirements file of the data base. In most cases, the suitability level on the sites file is likely to be OB = observed. The suitability levels are as follows:

OB	Observed	Any recorded site
SS	Suitable	A site on which a specified plant, pratice, etc. grows or function satisfactorily or well
NN	Not suitable	The specified plant, practice etc. grows or functions poorly
S1	Highly suitable	
S2	Moderately suitable	
S3	Marginally suitable	

LOCATION (All items included in Summary level)

Country	E.g. Kenya
Location	E.g. 105 km ESE of Nairobi
Latitude) Longitude)	These two items must be entered in standard form, as in the following examples:

22.34N	115.35E
22.00S	002.00W
02.30N	049.33-050.45E
20.30 - 23.00N	

Rel	Reliability of latitude and longitude, see reliability codes in Introduction above.
Altitude	In metres, e.g. 1350 m, 1200-1500 m
Rel	Reliability of altitude

GEOLOGY

Summary level

Class — See note on Recording of classes in Introduction.

Class	Explanation
Crystalline (non-basic)	Igneous or metamorphic, felsic ('acidic'), e.g. granite, gneiss
Basic	Igneous or metamorphic, basic or ultra-basic, e.g. basalt, andesite
Sedimentary	Sedimentary other than calcareous, e.g. sandstone,shale
Calcareous	Limestone
Superficial	Alluvium, blown sand, etc.
Other	
No data	

Rel	Reliability of geology class. Note that "No data" should always be recorded as reliability 9.

Level 1

Description	Any name, description or age, e.g. Jurassic sandstone, Bassment Complex

Level 2

Grain size	Coarse Medium Fine No data
Formation	E.g. Kapata Beds
Age	E.g. Jurassic, Precambrian
Lithology	E.g. Hornblende-biotite gneiss

LANDFORMS

Class

Class	Explanation	degrees	percent	
Steep	Dominant slopes	>17°	>30%	
Moderate	" "	5°-17°	8-30%	
Gentle	" "	<5°	<8%	(erosional landforms)
Flat	Dominantly level depositional landforms, e.g. flood plains (excluding areas dominantly swamps)			
Swamp	Sites largely or entirely waterlogged			
No data				

Rel	Reliability of landform class

Level 1

Description	General description of landforms
Slope angle	Degrees or percent, as a single value or a range
Relative relief	Local average altitude range e.g. between hill and valley, in metres

Level 2

Slope angle — Refers to shape in profile, i.e. cross-section; applicable to a small areas only:

Convex	Angle increases downslope
Straight	Angle constant
Concave	Angle decreases downslope
No data	

Slope position — Applicable to a small areas only:

Crest
Upper slope
Mid-slope
Lower slope
Base
Other (slopes of complex shape)
No data

CLIMATE

Summary level

Two classifications are recorded, a broadly generalized climatic class and the Köppen class. The definitions of the generalized types are in terms of the Köppen classes included in each; where sufficient data are available the Koppen class should be determined first. The guidelines are approximate only, for use where data to determine the Köppen class are not available.

Class gen. Generalized climatic class

Class	Köppen classes included
Humid tropics	Af, Am
Subhumid tropics	Aw, Aw2, Cw, Cw2
Semi-arid	BShw, BSk
Arid	BWh, BWk
Humid subtropics	Cfa
Mediterranean	Cs, BShs
Temperate (maritime)	Cfb
Cool or cold	D, E
No data	

Approximate guidelines

Code	Rainfall (mm)	Dry months	Notes	Typical location
Humid tropics	>1500	< 4	Permanently humid or short dry season	Singapore Belem
Subhumid tropics	600-1500	4-8	Seasonally humid with dry season(s)	Lusaka Caracas
Semi-arid	250-600	8-10	Short rainy season; 'steppe', 'sahel'; excluding Mediterranean, see below	Delhi Niamey
Arid	< 250	11-12	Desert	Khartoum Lima
Humid subtropics	High-sun (summer) rainfall		East sides of continents; includes also montane humid	Hongkong New Orleans
Mediterranean	Low-sun (winter) rainfall		Excluding arid, but including semi-arid winter rainfall	Rome San Francisco
Temperate maritime			Mild winters; west sides of continents	London Wellington
Cool or cold			Includes tropical high montane	Moscow Kilimanjaro

Rel. Reliability of Köppen climate class

Köppen climatic class For definitions and key to Köppen classes, see Attachment A. A computer routine to determine the class is available.

Koppen:	code	E.g. Af, BSh. Note that Köppen's Aw" and Cw" are recorded as Aw2 and Cw2.
	class	E.g. Humid tropics, permanently humid

Code Class

A: Hot climates

Af	Humid tropics, permanently humid
Am	Humid tropics, short dry period ('monsoonal')
Aw	Subhumid tropics, one wet season
Aw2	Subhumid tropics, two wet seasons

B: Dry climates

BSh	Semi-arid, hot
BSk	Semi-arid, warm to cold
BWh	Arid, hot
BWk	Arid, warm to cold

C: Warm climates

Cfa	Humid subtropical; also montane humid	
Cfb	Temperate maritime	
Cw	Highland subhumid, one wet season	)Including
Cw2	Highland subhumid, two wet seasons	)Köppen
Cs	Mediterranean	)a, b and c

D, E: Cold climates

D	Temperate continental; also tropical and subtropical montare zone
E	Cold tundra; also high montane zone
ND	No data

Notes Cfb is used as an abbreviation to cover Cfb and Cfc
Cs excludes winter-rainfall climates which fall into BS or BW.

Rel Reliability of Köppen class. Give as 1 if calculated or if estimated with much confidence; for other estimates, give as 2 or 3.

Altitude zone In zones of 500 m:

0-500 m	Where the site transgresses a limit, give boundaries of both or all zones included, e.g. 500-1500 m, 0-2000 m
500-1000 m	
1000-1500 m	
1500-2000 m	
2000-2500 m	
over 2500 m	
No data	

Level 1

Rainfall regime:

Code	Explanation
Unimodal	One rainfall maximum in high-sun period (summer)
Winter rainfall	One rainfall maximum in low-sun period (winter)
Bimodal	Two rainfall maxima. Only give as bimodal if there are two clear dry seasons, each at least two months long
Uniform	All year wet with no clear maximum, or all year dry
No data	

Note on climatic values Where the site covers a substantial area with a range of climate data entered may give either the range covered, e.g. mean annual temperature 23-25°C or the precise value for a specified station, e.g. 23.8°C.

Ann. temp	Mean annual temperature, °C
Ann. rainfall	Mean annual rainfall, mm
Dry months	Number of months with mean monthly rainfall <60 mm (tropics) or <30 mm (subtropics, latitude $>23.5°$)

Level 2

Mean temperature:	Hottest month, °C Coldest month °C
Driest month	Mean rainfall of driest month, mm
Occurrence of frost:	never or rare common every year no data
Mean annual Eo (mm)	Open-water evaporation, observed or calculated
By which method?	'Pan' = class A evaporation pan 'Penman' = calculated by Penman formula Or name other formula used
Humidity index r/Eo	Rainfall/evaporation ratio
Growing period	Days, as calculated by the FAO agro-ecological zones method (FAO, 1981). If this calculation has not been done, an approximate estimate may be entered as 'c', e.g. c120 days.

Mean Monthly Rainfall, mm

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR

Enter only single values, including total for year, for the station specified below.

Climatic details for	Name of station to which specific climatic data refer
Distance from site, km	Enter where there is no climatic station at or within site
Altitude, m	Of climatic station

One or more full climatic station records may be attached to the input form as supplementary data.

HYDROLOGY

Summary level

Class	Hydrology class refers to period of surface waterlogging
	None Seasonal Permanent No data
Rel	Reliability of hydrology class

Level 1

Groundwater	Fresh Saline No data
Depth, m: average	Approximate average for year

Level 2

Depth, m, lowest	Groundwater depth, late dry season
highest	" " , wet season

River regime: of largest river easily accessible from site (guideline <5 km)

Perennial	At least some discharge throughout year in every or nearly every year
Seasonal	Continuous discharge for some substantial period of every year, dry for part of year
Intermittent	Flow only for short periods, after rains
None	No accessible river
No data	

Degradation: Has river flow deteriorated adversely through human activities, e.g. lower or shorter base flow, more flash floods, increased sediment load?

Absent
Present
Severe
No data

Flooding: Never or rare
Common
Frequent
No data

SOILS

Summary level

The soil class(es) present may be given on any or all of: (i) a broadly generalized classification; (ii) the classification of the FAO/Unesco Soil Map of the World (FAO/Unesco, 1974); (iii) any other classification in use locally.

Class: gen.	Generalized soil class

Latosols — Words in brackets may be ommitted

Vertisols
Calcimorphic (soils)
Desert (soils)
Saline (or alkaline soils)
Alluvial (soils, gleys or peat)
Shallow (or immature soils)
Temperate (soil types)
No data

The definitions of the generalized soil classes are in terms of the FAO soil classes included in each. The guidelines and synonyms are for use where the FAO class is not known.

Class	FAO soil classes included	Guidelines & synonyms
Latosols	ferralsols, acrisols, luvisols, nitosols	'Red and yellow' tropical soils; includes ferallitic and ferruginous soils (CCTA, French), oxisols, ultisols and alfisols (US)
Vertisols	vertisols	Black cracking clays, 'black cotton soils'
Calcimorphic (soils)	chernozems, phaeozems, kastanozems, rendzinas	Free $CaCO_3$ present; includes brown brown soils of semi-arid regions (CCTA), 'chestnut soils'
Desert (soils)	xerosols, yermosols	Sand or rock; slight or no horizor development
Saline(or alkaline soils)	solonchak, solonetz	Of desert or coastal origin
Alluvial(soils, gleys or peat)	gleysols, fluvisols planosols, histosols	See note below
Shallow(or immature soils)	lithosols, rankers, regosols, arenosols, andosols	Excluding desert soils, see above
Temperate(soil types)	cambisols, podzols, podzoluvisols, greyzems	Brown earths, 'podzolic soils', podzols
No data		

Note. Poorly-drained soils of valley floors and swamps should be classed as Gleys, unless there is positive evidence of being widely-cracking black clays (= vertisols).

Rel	Reliability of generalized soil class
FAO	Soil class on the system of the FAO/Unesco Soil Map of World (FAO/Unesco, 1974). Guidelines are given as Attachment B. For full definitions, see reference cited.
Code	E.g. F, Fo, Lo
Class	E.g. Ferralsols, Orthic ferralsols, Orthic luvisols

Level 1

Other	The soil type on any other classification; this may be another international system (e.g. US taxonomy, French/ORSTOM), a national system, a soil series or a local descriptive name.
Classification	To which the above name refers, e.g. US, national, local
Properties	Generalized soil properties, predominant for profile:

	Class	Explanation
Texture	sandy	sand, loamy sand
	loamy	sandy loam, sandy clay loam, medium loam, silty textures
	clayey	sandy clay, clay, heavy clay
	no data	
Reaction	strongly acid	pH < 5.0 (only if clearly so)
	acid	pH 5.0-6.5
	neutral	pH 6.5-7.5 (or if profile transgresses 7.0)
	alkaline	pH >7.5
	no data	
Drainage	well drained	drainage classes excessive, well-drained
	imperfect	" moderately well, imperfect
	poor	" poor, very poor
	no data	
Other features:	shallow	limiting horizon (rock, laterite, etc.) at <50 cm
	saline	
	other	name the feature
	none	
	no data	

Level 2

The generalized soil properties given at level 1 are supplemented by more precise data if soil profile descriptions are available.

'Topsoil' refers to 0-20 cm depth or the plough/hoe layer.
'Subsoil' refers to the B horizon, typically c.50 cm depth.
Texture and drainage classes are according to FAO (1977).

Texture class:	topsoil subsoil	Enter capital-letter abbreviations, using Z for silt, silty, viz: S, LS, SL, ZL, SCL, CL, ZCL, SC, C
Reaction (pH)	topsoil subsoil	In water, at 1:2.5 if available
Drainage	Very poorly drained Poorly drained Imperfectly drained Well drained Somewhat excessively drained Excessively drained	'drained' or -ly drained' may be omitted, e.g. poor, well

Lim. horizon, cm	Depth to limiting horizon, e.g. of rock, laterite. Note that the usual unit for soil depth, centimetres, is employed.

Degradation: is it thought that soil properties have deteriorated and/or are deteriorating? The types of degradation are those given in FAO (1979) except that an additional and more generalized type is given, 'fertility decline', for use where more precise causes are not known.

Degradation: Severity	Absent Present Severe No data
Water erosion	Including sheet and/or gully erosion
Wind erosion	
Salinization (or sodication)	
Chemical degradation	Including acidification, lowering of bases or nutrients, toxicities (except salts)
Physical degradation	Loss of pore space, compaction, decline in permeability and water storage capacity, etc.
Biological degradation	Decline in organic matter, biological activity in soil
Fertility decline	Lowering of the capacity of soil to produce crops, through combination of chemical, physical or biological degradation.
No data	

VEGETATION

Two classifications of vegetation are recorded, a broadly generalized class and the Unesco (1973) classification. The broad class is given for the area as a whole and for the specific site where relevant. If the site is under agricultural, forestry or agroforestry use it is recorded as 'planted' vegetation.

Class: gen.	Area	Generalized vegetation class for area as a whole
	Site	Class for specific site where relevant
Rel		Reliability of generalized vegetation class

Class	Explanation
Rain forest	Including evergreen, semi-deciduous and montane
Seasonal forest (tropical)	Deciduous, including savanna woodland, crowns >40% cover; S. America cerradão
Savanna	Tree/shrub cover < 40%, predominantly broad-leaved, plus well-developed grass cover; S. America cerrado
Thorn scrub (or thorn woodland, thorn savanna	Xeromorphic vegetation, predominantly thorny and/or microphyllous
Grassland	Of any origin, including climatic, hydromorphic, montane, but excluding sown pastures ; see planted vegetation
Semi-desert (vegetation)	
Desert	
Deciduous woodland (temperate)	
Coniferous woodland	Excluding plantations, see planted vegetation
Montane (vegetation)	Excluding montane grassland, see grassland
Swamp	Including mangrove and other coastal swamp
Planted (vegetation)	Including crops, forest plantations, sown pasture (see also land use, below)
No data	
Unesco	Class of vegetation according to Unesco (1973). Give for site where site is not under planted vegetation, otherwise for area

I	CLOSED FOREST	IV	DWARF-SCRUB AND RELATED COMMUNITIES
I.A	Mainly evergreen forest	IV.A	Mainly evergreen dwarf-scrub
I.B	Mainly deciduous forest	IV.B	Mainly deciduous dwarf-scrub
I.C.	Extremely xeromorphic forest	IV.C	Extremely xeromorphic dwarf-shrubland
II	WOODLANDS	IV.D	Tundra
II.A	Mainly evergreen woodland	IV.E	Mossy bog formations with dwarf-shrub
II.B	Mainly deciduous woodland	V	HERBACEOUS VEGETATION
II.C	Extremely xeromorphic woodland	V.A	Tall graminoid vegetation
III	SCRUB	V.B	Medium tall grassland
IIIA	Mainly evergreen scrub	V.C	Short grassland
IIIB	Mainly deciduous scrub	V.D	Forb vegetation
IIIC	Extremely xeromorphic (sub-desert) shrubland	V.E	Hydromorphic fresh-water vegetation
		VI	PLANTED VEGETATION
		ND	No data

Rel Reliability of Unesco vegetation class

Level 1

Description	Physiognomic description of vegetation
Association	Dominant and other species (trees, grasses, etc.)

Level 2

Degradation: Is it believed that the vegetation is degraded as compared with its condition in some past period?

Severity	Absent Present Severe No data
Type	Nature of degradation

FAUNA AND DISEASE

There are no Summary level or Level 2 data for fauna and disease.

Level 1

Affecting plants
Affecting animals

Record significant fauna, pests or diseases affecting plant (trees or crops) or animals, e.g.:

- animal pests (e.g. rabbits)
- bird pests (e.g. Quelea)
- insect pests (e.g. locusts, termites)
- soil fauna (e.g. nematodes)
- plant diseases
- animal diseases (e.g. tsetse)

Pests affecting stored produce, and diseases of humans, are not currently included in the data base.

Rel	Reliability of information on fauna and disease

LAND USE

Summary level

The environmental data base is not intended for recording land use in detail. It records the main type(s) of use as a background to environmental data.

Class	Record class(es) of land use present, in order of area covered, e.g. 'animals, natural pastures, small areas swamp rice'. Where the land use is agroforestry record it as such and give details below.

Class	Explanation
Agroforestry	For details, see below
Annuals	Annual crops, including cassava, hill rice, vegetables if of a field scale; excluding swamp rice, vegetables on a garden basis
Swamp rice	If irrigated, list also as irrigation
Field perennials	Sugar cane, sisal, pineapple, bananas
Perennials	Tree and shrub crops, excluding field perennials, see above

Gardens	Intensive cultivation on small plots
Irrigation	Including rice if water brought to fields, but not if retention of rainfall only; including irrigated pasture, forest
Natural pastures	Livestock production from natural pastures, including nomadic grazing, ranching
Improved pastures	Livestock production from substantially improved or sown pastures
Forestry (natural forests)	For timber and/or other products
Forest plantations	For timber and/or other products
Wildlife (conservation)	With intention of this purpose
Catchments	With intention of water catchment use
Engineering	Any form of construction
Other use	Specify
Unused	
No data	

Rel Reliability of land use class

AF Class Agroforestry class

There is at present no standard or widely accepted classification of agroforestry practices or systems. The suggested form of entry is the major type(s) of system, as capital-letter abbreviations, followed by the practice(s) present, e.g.

AS: Alley cropping

Major types of agroforestry system

AS	Agrosylvicultural systems	Trees with crops
SP	Sylvopastoral systems	Trees with pastures
ASP	Agrosylvopastoral systems	Trees, crops, pastures
O	Other systems	Inc. mangrove

Agroforestry practices:

The following are not all mutually exclusive. Some may belong to more than one major type (e.g. taungya may be AS, SP or ASP). As it is not standardized, the list may be modified or added to.

Shifting cultivation (unimproved)
Tree fallow in improved shifting cultivation
Corridor systems
Tree fallow (in crop system, non-shifting)
Trees in croplands
Trees on rice-field bunds
Alley cropping
Shade trees in plantation crops
Plantation crop combinations
Trees in pastures
Protein bank (fodder-trees)
Home gardens
Tree gardens
Taungya
Border planting
Live fences
Trees on soil conservation works
Trees for soil conservation
Soil conservation hedges
Windbreaks
Shelterbelts
Trees for home shade
Fuelwood lots
Irrigated agroforestry
Mangrove systems

Rel Reliability of agroforestry class

Level 1

Description	General description of land use practices, including agroforestry where present. Two lines (140 characters) are allotted to this description.

There are no Level 2 data on land use.

NOTES

A short description of the main, or most distinctive, features of the environment at the site. Maximum of 4 lines.

ADDITIONAL DATA

There may be environmental variables not included in the standard data base which the user wishes to insert, as being relevant to the site and land use described. Give the name of each variable and its value. Name and value may each be up to 25 characters long, and may be letters, numbers or symbols.

Examples:

	Name of variable	Value
1:	Absolute minimum temp.	-6°C
2:	Root system	shallow, plus tap root

REFERENCES

If a bibliographic citation is given under Source, or elsewhere an the input form, give details. On the input form these may be written, for convenience in unused 'Additional data' space, or listed on a separate sheet. On computer entry they are stored in a separate source file.

SUPPLEMENTARY INFORMATION

Attach to the input form if possible:

1. Climatic records for one or more stations within or near to the site.
2. One or more soil profile descriptions, with analytical data
3. Any published descriptions of the physical environment of the site, or bibliographic references to these.

Where the data refer to an ongoing agroforestry or other field trial, monthly rainfall values should be recorded throughout its duration.

REFERENCES (TO LEGEND SHEET)

FAO 1977. Guidelines for soil profile description. Second edition. Rome: FAO.

FAO 1979. A provisional methodology for soil degradation assessment. Rome: FAO.

FAO 1981. Report on the agroecological zones project. Vol.3. Methodology and results for South and Central America. Rome: FAO World Soil Reosurces Report 48/3.

FAO/Unesco 1974. Soil map of the world. Vol.1. Legend. Paris: Unesco.

Unesco 1973. International classification and mapping of vegetation. Paris: Unesco Ecology and conservation 6.

Young 1983. An environmental data base for agroforestry. Nairobi: ICRAF Working Paper 5.

PLEASE RETURN THE COMPLETED INPUT FORM TO: ICRAF, BOX 30677, NAIROBI, KENYA. THANK YOU FOR YOUR KIND COOPERATION.

JUNE 1985 REVISION

ATTACHMENT A. THE KÖPPEN CLIMATIC CLASSIFICATION

The following simplified version of the Köppen classification is constructed with special reference to the tropics and subtropics, and to aspects relevant to agro-forestry. Köppen's definitions and values have not been modified. For descriptive names, see the Legend Sheet. *A computer subroutine is available to carry out identification.*

1. THE CLASSIFICATION

Code	Koppen class	Mean annual temp. °C =t	Mean annual rainfall mm =r	Temp. of coldest month °C	Temp. of hottest month °C	Rainfall driest month mm	Period of dry season
1	Af		Wetter than for B climates (codes 1–4)	>18		>60	
2	Am			>18		$>100-\frac{r}{25}$	
3	Aw			>18		drier than for Am (codes 3–4)	Low sun
4	Aw''			>18			Two
5	BSh	> 18	r/t formulae see below (codes 5–8)				
6	BSk	< 18					
7	BWh	> 18					
8	BWk	< 18					
9	Cfa		Wetter than for B climates (codes 9–15)	<18 >-3	>22	>30	
10	Cfb			<18 >-3	10-22	>30	
11	Cw			<18 >-3	>10	<30	Low-sun
12	Cw''			<18 >-3	>10	<30	Two
13	Cs			<18 >-3	>10	<30	High-sun
14	D			< -3	>10		
15	E				<10		

Formulae for B climates:

Season of rainfall	BS	BW	Notes
Summer/high sun*	$r < 20t+280$	$r < 10t+140$	Applies to most tropical and sub-tropical areas
Uniform	$r < 20t+140$	$r < 10t+70$	
Winter/low sun	$r < 20t$	$r < 10t$	Applies to 'Mediterranean type' climates

*Also equatorial climates with bimodal rainfall

Notes (i) B climates take precedence. In particular, 'Mediterranean type' climates in which rainfall is below the limits specified are placed in BS or BW, not Cs.
(ii) In this simplified form of the classification, Cfb includes Köppen Cfc. Cw, Cw'' and Cs include the Köppen temperature subdivisions a, b and c. The cold climates, D and E, are not here subdivided.

2. SOME SHORT CUTS FOR TROPICAL LATITUDES

The following guidelines are for use where data needed for Köppen rules are insufficient; they apply to the tropics only.

(i) Approximate mean annual rainfall known, but not temperature. Is it a B (dry) climate?

Rainfall >900 mm:	Not a B climate
Rainfall >750 mm:	Unlikely to be a B climate, unless annual temperature is unusually high (>23.5°C)

(ii) Approximate altitude known, but not temperature. Is it an A or a C climate?

Altitude >1200m Very probably a C climate

Note, however, that C climates can occur as low as 500 m close to the equator, and down to sea level close to 23½° latitudes N and S.

3. IDENTIFICATION KEY TO KÖPPEN CLIMATES

There is a computer subroutine to carry out this identification.

r = mean annual rainfall, mm t = mean annual temperature, °C

1. Is r less than:

20t+280	if rainfall is high sun or bimodal?)	YES	2
20t+140	" uniformly distributed)	NO	5
20t	" in winter/low sun?)		

(See also short cut (i) above.)

2. Is r less than:

10t+140	if rainfall is high sun or bimodal?)	YES	3
10t+ 70	" uniformly distributed)	NO	4
10t	" in winter/low sun?)		

3. Is t >18°?	YES	BWh
	NO	BWk
4. Is t >18°?	YES	BSh
	NO	BSk
5. Is temperature of coldest month >18°?	YES	6
	NO	9

(See also short cut (ii) above.)

6. Is rainfall of driest month >60 mm?	YES	Af
	NO	7
7. Is rainfall of driest month $>100 - \frac{r}{25}$?	YES	Am
	NO	8
8. Are there two distinct dry seasons?	YES	Aw"
	NO	Aw

9. Is temperature coldest month $> -3^{o}$?	YES	10
	NO	14
10. Is rainfall of driest month $>$30 mm?	YES	11
	NO	12
11. Is temperature of hottest month $> 22^{o}$?	YES	Cfa
	NO	Cfb
12. Are there two distinct dry seasons?	YES	Cw"
	NO	13
13. Is dry season in winter/low sun period?	YES	Cw
	NO	Cs
14. Is temperature of hottest month $\geq 10^{o}$?	YES	D
	NO	E

ATTACHMENT B. THE FAO-UNESCO SOIL CLASSIFICATION SYSTEM

1. List of soil units

J FLUVISOLS

- Je Eutric fluvisols
- Jc Calcaric fluvisols
- Jd Dystric fluvisols
- Jt Thionic fluvisols

G GLEYSOLS

- Ge Eutric gleysols
- Gc Calcaric gleysols
- Gd Dystric gleysols
- Gm Mollic gleysols
- Gh Humic gleysols
- Gp Plinthic gleysols
- Gx Gelic gleysols

R REGOSOLS

- Re Eutric regosols
- Rc Calcaric regosols
- Rd Dystric regosols
- Rx Gelic regosols

I LITHOSOLS

Q ARENOSOLS

- Qc Cambic arenosols
- Ql Luvic arenosols
- Qf Ferralic arenosols
- Qa Albic arenosols

E RENDZINAS

U RANKERS

T ANDOSOLS

- To Ochric andosols
- Tm Mollic andosols
- Th Humic andosols
- Tv Vitric andosols

V VERTISOLS

- Vp Pellic vertisols
- Vc Chromic vertisols

Z SOLONCHAKS

- Zo Orthic solonchaks
- Zm Mollic solonchaks
- Zt Takyric solonchaks
- Zg Gleyic solonchaks

S SOLONETZ

- So Orthic solonetz
- Sm Mollic solonetz
- Sg Gleyic solonetz

Y YERMOSOLS

- Yh Haplic yermosols
- Yk Calcic yermosols
- Yy Gypsic yermosols
- Yl Luvic yermosols
- Yt Takyric yermosols

X XEROSOLS

- Xh Haplic xerosols
- Xk Calcic xerosols
- Xy Gypsic xerosols
- Xl Luvic xerosols

K KASTANOZEMS

- Kh Haplic kastanozems
- Kk Calcic kastanozems
- Kl Luvic kastanozems

C CHERNOZEMS

- Ch Haplic chernozems
- Ck Calcic chernozems
- Cl Luvic chernozems
- Cg Glossic chernozems

H PHAEOZEMS

- Hh Haplic phaeozems
- Hc Calcaric phaeozems
- Hl Luvic phaeozems
- Hg Gleyic phaeozems

M GREYZEMS

- Orthic greyzems
- Mg Gleyic greyzems

B CAMBISOLS

- Eutric cambisols
- Bd Dystric cambisols
- Bh Humic cambisols
- Bg Gleyic cambisols
- Bx Gelic cambisols
- Bk Calcic cambisols
- Bc Chromic cambisols
- Bv Vertic cambisols
- Bf Ferralic cambisols

L LUVISOLS

- Lo Orthic luvisols
- Lc Chromic luvisols
- Lk Calcic luvisols
- Lv Vertic luvisols
- Lf Ferric luvisols
- La Albic luvisols
- Lp Plinthic luvisols
- Lg Gleyic luvisols

D PODZOLUVISOLS

- De Eutric podzoluvisols
- Dd Dystric podzoluvisols
- Dg Gleyic podzoluvisols

P PODZOLS

- Po Orthic podzols
- Pl Leptic podzols
- Pf Ferric podzols
- Ph Humic podzols
- Pp Placic podzols
- Pg Gleyic podzols

W PLANOSOLS

- We Eutric planosols
- Wd Dystric planosols
- Wm Mollic planosols
- Wh Humic planosols
- Ws Solodic planosols
- Wx Gelic planosols

A ACRISOLS

- Ao Orthic acrisols
- Af Ferric acrisols
- Ah Humic acrisols
- Ap Plinthic acrisols
- Ag Gleyic acrisols

N NITOSOLS

- Ne Eutric nitosols
- Nd Dystric nitosols
- Nh Humic nitosols

F FERRALSOLS

- Fo Orthic ferralsols
- Fx Xanthic ferralsols
- Fr Rhodic ferralsols
- Fh Humic ferralsols
- Fa Acric ferralsols
- Fp Plinthic ferralsols

O HISTOSOLS

- Oe Eutric histosols
- Od Dystric histosols
- Ox Gelic histosols

2. Brief description of soil classes

Fluvisols. Alluvial soils; developed from recent alluvial deposits, with depositional rather than pedogenetic horizons. Gleyed profiles are included.

Gleysols. Gleys; hydromorphic properties dominate others. Gleyed profiles on recent alluvium are classed with fluvisols. Nine other groups include *gleyic* units, in which hydromorphic properties are subsidiary (the printed definitions fail to make a clear distinction between gleysols and gleyic units, but the intention is clear).

Regosols. Weakly developed soils on unconsolidated materials, usually sands; lacking diagnostic horizons except possibly an ochric A horizon.

Lithosols. Soils with continuous hard rock at < 10 cm depth. Profiles with rock commencing at between 10 and 50 cm belong to the *lithic phase*, and very stony profiles to the *stony phase*.

Arenosols. Very sandy soils which have an identifiable B horizon; clay < 15 percent. *Ferrallic arenosols* are the sandy equivalent of ferralsols; *albic arensols* are lowland tropical podzols or 'bleached sands'.

Rendzinas. Shallow calcareous soils on limestones.

Rankers. Weakly developed shallow soils on consolidated rock.

Andosols. Soils developed from recent volcanic materials.

Vertisols. Dark cracking clays.

Solonchaks. Saline soils; having a high salinity (table 25).

Solonetz. Alkaline soils; having a natric B horizon. If the presence of free salts prevents the formation of a columnar structure, as required for a natric horizon, the profile remains a solonchak.

Yermosols. Desert soils; having an aridic moisture regime (table 25) and a very weak ochric A horizon (organic matter <0.5 percent).

Xerosols. Semi-desert soils; having an aridic moisture regime and a weak ochric A horizon (organic matter 0.5–1.0 percent).

Kastanozems. 'Chestnut soils' of the temperate steppe zone.

Chernozems. Black earths of the temperate steppe zone.

Phaeozems. 'Prairie soils'; as chernozems, but less dark.

Greyzems. Grey forest soils of cool temperate latitudes.

Cambisols. Primarily intended as the equivalent of those brown earths which do not have an argillic horizon, but have a cambic B ('structural B') horizon. The defining criteria in fact permit occasional identification in the tropics.

Luvisols. Having an argillic B horizon with base saturation > 50 percent. *Ferric luvisols* show ferric properties (table 25) and correspond approximately to the ferruginous soils of the CCTA and ORSTOM classifications.

Podzoluvisols. Intermediate between podzols and luvisols; having an argillic B horizon with an irregular upper boundary.

Podzols. The traditional meaning, having a spodic B horizon. Lowland tropical podzols (bleached sands), however, are albic arensols.

Planosols. Having an albic E horizon with hydromorphic properties, and a slowly permeable B horizon.

Acrisols. Having an argillic B horizon with base saturation <50 percent. These include tropical soils insufficiently weathered to be ferralsols but more strongly leached than luvisols. *Orthic acrisols* (normal), *ferric acrisols* (with ferric properties, table 25) and *plinthic acrisols* (with plinthite – in practice hardened plinthite, i.e. ironstone) are common in the savanna zone.

Nitosols. These are soils derived from basic rocks in the humid tropics. The root means 'shiny' and refers to the strongly developed clay skins which are in practice the diagnostic feature. This criterion has unfortunately been dropped from the definition, which in its final form refers only to a deep argillic B horizon with merging boundaries. They are subdivided into *eutric nitosols* (base saturation > 50 percent), *dystric nitosols* (base saturation <50 percent) and *humic nitosols*.

(continued)

Ferralsols. The INEAC term ferralsol is adopted for the highly weathered soils of the humid tropics, corresponding to the ferrallitic soils of the CCTA system. They are defined as possessing an oxic horizon, the definition of which is less demanding than in the US 7th approximation, essentially requiring a cation exchange capacity of the clay fraction of less than 16 m.e./100 g, i.e. virtual absence of 2:1 lattice clay minerals, and very few or no weatherable minerals. They are subdivided into *orthic ferralsols* (normal), *xanthic ferralsols* (yellow), *rhodic ferralsols* (red to dusky red), *humic ferralsols* (high in organic matter), *acric ferralsols* (extremely low cation exchange capacity, <1.5 m.e./100 g of clay) and *plinthic ferralsols* (with plinthite).

Histosols. Peats and mucks; having a histic A horizon.

3. A simplified key for classification of tropical soils

The following working procedure enables most tropical soils to be placed into a soil group:

(i) Note whether any of the given 'special features' are present, in which case the profile is likely to belong to the class indicated:

Derived from alluvium	*Fluvisols*
Gleyed at <50 cm depth, gleying dominant	*Gleysols*
Rock at <10 cm depth	*Lithosols*
Derived from recent volcanic materials	*Andosols*
Dark cracking clays	*Vertisols*
Free salts present	*Solonchaks*
Strongly alkaline but free salts absent	*Solonetz*
With strongly bleached eluvial horizon:	
No spodic horizon	*Albic arenosols*
With spodic horizon	*Podzols*
Peaty	*Histosols*
Very sandy	See (ii)

(ii) Very sandy profiles (clay <15 percent) are likely to be *albic arenosols* if they are deep bleached sands; *cambic, ferralic* or *luvic* arenosols if a B horizon is identifiable; or *regosols* if there is little or no profile development.

(iii) If none of the special features listed in (i) are present and the soil occurs in a dry climate (wet season <3 months), it is likely to belong to one of the following:

Clearly visible humic A horizon	*Xerosols*
Very weakly developed humic A horizon	*Yermosols*
No profile development (unconsolidated materials)	*Regosols*

(iv) If none of the special features listed in (i) are present and the soil occurs in a humid climate, it is likely to belong to one of the following:

Strongly developed clay skins; developed on basic rocks	*Nitosols*
Argillic B horizon with weakly to moderately developed clay skins:	
Base saturation of B horizon > 50 percent	*Luvisols*
Base saturation of B horizon <50 percent	*Acrisols*
No clay skins, very few or no weatherable minerals	*Ferralsols*

Soils with an ironstone horizon within 100 cm of the surface belong to the *petroferric phase* if it is massive or cemented nodular laterite or the *petric phase* if non-cemented nodular laterite.

Sources: A. Young (1976). Tropical soils and soil survey. Cambridge University Press.

4. Comparison between classification systems for tropical soils

FAO-UNESCO Classification	French Classification	U.S. Classification – Order	Suborder
Acrisols - A - Latin *acris*: very acidic Weak saturation rate Acrisols orthic (*orthos*) Ao Acrisols ferric (*ferrum*) Af Acrisols gleyic (*gley*) Ag Acrisols humic Ah Acrisols plinthic Ap Greek *plinthos*: bricks Spotted clayey material dried in the open air	Sols ferrallitiques (pt) Sols ferrugineux (pt)	Ultisols Greek: *haplous*: simple Latin *udus*: humid	Udults (pt) (Haplo audults) Ustults (pt) (Haplustults) Aquults Humults Plinthudults Plinthustults Plinthaquults
Andosols - T - Japanese: *an*: dark and *do*: soil	Andosols	Inceptisols Latin *inceptum*: beginning	Andepts
Arenosols - Q - Latin *arena*: sand		Entisols (pt)	Psamments (pt)
Cambisols - B - Vulgar Latin *cambiare*: change Color, structure, consistency changes due to in-situ alterations	Sols bruns eutrophes tropicaux (pt) Sols bruns acides (pt) Sols bruns calciqu·· (pt) Sols fersiallitiques non lessivés	Inceptisols	Ocrepts (pt) Tropepts (pt) Tropical: hot, humid climate
Ferralsols - F - Latin *ferrum* and *aluminium* High sexquioxide content Ferralsols orthic Fo Greek *orthos*: straight Rhodic Ferralsols Fr Greek *rhodon*: pink Humic Ferralsols Fh Xanthic Ferralsols Fx Greek *xanthos*: yellow	Sols ferrallitiques (pt) moyennement à fortement désaturés faiblement à moyennement désaturés fortement désatures humiques fortement désaturés jaunes	Oxisols	Orthox (pt) Torrox Ustox (pt) Orthox (pt) Humox Orthox Torrox (pt)
Fluvisols - J - Latin *fluvius*: waterway	Sols minéraux bruts d'apport alluvial ou colluvial Sols peu évolués d'apport	Entisols (pt)	Fluvents
Gleysols - G - Russian *gley*: muddy soil mass	Sols à gley peu humifères Sols humiques à gley	Mollisols Entisols (pt) Inceptisols (pt) (Sulfaquepts, sulfaquents)	Aquolls Aquents (pt) Aquepts (pt)
Lithosols - I - Greek *lithos*: stone	Lithosols	Lithic Subgroups	
Luvisols - L - Latin *luvi luo*: wash, clean An accumulation of clays	Sols fersiallitiques lessivés Sols ferrugineux tropicaux lessivés Sols podzoliques (pt) Sols à gley lessivés (pt)	Alfisols	Xeralfs, Ustalfs, Udalfs: Non Gleyic Luvisols Aqualfs (Gleyic Luvisols)
Nitosols - N - Latin *nitidus*: brillant Surfaces with brillant agregates Eutric Nitosols Ne Greek *eu*: good Dystric Nitosols Nd *dys*: bad, infertile, Humic Nitosols Nh	Ferrisols (pt) - Belgian Classification Sols ferrallitiques faiblement désaturés (pt) Sols ferrugineux tropicaux peu lessivés	Alfisols (pt) Ultisols (pt)	Udalfs Ustalfs Udults Ustults Humults
Podzols - P - Russian *pod*: under and *zola*: ashes Soils with highly whitened horizons	Podzols humo-ferrugineux Podzols ferrugineux Podzols humiques Podzols à gley	Spodosol Greek *spodos*: wood ash	Orthods (pt) Ferrods Humods Aquods
Regosols - R - Greek *rhegos*: cover Moveable bed of material covering hard subsoil rock	Sols minéraux bruts d'apport éolien ou volcanique	Entisols	Orthents (pt) Psamments (pt) Greek *psammos*: sand
Rendzines - E - Polish: *rzedzic* Noise made by plows on rocky soil	Rendzines	Mollisols	Rendolls Rendzina
Vertisols - V - Latin *verto*: turn Turnover of topsoil	Vertisols	Vertisols	Torrerts Uderts Usterts

Source: Roche, P. et al. 1980. Phosphorus in tropical soils, Scientific Publication 2, World Phosphate Institute, Paris.

APPENDIX 2

EXAMPLES OF OUTPUT FROM THE DATA BASE

The following examples are given:

The Malaysian site in the ICRAF collaborative programme, a forest reserve in Selangor State, Malaysia, output at:

- Summary level
- Level 1
- Level 2

The ICRAF Machakos Field Station, output at:

- Summary level
- Level 2

An output from the requirements file: environmental requirements of *Acacia senegal*. The table accompanying this output explains the structure of the requirements file.

ICRAF ENVIRONMENTAL DATA BASE, SUMMARY LEVEL

SITE 1 RANTAU PANJANG SELATAN FOREST RESERVE

		RELIABILITY
SOURCE	VARIOUS	
LOCATION	PENINSULAR MALAYSIA	
	100 KM NW OF KUALA LUMPUR	
	LATITUDE:	1
	3.25 N	
	LONGITUDE:	
	101.32 E	
	ALTITUDE ZONE: 0 - 500 M	
GEOLOGY	SEDIMENTARY, SILICEOUS	2
LANDFORMS	MODERATELY SLOPING	1
CLIMATE	HUMID TROPICS	1
KOPPEN:	AF HUMID TROPICS, PERMANENTLY HUMID	
HYDROLOGY	WATERLOGGING: NONE	2
SOILS	LATOSOLS	1
	FAO CLASSIFICATION:	2
	MAIN GROUP: A ACRISOLS	
	SOIL UNIT: NO DATA	
	OR SERDANG-MUNCHONG ASSOCIATION ON MALAYSIAN CLASSIFICATION	
VEGETATION	AREA: RAIN FOREST	
	SITE: RAIN FOREST	
LAND USE	FORESTRY, NATURAL FORESTS	
	SECONDARY FOREST (MALAY BELUKAR)	1
	AGROFORESTRY PRACTICES:	
	NONE AT PRESENT	

ICRAF ENVIRONMENTAL DATA BASE, LEVEL 1

SITE 1 RANTAU PANJANG SELATAN FOREST RESERVE

		RELIABILITY
SOURCE	VARIOUS	
LOCATION	PENINSULAR MALAYSIA 100 KM NW OF KUALA LUMPUR	
	LATITUDE: 3.25 N	1
	LONGITUDE: 101.32 E	
	ALTITUDE: 100 M	1
GEOLOGY	SEDIMENTARY, SILICEOUS SANDSTONES QUARTZITES ETC	2
LANDFORMS	MODERATELY SLOPING UNDULATING AND ROLLING TERRAIN WITH NARROW FLAT VALLEY FLOORS SLOPE ANGLE 6 - 12 DEGREES (10 - 21 PERCENT)	1
CLIMATE	HUMID TROPICS	1
KOPPEN:	AF HUMID TROPICS, PERMANENTLY HUMID ALT.ZONE: 0 - 500 M RAINFALL REGIME: BIMODAL ANNUAL TEMPERATURE 26.1 C ANNUAL RAINFALL 2437 MM WITH 0 DRY MONTHS	1
HYDROLOGY	WATERLOGGING: NONE GROUNDWATER: FRESH GROUNDWATER DEPTH, MEAN: NO DATA	2
SOILS	LATOSOLS OR SERDANG-MUNCHONG ASSOCIATION ON MALAYSIAN CLASSIFICATION TEXTURE: SANDY TO CLAYEY REACTION: ACID DRAINAGE: WELL DRAINED	1
VEGETATION	NATURAL	
	SITE: RAIN FOREST AREA: RAIN FOREST SECONDARY LOWLAND EVERGREEN RAIN FOREST DIPTEROCARP FORMATION	1
FAUNA,DISEASE	AFF. PLANTS: WILD BOAR SQUIRRELS	
	AFF. ANIMALS:	3
LAND USE	FORESTRY, NATURAL FORESTS SECONDARY FOREST (MALAY BELUKAR) AGROFORESTRY CLASS: NONE AT PRESENT	1

GENERAL NOTES ON SITE

TYPICAL PERMANENTLY HUMID LOWLAND RAIN FOREST ENVIRONMENT WITH STRONGLY LEACHED SOILS. RAPID PLANT GROWTH. DESCRIPTION REFERS TO INTERFLUVES. ALSO PRESENT ARE FLAT ALLUVIAL VALLEY FLOORS WITH POOR DRAINAGE (MALAY LOPAK)

ICRAF ENVIRONMENTAL DATA BASE, LEVEL 2

SITE 1 — RANTAU PANJANG SELATAN FOREST RESERVE

		RELIABILITY
SOURCE	VARIOUS	
LOCATION	PENINSULAR MALAYSIA 100 KM NW OF KUALA LUMPUR	
	LATITUDE: 3.25 N	1
	LONGITUDE: 101.32 E	
	ALTITUDE: 50 - 250 M	2
GEOLOGY	SEDIMENTARY, SILICEOUS SANDSTONES QUARTZITES ETC COARSE GRAINED AND FINE GRAINED GEOLOGICAL FORMATION: NO DATA TRIASSIC SANDSTONES QUARTZITES ETC	
LANDFORMS	MODERATELY SLOPING	1
	UNDULATING AND ROLLING TERRAIN WITH NARROW FLAT VALLEY FLOORS SLOPE ANGLE 0 - 20 DEGREES (0 - 36 PERCENT) RELATIVE RELIEF 50 M SLOPE CURVATURE: NO DATA POSITION : NO DATA	
CLIMATE	HUMID TROPICS	1
KOPPEN:	AF HUMID TROPICS, PERMANENTLY HUMID	1
	ALT.ZONE: 0 - 500 M RAINFALL REGIME: BIMODAL ANNUAL TEMPERATURE 26.1 C ANNUAL RAINFALL 2437 MM WITH 0 DRY MONTHS MEAN MONTHLY RAINFALL, MM:	

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OC'	NOV	DEC
179	132	202	303	207	149	134	165	173	268	277	248

HOTTEST MONTH: 26.6 C
COLDEST MONTH: 24.8 C
DRIEST MONTH : 132 MM
FROST NEVER OR RARE
ANNUAL EO : 2000 MM BY APPROX. ESTIMATE
HUMIDITY INDEX R/EO: 1.22
GROWING PERIOD: 365 DAYS

HYDROLOGY	WATERLOGGING: NONE	
	GROUNDWATER : FRESH	1
	GROUNDWATER DEPTH, MEAN : NO DATA LOWEST : NO DATA HIGHEST: NO DATA	

LEVEL 2 (CONTINUED)

	RIVER REGIME: PERENNIAL	
	DEGRADATION : ABSENT	
SOILS	LATOSOLS	1
	FAO CLASSIFICATION:	1
	MAIN GROUP: ACRISOLS	
	SOIL UNIT : NO DATA	
	OR SERDANG-BUNGOR ASSOCIATION ON MALAYSIAN CLASSIFICATION	
	TEXTURE: SANDY	
	REACTION:ACID	
	DRAINAGE:WELL DRAINED	
	TEXTURE CLASS, TOPSOIL : NO DATA	
	B HORIZON : NO DATA	
	DRAINAGE CLASS: WELL DRAINED	
	NO DATA ON DEPTH TO LIMITING HORIZON	
	DEGRADATION: NO DATA	
VEGETATION	NATURAL	
	SITE: RAIN FOREST	1
	AREA: RAIN FOREST	
	UNESCO CLASSIFICATION:	1
	SITE: 1.A MAINLY EVERGREEN FOREST	
	AREA: AS SITE	
	SECONDARY LOWLAND EVERGREEN RAIN FOREST	
	DIPTEROCARP FORMATION	
	DEGRADATION ABSENT	
FAUNA, DISEASE	AFF. PLANTS: WILD BOAR SQUIRRELS	
	AFF. ANIMALS:	3
LAND USE	FORESTRY, NATURAL FORESTS	1
	SECONDARY FOREST (MALAY BELUKAR)	
	AGROFORESTRY CLASS:	
	NONE AT PRESENT	

GENERAL NOTES ON SITE

TYPICAL PERMANENTLY HUMID LOWLAND RAIN FOREST ENVIRONMENT WITH STRONGLY LEACHED SOILS. RAPID PLANT GROWTH. DESCRIPTION REFERS TO INTERFLUVES. ALSO PRESENT ARE FLAT ALLUVIAL VALLEY FLOORS WITH POOR DRAINAGE (MALAY LOPAK).

ICRAF ENVIRONMENTAL DATA BASE:	EXPERIMENT STATIONS	Summary level

ICRAF MACHAKOS FIELD STATION

Ref. EXPT / 1 Source JIBE ET AL.1981 Input by AY Date 11.09.84

				Reliability
LOCATION				
Country	KENYA	Location	NR.MACHAKOS,60 KM ESE NAIROBI	
Latitude	1.30S TO	Longitude	37.10E TO	1
GEOLOGY	CRYSTALLINE			1
LANDFORMS	GENTLE TO MODERATE			1
CLIMATE	SUBHUMID TROPICS			1
Koppen	Aw2	SUBHUMID TROPICS, TWO WET SEASONS		1
Alt. zone	1500-2000			
HYDROLOGY	NO WATERLOGGING			1
SOILS	LATOSOLS			1
FAO	ORTHIC,FERRIC LUVISOLS,SOME LITHOSOLS			
VEGETATION	Area:	THORN SAVANNA		
	Site:	THORN SAVANNA, PARTS PLANTED		
LAND USE	FORMERLY GRAZING, NOW AGROFORESTRY			1
AGROFORESTRY	AS: VARIOUS TECHNIQUES			1

ICRAF Environmental Data Base: EXPERIMENT STATIONS Level 2

ICRAF MACHAKOS FIELD STATION

Ref. EXPT / 1 Source JIBE ET AL.1981 Input by AY Date 11.09.84

LOCATION

Reliability

Country KENYA Location NR.MACHAKOS,60 KM ESE NAIROBI
Latitude 1.30S TO . Longitude 37.10E TO 1
Altitude 1500 TO 1590 m 1

GEOLOGY

Class CRYSTALLINE 1
Description BASEMENT COMPLEX GNEISSES
Grain size Formation
Age PRECAMBRIAN Lithology BIOTITE GNEISS

LANDFORMS

Class GENTLE TO MODERATE 1
Description VALLEY SIDE, FROM CREST, THROUGH CONVEX SLOPE TO RIVER
Slope angle 0 - 13 degrees (0 - 22 %)
Rel. relief 90 TO m
Slope shape CONVEX Slope Position

CLIMATE

Class:gen. SUBHUMID TROPICS 1
Koppen Aw2 SUBHUMID TROPICS, TWO WET SEASONS 1
Alt. zone 1500-2000 Rainfall regime BIMODAL
Ann.temp. 21. - . C
Ann.rainfall 750 - mm with 7 - dry months
Mean temp.: Hottest month 23. - . C Coldest month 19. - . C
Driest month 3 mm Occurrence of Frost NEVER
Ann.evaportn 1930 - mm by PAN
Humid.index r/Eo = 0.39- . Growing period 90 - +90 days

Mean Monthly Rainfall, mm

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
37	44	96	137	74	8	4	3	4	40	185	95

Climatic details for EST.FOR STATION km from site, alt. 1580 m

HYDROLOGY

Class NO WATERLOGGING 1
Groundwater FRESH
Depth: Average . - . m Lowest . - . Highest . - .
River regime SEASONAL Degradation ABSENT
Flooding NEVER

SOILS

Class:gen. LATOSOLS 1
FAO LoLf,I ORTHIC,FERRIC LUVISOLS,SOME LITHOSOLS 1
or UHr1m,UHr2m,UHb4p on KENYAN classification
Properties: Texture LOAMY TO CLAYEY Reaction ACID
Drainage WELL DRAINED Other SHALLOW PATCHES
Texture class: topsoil SCL - Subsoil SC -
Reaction (pH): topsoil 6.0 - 6.5 subsoil 6.2 - 6.4
Drainage WELL DRAINED Lim.horizon - cm
Degradation: severity ABSENT Type

VEGETATION

Class:gen. Area THORN SAVANNA 1
Site THORN SAVANNA, PARTS PLANTED
Unesco IIIB MAINLY DECIDUOUS SCRUB 2
Description SAVANNA, MAINLY THORN, PART BROADLEAF
Association AC.TORTILIS,COMMIPHORA AFRICANA;ERAOROSTIS,THEMEDA
Degradation: Severity ABSENT Type

FAUNA AND DISEASE

Affecting plants NO DATA 9
Affecting animals NO DATA

LAND USE

Class FORMERLY GRAZING, NOW AGROFORESTRY 1
Agroforestry AS: VARIOUS TECHNIQUES 1
Description AGROFORESTRY DEMONSTRATION STATION, MANY TECHNIQUES INCLUDING ALLEY CROPPING, SOIL CONSERVATION, MPTs

NOTES BIMODAL UPLAND SUBHUMID CLIMATE, CLOSE TO BOUNDARY WITH SEMI-ARID, DROUGHT HAZARD INCREASED BY TWO WET SEASONS, BOTH SHORT AND UNRELIABLE; KOPPEN Aw2 BUT CLOSE TO BOUNDARIES WITH BOTH BS AND Cw2. SUBSTANTIAL EROSION HAZARD ON STEEPER PARTS.

THE ICRAF ENVIRONMENTAL DATA BASE: EXAMPLE OF OUTPUT FROM THE REQUIREMENTS FILE.

Explanation of headings:

LAND USE	On this file, species of multipurpose tree.
LAND QUALITY	Requirements grouped according to broad type, e.g. requirements for temperature regime, moisture regime, rooting conditions.
SUBDIVISION	Subdivision of land quality, e.g. temperature regime. Subdivided into growth (general) requirement, tolerance to high temperatures and tolerance to low temperatures.
LAND CHARACTERISTIC	The value employed to measure or express the land quality; e.g. different sources express tolerance to low temperatures as mean minimum of the coldest month, absolute minimum, and frost frequency.
LOCATION	The area to which suitability data refer.
SUITABILITY	The suitability level to which data refer:
OB	Observed (no data on growth or performance)
SS	Suitable (growth or performance satisfactory)
S1	Highly suitable
S2	Moderately suitable
S3	Marginally suitable
NN	Not suitable (performance not satisfactory)

The oblique stroke (/) indicates that suitability is bounded, the hyphen (-) that it is not bounded; e.g.

nn/ SS / nn	20 - 30 C	Suitable between 20° and 30° C and Not suitable outside this range
- SS -	20 - 30 C	Suitable between 20° and 30° C but suitability level beyond this range not known

LOWER VALUE/INCLUDED and HIGHER VALUE/EXCLUDED: Data in these columns appears in different forms illustrated by the following examples:

(a) Numerical data: example, temperatures for growth, expressed as mean annual temperature

- SS -		20 - 30 C	Suitable in range 20 - 30° C
- OB -	22 C		Observed on site with 20° C

(b) Non-numerical data: example, drainage (aeration) requirements, expressed as soil drainage class:

nn/ SS /nn	WELL DR.	* W'LOGGED	Suitable on well drained sites, Not suitable on waterlogged sites

SOURCE	Reference number to the source of data, details of which are stored on a separate file. Souce 1 is the ICRAF multipurpose tree inventory.
RELIABILITY	A subjective estimate of the reliability of the data: 1 High — Primary direct observation 2 Medium 3 Low — Including highly generalized data

Note that certain land characteristics, including latitude, soil texture, soil reaction and soil type, may be employed to express suitability in a manner which does not make it clear which kind of effect, i.e. which land quality or qualities, is being assessed. Such land characteristics are grouped at the end of the lists.

Table 4 (continued)

LAND USE	LAND QUALITY	SUB-DIVISION	LAND CHARAC-TERISTIC	LOC-ATION	SUITABILITY			LOWER VALUE/ INCLUDED	HIGHER VALUE/ EXCLUDED	SOURCE	RELIABILITY
ACACIA SENEGAL	TEMPERATUR	GROWTH	ANN.TEMP.	W.AFR.	-	S1	-	25	- 27 C	3	2
ACACIA SENEGAL	TEMPERATUR	GROWTH	ANN.TEMP.	WORLD	-	S1	-	25	- 27 C	4	2
ACACIA SENEGAL	TEMPERATUR	GROWTH	ANN.TEMP.	AFRICA	-	SS	-	22	- 32 C	2	2
ACACIA SENEGAL	TEMPERATUR	GROWTH	ALTITUDE	SUDAN	-	OB	-	575		1	1
ACACIA SENEGAL	TEMPERATUR	GROWTH	ALTITUDE	AFRICA	/	SS	-	0	- 500	2	2
ACACIA SENEGAL	TEMPERATUR	GROWTH	MEAN MAX.	SUDAN	-	OB	-	39 C		1	1
ACACIA SENEGAL	TEMPERATUR	GROWTH	MEAN MAX.	WORLD	-	OB	-	37 C +-		4	2
ACACIA SENEGAL	TEMPERATUR	GROWTH	MEAN MIN.	SUDAN	-	OB	-	13 C		1	1
ACACIA SENEGAL	TEMPERATUR	GROWTH	MEAN MIN.	WORLD	-	OB	-	20 C +-		4	2
ACACIA SENEGAL	TEMPERATUR	HEAT TOL.	MAX.HOTMO.	W.AFR.	-	SS	/nn		<45 C	3	2
ACACIA SENEGAL	TEMPERATUR	HEAT TOL.	MAX.HOTMO.	AFRICA	-	SS	-	30	- 40 C	2	2
ACACIA SENEGAL	TEMPERATUR	COLD TOL.	MIN.COLDMO	AFRICA	-	SS	-	16	- 28 C	2	2
ACACIA SENEGAL	TEMPERATUR	COLD TOL.	ABS.MIN.	SUDAN	-	OB	-	9 C		1	1
ACACIA SENEGAL	TEMPERATUR	COLD TOL.	FROST FREQ	WORLD	-	NN	-		* SENSITIV	4	2
ACACIA SENEGAL	MOISTURE	GROWTH	ANN.RAINF.	SUDAN	-	OB	-	280		1	1
ACACIA SENEGAL	MOISTURE	GROWTH	ANN.RAINF.	WORLD	-	OB	-	250	- 750 MM	4	2
ACACIA SENEGAL	MOISTURE	GROWTH	ANN.RAINF.	W.AFR.	-	SS	-	200	- 500 MM	3	2
ACACIA SENEGAL	MOISTURE	GROWTH	ANN.RAINF.	AFRICA	-	SS	-	200	- 500	2	2
ACACIA SENEGAL	MOISTURE	GROWTH	ANN.RAINF.	WORLD	s3/	SS	-	300	-500 MM	4	2
ACACIA SENEGAL	MOISTURE	GROWTH	RAIN REGIM	SUDAN	-	OB	-	HIGH SUN		1	1
ACACIA SENEGAL	MOISTURE	GROWTH	RAIN REGIM	AFRICA	-	SS	-	HIGH SUN		2	2
ACACIA SENEGAL	MOISTURE	CRIT.PER.	DRY SEASON	W.AFR.	-	SS	-	8	- 11 MO.	3	2
ACACIA SENEGAL	MOISTURE	CRIT.PER.	DRY SEASON	AFRICA	-	SS	-	6	- 8 MO.	2	2
ACACIA SENEGAL	MOISTURE	CRIT.PER.	DROUGHT	WORLD	-	OB	-	TOLERANT		4	2
ACACIA SENEGAL	DRAINAGE	-	CLASS	WORLD	-	NN	-		* W'LOGGNG	4	2
ACACIA SENEGAL	DRAINAGE	-	DRAIN.CL.	SUDAN	-	OB	-	SEAS.W/LOG		1	1
ACACIA SENEGAL	DRAINAGE	-	DRAIN.CL.	W.AFR.	-	SS	/nn	FREE DR.	* W'LOGGED	3	2
ACACIA SENEGAL	DRAINAGE	-	DRAIN.CL.	AFRICA	-	SS	-	FREE DR.		2	2
ACACIA SENEGAL	ROOTING	-	EFF.DEPTH	WORLD	-	SS	-	TOL.SHALLO		4	2
ACACIA SENEGAL			LAITIUDE	SUDAN	-	OB	-	13 N		1	1
ACACIA SENEGAL			LATITUDE	AFRICA	-	OB	-	11	- 18 N	2	2
ACACIA SENEGAL			SOIL TEXT.	SUDAN	-	OB	-	LIGHT		1	1
ACACIA SENEGAL			SOIL TEXT.	AFRICA	-	SS	-	LT/MED/HVY	* (NONE)	2	2
ACACIA SENEGAL			SOIL TEXT.	WORLD	-	SS	-	SDY/CLAY	* (NONE)	4	2
ACACIA SENEGAL			REACTION	SUDAN	-	OB	-	ALKALINE		1	1
ACACIA SENEGAL			REACTION	AFRICA	-	SS	-	NEUT/ACID		2	2
ACACIA SENEGAL			US SOIL	SUDAN	-	OB	-	TYP.QUARTZ	=IPSAMMENT	1	1

Sources: 1: ICRAF MPT inventory 2: Webb et al., 1980 3: FAO, 1974 4: Baumer 1983