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A SYSTEMS APPROACH TO AGROFORESTRY DIAGNOSIS AND DESIGN: ICRAF'S EXPERIENCE WITH AN INTERDISCIPLINARY METHODOLOGY

by

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SUMMARY

Agroforestry is an ancient system of land management, but a new field of organized scientific activity. Recently arisen to fill the gap in applied science created by the time honoured but artificial separation of agriculture, forestry and allied disciplines, agroforestry is an inherently interdisciplinary field. Although agroforestry research by multidisciplinary teams is the order of the day, the high degree of interdisciplinary synthesis which is needed to realize the full potential of agroforestry is not an easy goal to achieve. To complete the emerging paradigm for agroforestry research and development, a number of interdisciplinary methodologies are needed.

To answer part of this need, the multidisciplinary staff of the International Council for Research in Agroforestry (ICRAF) have been working since 1981 to develop a methodology for agroforestry Diagnosis and Design (D&D), as an aid to the identification of research and development priorities and as a basis for a coordinated interdisciplinary approach to project planning and implementation. Based on more than twenty test applications with international collaborators in a wide range of sites around the world, ICRAF has published two draft D&D methodology manuals and a number of case studies for wider review and comment.

This paper presents an introduction to the evolving D&D methodology and discusses key features of the interdisciplinary systems approach on which it is based. Beginning with a review of the requirements which must be satisfied by any methodology which seeks to catalyze an interdisciplinary approach to the improvement of land management systems, the paper goes on to explain the general conceptual and procedural framework of the D&D methodology, and concludes with an overview of ICRAF's experience in developing and disseminating this interdisciplinary approach.

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1. AGROFORESTRY AS AN INHERENTLY INTERDISCIPLINARY FIELD

1.1 Agroforestry Defined

It is customary to begin a paper on a new subject area with a definition of the field. As much as one would like to offer a universally accepted definition of agroforestry, alas, it must be acknowledged that there are almost as many definitions of agroforestry as there are people who deal with the subject (Editors, *Agroforestry Systems*, 1982). This diversity of viewpoint is in part due to the interdisciplinary nature of the field and, in fact, the history of attempts to define agroforestry reveals something of the disciplinary forces at work in the development of the field.

The first widely acknowledged attempt to outline the scope of the subject defined agroforestry as:

> ... a sustainable management system for land that increases overall production, combines agriculture crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population (Bene *et al.*, 1977).

This definition gives explicit recognition to the variety of biological components which may be combined in agroforestry systems and implicitly acknowledges the various historical roots of the agroforestry tradition in agronomy, tree crop horticulture, forestry and livestock sciences. By explicitly citing "sustainability" and "cultural compatibility" as criteria of agroforestry, this early definition also gives testimony to the formative role in agroforestry of two other disciplinary traditions: environmental/conservation and social science/rural development disciplines.

It is a *normative definition*, which states not merely what agroforestry is but what it *should be*, i.e. a land management system that is, by definition, *productive*, *sustainable* and *culturally appropriate*. Problems have arisen subsequently in maintaining a literal interpretation of this early normative definition. Strictly speaking, there is little justification for assuming that all land management systems which qualify as "agroforestry" from the standpoint of the combination of biological components (trees with herbaceous crops and/or animals) would *automatically* fulfill the above mentioned normative criteria. Poorly designed agroforestry systems, in fact, may fail on one or even all of these counts.

As scientific agroforestry emerges from the "awareness and enthusiasm" stage and begins to settle down to serious work, the tendency has been to retain these criteria as *attributes of good agroforestry design* while noting, however, that they must be *achieved* by the developers of agroforestry systems rather than merely *ascribed* to any system which

happens to meet the minimal definition of agroforestry. A more neutral and widely acceptable definition has been advanced which conceives of agroforestry as:

> ... an approach to land use in which woody plants are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or in sequence. The concept of an agroforestry system implies both ecological and economic interactions among the components of the system (after Lundgren, 1982).

The elevation of agroforestry to a field of study in its own right is based on the recognition of the need for an *integrated* approach to land use and the observation that many existing or yet to be developed land use systems all have, in their particular combination of components, a common denominator that is worth exploring and developing in a more systematic and scientific manner; namely, the deliberate use of the special productive and protective features of woody plants to increase, sustain and diversify the total output from the land (Lundgren and Raintree, 1983).

1.2 Multidisciplinarity and Interdisciplinarity in Agroforestry

A certain minimal degree of multidisciplinarity is virtually assured in agroforestry by the very nature and complexity of the subject, but the degree of interdisciplinary thinking that is needed to develop the full promise of the approach is not often easily acheived. In a field of applied science characterized by the study of interactions which cut across the traditional lines of disciplinary specialization it is not enough to understand each component in isolation. Nor is it sufficient, or even necessary, for purposes of good research to catalogue and study all conceivable interactions in detail — an impossible objective in any event. What *is* needed for agroforestry to progress as an applied science is an interdisciplinary research paradigm which is capable of identifying crucial research priorities, based on a structured but flexible and cost-effective methodology for understanding those *critical interactions* which determine the ability of land management systems to achieve the purposes for which they are designed.

The need for this type of an approach to the organization of agroforestry research is clearly stated in the charter of the International Council for Research in Agroforestry (ICRAF) and the means for addressing it have been carefully built into the Council's institutional strategy (Steppler, 1981; Steppler and Raintree, 1983; Lundgren and Raintree, 1983) and its programme of work (ICRAF, 1983c). Other institutions and individuals active in agroforestry are coming to similar conclusions, but everyone faces the same general constraints on the achievement of a coherent interdisciplinary approach: *disciplinary biases* in the training of researchers, *institutional constraints* on the conduct of agroforestry research, *communication problems* between members of multidisciplinary research teams, and *lack of appropriate interdisciplinary methodologies*.

To elaborate briefly on these constraints, the traditional *disciplinary biases* in the training of researchers has created a situation of acute shortage of well-rounded scientific manpower for broadly based approaches to agroforestry research. Although educational programmes are beginning to be developed to broaden the interdisciplinary training of agroforestry researchers (ICRAF, 1983), in the short and medium term most of the scientific and technical manpower available for agroforestry research and development will have been trained along traditional disciplinary lines. Even in the longer term it is likely that agroforestry workers will still need, in addition to their interdisciplinary training, a strong foundation in at least one of the major traditional disciplines. Discipline grounded "agroforestry generalists" may in time emerge from educational institutions, but the main strategy for meeting the scientific manpower requirements of agroforestry for the forseeable future will most likely be based on the fielding of *well-rounded multidisciplinary teams*, coordinated by interdisciplinary-minded team leaders. This trend is evident today in the multidisciplinary team approach which is becoming a standard feature of agroforestry project planning.

The ability to field such teams, however, is currently hampered by severe *institutional constraints*. In government institutions and universities, departments dealing with different aspects of land use are often separated by rigid institutional boundaries, often accentuated by fierce competition for scarce resources. Agroforestry as such typically has no single institutional base and the recruitment of an adequate multidisciplinary team must often depend upon fragile ad hoc arrangements for inter-institutional cooperation. While long term arrangements for institutionalizing agroforestry on a more permanent basis will have to be made (Steppler, 1981; Lundgren and Raintree, 1983; Catterson, 1982). the best hope for the short and medium term may be in the form of *projects* of prescribed duration, each with its own agroforestry-oriented budget and programme of work (Torres, 1983).

Even when these problems can be overcome and a secure framework established for a multidisciplinary team approach to agroforestry research and development, once the team is in the field enormous *communication problems* set in which, if not solved, will prevent the team from making the transition from *mere multidisciplinary* to *genuine interdisciplinarity* in its approach. With a few rare exceptions perhaps, any one who has ever sat down with a multidisciplinary group of scientists to thrash out a common interdisciplinary perspective will be familiar with the frustrations of trying to resolve the traditional differences of interest or perspective which are inherent in such groups. The problems are both cognitive and motivational in nature, but one has the feeling that the latter may be of overriding importance. Perhaps the best antidote to the pointless and often poisonous debates which arise in such contexts is to shift the whole activity out of the academy and into a real life field situation. Only when confronted by real and complex problems in urgent need of solution will individual team members be able to cross the *motivational threshold* which prevents them from submerging relatively minor disciplinary differences in favour of productive teamwork on the really major interdisciplinary problems and opportunities with which the field situation confronts them. There is nothing like a healthy dose of undiluted reality in the field to generate a completely new and refreshing set of problem-oriented priorities. Very often this is the *only* feasible way of integrating the human dimension into agroforestry research.

If this transition is successfully made, there may be no turning back. Scientists involved in this problem-solving or "mission-oriented" type of work often express a deeper sense of personal satisfaction with their work. Real problems are *harder*, not easier to solve than those derived from a purely theoretical or disciplinary orientation. Moreover, the inspiration afforded by the field situation for substantive theoretical or "pure science" contributions can be quite significant. Although the current emphasis on the interdisciplinary team approach in applied land management science can be seen as part of the larger society's strategy for coping with unprecedented human challenges (i.e. nothing less will suffice at this hour in human history), the high level of personal stimulation inherent in interdisciplinary work can itself provide sufficient psychological impetuous to keep the process going, once the threshold has been crossed.

All this is well and good, but experience indicates that *catalysts* are needed to assist multidisciplinary teams to cross the threshold of interdisciplinary activity. The field situation itself is one such catalyst, good will and a shared problem-solving motivation are also needed, but in the end little progress will be made unless the team can arrive at a shared and detailed blueprint of *how to proceed* in its investigation of the land management system at hand. This is where the need for an interdisciplinary *methodology* comes into the picture. A good methodology can bring the other catalysts into operation. Without such a methodology, no amount of good will and motivation will enable a multidiciplinary team to achieve a coherent interdisciplinary approach to the solution of complex land management problems.

The remainder of this paper is devoted to a discussion of one such methodology, the Diagnosis and Design (D&D) approach developed by ICRAF in collaboration with agroforestry workers around the world as a tool for agroforestry research and development projects.

2. AGROFORESTRY DIAGNOSIS AND DESIGN: AN INTERDISCIPLINARY SYSTEMS APPROACH

2.1 The State of the Art

How do you identify priorities and organize applied research in a field which has no research tradition? How do you insure a conscientious research-for-development orientation in a nascent subject like agroforestry which poses so many fascinating and unanswered questions of a purely academic nature? How do you avoid disciplinary or pet technology biases when designing agroforestry systems for rural development? What is the most efficient and logical sequence of steps to follow in analyzing existing land use situations to identify the real needs and potentials for agroforestry?

These are some of the questions faced by ICRAF's multidisciplinary staff in trying to develop a methodology for agroforestry Diagnosis and Design (D&D) as an aid to the formulation and implementation of relevant and cost-effective research and development programmes in agroforestry. Work to develop such a methodology was initiated at ICRAF in 1981. Now, after trial applications in over twenty sites in Kenya and elsewhere around the world (though ICRAF's Collaborative and

Special Projects Programme), the methodology has been tested and adapted to a wide range of environmental and socioeconomic circumstances and brought to a preliminary stage of completion in two draft manuals (ICRAF, 1983a, 1983b) which are currently being circulated for review and comment before being revised for wider distribution and testing. The object of this open-ended process is to continue to develop and refine the methodology on the basis of trial and user feedback until it reaches its potential as a genuinely useful and practical tool for agroforestry researchers and development workers in the field.

Examples of practical field applications of the methodology are given in a complementary series on *Case Studies in Agroforestry Diagnosis and Design*, published within ICRAF's Working Paper series in order to facilitate rapid dissemination of D&D results from around the world (see for example Raintree, 1983a; Torres and Raintree 1984; Hoekstra, 1984; Rocheleau and van den Hoek, 1984). The series also provides opportunities for publication of selected case studies resulting from application of the methodology by researchers outside of ICRAF.

To facilitate access to and comparison of D&D results from a wide range of sites, a computerized data bank of global D&D information is being set up at ICRAF offices in Nairobi. From time to time, analyses and book length collections of case study materials relating to particular environmental or problem-oriented themes will be published. Over time, hopefully, the analysis of case study information will assist in the development of agroforestry in a way which is analogous to the role played by case studies in the development of medical science.

The various outputs from the Diagnosis and Design Project at ICRAF represent one aspect of a coordinated effort to develop a full range of useful methodological tools and information banks to service the needs of the global community of agroforestry workers (see ICRAF 1983c for information on other developments).

2.2 Requirements for an Interdisciplinary Methodology: Ends and Means

The considerations evoked in the first section of this paper touch on fundamental aspects of the "charter" of interdisciplinary teams, but what specifically could we expect of an interdisciplinary methodology for agroforestry? What specific *ends* should it address, and what *means* might it use to achieve these ends? These questions from part of the essential background to the D&D methodology. Indeed, the working out of appropriate means-ends linkages is the fundamental core of any methodology development process. Before proceeding to more detailed methodological considerations, it may be useful to first indicate the general requirements which the D&D methodology attempts to meet. For the sake of brevity the various requirements are listed under only four major headings. An interdisciplinary methodology for agroforestry should:

1. Provide a neutral, comprehensive and generally acceptable overall framework for collaboration between all disciplines relevant to the identification and implementation of applied research to develop agroforestry's potential as a source of appropriate technology for improved land management systems.

2. Institutionalize an effective applied focus in technology-generating research by providing mechanisms for feedback and coordination between rigorous on-station experimentation and participatory on-site research and testing with the intended users of technological innovations.

3. Provide practical procedures for timely and cost-effective inputs to the identification, planning and implementation of interdisciplinary research and development projects.

4. Suggest ways of completing the research-for-development cycle by following through with adequate extension followup and continued adaptive research within the recommendation domain for new or improved technology.

Many other criteria could be listed but most of these, I would submit, are already implicit in the above short list of major objectives, or are explicitly elaborated in the specific methodological strategies and tactics which have been developed as means for achieving the identified ends (ICRAF, 1983a, 1983b; Raintree, 1983b). For example, learning from farmers, technology evaluation by adoption, and ability to assess the technological needs and opportunities of resource-poor farmers are all key elements of the new research-for-rural-development paradigm (Chambers, 1983) and critical elements of any adequate methodology for applied agroforestry, which are given priority and dealt with in some depth at various stages of the D&D process. In this brief introduction to the D&D methodology most of the crucial methodological detail must remain implicit. More detail is provided in the draft manuals (ICRAF, 1983a, 1983b), but even there the emphasis has been on describing *how* to implement the objectives of applied research-for-development in the case of agroforestry, rather than *that* these objectives should be addressed.

In partial fulfillment of the first of the criteria listed above, the emphasis in the D&D methodology on providing a basis for appropriate technology-generating and testing research is a direct consequence of the mission-oriented, impact-maximizing strategy which must be adopted if interdisciplinary activities are to have the kind of material effect on the land management scene which is expected of agroforestry (Raintree, 1983b). People are not fed, housed, kept warm or provided with the means to cook their food and satisfy other basic needs by journal articles or successful scientific careers. While technology is not the solution to every rural development or conservation problem, without technology there can be no lasting solutions; moreover, improperly conceived technologies may generate more problems than they solve. To be fruitful, research on improvement of land management systems must result in the *concrete technical means* by which people may be enabled to take greater control of their destiny and satisfy their primary production objectives. The ultimate practical aim of the D&D methodology is to get agroforestry out of the lecture halls, off the drawing boards and into the landscape of rural development. Hence, the D&D emphasis on generation of appropriate component technologies and land management systems.

With regard to the first and second criteria, it is crucial, for an impact-maximizing approach, to achieve a proper balance between *systems research* on the one hand and *component research* on the other. It is at the *technology interface* that these two types of research come together.

We will return to this point shortly, but for the moment let it be said that the failure of institutions to achieve a smooth running integration of these two types of research may be the single most important reason for the relatively low yield of society's investment in rural development through applied land management research.

Let us examine a familiar case in point. The adoption over the past decade of a Farming Systems Research (FSR) approach (Collinson, 1981; Hildebrand, 1981; Zanstra *et al.*, 1981; Shaner, *et al.*, 1982) by many international and national agricultural research institutions may be seen as part of society's effort to improve the return on its investment in applied agricultural research. Faced with mounting and interrelated problems of resource degradation and failing production systems throughout the developing world, international support for the Farming Systems approach is part of the global society's response to a crisis situation. In essence, the introduction of FSR as part of the overall research strategy of these institutions is an attempt to bring about a proper balance between systems research and component research, the lack of which was recognized as a constraint on the achievement of applied research and development goals.

The attempt to correct existing imbalances and broaden the research approach to focus more effectively on neglected aspects of farming systems has, in most cases, required the addition social scientists to existing multidisciplinary research teams. Unfortunately, the inevitable institutional "growing pains" involved in the adoption of FSR methodologies and the close association of social scientists with this institutional adjustment has in many institutions tended to divert the debate on the proper balance between systems and component research into unproductive lines based on a *false dichotomy* between social scientists and biotechnical scientists. Be that as it may, the real issue in the Farming Systems debate is not between the social vs. the biotechnical sciences, but between *discipline-oriented* vs. *systems-oriented* scientists of any disciplinary background. In other words, while the adoption of the FSR approach does indeed involve a very necessary and productive debate on the overall balance of disciplines in applied scientific research, the real issue is between *those applied scientists who derive their research objectives and satisfactions from disciplinary traditions and incentives* vs. *those who get their inspiration from attempting to satisfy the technological needs of real world farming systems.*

Until the real issue is taken up, the intrinsic complementarity between systems and component research in the technology generation effort will not be perceived, the interdisciplinary threshold will not be crossed, and multidisciplinary teams will fail to achieve "takeoff" to sustained interdisciplinary interaction. Ultimately, of course, the real losers will be the rural people themselves, insofar as this lack of institutional coherence retards the development of adequate interdisciplinary approaches to the solution of the complex land management problems which they are facing.

As the history of science tells us, obsolete paradigms are rarely ever conclusively "disproven," they are merely abandoned in favour of newer and more adequate ones (Kuhn, 1962). Agroforestry, lacking an established research tradition of its own, is in a unique position to learn from past experience and build a more adequate interdisciplinary approach into

the very foundations of its emerging research paradigm. What is needed to avoid unproductive impasses is a clear understanding of the conceptual basis for fruitful collaboration between component researchers and systems reseachers in the technology generation effort.

a)	Outer Environment ENDS → (Land Use System)	TECHNOLOGY	Inner Environment ← MEANS (Materials & Techniques)
b)	SYSTEMS RESEARCH — What is needed →	TECHNOLOGY DESIGN	← What is possible — COMPONENT RESEARCH
c)	Planning Stage • Diagnosis of system problems & potentials • Specification of technology needs	SYNTHESIS	• Appraisal of existing technology • Feasibility of new technology to meet identified needs
	Implementation Stage • In situ trial and evaluation of the appropriateness of new and existing technologies	RESYNTHESIS	• Component screening • Interaction and management studies • Data synthesis and establishment of "design curves"

Figure 1. Complementarity between systems and component research with respect to a) the definition of a particular technology, b) specifications for technology design, and c) inputs to the technology generation effort at project planning and implementation stages. The lefthand "systems" and righthand "component" portions of this diagram correspond, respectively, to the upper and lower circles of Figure 2 and, somewhat less precisely, to the lefthand "on-site" and righthand "on-station" boxes of Figure 3.

The conceptual basis for the synthesis behind the D&D methodology was laid some years ago by Herbert Simon (1981) in his lucid discussion of the nature of technical artifacts. The essential complementarity between systems research and component research is revealed when we consider what is needed to define any particular technology (Figure 1). Any piece of technology in this sense (or specific application of technological knowledge) can be seen as an *interface between two environments:* an *outer environment* which defines the purpose and functional requirements which the technology serves within the larger system (for our purpose, the "land management system" of which the technology is a part) and an *inner environment* which is defined by the particular arrangement and mode of action of the constituent elements (components) by which it serves its purpose (i.e. the "nuts and bolts" of the technology). Both sets of specifications are necessary to completely define any particular piece of land management technology, one corresponding to the information provided by systems research (system requirements and functional specifications) and the other to that which is provided by component research (component selection and management specifications).

As a research manager at one of the CGIAR centres once put it, "You cannot have systems without components, but components without systems are meaningless" (Nores, personal communication). The methodological corollary to Simon's interface concept is that, in the effort to generate appropriate land management technology, the respective roles of *systems researchers* (social scientists, economists, land resource specialists, climatologists, cropping systems specialists, etc.) and *component researchers* (foresters, agronomists, horticulturalists, livestock specialists, plant pathologists, etc.) should be seen as entirely *complementary* and *mutually supportive*. If either input is neglected, the technical specifications remain incomplete and the likelihood of the technology finding a niche in the intended system is correspondingly lowered. Without both sets of specifications, the technology generation effort remains a hit-or-miss affair.

The schematic conception given in Figure 2 illustrates the role of diagnostic and design activities in a research-for-development programme based on active complementarity between component technology and systems research. Fruitful collaboration at the "technology assessment" interface might take the form of the following dialogue: Systems researcher to component researcher, "What have you got for System X?" Component researcher to systems researcher, "What do you need for System X?" A lively discussion would then ensue on the specifications (external "system" and internal "component") for technology which would be appropriate and feasible in the context of System X. In due course this would lead to the design of appropriate technology and the planning of research to develop and test the identified technology.

Needless to say, it is neither necessary nor likely that individual scientists can be neatly classified once and for all under one of these two researcher categories. In practice individual scientists may contribute to both types of research. In the final analysis, the conceptual synthesis which is necessary to generate appropriate technology must take the form of a shared construct in the minds of all concerned, but some division of labour between members of an interdisciplinary team may be invoked in the development of this construct.

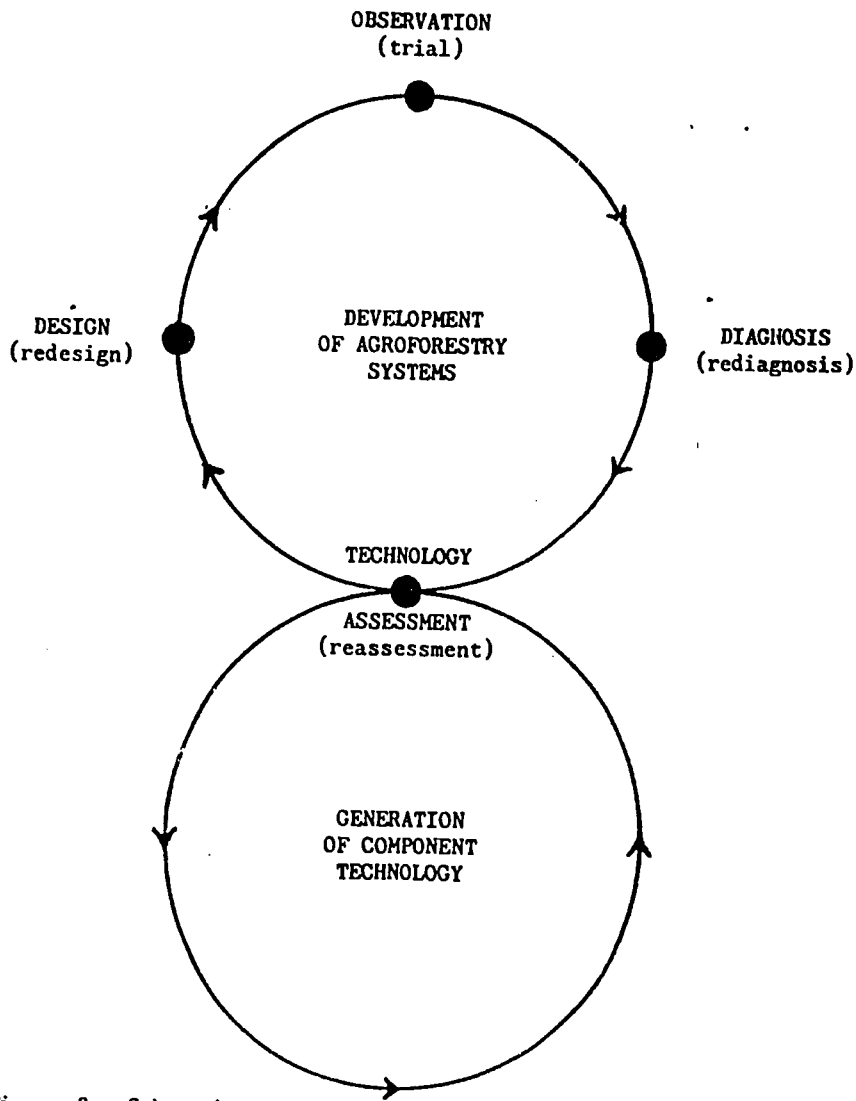

Figure 2. Schematic conception of a research-for-development programme based on complementarity between on-site systems research involving the iterative D&D process and component technology research involving rigorous experimental work on-station mainly but also, for some purposes, on-site. After the first round of the upper cycle (activities indicated in caps), the process is repeated as many times as needed to develop the system (activities indicated in parentheses). Interaction between the two circles at the "technology assessment" interface is designed to insure that the two mutually reinforcing types of research activity move in concert toward the shared goal of developing the system through the generation and application of appropriate technology.

If in principle there are no insuperable problems of interdisciplinary collaboration between researchers operating within the framework of the complementarity concept, there are nevertheless certain practical logistical constraints and requirements. The main one, which is implied the third criterion in our list of methodological requirements, is the limitation on time and personnel resources available for the type of survey work which is normally part of the discovery procedure needed to define the functional attributes and other system specifications for technology appropriate to a given land management system. We may refer to this as the "rapid appraisal" constraint, which has been the subject of considerable attention in recent years (Chambers, 1981; Longhurst, 1981; Pearce and Jones, 1981). Where research planning is a resource limited activity and where opportunities to accurately determine the appropriate direction for technology development are pre-empted by decisions taken in the press of time, systems researchers who ignore the rapid appraisal constraint do so at great peril to the success of their role in providing adequate system specifications for technology design.

Experience would indicate that lengthy survey work is neither necessary nor, in itself, sufficient to the information needs of the research planning phase of project development. The premium really is on *adequate analysis* of the system, rather than on any preconceived notion of the amount of survey work which ought on principle to be undertaken. Where the target land management system is already fairly well documented, very little survey may be needed to fill in the gaps in the knowledge required to derive appropriate technological specifications. Maximum use of available information can be made, but even where there is little or no baseline data, the information requirements of D&D can be rapidly met by steamlined survey procedures which involve senior members of the multidisciplinary R&D team directly in the collection of the essential information on which they will ultimately base their technology designs. Recalling what was previously said in section 1.2 about the need to focus on critical interactions, *essential information* may be defined as that which is needed to a) understand the critical means-ends linkages which govern the functioning of the target system (i.e. how the existing system works, its objectives, resources and technical means), b) diagnose its inherent problems and constraints (i.e. how *well* the system works), and c) assess the potential of the system to accommodate and benefit from discrete technological interventions of various types (leading to the development of design specifications).

The rapid appraisal approach to agroforestry Diagnosis and Design pertains mainly to the initial D&D exercise which is undertaken at the research planning stage to formulate an agroforestry R&D project. But diagnosis and design is a continuing, iterative process which can be repeated throughout the life of a technology-generating project to progressively deepen the diagnosis, assess the impact of introduced technology, and refine the prototype design to fit better the needs and potentials of the system. Once the project is on the ground with coordinated research activities on-station and on-site with farmers representative of the target land management system, the rapid appraisal constraint is no longer operative but the principles of efficient diagnosis and design continue to be applied as part of the projects "internal guidance system" (the basic mechanism in D&D for meeting the feedback requirements of criterion 2). Continuation of this same process into the

adaptive research activities of the extension stage of the project cycle is part of the D&D approach to satisfying the requirements of criterion 4.

The generalized flowchart given in Figure 3 illustrates the movement of information between the various research and development activities in an R&D project incorporating the D&D process, first as a basis for project formulation, then later as a means of coordinating feedback between on-going research activities (on-station and on-site) during the mid-project implementation stage, and finally as a means for handling feedback from a wider range of adaptive research trials at the dissemination stage. Figure 4 elaborates on the various roles served by the D&D process at different stages in the life cycle of a research and development project. The resulting process of "zeroing in" on an optimized land management system or component technology which the iterative use of D&D procedures can facilitate is illustrated by Figure 5.

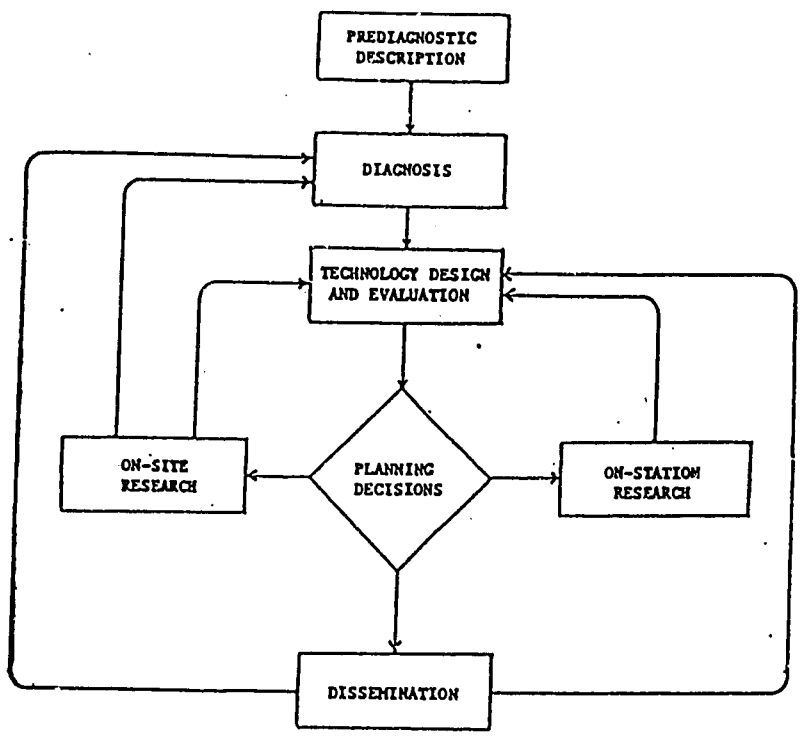

Figure 3. Components of project design incorporating the D&D process as part of the project's internal guidance system. Note feedback linkages.

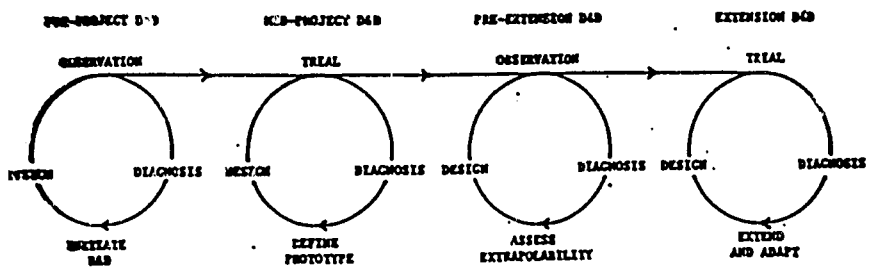

Figure 4. Repetition of the basic D&D process in different forms for different purposes at successive stages in the life of a technology generation and dissemination project.

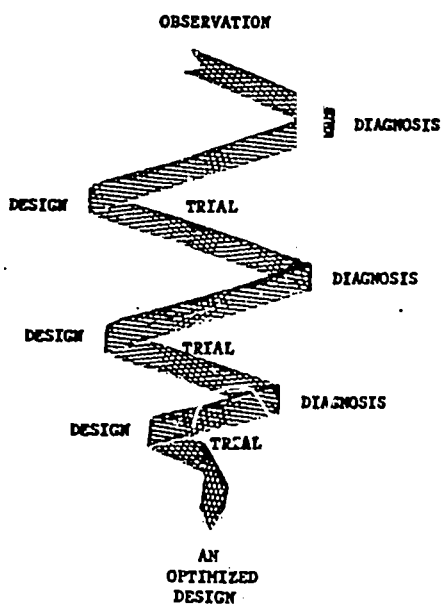

Figure 5. Beginning with an initial "best bet" design for a *generally appropriate* technology, the iterative D&D process leads, through a series of trial-and-error-reducing steps, toward the goal of a *specifically appropriate* technology for the target land use system.

2.3 Key Conceptual and Procedural Elements of the D&D Methodology

The foregoing discussion of methodological requirements and the general means by which the D&D methodology attempts to answer them has brought out some of the main principles of the approach. For purposes of this brief introduction to the methodology it still remains to give slightly more specificity to key elements in the conceptual and procedural framework of D&D applications.

Definition of "the System" for D&D Purposes

Given the concept of agroforestry as an approach to the improvement of land management systems, one of the prerequisites for successful application of the D&D methodology is a clear idea of what is meant by a "land management system." The concept adopted by the D&D methodology is based on the notion of a concrete, self-organizing "living system" as developed in General Systems Theory and widely applied in the biological and social sciences. This conception emphasizes analysis of the interactions among concrete system elements governed by the organized flow of matter, energy and information. It is distinguished from the alternative concept of "abstract systems" which deals with system variables at a more abstracted or idealized level of analysis (e.g. systems of causal relationships between components or states of concrete systems). Both types of systems analysis figure prominently in the D&D methodology, but the *definition* of "the system" for D&D purposes is based on the concrete systems approach.

Figure 6 illustrates the concept of the "land management system" which underlines the D&D approach. As shown in the illustration, the land management system, represented by the central pyramid, is part of the larger Man-Environment complex or "human ecosystem," represented by the square. At the top of the pyramid is Man, the manager, whose organizing influence (advertant or inadvertant) is felt throughout the human ecosystem but most clearly and directly expressed through the land management system. The base of the pyramid consist of those aspects of the Environment which are directly manipulated by Man to achieve his production objectives. The critical intervening variable in this interaction is the set of existing technical means by which the resource base is exploited to satisfy a given set of human purposes. In the functioning of the land management or production system, management flows down from Man (a movement of organizing information and energy) and production flows up from the resource base to Man (a movement of informed matter and energy).

The central point of this rather generalized dynamic model is that if any of the three main elements (human purpose, technology, resource base) were absent, the system would not function. The methodological corollary is that if any of the three essential elements are ignored, it will be impossible to *understand* how the system functions. Without such understanding, the effort to generate appropriate technology for the system will remain a hit-or-miss affair. Of course, it is not necessary to understand *everything* about the system in order to meet the information needs of good agroforestry design. What the model attempts to convey is a general notion of the kind of information that is essential for D&D purposes, i.e. an adequate knowledge of the means-ends linkages by which the land management system is organized to use available technology to exploit the resource base to satisfy human purposes.

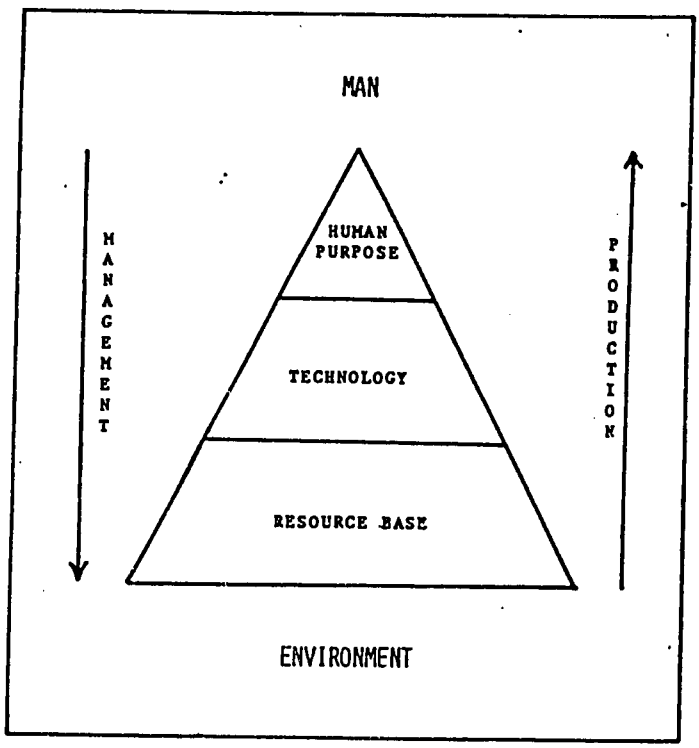

Figure 6. Concept of "the system" for D&D purposes. Within the "human ecosystem" represented by the square, the "land management system" which is the focal point of D&D activities is represented by the pyramid, illustrating the functional linkage of human purpose, technology and resources. An incomplete understanding of the system results if any of these three elements is ignored.

Just how the D&D methodology approaches this task is taken up shortly. For the moment another key aspect of the definition of "the system" for D&D purposes needs to be explained. Given the importance accorded in the above model to the central organizing role of human purposes, it follows that the analysis of the system must focus on the activities of the relevant *decision-making units* within the local human ecosystem. Identification of the focal units for D&D purposes gives additional specificity to the definition of the "land management system" and also defines the scale of relevant diagnostic and design procedures. Because the nature and composition of relevant decision-making units may vary widely from one geographical location to another, the D&D methodology has adopted a variable scale approach.

In most cases the primary focus for D&D activities will be on the *household land management unit*, i.e. the family farm, the household herd, or other elementary kinship-based production unit, for the simple reason that in most systems *this is where most of the major land management decisions are made* and it is these decisions which must be affected if agroforestry is to have any visible impact on the landscape.

Having said this, it must also be acknowledged that the household management unit may not be the only relevant decision-making unit to address in many cases. Agroforestry is an increasingly important management alternative for larger scale forest management units with their own forms of organization which must be taken into account. Even in farming systems applications many problems require a *larger-than-farm* scale of diagnosis and design. Watershed problems are a typical case in point, where erosion processes on one farm may originate or have impacts on other farms in the watershed. Boundaries between farms, roadsides, communal grazing areas, etc. are areas which may have problems which cannot be assigned to individual households and which may require larger scale landscape and community level solutions (Rocheleau and van den Hoek, 1984).

Smaller scale approaches to D&D may also be required to deal with *intra-household* level problems and potentials associated with the internal division of production responsibilities and opportunities (usually along sex role lines). These aspects may be particularly significant for agroforestry in regions where women, in addition to a heavy burden of domestic chores (food preparation, water supply, child care, etc.), may also have primary responsibility within the household for firewood collection, care of livestock and subsistence food production (Hoskins, 1980; Fortmann and Rocheleau, forthcoming).

For all of these reasons, a flexible variable scale approach to D&D is required. A systematic attempt to assess the role of scale factors in agroforestry diagnosis and design is currently underway at ICRAF (Rocheleau, 1984) to supplement the basic guidelines for variable scale analysis given in the current D&D documentation (ICRAF, 1983b).

A Diagnostic Approach to Design

There is a saying in the medical profession that *"Diagnosis should precede treatment."* We wouldn't dream of entrusting our health to a medical practitioner who made a habit of prescribing treatments without first diagnosing what ails us. We expect the same approach from automobile mechanics. What a strange anomaly it is, then, that we have tended to accept a lesser standard of practice when it comes to treating

problems arising from man's use of the earth. The fundamental rationale for a diagnostic approach to agroforestry design, and indeed to all systematic attempts to rectify land management problems, is that this same standard of professional practice should apply when devising strategies for technological interventions in existing land management systems. The time, if ever it existed, when we could settle for a hit-or-miss approach to land management is long past.

Diagnosis, however, is not an end in itself. To have *impact* on the land use scene a diagnosis must be followed by an appropriate technological prescription. The diagnostic process, conceived as a "discovery procedure" is, nevertheless, usually the most direct and logic route to an appropriate agroforestry design. Intuitive leaps leading to very good agroforestry designs can, of course, occur, but the essential point is an epistemological one: how does one *know* that the design addresses the real needs and potentials of the system unless it is substantiated by a diagnosis of the system? For a careful, professional approach to agroforestry, it must be acknowledged that the ability to solve a problem begins with the ability to define precisely what the problem is (Steppler, 1981).

It is a common experience (grounded, one suspects, in some fundamental and evolutionarily significant feature of human cognition), that the very act of seeing a problem clearly can itself suggest the nature of the required solution. One could perhaps go so far as to suggest a methodological corollary to this observation: *If the analysis of a problem does not suggest at least the general outlines of a solution, then the analysis is not yet adequate and should be pursued further.* The D&D approach is, in essence, a kind of algorithm for evoking insights of this type into the connection between problems and solutions. As such, it really contains nothing fundamentally new, but merely suggests an efficient procedure for taking advantage of the remarkable human capacity for problem-solving which is somehow wired into the very nature of our thought processes. Troubleshooting the system: The particular form of the algorithm used in the D&D approach is suggested in a general way in Figures 2 - 5 and described in more detail for the project formulation stage of the D&D process in section 2.4 of this paper.

Criteria of Good Agroforestry Design

There is no substitute for good design. The world is littered with land management schemes that have failed because the intended users of new technologies did not take them up. Numerous factors are cited as reasons for failure, but one suspects that in most cases it is due, at base, to faulty design. The criteria adopted by the D&D methodology for good agroforestry design are threefold: *productivity, sustainability* and *adoptability.*

The *productivity* criterion is a self-evident and virtually universal measure of the success of any technological innovation. There is no need here to elaborate much on this criterion except to note that the D&D approach embodies a somewhat broader type of productivity assessment than is normal, partly due to the broad range of productivity improvements which are within the scope of agroforestry to address, and partly as an attempt to correct for an implicit bias in conventional productivity assessments toward commercialized systems of production. It is often tacitly assumed that the raising of cash income will automatically improve the ability of farmers to satisfy their consumption needs. Cash, in todays world is certainly a basic human need, but it

will not solve the problem of food and firewood shortage in areas characterized by *absolute scarcity* of these commodities. In other words, cash is not *always* readily convertible into forms which satisfy other basic needs. These needs must often be addressed directly and, since it is in many cases within the scope of agroforestry to do so, the survey protocols of the D&D methodology encourage its users to make an *independent assessment* of problems with respect to each of the several "basic needs supply subsystems" and the ability of the land management system to meet these needs either directly through home production or indirectly through cash transaction.

The needs which are considered basic and universal, and which therefore enter explicitly into the D&D protocols are: *food, water, energy, shelter, raw materials* for local industry, *cash* (for normal expenses), *savings/investments* (for extraodinary expenses or development), and *social production* (for ceremonial exchanges and the like). Although the adoption of this "basic needs approach" does give the D&D methodology the capability to effectively address the needs and problems of resource-poor farmers, it does not necessarily imply an anti-commercial bias. The assessment categories are there to be used as needed. In highly commercialized production systems, the D&D methodology directs attention mainly to improvement of the cash subsystem; in poorly developed market economies, the methodology may suggest opportunities to satisfy the basic needs more directly. Agroforestry can contribute in various ways to each of the above listed subsystems (see ICRAF, 1983b, pp. 157-160 for elaboration of this point).

The *sustainability* criterion in agroforestry design reflects the special ability of agroforestry to solve or mitigate resource degradation problems in respect to deforestation, soil and water conservation, fertility maintenance, pasture regeneration, etc. In the D&D methodology the conservation objectives of agroforestry are expressed in terms of *sustaining production* for the simple but expedient reason that most smallholders are primarily concerned with production objectives and only secondarily concerned, if at all, with conservation objectives. To awaken interest in new technology it is often necessary (and with multipurpose agroforestry systems, entirely possible) to offer packaged solutions which meet both conservation and production objectives simultaneously. Assessing the sustainability of the existing system and designing for sustainable agroforestry systems is, therefore, a primary feature of the D&D approach. It could be argued that this is a neglected aspect of other diagnostic methodologies in the land management field. In agroforestry, certainly, it is one which is harder to ignore.

The *adoptability* criterion is simply a way of operationalizing all of those social and economic factors which interact with the particular attributes of any given technology to determine whether or not the technology is acceptable to the intended users. If a given technology is not in fact adoptable by the intended users, there is not much point in it. An analogous observation is made by nutritionists in noting that the nutritional value of any food that is not eaten is zero, regardless of its chemical composition. It has been more or less standard practice in the applied land management sciences for researchers to take their inspiration for new technology from the research tradition itself, rather than from an assessment of the chances for a specific technology in a given land management system. The result, all too often, has

been the failure of the intended users to adopt the new technology because it simply does not fit their system (with its inherent technology biases, resource limitations and other constraints). Unfortunately, the tendency in such cases has usually been to blame the intended recipients or, in many cases, the extension system for failing to sell the new technology to the farmers. In most cases, however, it will be more productive to take cognizance of adoptability criteria in the *design* of technological innovations, in the first instance, and to build the appropriate characteristics into the new technology from the very start of the R&D process. This, in fact, is the explicit rationale behind the incorporation in the D&D methodology of adoptability as a criterion of good agroforestry design, on an equal footing with productivity and sustainability (see Raintree, 1983b for further discussion of adoption strategies in agroforestry).

2.4 Procedures for Project Formulation

As indicated above, the D&D methodology recommends an iterative process of diagnosis and design which continues throughout the entire life cycle of a research and development project, from the project planning stage, through the technology generation stage to the final stage of technology dissemination and adaptive research. In its present state of development, the existing draft documentation on the methodology gives primary emphasis to a set of general guidelines (ICRAF, 1983a) and optional detailed procedural suggestions and resource materials (ICRAF, 1983b) for the project planning stage of the project cycle. Additional guidelines and resources are currently being developed for later stages and will be incorporated into revised editions of the manuals. This staggered process of methodology development is partly due to the longer time required to gain experience with the latter stages of the project cycle, but partly also to the *priority* placed in this early period in the development of scientific agroforestry on the *formulation* of well-conceived projects.

In order to fit the needs, resources and levels of interest of the widest possible range of potential users, the D&D guidelines for project formulation are presently offered at three levels of detail.

Level 1: Minimal Guidelines

Guidelines at this minimal level of detail consist of little more than urging scientists and development workers to adhere to the basic principle that *diagnosis should precede treatment*. In applying this principle, there are many possible ways to proceed and workers are encouraged to use their ingenuity in devising ways and means appropriate to their own needs and resources. As long as one first takes the time to diagnose the target land use system *before* starting to design improvements for it, the minimal requirements of the D&D approach will be satisfied. Still, it may be helpful to pass along some useful hints and suggestions, based on ICRAF's experience with the approach, on how one might organize one's thinking in approaching this task. Table 1 suggests a four stage breakdown of the D&D process and the basic questions and key factors which ICRAF field teams have found useful to consider at each stage.

Table 1. Summary of level 1 guidelines for project formulation based on a four stage breakdown of the 'minimal' logic of the D&D process.

D&D STAGES	BASIC QUESTIONS TO ANSWER	KEY FACTORS TO CONSIDER	MODE OF INQUIRY
PREDIAGNOSTIC	HOW THE SYSTEM WORKS (what does it look like, how is it put together, how does it work?)	PRODUCTION OBJECTIVES AND STRATEGIES	SEEING THE SYSTEM
DIAGNOSTIC	HOW WELL THE SYSTEM WORKS (what are its problems, limiting constraints and dysfunctional syndromes?)	PROBLEMS IN MEETING OBJECTIVES CAUSES OF IDENTIFIED PROBLEMS	TROUBLESHOOTING THE SYSTEM DERIVING SPECIFICATIONS
DESIGN	HOW TO IMPROVE THE SYSTEM (what is needed to improve system performance?)	PROBLEM SOLVING OR PERFORMANCE ENHANCING INTERVENTIONS	BRAINSTORMING AND EVALUATING ALTERNATIVES
PLANNING	WHAT TO DO TO DEVELOP THE IMPROVED SYSTEM (what specific R&D actions are needed to develop and implement the envisaged improvements?)	R&D PRIORITIES	PROJECT PLANNING AND RESEARCH DESIGN

Level 2. Semi-detailed Guidelines

This is the level of detail contained in the draft *Guidelines for Agroforestry Diagnosis and Design* (ICRAF, 1983a, 25 pp.). At this level of detail the suggested procedures for project formulation emphasize a "rapid appraisal" approach (Chambers, 1981) and consist of a series of information gathering and analytical steps, leading logically from one to the next. This stepwise procedure entails an hierarchical progression from the general to the particular, which is designed to economize on time and effort by excluding irrelevant information from further consideration while developing a progressively sharper focus on *essential information*. By means of this structured but open-ended approach the level 2 guidelines attempt to avoid the seemingly endless and needlessly detailed data gathering task which is often characteristic of less structured approaches to systems analysis. In the level 2 methodology the four stage procedure suggested at level 1 is further subdivided into a series of 12 discrete steps, as follows:

Prediagnostic Stage (Steps 1 - 3)

This stage covers 1) background description of the study area, including diagnostically relevant aspects of the biophysical and socioeconomic environment, 2) differentiation and selection of land use systems within the study area for further D&D attention, and 3) preliminary description of diagnostically relevant aspects of the selected systems.

Diagnostic Stage (Steps 4 - 6)

This stage includes 4) diagnostic survey of the selected systems and relevant aspects of the environmental setting, 5) diagnostic analysis and identification of major land use problems and potentials, and 6) derivation of specifications for appropriate technology (including non-agroforestry options but with special attention to agroforestry potentials).

Technology Design Stage (Steps 7 - 9)

This stage involves 7) appraisal and selection of candidate technologies for possible inclusion in the design, 8) synthesis of a general design concept for an improved land use system and development, if possible, of initial 'best bet' designs for component technologies, and 9) ex ante evaluation and refinement of the proposed design. The activities of this stage may involve reiteration of the above steps.

Follow-up Planning Stage (Steps 10 - 12)

This stage covers 10) identification of research needed to develop and/or test the identified agroforestry technologies, 11) identification of areas needing further D&D attention in followup activities and 12) development of a detailed project implementation plan to carry out the envisaged R&D programme.

Table 2 presents a summary overview of the four stage process in slightly greater detail than Table 1. The *Guidelines* document itself goes a little further than what is shown here in the form of a step-by-step outline which suggests ways to proceed at each step, listing the expected *output* of each step, the relevant *sources of information*, a more detailed list of *factors to consider*, and a brief catalogue of *potentially useful tools* and materials.

Level 3. Detailed Guidelines

For users of the methodology who, when developing their own set of adapted procedures, might be desirous of having the benefit of the full range of detailed methodological suggestions which ICRAF's experienced multidisciplinary staff is currently able to provide, a third level of detail is given in the draft *Resources for Agroforestry Diagnosis and Design* (ICRAF, 1983b, 383 pp.). This collection of optional resource materials contains a more detailed set of procedural suggestions for each of the 12 steps in the level 2 methodology, along with over 35 resource modules describing useful diagnostic tools, analytical techniques and design materials for possible consultation at appropriate steps in the project formulation process. It would be unlikely, and indeed impossible in a "rapid appraisal" type of project formulation exercise, that all of the suggested procedures, tools and materials would be needed or used.

What must be emphasized, in any case, is that users of the D&D methodology in its more detailed form will almost always need to modify and adapt the suggested procedures to fit the particular application. This resource collection is designed to serve as a source of ideas to aid the user in this process. Many of the resource modules may also have value for agroforestry independent of the D&D process.

Table 2. Summary overview of level 2 project formulation guidelines showing how the D&D process relates to the concepts of the "land management system" and the "human ecosystem" illustrated in Figure 6. Stages of the D&D process are shown at the top of the table, the major analytical techniques at the bottom, and the key questions and factors to consider in each of the internal cells of the table.

HUMAN ECOSYSTEM / LAND USE SYSTEM	PREDIAGNOSTIC DESCRIPTION	DIAGNOSIS OF PROBLEMS & POTENTIALS	TECHNOLOGY DESIGN	FOLLOW UP PLANNING
MAN	WHO IS INVOLVED? - LAND USERS - GOVERNMENT AUTHORITIES - OTHER INTERESTS	WHO HAS WHAT PROBLEMS? INTERACTIONS	FOR WHOM IS THE TECHNOLOGY INTENDED?	WHO SHOULD CARRY OUT THE NEEDED R&D WORK?
PURPOSE	MANAGEMENT (PRODUCTION/ CONSERVATION) OBJECTIVES OF THE DIFFERENT INTEREST GROUPS	PROBLEMS IN ACHIEVING MANAGEMENT OBJECTIVES, INAPPROPRIATE OBJECTIVES, STRATEGIES	SPECIFICATIONS FOR RELEVANT TECHNOLOGY	INSTITUTIONAL ARRANGEMENTS
TECHNOLOGY	OVERVIEW OF TECHNICAL MEANS IN CURRENT USE	TECHNICAL CAUSES OF IDENTIFIED PROBLEMS, FUNCTIONAL POTENTIALS FOR TECHNICAL INTERVENTION IN THE SYSTEM	APPROPRIATE DESIGNS FOR IMPROVED LAND MANAGEMENT TECHNOLOGY	PLAN FOR TECHNOLOGY GENERATING R&D
RESOURCES	OVERVIEW OF RESOURCE BASE	RESOURCE USE SUSTAINABILITY ASSESSMENT	RESOURCE REQUIREMENTS SUSTAINABILITY PROJECTION	PROJECT RESOURCES
ENVIRONMENT	STRUCTURE AND FUNCTION OF THE HUMAN ECOSYSTEM/ LOCAL COMMUNITY	WIDER ENVIRONMENTAL IMPACTS	WIDER ENVIRONMENTAL IMPACTS	IDENTIFICATION OF WIDER RECOMMENDATION DOMAIN
	BASIC NEEDS ANALYSIS	TROUBLE-SHOOTING ANALYSIS; PRODUCTIVITY, SUSTAINABILITY, ADOPTABILITY CRITERIA	MEANS-ENDS ANALYSIS	ITERATIVE D&D PROCESS

D&D METHODOLOGY

Even in its most detailed form the D&D methodology cannot anticipate and provide answers (or even suggest ways to find answers) to every question which could arise in site-specific applications. At its present stage of development the D&D methodology is really a tool for an interdisciplinary *group process* approach to agroforestry diagnosis and design by a multidisciplinary team of experts (or, in some cases, by an interdisciplinary-minded individual with backup from a multidisciplinary pool of experts). Like all tools, the successful application of the D&D methodology relies heavily on the flexibility, competance and creativity of its users.

Level 4 Guidelines?

It is not clear just how far it is practical or useful to go in developing methodologies like D&D. Perhaps after the draft manuals are revised to incorporate user feedback it will be decided that ICRAF has gone far enough in this effort and the emphasis will then shift to the accumulation and analysis of case studies and the development of broader geographical perspectives on agroforestry needs and potentials. Certainly, it is only through *application* that the methodology will bear fruit in concrete form and have the kind of impact on the landscape of rural development that is intended. However that may be, it is still conceivable that this type of a methodological approach could aspire to a higher level of rigor and detail, as would be required to achieve the capability of *positive diagnosis* and *precision design*, with less reliance than at present on the knowledge and skill of particular multidisciplinary teams. Such a methodology, essentially an elaboration and refinement of level 3 procedures, would involve the use of system specific "diagnostic keys" and detailed "design algorithms," but it would require an empirical and theoretical understanding of agroforestry, indeed of land management systems in general, that is well beyond the present capabilities of the field. Whether or not this is an attainable, or even desirable, goal is a moot point, but perhaps it is one that should be kept in mind for the future.

3. PRELIMINARY EVALUATION OF ICRAF'S EXPERIENCE WITH THE D&D METHODOLOGY

It is much too early to give anything more than a very preliminary account of ICRAF's experience with the interdisciplinary D&D methodology. It is difficult, moreover, to evaluate that experience without sounding self-serving. Nevertheless, it does seem possible at this early stage to draw certain tentative and reasonably objective conclusions about ICRAF's experience in developing and applying the D&D methodology. It should be noted, however, that the perspective expressed here is the sole responsibility of the author and, while I have no reason to anticipate substantial disagreement from my colleagues, the following statements have not been subjected to systematic in-house review and, therefore, do not necessarily reflect the considered institutional judgement of ICRAF as a whole.

Let it be said straightaway that any success which may be attributed to the D&D methodology effort at ICRAF is in large measure due to the very favourable climate created for such work by the Council's mandate, institutional strategy and programme of work. The ultimate goal of ICRAF's work, as stated in its Charter, is "to improve the nutritional,

economic and social well-being of the peoples of developing countries by the promotion of agroforestry systems designed to result in better land use without detriment to the environment." As a research council without extensive field research facilities of its own, ICRAF's role is mainly to assist national and international institutions to develop and implement well-conceived research-for-development programmes in agroforestry The current programme of work, thus, emphasizes three main focal points:

1) the development of methodologies for identifying social, economic and ecological constraints in land-use systems and for assessing the potential of agroforestry technologies to overcome such constraints;

2) the systematic collation and assessment of agroforestry knowledge and the development of methods of studying and evaluating agroforestry technologies;

3) the efficient dissemination of methodologies and knowledge to scientists and development planners in the tropical and sub-tropical developing world (ICRAF, 1983c).

The need for a methodology to assist agroforestry workers to identify research and development priorities, based on a clear-eyed assessment of agroforestry-related constraints and potentials in existing land use systems, was identified as a priority focus for the Council early in the development of its institutional strategy (Steppler, 1981). Consequently, the D&D work was initiated in 1981 and later formalized as a project which received a major share of ICRAF's personnel and financial resources within the overall programme of work. A key element of ICRAF's strategy was to recruit a multidisciplinary team of 15 or 16 scientists whose first task would be to pool their collective experience to develop such a methodology.

3.1 In-House Development Phase

A brief discussion of some of the key elements of the institutional milieu in which the D&D methodology was developed may be of some relevance to the theme of this congress. In the first instance, the very complexity of agroforestry as an approach to the development of improved land management systems created an unusually favourable climate for a systems perspective among ICRAF's scientific staff. The newness of the field, lacking strong disciplinary conceptions of business-as-usual and, indeed, possessed of a kind of revolutionary elan, was no doubt another important and very favourable factor in the setting in which D&D developed. Few, if any, of the current systems methodologies in the land management field have enjoyed such a favourable institutional setting.

At the initiation of concerted D&D development activities in early 1981, the senior staff consisted of the Interim Director General and four scientists. While this might seem an inordinantly small staff complement for an organization with such a large mandate, it did promote an unusually intense and fruitful interaction among the scientific staff. The long, almost continuous, and sometimes very animated discussions which occured in this "think tank" atmosphere laid a sound foundation of shared interdisciplinary understanding which has formed the basis for much of ICRAF's subsequent work.

Early in the D&D methodology development two of ICRAF's scientists joined forces to spearhead the methodology development effort: an ecological anthropologist (later named project leader) with training in tree crop horticulture and psychology and a strong technology bent, and a livestock/range management scientist with an early background in agronomy and considerable experience in the management field. Two points are worth noting here: First, the interdisciplinarity of the individuals themselves, and secondly, the basic social science-biological science complementarity between these individuals, which in effect invoked the "pairing principle" which has figured so prominently in many of the Farming Systems methodologies. Another important element in the early D&D equation was the strong committment of this core team to the "new professionalism" (Chambers, 1983) of the research-for-development paradigm. The general committment of the Council as a whole to the ideal of an *applied* agroforestry science and the critical support of the other staff members (a horticulturalist and an agronomist) constituted a rich nutrient broth for the nascent D&D methodology. It was during this period that the basic framework for the D&D methodology was laid down.

One further element of the early methodology development work which was absolutely *crucial* to its success was exposure of the D&D team to realistic field conditions. Most of the early applications took place in Kenya at a variety of sites representing a range of ecological and socioeconomic conditions. One of these sites was developed as a special project site for in-house methodology development work and is now into its fourth year of on-farm agroforestry trials (Lundgren and Raintree, 1983; Rocheleau and van den Hoek, 1984; Vonk, forthcoming).

Gradually as other disciplines were added, notably a farm economist who brought fresh insights and greater rigor to the methodology and a forester who supplied an essential missing element, the basic framework of the methodology was fleshed out in greater detail and multidisciplinary rigor. It was not until 1983, however, that the full complement of disciplines originally envisaged for ICRAF's multidisciplinary team was reached (see ICRAF, 1983c for a listing of the more than 10 disciplines represented in ICRAF's current complement of 18 senior scientific and professional staff members). With the addition of a bioclimatologist, a land evaluation expert and a geographer/systems ecologist, the D&D methodology project was able to draw on a multidisciplinary staff whose breadth and sophistication is unlikely to be equalled anywhere else in the agroforestry field. This might, at first glance, seem to indicate a constraint on the application of the D&D methodology outside of ICRAF where such well-rounded multidisciplinary teams are rare, but this would be an erroneous conclusion since, as everyone knows, there is an enormous difference between the *development* of a methodology and its *application* by users. Right from the beginning, ICRAF's institutional strategy has distinquished three phases in the development of any of its methodologies:

Phase 1: Development of the in-house *capability* to accomplish a particular methodological objective

Phase 2: Expansion of ICRAF's in-house *capacity* to carry out a sufficient amount of methodology application work (as a service to clients)

Phase 3: Attainment of the status of a fullfledged *methodology* by transfer of the developed methodological capability to others for independent application (i.e. through documentation and/or training)

The D&D methodology is in the early stages of Phase 3. Conceived from the start as an activity which would involve the collaboration of potential users of the methodology in its development, the D&D methodology will not be complete until the current review period is over and suggested improvements have been incorporated into revised versions of the present draft manuals.

3.2 Dissemination Phase

There has been a high degree of overlap between the development and dissemination phases of the D&D methodology, inasmuch as the development of the methodology was largely accomplished through trial application and refinement at a range of sites around the world. Most of these applications have been organized under the umbrella of ICRAF's Collaborative and Special Projects Programme (COSPRO) and have involved collaboration of ICRAF scientists with local multidisciplinary teams of national and international scientists and, therefore, automatically involved dissemination of the evolving methodology. This repeated exposure to new ecological and socioeconomic circumstances, along with the feedback received from scientists representative of the methodology's main client group, has been a key element in the elaboration and refinement of the methodology. Few farming systems methodologies have been exposed to such a wide range of geographical conditions and user feedback.

For the purposes of this congress it may be instructive to consider how scientists exposed to the D&D methodology as part of the COSPRO project formulation experience have responded to the approach. The typical initial reaction to the methodology has been one of scepticism. "Is all this really necessary?" is the typical initial comment, recently expressed by an Indian scientist at the beginning of a D&D exercise in the Himalayas. Scientists have been formulating research projects without the benefit of the D&D methodology for years and the initial response is characteristic of scientists' reaction to what they often perceive as an intrusion on "business-as-usual" in a form which, at least implicitly, seems to call their professional competance into question. For the most part, the scientists recruited by their superiors for participation in ICRAF led D&D training-cum-project-formulation exercises are there not because of a burning interest on their part in improving their ability to identify meaningful priorities for applied agroforestry research, but because the need for such improvement has been recognized by higher management levels in their organizations. This is what one would expect. Research managers are more directly exposed to political demands for practical "results" that are part of society's response to the crisis situation facing many developing countries; while scientists, still relatively secure within the present system of disciplinary rewards, are sheltered from these pressures.

Be that as it may, given the long gestation period for the agroforestry technologies initiated by the D&D process, one of the few sources of empirical confirmation of the validity of the D&D process which we can presently offer is the fact that scientists initially expressing scepticism regarding the methodology, at the conclusion of the typical two week field exercise consistently express acceptance of and often real enthusiasm for the approach. Quite often it is the most vociferous sceptics who become the most vigorous champions of D&D. The phenomenon is so striking that one is tempted to compare it to the psychology of the classical "conversion experience."

The typical comment at the conclusion of a D&D field experience is on the order of "You know, I really wasn't too impressed with all this D&D business to start with, but I really did learn a whole new way of thinking about my research AND it wasn't really all that complicated or time consuming. It will be useful to me in my future agroforestry work."

Of course, the reaction is not always so positive. Individual scientists are differentially susceptible to innovations in methodology. In trying to discover whether there are any patterns in the response to D&D, we don't seem to find any clear cut disciplinary biases. Some soils scientists and foresters are as receptive to D&D as many economists and sociologists. The only clear pattern of resistance to D&D that we can presently discern is in cases where the individual has a strong personal committment to some "rival" methodology or deep ego involvement in previous work of a similar nature at the site. In the former case, the resistance may be misplaced, since ICRAF has never claimed to be in exclusive possession of the methodological holy grail. There are many ways to skin a cat, and the D&D methodology has always been presented as only one, perhaps more than usually systematic and efficient, example of what is after all a very general and fundamental problem-solving approach. In the latter case, we are confronted with a more delicate problem, which may indicate the need for caution in accepting the host country's nomination of a D&D training site at which there is a long history of prior scientific involvement, particularly when demonstrating the methodology for the first time in a country. In some cases it won't matter, but normally such sites involve psychological complexities that are best avoided in training exercises.

What, in fact, do participants in ICRAF led D&D demonstrations actually take away with them from the experience? What indications are there that D&D is being successfully adopted and adapted for independent service in host country institutions? Several D&D-based agroforestry research and development projects are underway at various places in the developing world and certain countries and regional research organizations have expressed the intention of adopting the D&D methodology as a basis for project formulation in national and regional agroforestry research networks but it is simply too early for the methodology to have diffused outward from its point of introduction and, therefore, too early to evaluate the actual adoption and adaptation process. Likewise with the ultimate impact of the methodology on the agroforestry landscape.

It is not too early, however, to profit in the methodology refinement process from early feedback on the D&D approach received from collaborators in the field, participants in ICRAF training courses which prominently feature the D&D methodology, and comments and suggestions received from reviewers of the current draft methodology documents. The positive aspects of the methodology more-or-less speak for themselves. Let us concentrate, instead, on the negative feedback, since this is the source of valuable course correction information. What are the difficulties users have with the methodology and/or its current forms of presentation?

One relevant point is based more on observation of first time D&D participants rather than comments received. To handle the complexity of the on-the-spot data processing task involved in the rapid appraisal of complex land management problems and potentials, the D&D methodology relies on a flexible but structured "first things first" approach. In

developing the methodology through repeated trial application, we have arrived at what seems to be a logical sequence of steps for an efficient and timely procedure. While the methodology allows and suggests flexibility in dealing with this progression, the general direction of movement (i.e. from general to particular and from diagnosis to design) can be ignored only at great peril to the timely completion of a coherent exercise. Some such "blueprint" for the exercise, adapted and agreed upon by the participating scientists at the outset, is a crucial requirement for fruitful multidisciplinary collaboration. Without it, everyone simply goes off in a different direction. The problem is that, even after having agreed on the procedural agenda, many scientists seem to have trouble sticking to it. As with all "committee" processes, a strong chairman who is thoroughly familiar with the demands of his role as leader of a D&D exercise is a must. The larger the group, the stronger the leadership needed. ICRAF's experience, consistent with the general findings of small group psychology, is that a team of about 5 or 6 scientists is about right for a smooth application of the D&D group process methodology. If a larger group is involved, it is best broken down into teams of about this size.

Part of the problem, if one may be allowed a bit of speculation on the cognitive processes involved, seems to be a lack of prior training in structured approaches to data. The concept of "structured programming" in the computer field is the clearest example of what we mean by a structured approach to problem solving: to tackle a complex, non-linear data processing task, it is helpful to first break the problem down into a set of smaller problems, blockout the main analytical tasks, and *then* proceed to work out the details. The advantages of this "top down" structured progression from the general to the particular are so striking, as compared to just "muddling through," that it really must be considered an essential ingredient of a rapid appraisal approach to systems analysis. The more complex the system and the shorter the time alloted to the task, the greater the need to stick to a structured approach.

This doesn't necessarily mean following the detailed D&D guidelines to the letter, but it does require an understanding of the general concept and technique of structured systems analysis, at least on the part of the team leader, and the grace and goodwill of the team in sticking to the agenda. The most common problem, often causing great frustration to those team members who have caught onto the approach and are trying diligently to keep the discussion focused, is that every team seems to include at least some members who are unable or unwilling to stick to business. The major disruptive cognitive factor is the tendency to proceed directly into detailed treatment of one aspect of the system (often someone's speciality area) before bringing the analysis of other interrelated aspects of the system to a comparable point. While they may agree to it in principle, in practice many first time D&D participants have difficulty in setting aside a problem and coming back to it later. This is not an insuperable difficulty, but it is one that needs the attention of a good interdisciplinary-minded group leader.

As regards feedback on the current draft documentation of the D&D methodology, we have been confronted with a bit of a paradox. On the one hand, many reviewers have suggested that the documentation needs to be shortened and simplified, while on the other hand, there are some who have expressed the desire for *more detailed* guidelines on particular aspects. Before simply accepting Abraham Lincoln's dictum

that "You can't please all of the people all of the time," ICRAF's writers will attempt to effect a reasonable compromise in the upcoming revision process. Our feeling is that both demands need to be satisfied, and that is why we will attempt to improve the documentation without changing the current two volume draft manual format (short form *Guidelines* plus optional *Resources* collection). In this regard, it is pertinent to note that the individual users' demand for written documentation seems to increase with increasing acceptance of the general approach. In the developing country context, where the printed word seems to exert a less dominant influence on the scientific subculture than in more developed countries, it may be too optimistic to expect first time D&D team members to read even the short form *Guidelines* before the field exercise; whereas, *after* the exercise, once the general approach has been grasped and the relevance of the more detailed guidelines and resource materials more readily perceived, the demand for more detailed documentation of the suggested procedures and analytical tools may be expected to rise sharply. This suggests the primacy of a "hands-on" approach to D&D training, in the first instance, with written documentation playing a secondary, backstopping role.

Once again, it may be worth pointing out the extraordinary impact of the *field situation* on scientists who have previously confined themselves to research stations. For many of them it may be the first time they've really *seen* a village in terms intimately related to their research concerns. The psychological impact of just being in the village (surrounded by real people with real and unignorable problems) is enormous, but the main impact comes with the realization that *one is there for scientifically respectable purposes* which may, in future, be a factor in the success of one's career. This reaction is often indicated by the somewhat bemused or occasionally stupified expressions one reads on the face of such scientists in the first day or two of fieldwork. What a relief it is then to discover, after another couple of days, that the research improving process really isn't that difficult to carry out.

Having said that, it must still be acknoledged that there may be a tradeoff in any methodology, as in the technology-generation process itself, between professional standards of *technical adequacy* and the pragmatic standard of *easy adoptability*. While the latter criterion must be satisfied if a methodology is to have any chance of widespread adoption by scientists, compromises with respect to the technical complexity of the methodology can only be pushed so far without endangering the overriding objective of *solving the complex land management problems of rural people*. The reason these problems have proven so resistant to more casual approaches is that, in many cases, they simply *are* rather difficult to diagnose and solve. It is a bit superficial to insist on too much simplicity in methodologies for solving complex problems.

Paradoxically, it often seems to be the representatives of aid *donor organizations* who argue most forcefully for the lowering of professional standards in order to ease the adoption of systems methodologies by developing country scientists. These same organizations have played a major role in promoting the general policy changes behind the new research-for-development emphasis in developing countries. It would be good of them now to follow through with well orchestrated support for the methodologies which have arisen to meet the more stringent objectives of the new policies.

The "new professionalism" (Chambers, 1983) demands higher, not lower standards of applied scientific excellence. If, in the final analysis, methodologies like D&D entail an unavoidable conflict of interest between scientists and the people they are commissioned to serve, it is clear whom we must ask to shoulder the additional burden. In thinking about how much room there is for improvement in this regard, I am reminded of a developing country scientist who once asked me "When is ICRAF going to put out a *short* description of the D&D methodology?" "But the *Guidelines* are only 25 pages," I answered in bewilderment. "Ah yes," he said, "but they are A-4 size pages!"

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