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DESIGNING AGROFORESTRY SYSTEMS FOR RURAL DEVELOPMENT: ICRAF'S D&D APPROACH

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Research is research and development is development. Although the two can be effectively combined in an integrated "research for development" approach, all too often the degree of integration is less than what is needed to meet the challenges of rural development in today's world. Recognizing the need to gear applied technological research more effectively to the needs and potentials of rural populations and land use systems, considerable progress has been made in recent years to develop workable interdisciplinary methodologies and institutional arrangements to achieve the goals of national development policies. Two such innovations developed in India, the "Operational Research" and "Lab to Land" programmes of the Indian Council for Agricultural Research are examples of the renewed emphasis on research for rural development.

Agroforestry, as an approach to integrated land management, is widely thought to have enormous potential as a source of technological solutions to problems of rural development. Although agroforestry is an ancient form of land use practiced by many generations of rural people in many parts of the world, it is a relatively new field of organized scientific activity, lacking an established research tradition of its own. This is both a constraint and an opportunity. In a bid to take advantage of the special opportunity represented by the nascent state of the field, the International Council for Research in Agroforestry (ICRAF) has given emphasis in its current programme of work to the development of agroforestry methodologies which are explicitly designed to support the applied "research for development" approach. ICRAF's Diagnosis and Design Methodology (D&D) is one such methodology, the basic aim of which is to assist interdisciplinary research and development teams to arrive at good agroforestry designs for rural development (ICRAF, 1983a, 1983b).

1. SOME CRITERIA OF GOOD AGROFORESTRY DESIGN

In one of the earliest widely published attempts to outline the scope of this new field of applied science, agroforestry was defined 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 is a normative definition which states not merely what agroforestry is, but also what it should be, i.e. a land management system that is *productive*, *sustainable* and *culturally appropriate*.

While we may all agree that these three criteria are desirable attributes of agroforestry systems, strictly speaking there is little justification for assuming that all land management systems which could be considered "agroforestry" on the basis of the combination of components (trees with herbaceous crops and/or animals) will automatically satisfy these criteria. Subsequently, a more neutral definition of agroforestry has been proposed 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).

If this latter definition is adopted, the three attributes embodied in the earlier definition can still be retained as *criteria of good agroforestry design*, while recognizing that they have to be *achieved* by the developers of agroforestry systems and not just ascribed to any system which happens to meet the minimal definition of agroforestry. In operational terms then, a well designed agroforestry system should meet high standards of *productivity*, *sustainability* and *adoptability*.

1.1 Productivity Criterion

The productivity criterion applies not just to agroforestry, of course but to any innovation in technology. In other words, any agricultural, forest management, or agroforestry innovation should be more productive than what is already on the ground. There is little need to elaborate on this criterion, except to note that, because of the potential complexity and scope of agroforestry systems, a broader and more open-minded approach to productivity improvement is needed than in simpler systems possessing less scope. Well designed agroforestry systems can contribute to the improvement of rural welfare through a variety of *direct* "production roles" (food, fodder, fuel, and fiber in many different forms) as well as through a whole range of *indirect* "service roles" (soil and water management, fertility improvement, microclimate amelioration, live fencing, etc.).

In some cases, agroforestry systems designed to produce marketable commodities in excess of household consumption needs may contribute significantly to improvements in rural welfare through increased income of rural families. In other cases, it may be necessary to take a more direct approach to the satisfaction of specific consumption needs, particularly where the market mechanism is unable to supply needed commodities in sufficient quantity at affordable prices. For example, where deforestation or overgrazing have created *absolute scarcities* of fuelwood or animal feed, merely raising household income may contribute little to improving the household supply of these basic commodities. Examples of successess and failures can be found for both strategies, but it is pointless to debate the *general desirability* of "market-oriented" vs. "subsistence-oriented" approaches to agroforestry, when what is needed in each case is a careful assessment of the actual production needs and potentials of a given area in order to identify the *particular mix* of production strategies and technologies which can best contribute to the development of the area.

Given the enormous potential, moreover, for agroforestry systems making flexible use of multipurpose trees and other components, "good agroforestry design" implies a willingness to explore possibilities for achieving *multiple production objectives* through clever combinations of components in integrated agroforestry systems.

1.2 Sustainability Criterion

The sustainability criterion in agroforestry design addresses the "conservation" aspect of agroforestry's role in rural development. Atempting to address this concern directly in agroforestry designs raises considerable difficulties, however. Most farmers the world over are primarily interested in production and only secondarily, if at all, interested in conservation objectives. Expressing the goal in terms of improving the "sustainability" of the production system is simply a way of operationalizing the conservation objective in terms of the farmer's own priorities.

Thinking of it this way creates a different kind of "design problem." While it could be argued that conservation practices designed to increase the long term productivity of the production system, even at the expense of a certain decrease in present productivity, are in the farmer's own long term interest, many farmers have notoriously short time horizons when it comes to the planning of conservation measures. This applies to farmers in developed as well as developing countries, although in the latter case, where vast numbers of farmers operate close to the margin of subsistence despite decades of development, the tendency to forego long term benefits in favour of immediate production is more understandable.

In either case incentives are normally needed to facilitate the adoption of conservation farming practices. In developed countries the incentives often take the form of government subsidies. In less developed countries, where funds for massive subsidy programs may be lacking, a more appropriate design strategy for agroforestry might be to try to build the necessary incentives directly into the technology itself in the form of production benefits, above and beyond the conservation function, which come as "by-products" of the conservation practice. Again, there is enormous scope in agroforestry for combining long term sustainability benefits with short and medium term production benefits in cleverly designed multipurpose systems (e.g. fuelwood or fodder hedgerows planted on the contour and managed for erosion control).

1.3 Adoptability Criterion

The inclusion of the adoptability criterion, on an equal footing with the productivity and sustainability criteria, is an expression of the practical intent of agroforestry. No matter how productive, sustainable or indeed "elegant" it might be, an agroforestry design that is not adopted by its intended users will have little impact on the land use scene. With reference to the "cultural appropriateness" criterion, the adoptability criterion is simply a practical way of operationalizing all of those social, cultural and economic considerations which affect the acceptability of an agroforestry innovation to the intended users. It implies that the ultimate and, indeed, most relevant assessment of a new technology is that which will be made by the intended users themselves through their decision to adopt or not to adopt the technology.

The tendency, all too often, has been to design technological innovations without explicit reference to this criterion, and then to blame their non-adoption on some vague notion of "social resistance" to change or,

equally unfairly, on the extension service for failing to "sell it to the farmer." A more effective strategy might be to think of it as, in the first instance, a *design problem* and to deliberately try to build the attributes of adoptability into the new technology from the beginning. This is not to say that extension problems, or even cultural resistance to change, do not exist, but rather that the extension/adoption process, with all its difficulties, will only have a fair chance of succeeding if it starts out with a genuinely adoptable technology. One of the best ways to simplify the extension problem, and also to insure that the relevant "adoptability attributes" are identified and incorporated into the design, is to involve the intended users directly in the technology generation process through participation in the design and on-farm trial of agroforestry innovations. Not only would this give the extension process a head start, but it would also go a long way toward insuring the adoptability of the eventual technology product (Raintree, 1983b).

2. INFORMATION REQUIREMENTS FOR GOOD AGROFORESTRY DESIGN

There is no substitute for good design. ICRAF's D&D methodology is essentially a procedure for gathering and processing information relevant to the development of appropriate agroforestry designs for a given land use situation. What kind of information, then, is needed for agroforestry design? In answering this question it is possible to identify a number of general and specific requirements.

2.1 General Requirements

In general, the information input to the design process should be adequate to the development of a *complete set of specifications* for the design. An engineer, in setting out to design a bridge, a dam or a new automobile, would not proceed very far into the design activity until he had what he considered to be a complete set of design specifications to work from. The same applies, no less, to agroforestry design.

This implies two general kinds of information: information about the land use *system* for which the agroforestry technology is being designed, and information about the availability and appropriateness of *component technology* for inclusion in the design. Both types of information are necessary to complete the specifications for any particular technology. From an analysis of the existing land use system comes the information needed to define the *purpose* or *functional role* of the technology within the system, along with information on other factors which should be borne in mind when designing technology for the system (e.g. additional design constraints, positive attributes to be incorporated into the design, etc.). From a survey of existing knowledge on possible component technologies and management practices comes the information needed to give concrete substance to the design, i.e. to specify the *"nuts-and-bolts"* of the technology. Systems information, essentially, specifies the *what* of the technology, component technology information the *how*.

These two types of information are entirely complementary. If either is incomplete in some critical respect, the likelihood is increased that the design will fail. In practice, reliable information on the performance and systems impact of component agroforestry technologies may often be lacking, due to the dearth of research in the field. Difficulties of this

type signal the need for research in order to obtain the information necessary to complete the design with confidence. On the other hand, the very process of attempting to arrive at a detailed design is part of the "discovery procedure" for identifying practical research priorities.

One general aspect of the required systems information, is the need to consider the relevant *socioeconomic* as well as the biophysical dimensions of the system under consideration. By definition, the concept of a land use or land management system implies the existance of a "user" or "manager" who exerts a controlling influence on the system. Typically, in the design of new land management technology, the environmental parameters of the target system are well understood and adequately considered, the biophysical aspects of the existing land management technology somewhat less so, and the socioeconomic and cultural dimensions of the system least adequately handled. In view of the cental organizing role of *human purpose* in such systems, the socioeconomic aspects of system structure and function are ignored at great peril to the potential success of any agroforestry design.

The D&D methodology does not, in the first instance, suggest an elaborate and separate treatment of "social factors" in agroforestry design, but rather seeks to deal with these aspects as an integral dimension of system organization, along with the relevant biophysical factors. This "discipline neutral" systems perspective has, in general, enjoyed a high degree of acceptance among members of multidiciplinary teams using the D&D methodology as a basis for the planning of applied research and development projects in agroforestry (Raintree, 1984).

A number of other aspects under the heading of general information requirements vis-a-vis the "systems" side of agroforestry design could be listed briefly as follows:

1. What is on the ground already? (minimal descriptive understanding of the existing land use system, including existing agroforestry practices)
2. What are the agroforestry-related needs and potentials of the existing system? (diagnosis of problems and potentials)
3. Systems specifications for functional improvements in system performance (positive specifications of functional roles for agroforestry, desirable attributes and suitable locations for AF technologies, etc., as well as negative design specifications or constraints on new technology based on a realistic assessment of system limitations)
4. Information relevant to the formulation of an appropriate development strategy for the system (with influence on the selection and phasing of alternative technologies).

Since most of these requirements are self-explanatory, brief comments will suffice. The existing system of land use is the "base on which improvements can be most easily grafted" (Collinson, 1981). Failure to adequately understand the organization and function of the existing system can lead to embarrassing mistakes in design, particularly if there are unperceived agroforestry practices already in place. In short, it is never a good idea to design in ignorance of what is already on the ground

in the existing system and it is particularly important to understand existing land management practices in relation to the production objectives of the local people.

Such descriptive information provides a basis for diagnosing the system to identify problems which the land managers have in meeting their objectives, which in turn defines which aspects of the system need to be examined in greater detail in order to ascertain the underlying causes of poor performance. "Trouble-shooting" the system in this way to identify its inherent constaints and unrealized potentials for meeting the producer's objectives provides a basis for identifying the "leverage points" in the system where appropriate agroforestry (or non-agroforestry) interventions have a potential to improve system performance. Once these "functional intervention points" are identified, it then becomes possible to develop functional design specifications for the relevant technologies.

The fourth of the above points raises two interelated design questions: "How much change is the system able to absorb?" and "How to deal with the time dimension in agroforestry design?" The answer to the first question determines which of two fundamentally different development strategies it is appropriate to apply to a given system: an "improving approach" or a "transforming approach" (Torres, 1980). Whereas the "improving" approach takes the existing technological base as the starting point for design activities and seeks to introduce key technological innovations at critical points in the system, the "transforming" approach more-or-less assumes a "blank slate" and proceeds to develop a completely original design for the entire system. While it is impossible to say which of the two approaches is best for a particular system without first examining the system to determine its inherent potentials and limitations, in working with small-scale, traditional farmers one is usually on safer ground vis-a-vis the "adoptability" criterion when following an "improving" approach. On the other hand, if the target system has demonstrated an openness to radical change in the past *or* if the existing system is in serious trouble and incapable of being significantly improved by limited technological interventions, then a more radical "transforming" approach may be indicated.

A related set of questions concerns the advisability of a "high technology" vs. a "low technology" approach. The D&D methodology itself has no inherent biases toward either. The point is always to use "appropriate technology." Whether this turns out to be a high or low technology or, as will often be the case, an appropriate mixture of the two, depends on the system in question. The decision must be made, but it should not be made out of ignorance about the realistic capacities of the system (including its human elements) to accept change. In practice some appropriate combination of "high" and "low" technology, system "improving" and system "transforming" approaches may be indicated, each addressing different parts of the system. In other words, a mixed or "supplemental" approach (Rocheleau, personal communication) to the development of the system may be indicated, improving the productivity of existing enterprises where profitable and adding new enterprises where relevant and possible. Even when a predominently "transforming" approach is deemed appropriate, however, it will always be conducive to a higher rate of adoption to retain some familiar elements of the existing land use system, particularly in regard to deeply entrenched production objectives or consumption preferences. Cash crop enterprises are generally more open to radical change than those geared to the production of traditional staple foods.

It is important to give careful consideration to these matters in arriving at a *realistic development strategy* for the system in question. An ambitious strategy which fails is, in the final analysis, a failure pure and simple; whereas, a less ambitious strategy which succeeds will have real gains to show at the end of the day. Public sector institutions have in the past demonstrated a remarkable capacity for self-delusion as regards their ability to legislate land use change. A more enlightened "marketing" approach, which gives people what they need, want and are willing to accept, might in the end prove to be a more effective strategy for rural development in "conservative" areas.

With regard to the time dimension in agroforestry design, it is well for agroforestry designers to take the time to plan carefully for the future, in the realization that tree-based production systems, once established, are not easily changed. The need for more careful planning of experimental agroforestry systems is in direct contrast to research on annual crop, or even livestock, systems which, because of the shorter time required to complete an experiment, are much more amenable to a "trial-and-error" approach.

In assessing the "sustainability" of proposed agroforestry designs it is, therefore, advisable to look beyond present conditions to take account of trends which may affect the future appropriateness of the proposed technologies. In many cases it may be important to estimate the future demand on the system under different population growth scenerios. If a "high growth" future seems likely to lead to far higher levels of production demand than at present, the design should include scope for intensification of land use in order to support higher future populations on the land. If, for one reason or another, it is not presently possible to get people to adopt land use practices appropriate to the high density situations of the future (Raintree, 1983a), it may still be possible to conceive of a *phased approach* to the development of the system, incorporating a *succession* of increasingly intensive agroforestry technologies. This will only be possible if present designs leave scope on the landscape for future changes. A succession of carefully planned incremental changes over time may be a way of gradually achieving total transformation of a system which could not otherwise accommodate an abrupt change of the same magnitude (Raintree, 1983b).

In any event, a few extra days or weeks of additional effort at the beginning of the research and development process to assess future requirements and develop truly well conceived agroforestry designs, may prevent years if not generations of misery for future populations.

2.2 Specific Requirements

So much for the general information requirements. A more precise answer to the question of what information is needed for good agroforestry design may be obtained by considering what information is required to answer the following set of design questions. The design of agroforestry systems and technologies normally involves either the integration of trees into farming systems or the integration of agricultural crops and/or livestock into forest management systems. For simplicity sake the following questions are expressed in terms of agroforestry systems designed around the role of the introduced tree component, although they apply equally well if other types of components are substituted in the place of trees. The point in all cases is to complement the existing production system through the addition of the "missing" components or management practices.

1. *What functions* should the tree or agroforestry combination perform within the land management system?

2. At *what locations* within the landscape should these functions be performed?

3. *What components* or component combinations are best used to perform these functions?

4. *How many* of each component is required to meet the needs of the system?

5. *What exact arrangement* of components is envisaged (details of spatial and temporal associations at a given location)?

6. *What management practices* are envisaged in order to achieve the desired performance characteristics?

These, really, are the questions that need to be answered to arrive at a specific design for an agroforestry system or component technology. More detailed design considerations may crop up at more advanced stages of research (Huxley, 1983, Huxley, in preparation; Hoekstra, 1983; Rocheleau & van den Hoek, 1984), but the above set of questions constitute a kind of minimal "design algorithm" for the initial stages of agroforestry research. To begin with, the questions may be dealt with in the sequence shown above, but because the answer to any one question may affect the answers to other questions, it will usually be necessary to repeat the sequence a few times, adjusting the various elements of the design to each other until a coherent design output results.

Possibly, the only invariant in the use of this design algorithm is to first give at least provisional answers to questions 1 and 2 before proceeding to the others. The reason for this is that these two questions fix the main systems parameters for the design and, after all, the design is presumably being developed to meet the development needs and potentials of some *particular* land use system or system type. Although systems considerations enter into each of the remaining steps, the role of "component technology" information (derived not so much from analysis of the system as from a survey of the general state of knowledge) becomes more prominent in the latter questions. The first two questions specify *what* and *where* the needed functions are to be performed, the latter answer the question of *how* it is to be done. For further discussion of this design algorithm and for a range of optional, potentially useful analytical tools and design materials, the reader is referred to ICRAF (1983b).

3. GUIDELINES FOR AGROFORESTRY DIAGNOSIS AND DESIGN: THE PROJECT PLANNING STAGE

If the foregoing analysis of the information requirements for agroforestry design is accepted, then the question arises: "How does one go about collecting and processing the necessary information in a timely and efficient manner?" This is the basic question which the developers of ICRAF's D&D methodology have tried to answer. Before outlining the basic procedures, it should be emphasized that the D&D methodology, in its present preliminary state of completion, is the product of vigorous collaboration and field testing of the evolving procedures with national scientists and development workers in a wide range of sites around the world. Far from being simply a "desk exercise" in methodology development, it is this "hands-on" involvement of representatives of the major users of the methodology which gives ICRAF the confidence to conclude that it is indeed an efficient and workable approach. Although we do not claim that it is the *only* workable methodology, based on feedback from users in the field we do feel justified in saying that use of the basic D&D methodology does indeed lead to the goal of good agroforestry design in a timely and cost-effective manner. We feel confident, therefore, in recommending its use as a "short-cut" alternative to more time and resource consuming approaches.

In documenting the D&D methodology so that it can be widely disseminated and independently applied by interested users, we have tried to take account of the fact that users differ in regard to the level of methodological detailed required to apply the methodology. Some users require only minimal guidelines and prefer to work out the details themselves. Others seem to appreciate a more complete set of procedural suggestions. In all cases, users seem to desire a "summary overview" of the methodology before getting into the details of the suggested implementing procedures. Accordingly, the current documentation presents the methodology at 3 levels of detail. Level 1 (Raintree, 1984) and Level 2 (ICRAF, 1983a) are summarised below for general introductory purposes. Level 3, the more detailed guidelines and optional resource materials, is presented in *Resources for Agroforestry Diagnosis and Design* (ICRAF, 1983b), available in draft form from ICRAF on request. Whichever level of detail is employed, users of the D&D methodology will still always be required to exercise flexibility and judgement in adapting the suggested procedures to the specific needs and resources of their particular application.

3.1 Level 1 'Minimal' Guidelines

At this "minimal" level of detail, there is little to say beyond emphasizing the basic principle that *diagnosis should precede design.* In applying this commonsense principle, which is fundamental to all problem-solving approaches, there are many possible ways to proceed. As long as one first takes the time to examine and diagnose the actual needs and potentials of the target land use system *before* starting to design "improvements" for it, the basic requirements of the D&D approach will have been satisfied. Still, it may be helpful to pass on some minimal suggestions, based on ICRAF's experience with the approach, on how one might organize one's thinking to deal with this task efficiently. Table 1 presents a four-stage breakdown of the D&D process which suggests certain basic questions, key factors and modes of inquiry which the ICRAF team has found useful in approaching the project planning task.

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 problem-generating 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

3.2 Level 2 'Semi-detailed' Guidelines

To give greater detail to the suggested procedures, ICRAF (1983a) has further subdivided the basic four-stage process into a set of 12 steps, 3 for each of the above listed stages. These are presented in outline form below, along with the suggested *output* of each step, *sources of information*, the *main factors to consider*, and an optional list of *useful tools* and resource materials which the user might wish to consult at the various steps (the latter are found in ICRAF, 1983b).

PREDIAGNOSTIC STAGE

Step 1. Environmental Description of the Study Area

Output: A descriptive understanding of the diagnostically relevant characteristics and organization of the selected environment

Sources of information: Mainly existing documentation on the study area, supplemented by limited field survey and interviews with qualified informants

Factors to Consider:
- Biophysical parameters
- Socioeconomic parameters
- Structure and function of the human ecosystem of the area

Useful Tools: Environmental Data Base for Agroforestry (Young, 1983); worksheets for relevant biophysical and socioeconomic data and guidelines for description of the human ecosystem (ICRAF, 1983b)

Step 2. Differentiation of Land Use Systems Within the Study Area

Output: Identification of distinctive land use systems requiring separate D&D treatment; selection of priority system(s) for D&D attention

Sources of Information: as above

Factors to Consider:
- Land units (possessing a similar set of biophysical characteristics)
- Management units (with similar production objectives and resources)
- Land use systems (distinctive combinations of land units and management units)
- Criteria for system selection

Useful Tools: Worksheet for differentiation of land use systems and suggested criteria for selection of systems for D&D attention (ICRAF, 1983b)

Step 3. Preliminary Description of the Selected Land Use System(s)

Output: A preliminary characterization of the objectives and the internal organization of the land use system(s) (for reference use by the D&D team at the Diagnostic Stage)

Sources of Information: As above

Factors to Consider:
- Structure and function of supply subsystems at the management unit level
- Additional descriptive information on production activities (agricultural, forestry, livestock and agroforestry practices; water management)

Useful Tools: Various worksheets, guidelines and appendices on the use of ICRAF's 'basic needs' approach for description and diagnosis of household production systems, with supplementary guidelines for forestry and watershed applications, input-output analysis, matrix tools, modeling techniqeus and other useful tools (ICRAF, 1983b).

DIAGNOSTIC STAGE

Step 4. Diagnostic Survey

Output: Information necessary for a diagnosis of land use problems and potentials (both agroforestry and non-agroforestry) at the management unit (farm) and ecosystem/community level

Sources of Information: Area reconnaissance and diagnostic surveys of representative management units (the latter is based on a 'trouble-shooting' procedure for identification of the causes of problems within the supply subsystems)

Factors to Consider:
- Problems and potentials at the ecosystem level
- Problems and potentials at the management unit level (supply problems, causal factors involved in the creation of supply problems, present constraints and problem-causing syndromes, future sustainability problems, undeveloped potentials)
- Farmers' strategies for coping with identified problems

Useful Tools: Suggested survey techniques and interview guidelines, sample diagnostic survey instrument (ICRAF; 1983b)

Step 5. Diagnostic Analysis

Output: A diagnosis of major land use problems and potentials

Sources of Information: Findings of the diagnostic survey; information provided by all preceeding steps

Factors to Consider:
- Present problems and potentials at the ecosystem level
- Present problems and potentials at the management unit level
- Sustainability problems

Useful Tools: Analytical worksheets, detailed analytical guidelines and queries, causal and functional diagramming tools (ICRAF, 1983b)

Step 6. Derivation of Specifications for Appropriate Technology

Output: A reasonably complete set of design specifications for problem-solving and potential-realizing technologies appropriate to the needs and potentials of the diagnosed land use system

Sources of Information: All preceeding steps

Factors to Consider:
- General development strategy for the system
- Functional potentials for problem-solving interventions
- Potentials for improving resource utilization
- Possible constraints on candidate technologies

Useful Tools: Checklists and guidelines to assist in developing a complete set of specifications for appropriate AF technology (ICRAF, 1983b)

TECHNOLOGY DESIGN STAGE

Step 7. Technology Appraisal

Output: A relevant set of candidate technologies with potential for inclusion in a design for an improved land use system

Sources of Information: Review of the body of technical knowledge

Factors to Consider: Main criteria are given in the design specifications (output of step 6); state of the art with respect to the various candidate technologies (both agroforestry and non-agroforestry)

Useful Tools: Classification and examples of agroforestry systems and practices from around the world, lists and characteristics of multipurpose trees and shrubs, their uses and ecological requirements, selection considerations, design concepts, etc. (ICRAF, 1983b).

Step 8. Technology Design

Output: General design for an improved land use system and specific designs for component technologies

Sources of Information: Creative synthesis of relevant information from all preceeding steps; supplementary design information from additional sources, as needed

Factors to Consider:
- Design specifications (Step 6)
- Candidate technologies (Step 7)
- Function and location of components within the system, component species, number and spatial arrangement of components, and management of component combinations
- Overall productivity, sustainability and adoptability of the design

Useful Tools: General design principles for agroforestry systems, an iterative initial design algorithm, plant arrangement considerations, notes on shelterbelt design, etc. (ICRAF, 1983b) see also design materials listed under step 7

Step 9. Design Evaluation

Output: Ex ante evaluation of the design; improvements in the design suggested by the evaluation process

Sources of Information: Relevant information from all preceeding steps; farmers' preliminary evaluation of the design proposals; the D&D team's own experience and judgement

Factors to Consider:
- Productivity
- Sustainability
- Adoptability

Useful Tools: Design evaluation scoresheet, guidelines for ex ante economic, ecological and social evaluation (ICRAF, 1983b, Hoekstra, 1983; Etherington and Mathews, (1984).

FOLLOWUP PLANNING STAGE

Step 10. Research Needs

Output: Identification of the type of research needed to develop and test the component technologies and overall land use system designs

Sources of Information: Team review and assessment of the following factors

Factors to Consider:

- State of the technology art and the suitability of different classes of technology (notional, preliminary, validated) for different types of research (on-station, on-farm)
- Whether the envisaged followup to the D&D exercise is essentially research-oriented or development/dissemination-oriented
- Farmers' and research/extension officers' attitudes toward on-farm experimentation
- Riskiness of the proposed technologies
- Need for candidate technologies to be exposed to a wider or more realistic set of environmental and farming system conditions (than would be available on research station)

Useful Tools: Suggested criteria for initial state of the art evaluation, notes on experimental approaches in agroforestry (ICRAF, 1983b; Huxley, in preparation).

Step 11. Topics Requiring Further D&D Attention

Output: Identification of topics needing further diagnostic survey or design thinking, particularly in rapid appraisal applications where time constraints may have left gaps in the D&D outcome; suggested procedures for collection and processing of additional information required to deepen the diagnosis and/or refine the design

Sources of Information: Team review and assessment of D&D results

Factors to Consider:

- Requirements for additional diagnostic information and analysis
- Requirements for more complete information on candidate technologies needed to refine the initial design
- Requirements for in-depth economic, ecological and social evaluation of the proposed design

Useful Tools: N/A

Step 12. Project Implementation Plan

Output: Guidelines for implementation of followup project activities, at different levels of detail appropriate to different stages in the project cycle: a) a general outline of major project activities (research and/or dissemination), suggested by the D&D team; b) a more detailed project proposal suitable for submission to potential donors, prepared by a small pre-project working group; c) detailed project implementation plan, prepared by the project implementation team; d) revised mid-project working plans prepared by the implementation team from time to time, reflecting modifications in technology design suggested by experience in the field or from on-station research

Sources of Information: Results of previous D&D steps (a); pre-project followup activities (b&c); the iterative D&D process during the course of project implementation (d)

Factors to Consider:

- Topics needing further D&D attention (output of Step 11)
- Research needs (output of Step 10)
- Feedback from on-site trials (including farmers' evaluation and suggestions) and on-station experimental work in the course of the project (suggesting modifications and refinements in the technologies and the plan of work).

Useful Tools: Forthcoming; see also ICRAF (1983b)

4. GUIDELINES FOR PROJECT IMPLEMENTATION: THE CONTINUING D&D PROCESS

The usefulness of the basic problem-solving approach embodied in the D&D methodology does not end with the completion of the project planning process outlined above. As a scientist commented at a recent training course at ICRAF, "D&D Is Forever!" Although the comment was facetious (perish the thought that any methodological process should continue forever!), commonsense argues for a continuing role for the basic D&D process throughout the implementation phase of a technology-generating agroforestry project. Whereas the initial "rapid appraisal" application of the D&D logic will normally lead to the design of a "prototype" agroforestry technology which is *generally appropriate* to the target land use system, in most cases further research and development will be needed to develop and test this technology and to make it *specifically appropriate* to the system in question. Through repeated application of this same basic logic, to *re-diagnose* the system once the new technology is in place (to assess its impact on diagnosed problems and potentials) and *re-design* the prototype technology to incorporate modifications and design refinements suggested by trial application within the target system, the D&D process uses *feedback* to "zero-in" on an optimal design.

One of the most important sources of design-optimizing feedback is the participation of local farmers in the conduct and evaluation of *on-farm trials* of the prototype technology. The adoption decision itself is the ultimate form of feedback from the intended users of the new technology, but researchers should not underestimate the potential contribution of farmer-originated innovations in modifying the initial prototype to *create* an adoptable technology. To achieve the potential for really fine tuned feedback of this type, project managers must be willing to learn from farmers and encourage a vigorous *two-way* flow of information. The other important source of corrective feedback, of course, is the complementary set of detailed experimental investigations which are conducted under controlled conditions on the *research station*.

The process of "on-farm" trial and refinement of the prototype technology, complemented by more rigorously controlled "on-station" research into fundamental interactions between components and other research questions (e.g. screening of a wider range of possible components, etc), ought in principle to be conducted in a highly coordinated fashion. The iterative D&D process can provide the basis for this coordination between the two research components of an integrated research and development project, as shown in Figure 1. As such, the continuing D&D process is part of the "internal guidance system" of the project, providing a means of integrating the findings of these complementary types of research and suggesting "midcourse corrections" in project planning based upon the combined feedback.

As suggested in Figure 1, the iterative process continues until project managers feel that the refined technological product is ready for dissemination and testing in a wider range of sites throughout the "recommendation domain" of the technology. The D&D process then provides a basis for "adaptive research" to modify the technology according to the specific needs and circumstances of different sites within the range of potential application. Thus, although the process of D&D is "system specific" in its focus, systems and system types can be broadly defined and the ultimate products of the D&D process need not, and should not, be "site specific" in their application. It is up to the users of the D&D methodology to choose field sites which are representative of the major development problems of the country.

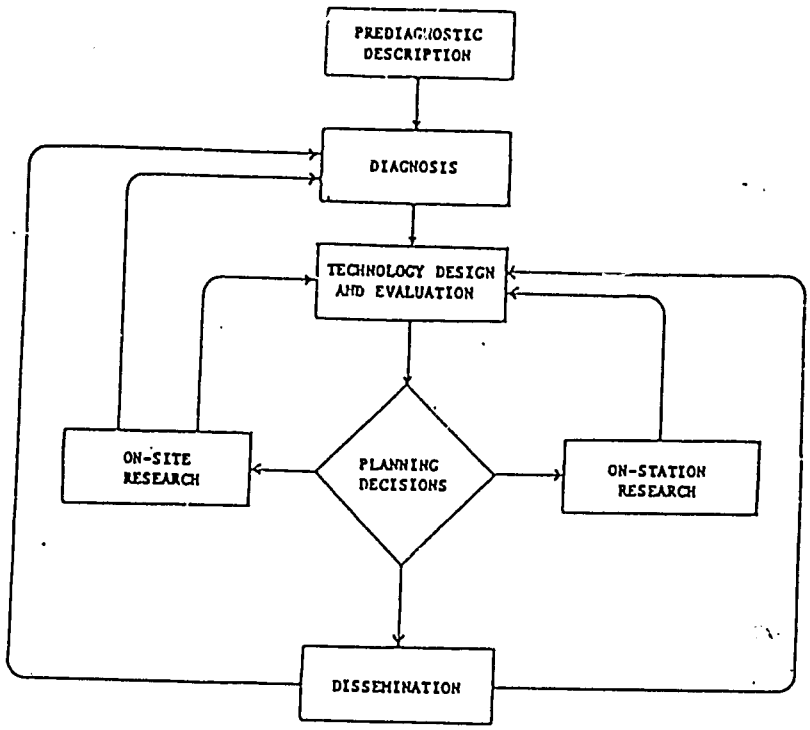

Figure 1. Components of project design incorporating the D&D process as part of the project's internal guidance system. Note feedback linkages.

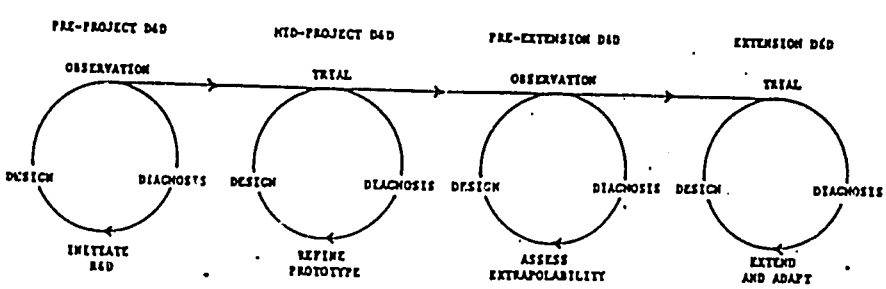

Figure 2. Repetition of the basic D&D process in different forms for different purposes at successive stages in the life of a technology generation and dissemination project.

Figure 2 summarizes the different uses to which the basic D&D process can be put at different stages in the life cycle of a research for development project. The schematic representations shown in Figures 1 and 2 together constitute a kind of "minimal" set of guidelines for the use of D&D at latter stages of the project cycle. Unfortunately, because of the longer time required to gain experience with the latter stages, more detailed guidelines comparable to the level 2 (ICRAF, 1983a) and level 3 guidelines (ICRAF, 1983b) currently available for the project planning stage, are not yet available for the project "implementation" and "technology dissemination" stages. In response to considerable demand from rural development projects, however, preliminary guidelines are now being prepared at ICRAF which will be published in draft form and, in due course, subjected to the same kind of collaborative testing and refinement which has characterized the development of the D&D guidelines for research project planning.

5. CONCLUSION

As the saying goes, "there are many ways to skin a cat." The Diagnostic and Design methodology is one approach to the design of agroforestry systems and technologies which has been specifically developed to meet the urgent requirement for a coherent approach to rural development. Like any "tool," the D&D methodology relies heavily on the skill, resourcefulness and intentions of its users.

In itself, the methodology has no inherent bias toward either a "high technology" or a "low technology" approach to agroforestry, but rather is intended to assist its users to arrive at *appropriate agroforestry technologies for a given set of design conditions*. Although the D&D methodology is not inherently limited to solving the development problems of "resource poor farmers" (Chambers and Ghildyal, 1984), it is certainly *hoped* that research and development planners will make use of the specific in-built capabilities of the methodology (in its more detailed forms), to address the urgent needs of this group and that they will give priority to the developmemt of agroforestry's special potential in this regard (Lundgren and Raintree, 1983; Raintree, 1983c; Bentley, Chambers and Ghildyal, 1984; Chambers, 1984).

At the same time, ICRAF recognizes that a balanced approach to national development may also seek to raise the general welfare through commercial development of highly sophisticated agroforestry-based systems of industrial production, and it is hoped that the D&D methodology may also contribute in this regard (Lundgren and Raintree, 1983). Although the events of recent decades have made it difficult to countenance uncritical acceptance of the "trickle down" theory of development, a balanced view requires that due acknowledgement be given to positive elements of the classical modernization process.

In order to facilitate the successful harnessing of national technological research capabilities to the real needs and potentials of rural development, it is necessary to give careful consideration to the social dimensions of agroforestry design. The D&D methodology seeks to accomplish this objective not, in the first instance, by turning the treatment of social concerns into a separate technical exercise conducted exclusively by social science experts, but by a more integrated approach based on a discipline-neutral systems perspective in which the socioeconomic and biophysical aspects of agroforestry design are seen as integral dimensions

of the land use systems and technologies to be developed. It is hoped that ICRAF's rather positive experience with this systems approach to date can be replicated by users, and that the continued development and refinement of the D&D methodology may be assured through the continued and active participation of its users.

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