Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research

Volume I: Diagnosing Agricultural Research System Constraints

Proceedings of the ISNAR/Rutgers Agricultural Technology Management Workshop, 6-8 July 1988, Rutgers University, New Jersey, USA

International Service for National Agricultural Research

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands, on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing, and operations.

Of the thirteen centers in the CGIAR network, ISNAR is the only one that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, thus complementing the activities of other assistance agencies.

ISNAR has active advisory service, research, and training programs.

ISNAR is supported by a number of the members of CGIAR, an informal group of approximately 43 donors, including countries, development banks, international organizations, and foundations.

Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research

Volume I: Diagnosing Agricultural Research System Constraints

Proceedings of the ISNAR/Rutgers Agricultural Technology Management Workshop, 6-8 July 1988, at Rutgers University, New Jersey, USA

Edited by
Ruben G. Echeverría
1990

isnar

International Service for National Agricultural Research

EVALUATING INSTITUTIONAL CAPACITY FOR AGROFORESTRY RESEARCH

Sara J. Scherr

Abstract

Agroforestry can be defined as the intentional growing of multipurpose trees and shrubs in combination with crops, livestock, or other land uses for specific products (e.g., fuelwood, fodder) or services (e.g., organic soil mulch, shade). As a new discipline, agroforestry research faces serious institutional constraints: assigning responsibility for setting research priorities, organizing multidisciplinary research teams within and across discipline-specific institutional barriers, assigning responsibility for engineering integrated prototype systems from component research, and establishing exploratory on-farm research within station-oriented research programs. This paper describes the methods and organizational framework being used in the Agroforestry Research Network for Africa (AFRENA) by the International Council for Research in Agroforestry (ICRAF) to identify and overcome these constraints. Through AFRENA networks, ICRAF is trying to promote and support multidisciplinary, multi-institutional, client-targeted agroforestry research implemented in collaboration with national research institutes. The paper has three parts. The first reviews the institutional requirements for effective, technology-oriented agroforestry research. The second shows how ICRAF's approach of "Diagnosis and Design" is being extended to evaluate institutional resources and constraints to agroforestry. The third part discusses some of the institutional mechanisms that are currently being tested to overcome identified institutional constraints in different AFRENA ecozonal and national programs.

Overview: The State of Agroforestry Research

Over the past decade, the level of national and international resources made available for agroforestry[1] research has risen dramatically and promises to increase steadily in the foreseeable future. This expansion, however, has been fraught with institutional problems, and subject to intense debate within the agroforestry research and development communities. The fundamental issue in this debate is the appropriate structure of research to generate agroforestry technologies that can be adopted by farmers through the burgeoning agroforestry extension movement.

The situation in the past decade has been quite polarized. On the one hand, increasing numbers of researchers in research institutions have become interested in agroforestry and have set up small research projects focused rather narrowly on specific scientific problems, often only obliquely related to practical problems and potentials in the field. On the other hand, there have been myriad agroforestry extension projects which — lacking any significant support from formal research institutions — initiated their own field research to generate and test agroforestry interventions, with results largely inaccessible to scientists outside the project

By contrast, a strong national agroforestry research system would be effectively and efficiently able to select research priorities; plan and coordinate research projects; implement on-station and on-farm research activities; design, test, and evaluate technologies with a network of farmers; and provide technical input into the policy and investment decisions needed to encourage farmer adoption of new agroforestry technologies. Such an agroforestry research system would be broadly defined to include all institutions involved in planning, implementing, or using the results of agroforestry research. But this ideal faces major institutional constraints. National leaders in agroforestry research and development need to evaluate the research system systematically. This must be done to identify ways of strengthening its capacity to address the special needs of agroforestry research, both as an integrated system and in individual institutions.

The purpose of this paper is to identify the special institutional factors that need to be present for effective agroforestry research, to provide a checklist

[1] *Agroforestry* is a collective name for all land-use systems and practices in which woody perennials are deliberately grown on the same land-management unit as crops and/or animals (either in a spatial arrangement or a time sequence). To qualify as agroforestry, a given land-use system or practice must permit significant economic and ecological interactions between woody and nonwoody components (Lundgren 1987: 48). By this definition, agroforestry includes a wide range of practices, such as alley-cropping, mixed intercropping of trees in cropland or pasture, rotational fallows using trees or shrubs, multistrata homegardens, border plantings of trees or shrubs adjacent to cropland, or understory crop production in forests or woodlots.

of factors that can be explored in institutional assessment, and to review the common strengths and weaknesses of different types of institutions for agroforestry research. National agroforestry planners can use this rapid appraisal evaluation approach with key participants in the agroforestry research system as a tool in developing a program for national institutionalization of technology-generating agroforestry research.

Five Institutional Requirements for Effective Agroforestry Research

A review of recent experience suggests that a number of institutional factors have led to major failures or constraints in agroforestry research:[2]

- interinstitutional conflict or lack of coordination in allocating responsibility and resources for agroforestry research;
- lack of a development perspective in setting research goals and in the reward system for scientists;
- inadequate breadth of scientific perspective for evaluating and modifying integrated, multicomponent, land-use systems;
- research divorced from the realities, insights, priorities, and context of the eventual users of agroforestry, i.e., farmers and other land users;
- a conservative institutional environment that discourages the exploration and utilization of innovative approaches to the new types of research problems posed by agroforestry.

The checklist suggested here thus approaches institutional evaluation in terms of these factors: political coordination of the research agenda, a development focus in research, multidisciplinary coordination, an on-farm focus for research, and an environment conducive to research innovation.

This approach was developed in connection with research planning exercises for the Agroforestry Research Networks for Africa (AFRENA) in nine African countries: Burundi, Cameroon, Kenya, Malawi, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe. A variety of methods, approaches, and sources were explored. The suggestions presented in this paper are based

[2] The conclusions of this paper are drawn from a review of institutional experiences with agroforestry research in a wide range of countries. References to this material include: Beer, Borel and Bonneman (1989), Depommier (1988), Djimde (1988), Djimde and Hoekstra (1988), Kwesiga and Kamau (1989), Minae and Akyeampong (1988), Minae (1988), Mueller and Scherr (in press), Ngugi and Buck (1989), Rocheleau (1987), and Scherr (1987c, 1986a, 1986b, 1986c).

on this experience, although the specific, integrated, committee-based approach proposed was not tested (for agroforestry).

The proposed approach is one of rapid appraisal of institutions, implemented by an interinstitutional (or in the case of a single institution, interdepartmental) committee. This group evaluates the five key factors, as suggested below, using interviews with institutional managers and researchers and interviews with key public policymakers and potential/actual users of research results, supplemented by institutional documents and institutional reviews by ISNAR and other external agencies. A system of ranking is used to indicate whether a factor is strong (or well-institutionalized), moderately well-institutionalized, or weak and problematic. This approach encourages direct and joint participation of researchers and institutional managers in information collection and evaluation, as well as in the formulation of institutional recommendations. Identification of the different institutions involved in agroforestry research is the initial step in analyzing the agroforestry research system and needs to be done both at the national level and for important agroecological zones. This inventory should include the institutions involved in extension because their capacity and structure for dissemination of information and their own research activities should affect the type of agroforestry research done.

It may also be valuable to inventory institutions that influence general land use and rural-development policies in the country or region. A national commitment to agroforestry is commonly reflected in planning documents and may reflect likely decisions in resource allocations to research. Specific past and current decisions to develop tree nurseries, disseminate tree seed to land users, encourage the planting of individual trees through changed land-use regulations, and develop public promotion of agroforestry will influence the patterns of agroforestry research.

Table 1 lists institutions in which agroforestry research, extension, and land-use/rural-development policy may be found. The example of Kenya reflects a particularly complex institutional structure.

Political Coordination of the Research Agenda

Research coordination and priority-setting in agroforestry is crucially important for three main reasons: the plethora of research topics; the frequent need for multi-institutional collaboration, coordination, or approval to address particular research problems; and the need to coordinate investments in infrastructure required for farmer adoption of agroforestry.

Table 1. Inventory of Institutions in Agroforestry Research, Extension, or Development Policy (An example from Kenya, 1987)

Government Ministries

Ministry of Agriculture, Dept. of Soil Conservation (fruit trees)
Ministry of Livestock Development (fodder trees)
Ministry of Environment and Natural Resources, Dept. of Forestry (Rural Afforestation Extension Service)
Ministry of Energy and Regional Development (Kenya Renewable Energy Development Project, Kenya Woodfuel and Agroforestry Project)
Ministry of Science and Technology (Kenya Agricultural Research Institute, Kenya Forestry Research Institute)
Ministry of Planning and Finance
Office of the President (land-use regulations)

Rural-Development Projects

Turkana Rural Development Project
Baringo Rural Development Project

Other Public or Parastatal Research Institutes

Coffee Research Institute
Tea Research Institute
National Tree Seed Centre (part of KEFRI)
National Herbarium

University Research in Agroforestry

University of Nairobi
Moi University
Egerton University
Kenyatta University
Departments of agriculture, range management, forestry, land policy, natural resources, economics; soil science, agricultural engineering, horticulture, plant science

International Nongovernmental Organizations in Agroforestry Extension and Research

CARE International
World Vision
World Neighbors

National Nongovernmental Organizations in Agroforestry

Church of the Province of Kenya, Diocese Maseno and Kisii
Saradidi Project

Donor Institutions Promoting Agroforestry Research and Development

USAID, NORAD, SwissAid, SIDA, CIDA, DANIDA, GTZ

Private-Sector Agroforestry Research and Development Activities

Bamburi
British-American Tobacco, Ltd.

Note: Institutions should be identified as having national and/or regional mandates.

Why Is Research Coordination Essential?

The acceptance of agroforestry as a legitimate research focus, attractive to donors and politicians alike, has led in many countries to a debilitating "turf battle" among different research institutions. Because of the multidisciplinary nature of agroforestry (discussed below), it may be justifiably housed in any disciplinary organization. Where interinstitutional competition is the rule, agroforestry research efforts are commonly fragmented and uncoordinated, with inadequate information exchange among potentially interested institutions.

This is particularly problematic because of the dramatic imbalance between available research resources and the enormous number of potential agroforestry components and technologies. This bewildering variety of potential functions, components, combinations, and arrangements — and the often limited recommendation domains of specific technology designs — makes it essential to develop mechanisms for setting research priorities. ICRAF has developed an approach to setting national or local research priorities ("diagnosis and design"), based on systematic analysis and prioritization of (1) the needs of land users in different land-use systems and (2) the potential of different agroforestry practices for addressing those needs. A methodology for this exercise is described in Raintree (1987) and Scherr (1987a, 1987b, *in press* a).

This planning process requires multidisciplinary input and multi-institutional decision making about responsibility for different aspects of the research process. Take the example of contour hedgerows in cropland, using shrubs for fodder for dairy cows. The decision to carry out major research on this technology may require the agreement of the ministry of livestock development (which may have a potentially competing program to develop Napier grass strips) and the ministry of agriculture (which may be opposed to trees in cropland). Screening of shrub species for fodder may be carried out most efficiently by the university department of range management, using seed collected by the forest research institute. The testing of hedgerow technologies with farmers may be carried out most easily through an existing NGO dairy extension project, whose managers will probably want to be involved in planning the research if they are expected to test it later.

Other key areas for coordination involve planning research collaboration between different institutions, accessing and disseminating research and extension findings from other countries, and providing input into the planning of agroforestry support investments, such as MPT germplasm distribution systems, farmer training, marketing initiatives, etc., all of which are commonly in a very early stage of development.

Assessment of Research Coordination

How can these functions for integrated research planning for agroforestry be applied? How will decisions be made and implemented? One can evaluate four areas of interinstitutional interaction:

1. ***Decision making for coordinated research planning.*** The first focus is on existing processes for decision making and coordinated research planning for agroforestry. This is influenced by whether the agricultural, livestock, and forestry research institutions are functionally integrated and/or have institutionalized joint planning. Countries where all major land-use research programs are housed in the same institution have found it easiest to develop integrated agroforestry programs. The greatest difficulties are in countries where research activities are in separate institutions, under different ministries.

   In recent years national coordinating or steering committees for agroforestry have emerged in many countries. These have varying levels of integration, collaboration, and control over the different types of research and development institutions in their countries. Some key questions to ask in evaluating their effectiveness include the composition of the committees, frequency and attendance at meetings, authorization for making decisions for constituent institutions, and access to important decision makers.

2. ***Status of agroforestry research.*** A second consideration in judging the likely effectiveness of agroforestry planning is the status of agroforestry research. This can be determined from the research, funding, and staffing priorities assigned to agroforestry in different institutions and the history (and thus internal support) of agroforestry research.

3. ***Development perspectives in research planning.*** A third important issue is the integration of development and extension concerns in agricultural research planning. Aspects to evaluate include the quality and frequency of their interaction in planning with the research institutions, the extent to which they are consultative or joint decision makers, and established mechanisms for sharing information between research and extension institutions.

4. ***Experience in multi-institutional project implementation.*** There can be many logistic difficulties in managing multi-institutional research projects. When these are being proposed, prior experience and protocol should be evaluated in terms of effectiveness for decision making, budgetary control, assignment of credit for project results, and control over data release.

Technology-Development Focus

One of the most difficult issues in research related to land use in general involves the competing claims of either expanding the frontiers of scientific knowledge in the long term or generating practical technologies for the current generation of farmers. The problem may be simplified as one of the *audience* for research results. *Scientific* research has as its major audience other scientists; *technology-generating* research has as its major audience farmers or other land users, directly or indirectly through extensionists.

Why Is a Technology-Development Focus Essential?

In agroforestry, scientific research cannot be relied upon to provide immediate spinoffs in terms of technology generation. In large part, this is due to the complexity of agroforestry systems. Intensive studies of components (e.g., studies of MPT phenology, water-utilization, rhizobium interactions), while valuable in themselves, rarely lead directly to farmer recommendations. This is because the actual productivity of the system will depend upon too many other variables: tree spacing and density, configuration of trees and crops, management of trees and crops, etc. Also, the range of selection of appropriate species, as well as spacing and management, will be strongly affected by farmers' existing practices. Technology development thus requires a judicious effort to pull together scientific research results in a combination appropriate to farmers' conditions. This may require much less elegant types of research and experimentation and more on-farm research (with its greater difficulties in statistical rigor), which may make publication in research journals more difficult and/or require more time in field pursuits.

Assessment of Technology-Development Focus

Whether an institution is organized to support technology-generating agroforestry research can be determined by looking at several variables. The first is the actual mandate of the institution and its history of pursuing this mandate. Will the institution receive greater recognition or funding for solving field problems? Will their success be measured by the extent of farmer adoption or by international scientific recognition? (The second variable is the reward structure set up for scientists.) Is promotion based on journal publications and sophisticated research design or on whether farmers adopt the technology? How is promotion and recognition affected by participation in multidisciplinary research? By participation in on-farm research? If institutions seriously want to pursue technology-generating agroforestry research, the system of institutional and personal rewards will commonly need substantial modification.

Multidisciplinary Coordination

For agroforestry, multidisciplinary research is essential. It is important not only for good disciplinary scientists to participate, but also for them to interact closely. Take, for example, the knowledge that may be required to evaluate a multiproduct alley-cropping technology: expertise in seeds for identification and provision of suitable tree seed, expertise in forestry for tree establishment and management, expertise in soils for analysis of soil fertility changes in the alley-cropping system, expertise in animal nutrition to evaluate the fodder component of the system, economic expertise to evaluate the economic viability of the system, and expertise in social systems to evaluate household and community impacts and the constraints of introducing the new technology. At the same time, the design of practical agroforestry technologies requires the active integration of disciplinary information in the context of farmer requirements and preferences: thus the need for collaboration. A large full-time team is not necessary, but regular access to disciplinary expertise is essential.

Why Is Multidisciplinary Research Essential?

Bjorn Lundgren (1987: 43, 49) introduces a recent review of institutional aspects of agroforestry with the following assertion:

> [T]he main constraints to a full realization of the potential of agroforestry [are] of an institutional nature and related to the rigid disciplinary compartmentalization which characterizes institutions working in the field of land use. . . . agroforestry as a science and practice must cut across conventional institutional areas and draw upon several disciplines in the social, production and environmental sectors if its full potential for improving land use is to be realized.

Lundgren attributes this compartmentalization to historical factors separating land-use specialties between forest, range, and agricultural lands in the temperate regions (then borrowed by tropical countries) and an emphasis on land-use specialization in production and development. An additional barrier is created by differences in the training, interests, and perspective of researchers and those of extensionists, even within the same field.

Farming-systems research and training in many countries have encouraged a more integrated approach to identifying problems in farming systems. It has also led the way in exploring mechanisms for combining disciplinary expertise with a systems perspective. But these experiences also illustrate the kinds of institutional problems that can arise in organizing such research. Institutions must manage the psychological conflicts that arise from disciplinary chauvinism, and which are related to the lack of a common vocabulary and conceptual framework as well.

Assessment of Multidisciplinary Resources

Evaluation of institutional capability for multidisciplinary research requires identification and assessment of the availability of multidisciplinary expertise, mechanisms for effective multidisciplinary interaction, existing programs of multidisciplinary research (including agroforestry), and curricula in leading university departments in disciplines related to land use.

In a rapid appraisal exercise, it is difficult to evaluate the effectiveness of multidisciplinary interaction, but a good sense of current problems and potentials can be gained by looking at existing resources and the level of experience in managing multidisciplinary teams.

Potential for multidisciplinary staffing. The first criterion for judging the capacity of national institutions for multidisciplinary research is the actual scientific staffing potential. In many countries, multidisciplinarity is seriously constrained by a shortage of scientists. This may be due either to institutional factors that restrict the hiring or promotion of scientists outside the principal discipline of the institution, competing professional opportunities, or an absolute shortage of trained scientists.

There are, of course, management options to address problems of shortages in particular disciplines. These include programs of advanced training, collaboration between institutions with different staff resources, secondment of scientists for special projects, etc.

Mechanisms for effective multidisciplinary interaction. A second focus of evaluation is on existing mechanisms to promote effective, harmonious multidisciplinary interactions. These include interdisciplinary training of participating researchers, mechanisms for sharing research results among component (disciplinary) and systems researchers, and clear guidelines for research responsibility and authorship of scientific papers.

Existing multidisciplinary research. A third criterion to assess is institutional experience in working through multidisciplinary research teams. The major places where this experience has been acquired are in integrated crop research programs, integrated rural-development programs, and regionally focused research centers. Experience in such projects may have influenced scientists' perceptions as to whether they will gain or lose status for being involved in multidisciplinary projects.

Interdisciplinary training. A fourth criterion to examine is the extent of interdisciplinary and farming systems training/experience of technical and social scientists. Scientists with a strong background in farming systems are generally much more proficient in carrying out land-use system diagnosis

and agroforestry design. This integrated perspective is also encouraged when biophysical scientists receive broad agriculture/land-use training in their undergraduate studies, in contrast to those where disciplinary specialization began very early. A common constraint to successful agroforestry research is that while forestry expertise is often indispensable, forestry education is only beginning to include training in the agricultural sciences, farming systems, rural socioeconomics, and farmer communication.

On-Farm Research Focus and Integration with Extension

A strong on-farm focus is essential in agroforestry research. Indeed, the on-farm research component should be considered the central research activity in technology generation, the one that drives priority-setting in on-station experimentation. This contrasts with conventional agricultural research, where the on-farm component is usually secondary. This reversal comes about because the bulk of current data sources are found in existing agroforestry systems and because technology generation in multivariate agroforestry systems needs to be done in close interaction with the ultimate users. The major institutional issue is that on-farm research in agroforestry requires that researchers have access to communities and networks of farmers on a long-term basis.

Why Is a Focus on On-Farm Research and Extension Essential?

Because of the paucity of scientific data from formal agroforestry research in the past, agroforestry researchers must depend heavily on direct collection of information from existing agroforestry plots and from the experience of agroforestry development projects. Agroforestry scientists are in a position similar to that of crop scientists operating a century ago, who began work in little-explored fields by studying the practices of farmers who were getting better yields than their neighbors, and then taking those ideas to the research station, rather than vice versa. The development of agroforestry technology is still so young that farm-focused research probably offers more scope for impact than highly specialized station-based research.

This dependence on the field is evident in many areas of agroforestry research. Very few tree and shrub species used in agroforestry have been subjected to systematic breeding, so there is extremely high genetic variability in the germplasm. In many cases basic phenological and morphological data are unavailable. This not only makes it more difficult to draw definitive conclusions from on-station species trials, but again makes field operations away from the research station (e.g., seed collection, or observation and measurement of trees growing under different ecological conditions and husbandry) an important part of research (Huxley 1987).

On-farm research in agroforestry will also include studies related to tree-crop management and technology testing. This may involve not only (or even primarily) experiments designed on-farm to test components and systems under on-farm site and management conditions, but also ecological surveys, individual and group farmer discussions, monitoring and evaluation of existing and introduced agroforestry management systems, and superimposed treatments on existing agroforestry plots (Scherr *in press* b).

On-farm research can play a well-recognized role in helping researchers know their client. incorporate farmer conditions into research projects, involve farmers directly in research and access useful indigenous knowledge, and evaluate farmer adoption (Merrill-Sands et al. 1989). The quality of multidisciplinary scientific interaction may improve by focusing the team's work on problem-solving for a particular group of farmers.

Direct collaboration with farmers also helps focus research on issues of technology design and problem solving. The design of any product is easier when the client is clearly identified and can discuss and evaluate design specifications directly (Rocheleau 1987). Interaction with farmers under field conditions is likely to lead to improved selection and implementation of complementary on-station experimental trials. It also exposes researchers to farmer-developed innovations (Atta-Krah and Francis 1987).

On-farm research can also improve research-extension-farmer linkages by offering a site where they can work together regularly. The process of translating research results through extension into sustained farmer adoption is greatly facilitated. This is so both because there has been early testing of technology under active evaluation and input from the eventual users (both extension workers and farmers) and because, through early and sustained interaction, the institutions develop more effective communication. Indeed, in agroforestry the lines between research and extension may be quite blurred. Researchers who work with networks of farmers for technology development will inevitably be drawn into some extension activities. Extensionists have an opportunity to exploit their everyday interaction with farmers (as well as with structured monitoring systems) to test and evaluate agroforestry interventions and their adaptation by farmers (Mueller and Scherr *in press*; Beer et al. 1989; Raintree and Hoskins 1988).

While these are strong reasons for emphasizing on-farm research in agroforestry, many institutional constraints face such a program. Not only are few research-sector scientists trained or experienced in on-farm research and extension, but many have been trained in a paradigm which expressly identifies the farmer, and usually even the extension agent, as playing only a passive role in receiving scientific results from researchers.

There are also logistic and administrative problems involved in multi-institutional on-farm research sites, similar to those for on-farm research on any topic, e.g., responsibility for farmer contact and organization, division of responsibilities for data collection and evaluation and coordination of extension and research inputs (see Merrill-Sands et al. 1989).

Assessment of On-Farm Agroforestry Research Capacity

In evaluating institutional capability for on-farm research, some of the information to be collected and assessed includes on-farm research experiences, institutional arrangements in existing on-farm agroforestry research, and governmental and nongovernmental agroforestry/tree-growing extension projects which could benefit from on-farm research.

Experience and attitudes toward on-farm research. The first criterion evaluated was the experience and training of scientists in on-farm research. It is important to identify the content of the on-farm research activities, for example, as among the following:

- objective to test new technologies under the biophysical conditions of farmers' fields and management practices or to encourage farmer input into the design and evaluation of new technologies;
- evaluation of farmers' existing practices, relative to the testing of new technologies;
- collaboration of social scientists with technical scientists in on-farm trials or in surveys of farming practices and constraints;
- assignment of on-farm research perceived as a promotion or demotion.

Experience with on-farm agroforestry research. A second factor to assess is experience with on-farm agroforestry trials and other types of on-farm research (e.g., surveys of local knowledge and use of trees and shrubs by farmers), also looking at the issues raised in the preceding section. These can be important training grounds for agroforestry researchers and will influence the direction of future research planning.

Involvement of development institutions in research. The third factor to assess is the potential for using development project sites for agroforestry research and technology testing. On-farm research is commonly constrained by the researchers' lack of experience and resources for organizing farmers effectively, developing reliable networks for provision of necessary inputs, negotiating the terms of trials with farmers, monitoring participant farmers frequently, etc. In many cases, it would be more resource-efficient to utilize

existing networks of farmer and extension workers in agricultural or agroforestry development projects, rather than initiating new, independent, researcher-managed networks. Such an approach also facilitates pilot extension testing of new technologies and early input of farmer and extension expertise in technology design. These projects must, however, be given a serious commitment to technology generation over the medium to long term in the research area, and they must be organized to permit systematic monitoring and evaluation of farmer adoption and practices.

Environment for Research Innovation

The need to encourage research innovation is, of course, not peculiar to agroforestry, but it deserves emphasis here because of the newness of scientific agroforestry. The lack of established methods and approaches is an important constraint to effective research. Conventional agricultural and forestry research methods are commonly inappropriate in situations where components are mixed, although they are the most acceptable to conservative research organizations.

Why Focus on Research Innovation?

There is potential for important breakthroughs in agroforestry through support of individual initiative and innovation. The body of scientific information about MPT species (even basic phenology, morphology, or treatments for seed germination), their interaction with nonwoody species or response to different management regimes, is very small. There is no standardized set of methods for assessing agroforestry components or systems. Indeed, agroforestry research only came of age after important methodological advances had been initiated in agricultural research related to intercropping, multiobjective and multiperiod analysis, and resource sustainability. We are still far from understanding how to handle these issues efficiently in most agroforestry systems.

We understand even less about the processes of farmer adoption, adaptation, and intensification of agroforestry systems. This makes it difficult to develop research strategies and priorities, and it again demands researcher innovation in approaching farmers' needs and collaboration.

Assessment of Institutional Environment for Innovation

Institutional characteristics affecting research innovation in agroforestry are little different those that affect other types of research. Innovation tends to be hindered where there is excessive bureaucracy, excessive resource limitations that restrict initiation of new experiments, an entrenched hierarchy, defensiveness about research topics, or rigid adherence to specific

methods and approaches. Individual scientists need to have some scope within the program or project structure to pursue unexpected findings, methods and opportunities.

These factors are difficult to assess in a rapid appraisal exercise, but indicators may be found by reviewing a list of research projects and by exploration of the process by which individual research projects originated.

Assessment of Alternative Institutional Arrangements for Agroforestry Research

An active debate is going on in many countries about where to house agroforestry research institutionally. In this section, we will review the different possible institutional niches for technology-generating agroforestry research, as well as their relative strengths and weaknesses (as commonly constituted) in terms of the five factors discussed above.

Institutional Models for Agroforestry Research

Four major groups of institutions can and do participate in agroforestry research: national research institutions, national extension institutions, independent research institutions, and development projects. In each group, one may find at least three distinct variants that imply different institutional arrangements for agroforestry. In addition, agroforestry researchers may be linked in various ways through formal collaborative networks that are either focused on special topics or are more integrated. Each of these alternatives is described briefly below.

National Research Institutions

Agroforestry research programs in national research institutions come in three forms. Independent or autonomous disciplinary research institutions are the most common institutional framework for formal-sector agroforestry research. Examples are the Kenya Forestry Research Institute and the Kenya Agricultural Research Institute, under the Ministry for Science and Technology. A modification allows for formal arrangements for joint research between scientists in different disciplinary research institutions or departments. A third model is the distinct agroforestry research institution or large-scale program for agroforestry research. Examples of such institutions include the Department of Agroforestry of Burundi's ISABU, the All-India Coordinated Agroforestry Research, and ICRAF itself (for selected research activities).

Table 2. Checklist for Evaluating Institutional Capacity for Agroforestry Research

Interinstitutional Planning and Coordination

Decision-Making for Coordinated Research Planning
- ☐ Integration of agriculture and forestry research institutions
- ☐ Coordinated planning of agricultural and forestry research
- ☐ Integrated research planning for agroforestry

Status of Agroforestry Research
- ☐ Agroforestry as a research priority
- ☐ Extent of past agroforestry research

Development Perspectives in Research Planning
- ☐ Integration of extension, policy, and land-use interests in research planning
- ☐ Mechanisms for linking research and extension

Experience in Multi-Institutional Project-Implementation
- ☐ Management and budgeting
- ☐ Assignment of scientific credit, control, and data release

Development Focus in Research

Institutional Commitment to Development Focus in Research
- ☐ Institutional mandate for development-focused research
- ☐ Sensitivity of funding to development impact

Scientists' Commitment to Development Focus in Research
- ☐ Internal reward structure for scientists for development impact
- ☐ Prior experience of scientists in development programs

Multidisciplinary Research

Potential for Multidisciplinary Staffing
- ☐ Multidisciplinary staffing of research institutions/departments
- ☐ Type and number of biological scientists for agroforestry research
- ☐ Type and number of social scientists for agroforestry research

Mechanisms for Effective Multidisciplinary Interaction
- ☐ Interdisciplinary training for participating researchers
- ☐ System for sharing research results between scientists working on component and systems research
- ☐ Clear guidelines on authorship of scientific papers

Existing Multidisciplinary Research
- ☐ Existing farming-systems research programs
- ☐ Experienced multidisciplinary research teams
- ☐ Existing field sites with integrated multidisciplinary research

Interdisciplinary Training
- ☐ Interdisciplinary or farming systems training in agricultural education
- ☐ Interdisciplinary or farming systems training in forestry education

On-Farm Agroforestry Research

Experience and Attitudes towards On-Farm Research
- ☐ Tradition of on-farm trials/testing by research institutions
- ☐ Tradition of on-farm social science research
- ☐ Existing farming-systems research

Experience with On-Farm Agroforestry Research
- ☐ Experience with on-farm agroforestry experimentation/research
- ☐ Existing information on farmer use and knowledge of trees and shrubs

Extension Involvement in Research
- ☐ Tradition of on-farm trials/testing in extension/development projects
- ☐ Tradition of collaboration between research and development institutions
- ☐ Past collaboration between research institutions and extension institutions in agroforestry/forestry/tree crops

Research Innovation

Effect of bureaucracy and hierarchy on research planning and decision-making

Attitudes toward novel scientific methods and approaches

National Extension Institutions

Research programs in national extension institutions are the second major locus for agroforestry research. Again, there are three different institutional models. The first is the disciplinary extension institution which includes a research department or unit, such as Agritex in Zimbabwe. Agroforestry research tends to be focused on specific tree outputs or services considered a priority in the institution and in priority farming systems. A second model is the agroforestry institution or program that combines research and extension responsibilities. Such an institution will generally view agroforestry as a more integrated land-use approach and will work with a wider range of tree species for a wider range of uses and niches.

A third model is the integrated institution with responsibility for all aspects of rural land-use research and extension, including agriculture, livestock, forestry, and agroforestry. This is conceptually the most satisfying model for integrating agroforestry into national land-use planning and research. Such an institution would work on the basis of integrated land-use/farming systems analysis and the selection of the most promising interventions for each system among the disciplinary alternatives. Rivalries for resources and control, however, have so far prevented this approach from being widely adopted. In practice, even where a single ministry or regional development authority is given jurisdiction over development and research in agriculture, livestock, and forestry, there has been effective functional separation.

Independent Research Institutions

A number of research organizations are relatively independent of the pressures of national research or development policies in the selection and pursuit of research. These include much university-based research, individual scientists supported by independent research grants, and private-sector research institutions.

Much of the basic research in agroforestry found in the tropics has been carried out in universities, and there is a growing body of thesis literature that has been largely untapped by the agroforestry development community. Such research is found in a very wide range of departments, including agronomy, range management, agricultural engineering (for soil conservation), plant science, natural resource management, forestry, agricultural economics, and land-use policy. Projects are mainly small, and experimental work is nearly always carried out on university research stations.

A second model is the "independent" researcher, who may or may not be university-based, but whose funding has been provided on an individual basis, rather than as an institutional project. Some members of the research

community contend that bureaucratic approaches to research planning and implementation are contrary to the flexibility required for scientific innovation and discovery. Thus, many research organizations and donors operate on the basis of research grants or budgets tailored to individual scientists, rather than to "priority" topics per se, on the hypothesis that committed scientists must be allowed to follow their own direction and have the opportunity to work with limited constraints from existing policy, extension preferences, etc. Where research coordination, extension linkages, or multidisciplinary consultation are desirable, it is assumed they can be achieved informally or through separate grants for workshops and conferences.

This approach has been losing ground, with increased emphasis by national and international research policymakers on targeting priority research objectives for a coordinated push on key land-use problems. Nonetheless, a number of organizations that place a particular premium on scientific innovation channel much of their funding in agroforestry to individual scientists. Projects must still be carefully justified by the scientist as relevant to a general priority problem, but once they have been justified, the scientist is granted substantial scope for independence. These organizations include, among others, the Nitrogen-Fixing Tree Association (NFTA), the Board on Science and Technology for International Development (BOSTID), the International Foundation for Science (IFS), the Ford Foundation, and the International Development Research Centre (IDRC) of Canada. It can be argued that in a relatively new field like agroforestry, it is particularly important to reserve a role for such innovators.

The third group of independent researchers is found in the private sector. They now play a minor role in agroforestry research but have the potential for making important contributions in the future, particularly with increased commercialization of tree products from agroforestry systems. While there is an interesting array of small private research projects undertaken by individuals commitment to natural resource conservation (e.g., Bamburi quarry reclamation in Kenya), most efforts are commercial. Examples include efforts to develop agroforestry systems for production of fuelwood for tobacco; studies of tree leaf fodder; commercial testing of little-known indigenous tree species for wood, fruit, pharmaceuticals, resins, or other products; and organizations of larger-scale farmers in certain areas who sponsor research on incorporation of trees in pastures, or tree-derived feed for feedlots. The focus and resources provided to researchers in these settings can provide high-quality applied research.

Research Based on Development Projects

In the conventional model of agricultural research, new ideas are generated by research scientists, tested on-station, then in on-farm trials, then re-

leased to extensionists for pre-extension testing and modification, and finally large-scale extension to farmers. This model is inappropriate for many types of agroforestry research. Information on and experience with agroforestry practices and technologies is currently concentrated in indigenous farming systems and in projects of agroforestry extension. The latter are commonly initiated before reliable research results have been generated regarding effective and appropriate technology design and management. Indeed, the fourth important locus of technology-generating agroforestry research is in the context of local or regional development projects, where most experience in agroforestry research has been generated in the past decade. Three models may be identified.

The first model is the extension project with its own research component. Because of the general paucity of agroforestry research, researchers in projects that involve testing and improving interventions are forced to develop their own research programs. A survey of over 100 extension projects undertaken by ICRAF in 1988-89 found that over 80% were involved in technology evaluation, including research plot, on-farm species, and technology trials; field and farmer surveys to evaluate technologies, etc. (Mueller and Scherr *in press*). Some examples include the Nyabasindu Project in Rwanda, a number of agroforestry extension projects implemented by CARE International, and the Ministry of Energy program of agroforestry research and pilot extension in the Kenya Renewable Energy Development Project (KREDP). In geographic regions that cannot be served by research institutions in a cost-effective or reliable way, projects may be the only realistic option for agroforestry research (see Thiele et al. 1988).

A second model is the research-for-development field project. In this model, a multidisciplinary research team works to solve a defined set of field problems, on site, for a defined set of land users. An example of this approach is the CRSP Small Ruminant Project in western Kenya, which is exploring ways of introducing intensively managed dairy goats into the farming system in collaboration with the Ministry of Livestock Development. One component of the project is research on agroforestry alternatives for goat fodder production, and this activity is integrated with other components (goat breeding, goat management, and nutrition) in on-station, on-farm, and extension trials. Agroforestry research projects of this type are also found in integrated rural-development projects.

A third model is the establishment of formal linkages between research institutions and extension projects. In this model, the research activities are supervised and/or carried out principally by professionals in the research institution, but the extension project staff and farmers identify priority research problems and may participate in trial design and evaluation and on-site testing. An example of this approach is the collaboration between the

KEFRI and CARE Agroforestry Extension Project in Kenya on species and technology testing for the project's main interventions (KEFRI and CARE 1986).

A fourth approach is the "action research" approach, in which strategic and applied research objectives are met in the process of carrying out a carefully documented development activity (Rocheleau 1987). A number of examples for agroforestry may be found. The Kenya Woodfuel Development Project (KWDP), a Beijer Institute project attached to Kenya's Ministry of Energy, sponsors research on agroforestry species selection, management, and extension methods, while carrying out an extension program. Other research projects of this type have been undertaken by ICRAF at its Kathama field site in Kenya (Rocheleau 1987; Raintree 1987) and, to some extent, by ILCA's alley-farming field projects in Nigeria (Atta-Krah and Francis 1987).

Collaborative Research Networks

A number of new research networks have been organized in recent years to increase resources for collaboration and information exchange between individuals and institutions doing agroforestry research. These have taken several forms, with varying levels of involvement by network organizers in research implementation, information exchange, and institutional development. The two principal models are the network as a conduit for research resources on specific agroforestry topics and the model of integrated agroforestry research planning, implementation, and institutionalization. The latter will be explained more fully below, as an example of institution-building for agroforestry research.

The research networks that deal with special topics include organizations such as the Nitrogen-Fixing Tree Association, the F/FRED network in Asia for research on fuelwood species, and the Alley-Farming Network (IITA/ILCA/ICRAF) in Africa. National collaborators receive financial support for research on network topics and commonly focus on multilocational trials through the network of collaborators. The networks provide a number of services, such as newsletters, workshops, training programs, etc., which enhance scientific interaction and improve the quality of research.

Since 1985, ICRAF has been helping to organize the Agroforestry Research Networks for Africa (AFRENAs), which represent a second network model designed explicitly for institutional development, as well as technology generation. The AFRENAs each include several countries and have been set up for the humid highlands of east Africa, the subhumid plateaux of southern Africa, the humid lowlands of west Africa, and the semi-arid lowlands of the Sahelian zone (Scott 1988; Torres 1987).

Coordinated research planning in the AFRENAs is institutionalized through a national agroforestry steering committee in each collaborating country, comprised of senior representatives of a wide range of research and development institutions with an interest in agroforestry. For each ecozone network, the role of policy-making, research, and budget review is undertaken by a regional steering committee, with representatives from each of the national steering committees. Day-to-day coordination of research is the responsibility of ICRAF zonal coordinators (Scott 1988).

The key implementing agencies in the AFRENA projects vary considerably from country to country and include examples of many of the above-mentioned models:

- an agroforestry research unit (Burundi);
- collaborating forestry and agriculture research institutions (Malawi, Tanzania, Kenya — with support from the energy ministry);
- a combined agriculture/forestry research institution (Cameroon, Rwanda);
- collaborating line ministries (forestry and agriculture in Zambia; forestry, agriculture, and livestock ministries plus the university in Uganda).

The network in southern Africa is coordinated by the Southern Africa Committee for Coordination of Agricultural Research (SACCAR), and the network now being formed in the sahelian zone of west Africa is coordinated by SAFGRAD.

The selection of research projects and objectives is based on a systematic process of land-use system diagnosis and agroforestry design. A multidisciplinary, multi-institutional task force is trained to implement a macro D&D of all major land-use systems for the steering committees to use as a basis for selecting priority land-use systems and agroforestry practices for research. This is followed by a detailed diagnosis and design (D&D) exercise in selected land-use systems to identify design priorities and constraints to development of selected agroforestry interventions and to prepare a research program (Scherr 1987b, 1987c).

Each project includes three parallel research activities: selection and improvement of MPTS germplasm for use in selected agroforestry practices, management trials to identify management options for specific agroforestry interventions (e.g., establishment, tree management, crop management, harvest), and design and testing of composite prototype systems for and with the identified client land users. Research in any of these lines may include

on-station experiments, on-farm experiments, or on-farm surveys of MPTS and farmer management in existing agroforestry systems, as determined by specific information needs for technology development. On-farm research may be organized directly by the research team or through collaboration with existing on-farm research programs or agroforestry extension projects.

All AFRENA training activities and D&D studies are undertaken with multidisciplinary groups. Research in each site-specific or zonal research project is undertaken by multidisciplinary teams of national and ICRAF scientists. ICRAF zonal outreach staff provide technical backstopping to project scientists in agronomy, forestry, soil science, and agroforestry; social scientists from headquarters will join them soon.

Relative Strengths of Different Institutional Models

Table 3 summarizes the strengths and weaknesses of the 15 different institutional models described above. This reflects what is characteristic of particular institutional arrangements, given their typical resources and structure. It is essential to recognize, however, that almost all identified constraints can be overcome through specific institutional interventions.

Institutional Coordination

In terms of effective coordination with other agroforestry researchers and with relevant policy and extension institutions related to agroforestry, the most successful single-institution model is likely to be the agroforestry extension institution, which includes research functions. One would also expect integrated land-use institutions to be strong in this area, but we have little experience with these. For the agroforestry research system as a whole, however, the integrated collaborative networks — as illustrated by the AFRENAs — seem to offer the best alternative for systematic, institutionalized, interinstitutional planning and consultation.

By contrast, disciplinary research or extension institutions will tend to find coordination difficult, while the independent research institutions (universities, independent researchers, and the private sector) are generally little concerned with institutional coordination. Extension projects are often geographically and institutionally isolated, even from other institutions operating in the same areas.

Development Focus

As would be expected, the institutions with the strongest institutional and researcher mandates for development-oriented research are the extension institutions, i.e., the researchers attached to national extension institutions

Table 3. Alternative Models for Organizing Agroforestry Research: Institutional Strengths and Weaknesses

Model	Coordination	Devel. Focus	Multidiscipl.	On-Farm Focus	Innovation
Disciplinary Research Institute					
Disciplinary research institutions	–	?	–	–	–
Joint research projects	+	?	+	–	–
Agroforestry research institutions	+	?	++	–	++
Disciplinary Extension Institutions					
Disciplinary extension institutions	–	++	+	+	–
Agroforestry extension institutions	++	++	++	+	–
Integrated land-use institutions	++	++	++	+	+
Independent Research Institutions					
University research	–	+/–	+	–	+
Independent research support	–	?	–	–	+
Private-sector research	–	+	–	+	+
Project-Based Research					
Research based on extension projects	–	++	–	++	+
Research-for-development field projects	+	++	+	++	+
Research/extension project collaboration	+	+	+	++	++
Action research projects	+	++	+	++	++
Research Networks					
Special-topic research networks	+	?	–	?	+
Integrated collaborative networks	++	?	++	–	–

Note: This table represents the likely strengths and weaknesses of specific types of institutional arrangements in terms of the factors discussed in the text.
Ranking: ++ Strong + Intermediate – Weak ? Variable

or those attached to extension projects. It is difficult to draw generalizations about the other institutional models, as they are highly variable.

Multidisciplinary Coordination

Institutional models that could most easily provide multidisciplinary coordination include agroforestry institutions in research or extension and the integrated land-use institutions, which would have multidisciplinary staffing. Integrated research networks offer the potential for multidisciplinary, multi-institutional projects, although a major effort to develop multidisciplinary team mechanisms is often needed. This is also the case in joint projects between national research and/or extension institutions or projects.

Effective multidisciplinary teams may be the most difficult to establish in disciplinary research institutions, in smaller-scale extension projects, and among university researchers working either independently or in projects.

On-Farm Research Focus

Not surprisingly, the most effective on-farm research focus is found in those institutional models whose central activities are in the field, i.e., extension and action research. Such projects select research priorities based on problems identified with farmers during the extension process. They tend to focus on short- to medium-term research problems, and may be reluctant to carry out science-generating research with little immediate connection to extension. While some researchers raise questions about the longevity of extension projects from a research perspective, the evidence suggests that in many areas they are longer-lived than their government counterparts, which may suffer from major shifts in government resources over time (Thiele et al. 1988).

Typically, national research institutions and university-based or independent researchers will have the most difficulty establishing or accessing farmer networks for on-farm research. This may be overcome by linking up with existing farming-systems research programs or by linking directly with extension projects. The latter option, while promising, must be planned and managed carefully to ensure that there is a real congruence of research interests.

Environment for Research Innovation

One would expect that the environment for research innovation would be most open in agroforestry research institutions and in research-for-development field projects. In most cases, the mandate of these programs would promote innovation. By contrast, single-discipline institutions will not be provided with cross-disciplinary interaction, particularly where there is no regular contact with complex on-farm agroforestry. Those institutional models that require interinstitutional compromises for implementation may be forced into greater rigidity about methods and approaches because of the highly formalized planning process.

The Future Development of Agroforestry Research Institutions

Some tentative conclusions regarding the institutionalization of agroforestry research are suggested by the evaluation of agroforestry research systems undertaken to date.

The Future Profile of Agroforestry Research Institutions

The actual structure of research institutions appears to be less important to their capacity for carrying out good agroforestry research than the internal policies and arrangements regarding research coordination, development focus, multidisciplinarity, on-farm activities, and researcher innovation. There is probably far more room for maneuver within the framework of even fairly rigidly structured institutions than has sometimes been thought. Thus, the main aim of evaluating institutions in the agroforestry research system will generally be to identify weaknesses, strengths, and opportunities in existing institutions so that these can be effectively addressed in institutional planning, rather than to devise new institutions. The key to finding and exploiting opportunities within disciplinary research and extension institutions is the education of senior managers about the potential and needs of agroforestry research.

A wide range of modest modifications can be proposed in any type of institution to address weaknesses in the basic organizational structure or interinstitutional linkages. Research institutions without on-farm research facilities can develop collaborative programs with extension or on-farm research projects. Individuals with responsibility for research/extension linkages, or coordination with other research institutions, can be given more status and authority within an institution traditionally weak in coordinating its research planning and implementation. Secondment or direct hire of scientific staff from disciplines not traditionally found within the institutions, can be used to strengthen multidisciplinary teams.

The Role of Projects versus Institutions in Agroforestry Research

The main locus of agroforestry research in the past has been in either research or extension projects with operational independence that have had special status as pilot projects and innovators. As agroforestry becomes increasingly recognized as a mainstream scientific field, we can expect to see more agroforestry research move from these special projects to formal national research and development institutions. This will be especially true for the following: the long-term research trials that are required to obtain conclusive information about management regimes and sustainability of agroforestry systems, the research necessary to explain in detail how these systems work, and the more specialized types of research. The move to agroforestry research in formal institutions fits well into the general trend of research interests in integrated land-use management and sustainability.

But projects will continue to play an important role in agroforestry research, particularly if — as is to be hoped — more extension projects can improve their research commitment and capability. Their strengths are in the design,

testing, and adaptation of agroforestry technology for specific land users, and as collaborators with formal research institutions in on-farm research. They are likely to remain important innovators in the field. But perhaps their main role will be to keep agroforestry research demand-driven, i.e., focused on the research needs of farmers and extensionists, where pressures within formal institutions favor less practical research.

This potential needs to be exploited by the formal research sector. The agroforestry extension community should be represented on national steering committees and other decision-making bodies for research. Formal institutions and extension/development projects should seek active collaboration, to strengthen both the quality of research being undertaken in the projects and the ability of formal-sector researchers to identify and address key applied research problems.

Interdisciplinary Exchange of Methods and Findings

In the future, agroforestry researchers will need to develop greater "interdisciplinarity." Because of the current lack of solid interdisciplinary training and interaction, there is substantial reinvention of the wheel occurring in agroforestry, as disciplinary specialists are forced by the nature of agroforestry to move into fields for which they have not been trained. Agronomists, ecologists, foresters, horticulturalists, range managers, livestock-production specialists, socioeconomists, anthropologists, and rural extension specialists must be aware of one another's research methodologies and findings that are relevant to agroforestry, as well as their past experience with now-discarded methodologies. If provision for this sort of exchange of information and experience can be built into existing training and institutional arrangements, then research coordination, multidisciplinary work, on-farm research, and innovation could be substantially enhanced.

Research Support Institutions

Research institutions do not stand alone. Their policies and potential are strongly influenced by the general environment within which their scientists operate and have been trained. Managers of support institutions need to modify their perceptions and activities before one can expect research institutions to address agroforestry development needs fully. Of particular importance are donors, educational institutions, professional journals and organizations, and the agroforestry extension/development community.

Donor perception of the role and needs of research will have to change; much greater resources are needed for institutional and multidisciplinary staff development. At the same time, there is a striking imbalance between resources going to research and those going to extension in agroforestry.

This could be ameliorated by creative approaches to extension-research linkages and by donor recognition of the need for longer-term programs of scientific research to parallel the resources invested in technology-generating research.

Consistently high-quality research in national research institutions will require programs of professional education in the key disciplines that address the needs and perspectives of agroforestry. This is a major topic which cannot be discussed here, but it should suffice to insist that any program aimed at institutionalization of agroforestry research should logically be coupled with a parallel set of activities to institutionalize agroforestry in professional education (Zulberti 1987).

By the same token, agroforestry research is currently in an uncertain state as regards the professional output of researchers. The structure of professional organizations and publications is such that a premium is placed on disciplinary specialization. If institutions expect to attract and retain high-quality researchers in agroforestry, then more outlets must be developed and supported for rigorously peer-reviewed publication of applied, interdisciplinary agroforestry research.

Finally, the agroforestry extension/development community needs to shed its trepidation about undertaking research within its own projects and programs. The development community will for some time continue to bear the main responsibility for the development, improvement, and dissemination of agroforestry extension recommendations. This situation presents a clear mandate for a research component in most agroforestry development projects. This means the hiring and support of some staff with research capability—at least the ability to collaborate with formal-sector researchers to define research objectives, implement simple trials, and discuss research results. It also means some commitment on the part of these projects to share the results of technology-generating research and adopt methods of data collection that will facilitate this type of sharing (Raintree and Hoskins 1988; Scherr 1989). The CARE International/FAO Agroforestry Monitoring and Evaluation Methodology Project represents a step forward (Ngugi and Buck 1989), but greater efforts are needed.

Innovation in the Agroforestry Research Process

A final conclusion of this study is the need to maintain a perspective that sees the agroforestry research process itself as a subject for experimentation. There is a need to monitor and evaluate alternative institutional approaches to research planning and coordination, technology focus, multidisciplinary research, on-farm research, and opportunities for innovation. We also need to evaluate the cost-effectiveness of different types of research, undertaken

by different types of institutions, in generating and field-testing agroforestry technologies. Both ISNAR and ICRAF could play a valuable role in collaborating with national agroforestry institutions in this type of institutional research.

References

Atta-Krah, K. and P. A. Francis. 1987. The role of on-farm trials in the evaluation of composite technologies: The case of alley-farming in southern Nigeria. *Agricultural Systems* 23: 132-152.

Beer, J., R. Borel and A. Bonnemann. 1989. On-farm agroforestry research planning in Costa Rica. Paper presented to the International Symposium on Planning Agroforestry Projects. Pullman, WA: Washington State University.

Depommier, D., ed. 1988. Potential agroforestier des systemes d'utilisation des sols des hautes terres d'Afrique de l'est a regime pluviometrique bimodal Burundi. AFRENA Report No. 2. Nairobi: ISABU/CRAF and ICRAF.

Djimde, M., ed. 1988. Potential agroforestier dans les systemes d'utilisation des sols des hautes terres d'Afrique de l'est a regime pluviometrique bimodal Rwanda. AFRENA Report No. 1. Nairobi: Le Groupe de Travail Rwandais pour la Recherche en Agroforesterie and ICRAF.

Djimde, M. and D. Hoekstra. 1988. Agroforestry potentials for the land use systems in the bimodal highlands of eastern Africa, Uganda. AFRENA Report No. 4. Nairobi: Uganda Agroforestry Task Force and ICRAF.

Huxley, P. A. 1987. Agroforestry experimentation: Separating the wood from the trees? *Agroforestry Systems* 5: 251-276.

KEFRI and CARE. 1986. Memorandum of understanding between the Kenya Forestry Research Institute and CARE International in Kenya. Nairobi.

Kwesiga, F. and I. Kamau, eds. 1989. A blueprint for agroforestry research in the unimodal upland plateau of Zambia. AFRENA Report No. 7. Nairobi: Zambian Agroforestry Task Force and ICRAF.

Lundgren, B. 1987. Institutional aspects of agroforestry research and development. In *Agroforestry: A decade of development*, eds. H. A. Steppler and P. K. Nair. Nairobi: ICRAF.

Merrill-Sands, D. P. Ewell, S. Biggs and J. McAllister. 1989. Issues in institutionalizing on-farm client-oriented research: A review of experiences from nine national agricultural research systems. Staff Notes No. 89-57. The Hague: ISNAR.

Minae, S., ed. 1988. A blueprint for agroforestry research in the unimodal upland plateau of Malawi. AFRENA Report No. 5. Nairobi: Malawi Agroforestry Task Force and ICRAF.

Minae, S. and E. Akyeampong, eds. 1988. Agroforestry potentials for the land use systems in the bimodal highlands of eastern Africa, Kenya. AFRENA Report No. 3. Nairobi: Kenya National Task Force for Agroforestry and ICRAF.

Ngugi, A. and L. Buck, eds. 1989. Proceedings of the First Monitoring and Evaluation Methodology Program (AFMEMP) Regional Workshop, Kisumu, Kenya. Nairobi: CARE International.

Raintree, J. B. 1987. The state of the art of agroforestry diagnosis and design. *Agroforestry Systems* 5(3): 219-250.

Raintree, J. B. and M. W. Hoskins. 1988. Appropriate R&D support for forestry extension. Paper for the FAO Expert Consultation on Organization of Forestry Extension. March 7-11, 1988, Bangkok, Thailand.

Rocheleau, D. 1987. The user perspective and the agroforestry research and action agenda. In *Agroforestry: Realities, possibilities, and potentials*, ed. H. L. Gholz. Dordrecht/Boston/Lancaster: Martinus Nijhoff Publishers, in cooperation with ICRAF.

Scherr, S. J. 1986a. Tanzania: Pre-diagnostic evaluation of policy institutions for agroforestry research. Nairobi: ICRAF.

Scherr, S. J. 1986b. Zambia: Pre-diagnostic evaluation of policy institutions for agroforestry research. Nairobi: ICRAF.

Scherr, S. J. 1986c. Malawi: Pre-diagnostic evaluation of policy institutions for agroforestry research. Nairobi: ICRAF.

Scherr, S. J. 1987a. Planning national agroforestry research: guidelines for land use system description. ICRAF Working Paper No. 48. Nairobi: ICRAF.

Scherr, S. J. 1987b. Designing agroforestry research programs: A case study from the humid lowlands of Cameroun. In *Technical seminar on ICRAF's approach to multipurpose tree research—An evaluation*, eds. S. Westley and P. Huxley. Nairobi: ICRAF.

Scherr, S. J. 1987c. Kenya: Pre-diagnostic evaluation of policy and institutions for agroforestry research. Nairobi: ICRAF.

Scherr, S. J. 1989. The legislative context for agroforestry development in Kenya. In *Forestry Legislation*, ed. F. Schmithusen. IUFRO Working Party on Forest Policy, Law and Administration. Zurich: IUFRO.

Scherr, S. J. In press *a*. Designing agroforestry Systems for Rural Development: Implications for the Research agenda. In *Farmers and food systems*, eds. R. Rhoades and J. Moock. New York: CIP and Rockefeller Foundation.

Scherr, S. J. In press *b*. Choosing priorities in agroforestry research. In *Social science perspectives in agricultural research*, eds. D. Groenfeldt and J. Moock. New York: IIMI and Rockefeller Foundation.

Scott, B. 1988. ICRAF's cooperation with national institutions for agroforestry research and development. Collaborative Programs Division (COLLPRO). Nairobi: ICRAF.

Thiele, G., P. Davies and J. Farrington. 1988. Strength in diversity: Innovation in agricultural technology development in eastern Bolivia. Agricultural Administration (Research and Extension) Network Paper No. 1. London: Overseas Development Institute.

Torres, F. 1987. ICRAF's approach to international cooperation. *Agroforestry Systems* 5(3): 395-417.

Zulberti, E. 1987. Agroforestry training and education at ICRAF: Accomplishments and challenges. *Agroforestry Systems* 5(3): 353-374.