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Sustained Agroforestry

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ICRAF

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SUSTAINED AGROFORESTRY

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The agroforestry approach — potentials and constraints

Definition and scope

"Agroforestry" has arrived and become firmly established as a term and concept in international development and rural science terminology in a surprisingly short time. It was not until the late 1960s and early 1970s that the word started to appear, occurring then mainly in forestry circles as a wider, collective name for all the various forms of taungya afforestation systems long in practice in many tropical countries (King, 1968). General textbooks on tropical agriculture and farming systems from the 1970s do not even mention the word (e.g, Ruthenberg, 1980; Manshard, 1974). The final "breakthrough" of the concept can probably be dated to the report of Bene et al. (1977).

Since 1977 at least a dozen international meetings specifically about agroforestry have been held; major UN conferences held during the last five years invariably mention the value of agroforestry in their resolutions and recommendations (e.g., the FAO World Forestry Congress, 1978, and UN Desertification Conference, 1977; the UN Conference on New and Renewable Energy Sources, 1981; and the UNEP Session of a Special Character, 1982); all principal donor agencies, both bilateral and multilateral, have recently taken up agroforestry in their lending and spending programs; international and national institutions, journals, and consultants specializing in agroforestry are mushrooming all over the world.

There are probably many interrelated reasons for this explosive increase in interest. No doubt the built-in dynamics of "fashion" have stimulated the process, but there is much more to it than that. Agroforestry is the first concrete concept that builds on a synthesis of much of the practical experience and scientific knowledge acquired over the past decades in tropical agriculture, forestry, ecology, soil science, and rural socio-economics. Our increased understanding of tropical environments, both social and ecological, and our frequent disappointments and failures when trying to implement modern land-use technologies in ecologically sensitive and socio-economically complex situations have led to a realization that alternative approaches to land development must be given higher priority.

What then is agroforestry? There is certainly no general consensus. Many definitions have been proposed, good and bad, broad and narrow. Many, unfortunately, make subjective and presumptuous claims that agroforestry, by definition, is a superior and without doubt a more successful approach to land development than others. It would, however, serve no purpose here to list a large number of definitions (see *Agroforestry Systems,* 1982). The following definition has the advantage of being objective:

> Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, either on the same form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components.

This definition outlines the broad boundaries of agroforestry and the typical characteristics of such systems:

1. agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial;
2. an agroforestry system always has two or more outputs;
3. the cycle of an agroforestry system is always more than one year;
4. even the most simple agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a monocropping system.

It is apparent that this definition of agroforestry encompasses many well-known land-use systems long practised in the tropics. Traditional shifting cultivation and bush fallow systems, for example, are included: woody fallows are clearly a deliberate and important part of the system, interacting both ecologically and economically with the crops grown in the cultivation phases. Systems with natural fallows can, of course, be classified as "primitive" agroforestry since no deliberate choice and planting of woody species takes place.

Furthermore, all forms of taungya afforestation systems are included, as well as systems in which tree crops, such as rubber, oil palm, coconut, are underplanted with other crops or pastures.

Naturally, more typical agroforestry systems, such as the home gardens of many wet tropical regions, or the deliberate use of fodder trees and shrubs in the dry tropics, are part of the concept.

The definition—and all that it includes—brings out the very important point that agroforestry is only a new word, not a new practice. Its novelty lies in the realization that so many different land-use systems and practices, some of which have traditionally fallen into the field of horticulture, some into agriculture, some into forestry, and a considerable number of which have not attracted any systematic attention at all, have a common denominator in approach worth exploring and developing in a more systematic and scientific way.

The word agroforestry is admittedly rather unfortunate in that it linguistically evokes the notion of its being a subdivision of forestry (Steward, 1981) rather than an integrated form of land use in a much wider sense. The word is now so firmly entrenched, however, that there is no point in wasting energy or effort trying to find a better one.

Potential of agroforestry

The aim and rationale of agroforestry systems and technologies is to optimize positive interactions between components (trees/shrubs and crops/animals) and between these components and the physical environment in order to obtain higher total, more diversified, and/or more sustainable production from available resources than is possible with other forms of land use under prevailing ecological and socio-economic conditions.

The attractiveness of an agroforestry approach to land development lies in the potential role of trees/shrubs to alleviate some of the major physical and economical constraints facing farmers and pastoralists in many parts of the tropical world.

The most apparent ecological potential exists in areas where soil fertility is low and depends mainly on soil organic matter, where erosion potential is high. On such marginal lands the deliberate use of woody perennials may, if properly integrated in the land-use systems, enhance both land productivity and sustainability. The fewer capital and technology inputs available to farmers, the more motivated they will be, theoretically, to use trees and shrubs to enhance organic matter production, to maintain soil fertility, to reduce erosion and to create a more even micro-climate.

The value of agroforestry is, however, by no means restricted to marginal lands. Some of the most successful small farmers' systems in the tropics are in fact found on high potential, fertile soils, where intensive agroforestry systems have for many years proved their ability to support dense and growing populations economically.

Further potential for agroforestry, equally applicable on marginal and rich land, exists in socio-economic situations where land tenure and/or lack of rural infrastructure (communications, markets) and cash make it vital for people to produce most of their basic needs (food, fodder, fuel, shelter, etc.), from a limited land area, in favorable instances their own.

In general terms, therefore, the idea and approach of agroforestry seem sound. Erosive rains, organic-matter-dependent soil fertility, an increasing fuelwood scarcity, and a lack of cash and infrastructure among the vast majority of tropical land-users are some of the most relevant ecological and socio-economic arguments for tree integration into farming and pastoral areas (Bene et al., 1977; Eckholm, 1979; FAO, 1981c; World Bank/FAO, 1981). Indirect arguments in favor of the agroforestry approach to land use are the all-too-frequently-observed productivity declines and land problems that almost invariably follow indiscriminate removal of permanent vegetation cover (be it forest, woodland, or planted trees). Agronomists are also realising increasingly that the only feasible, long-term approach to development for some crucial tropical areas, the Amazon rainforest, for example, is a tree-based land-use system, either horticultural crops, forestry, or agroforestry (Alvim, 1979; Hecht, 1982).

The systematic and scientific development of agroforestry appears to hold especially great promise in the practically unexplored field of genetic improvement of multi-purpose tree/shrub species. In agriculture, horticulture, and forestry, systematic and determined efforts to improve desirable characteristics in crops through selection and breeding have achieved remarkable results. The green revolution, a major part of which has been the development of improved varieties of rice, maize and wheat, is the most widely known example. No less spectacular results have been obtained in forestry and horticulture. Palmberg (1981), for example, reports of *Eucalyptus camaldulensis:* "The results (of trials) showed that the potential gain in productivity which can be achieved simply by selection of the best-adapted provenances for prevailing environmental conditions could amount to several hundred percent." Likewise, the average yield of rubber has increased 17-fold in a century as a result of breeding and improved management (Nair, 1981).

There is no scientific reason why selection and breeding to improve features desirable in agroforestry, such as fodder, food and fuel quantity and quality, rooting characteristics and phenology favorable to interplanting with annual crops, nitrogen-fixation, pest resistance, and drought resistance, cannot result in equivalent success. Indeed, rewards from the very few efforts towards systematic improvement that have already been made prove the point. As a result of the "sorting out" of provenances, sub-species, and varieties of *Leucaena leucocephala*, for example, a situation exists today where it is possible to obtain seed meeting particular requirements, e.g., growth habits. Even more exciting is the apparently highly successful work being conducted at CIAT to "breed out" the two major disadvantages of *Leucaena:* its high-mimosine content and its intolerance of acid soils (Hutton, 1981).

Potential gains from systematic improvement of agroforestry species have been strongly emphasized by the World Bank which has declared its special interest in supporting such work (World Bank, 1981a). A thorough discussion of the potential and problems of genetic improvement of tree species, for agroforestry among other purposes, appears in Burley (1979).

At present it would appear that an almost unlimited scope exists in agroforestry for the innovative and imaginative development of technology packages. The alley-cropping work at IITA is a good example of how unconventional thinking has resulted in an agroforestry solution to the problem of declining soil fertility and crop production. Introduction of shade-tolerant forage grasses and legumes under pine plantations has in places increased land productivity substantially, e.g., in the Jari project in the Brazilian Amazon (Briscoe, 1981). The possibility of addressing particular land productivity problems, e.g., soil erosion, organic matter and fertility, drought seasonal fodder shortages, and fuel and building pole needs, by combining trees and shrubs with desired characteristics in suitable spatial or temporal arrangements with annual crops and/or animals, poses new challenges to research and development organizations.

Some problems and constraints

Before agroforestry systems and technologies can and will achieve any significant impact on the alleviation of tropical land productivity problems, many constraints must be overcome. Several authors have recently discussed the difficulties which agroforestry faces. This paper, although arranged in a slightly different way, is based on papers by Adeyoju (1981), Andriesse (1978), Arnold (1982), Budowski (1981), Burley (1980), Catterson (1981), and Openshaw and Moris (1979).

Among the most obvious general constraints to a significant contribution by agroforestry toward increasing the productivity of tropical lands is the very magnitude of the problem itself. We are talking about hundreds of millions of farmers and landless people spread over vast expanses of tropical lands. Physical as well as socio-economic limitations to rational land use are innumerable. Rapid population growth, unsafe land tenure, erosion, droughts, floods, declining soil fertility, lack of infrastructure, political instability, and illiteracy are characteristic of regions where agroforestry approaches to land use have a potential role to play. It is self-evident that agroforestry development can never be seen in isolation from general social and physical development problems.

The development of agroforestry systems and techniques requires, at many levels and stages, the kind of integrated and multidisciplinary approach for which existing institutions, both national and international, are rarely equipped. Education at technical and professional levels almost always takes place along traditional disciplinary lines, i.e., forestry, agriculture, animal husbandry, etc. In a similar way research institutions ordinarily work on strictly discipline-oriented problems. Even where systems research programs are being undertaken, these are often, and understandably, strongly biased toward the basic discipline of the institute where the program is housed.

At government and administrative levels, rigid boundaries more often than not separate departments dealing with different aspects of land use. Today such division is being accentuated by increasing competition for scarce development resources. In many, probably most, tropical developing countries, forestry and agriculture are under different ministries. The latter is likely to be the more prestigious and powerful ministry with respect to land management, while the former usually carries responsibility for agroforestry (i.e., in the few countries where any formal agroforestry program exists).

Land legislation and its supervision often reflect administrative divisions: distinct laws govern forest as opposed to agricultural land. Some countries even have laws making all trees, including planted ones, government property. It goes without saying that such laws effectively undermine attempts to convince farmers to plant trees.

Although most international agencies, e.g., UN bodies, development banks, and bilateral aid agencies, pay lip service to agroforestry and to an integrated approach to land development, nonetheless traditional disciplinary boundaries still impede the effectiveness of their work, too. As in the case of national institutions, agroforestry is often considered as a branch of forestry, or even of environmental conservation, which means that resources for its promotion and development are allocated via forest divisions or departments. As a consequence, unfortunately, international research and development funds for agroforestry are, in relative terms, scarce.

Without in any way underrating the importance of the determined efforts made by the World Bank, FAO and other international bodies in the field of agroforestry, it is still doubtful whether they will have any major impact, unless there is a radical rethinking within these organizations of the nature and potential role of agroforestry. Here are some examples in support of this contention:

1. agroforestry is strongly promoted by the World Bank, but mainly in its "Forest Sector Policy Paper" (World Bank, 1978);
2. agroforestry development support is incorporated into the "Forestry for Rural Communities" program of the FAO Forest Department;
3. agroforestry has been identified as a priority research field in tropical forestry in a joint World Bank/FAO (1981) report prepared for the International Union of Forestry Research Organizations (IUFRO) conference in Kyoto, Japan, in 1981;
4. when the same paper was presented to the "Sixth Session of the FAO Committee on Forestry" in May 1982, the following introductory words were used when summarizing the section on agroforestry: "To achieve the integration of social with production and protection objectives, integrated forest management needs to involve a holistic approach to the use of forest land and forest resources" (FAO 1982);
5. similarly, when the International Council for Research in Agroforestry (ICRAF) was created in 1978, it was the result of an IDRC-sponsored study to identify the major priority area in tropical forestry research (Bene et al., 1977);
6. ICRAF was not admitted to the Consultative Group on International Agricultural Research (CGIAR) on the grounds that forestry was not in the mandate of the CG institutes.
7. two of the most important recent reports on how to tackle problems of agricultural production in developing countries, reports which will have far-reaching implications for the international communities' funding priorities, "Agriculture: Towards 2000" (FAO, 1981c) and "Accelerated Development in Sub-Saharan Africa — An Agenda for Action" (World Bank, 1981b), do not mention agroforestry at all, nor an equivalent approach to land use under any other name.

Such evidence illustrates a fundamental institutional constraint with respect to agroforestry, one which, in a crude summary, might read, "Agroforestry is institutionally considered a sub-division of forestry. Forestry institutions deal with forestry and forest land. The major potential of agroforestry lies in the integration of trees into agricultural and pastoral lands. The development of these lands is the mandate of agricultural institutions. Agricultural institutions are not mandated to deal with agroforestry."

Another impediment to the progress of agroforestry is the difficulty inherent in technology transfer. Extension may be relatively easy in well-established and moderately prosperous agricultural areas where the physical and administrative infrastructure is well developed, but it is far more difficult in those vast expanses of lands where the agroforestry approach to land use is most acutely needed. Here the unavailability of extension services competent to teach integrated land development is a serious shortcoming indeed; even where roads and funds are adequate to enable extension workers to reach target farmers, extension workers, just as their "mother" ministries, are all too likely to be oriented to single or separate disciplines.

Farmers, moreover, will have to be convinced about the benefits of new technologies. It may not be very difficult to introduce new and better species or, in areas where trees are already part of the traditional land management system, to make farmers adopt marginal improvement in management practices. It is considerably more of a challenge where managed trees and shrubs are novelties. The period between planting a tree and achieving appreciable benefits from it involves risks that farmers with limited resources may not be prepared to take. Similarly, it may be next to impossible to convince land users to make long-term obstacles to adopting sound agroforestry practices locally. It is certainly worthwhile for development and extension personnel to analyze such attitudes closely, for they may very well be in good part rational. People's negative position towards trees in tse-tse-fly-infected areas is a case in point.

Finally, there are many down-to-earth management constraints to be overcome before functioning agroforestry systems can be implemented. Raising, establishing, protecting, and managing trees require skills and sustained effort new to many farmers. Water availability for nurseries, protection of young plants against domestic animals, increased time needed in managing more than one production component, minimizing negative interactic between trees and crops, all these tasks are likely to require additional resources, both labour and capital, which may be beyond the means of poor farmers. Credit and aid schemes will have to ensure the possibility of wide participation in the establishment phase of agroforestry systems.

Some examples of agroforestry practices

As with many new sciences in search of an identity, agroforestry has had its fair share of classification efforts (Combe & Budowski, 1979; King 1979; Torres, 1979; Grainger, 1980; Vergara, 1981). It would take too long here to make a detailed review of all the proposed classification systems. Certain criteria for differentiation of agroforestry systems, however, commonly recur:

1. physical structure — in particular the spatial arrangement of woody components in relation to crops (e.g., if trees are planted at regular intervals, in alleys, in patches, or in a haphazard way, and type of vertical stratification (e.g., if it is a two-story or multi-story system);
2. temporal arrangement — whether crops/animals and trees are permanently mixed or rotated (fallow system), and the periodicity of tree rotation;
3. relative importance and role of components—whether the system is agro-silvicultural (i.e., aiming to establish tree plantations), silvopastroral (trees/shrubs supporting animal production), agrosilvopastroral (crops, trees, and

animals in mixture), or whether trees serve only a protective/supportive role for crop production;
4. production aims/outputs from the system—whether food, wood, fodder, or any other single product dominates, or whether it is a multiple-output system;
5. social and economic features—whether the venture is large-scale or small-scale, commercial, subsistence, or intermediate.

There are innumerable examples of traditional agroforestry systems and practices in the tropics, some highly successful, others succumbing to the pressure of expanding human and domestic animal populations. Global reviews of such practices can be found, for example, in Combe and Budowski (1979) and Nair (1982). Several regional and country accounts have also been compiled in recent years (e.g., Budowski, 1979 for Central and South America; von Maydell, 1979 for the Sahel in Africa; Atmosoedaryo and Wijayakusumah, 1979 for Southeast Asia; and FAO, 1981a for India and Sri Lanka).

It is probably safe to say that the most diverse range of successful, traditional agroforestry practices exists in the two regions of Southeast and South Asia. It is also in these regions that the most active research and development efforts are being made today to improve agroforestry practices further. Similarly, institutional disciplinary constraints on agroforestry are probably less severe here than in other regions or at the international level. It is certainly no coincidence that agroforestry has been included as an issue in agricultural research at the present regional meeting.

In India two traditional systems of great importance are the small-holder coconut plantations underplanted with food crops, spices, and pastures in the humid South-West Coastal region (Nair, 1979; Nair and Varghese, 1980), and the agrosilvopastoral systems of the Rajasthan Desert based on the remarkable tree *Prosopis cineraria* (khejri) (CAZRI, 1981; Mann and Saxena, 1980). Various forms of tree or home gardens here on Java occupy about 20% of the arable land and represent one of the most successful, multiple-output traditional tropical land-use systems based on a combination of perennial trees and crops. It is important to note that these tree gardens as a rule form part of a whole farm system which also comprises fields of annual crops (Wiersum, 1982; Bompard et al., 1980).

The integration of multipurpose trees, such as *Leucaena leucocephala* (ipil-ipil) and *Albizia fakata,* into small farmers' land for commercial and protective purposes is a common and rapidly expanding practice in the Philippines (Generalao, 1982; Pollisco, 1979; Veracion, 1980).

In Malaysia systematic developments are being undertaken to introduce livestock into small-holder rubber plantations (Wan Embong, 1979; Wan Embong and Abraham, 1976); and in Sri Lanka projects are being implemented to develop the traditional mixed Kandy forest gardens.

These examples illustrate how rich the Indian subcontinent and the Southeast Asian region are in agroforestry experience, much of which is transferable to other tropical regions.

Agroforestry research today

There are probably few fields in which there is such a high potential for substantial pay-offs on investments in research as in agroforestry. Systematic research for generating suitable new technologies incorporating woody multipurpose perennials in agricultural land-use systems is barely in its infancy.

If we keep in mind the broad definition of agroforestry cited earlier, then certainly agroforestry research has been, and continues to be, conducted at several discipline- and commodity-oriented research institutes throughout the tropics. Examples include research to refine pasture establishment and underplanting in tree crops (especially rubber and coconut); research on shading coffee, tea, and coca; studies of traditional shifting cultivation; research on suitable taungya practices; fuelwood tree species trials; and work on browse species in dry regions.

Although much of this work is of direct relevance and interest to the systematic development of agroforestry systems, it is also clear that most of it is being done with strongly discipline- or commodity-biased aims: to maximize productivity of rubber estates, increase yields of coffee, minimize costs of timber plantation establishment, and find the fastest-growing fuelwood or the most high-yielding or nutritious browse species. All such objectives are appropriate to the mandates of the institutions carrying out the research.

There is, however, little ongoing research towards developing technologies and systems which, through the optimum use of multipurpose trees and shrubs, address the multiple problems faced by small- and medium-sized subsistence (or mixed subsistence/cash) farmers or pastoralists in the tropics. This is where the great challenge and potential of agroforestry technology-generating research lies and where scope exists for almost unlimited innovative and imaginative thinking and work. Finding and improving the best locally adapted (ecologically and socially) species for meeting farmers' combined fuelwood and dry season fodder needs, finding the spatial arrangement and management of this species which minimizes its competition with annual crops and maximizes its positive soil- and miroclimate-enhancing potentials, finding a woody species that combines cash production (e.g., fruits, nuts, fuel) with excellent features as a soil terrace stabilizer—these are the kinds of discoveries to which agroforestry research aspires.

Why is more not being done in this field? The main reason would seem to be the institutional constraint referred to earlier. As a result of the rigid disciplinary lines along which most land-development research is being conducted, there simply are no institutions with the mandate or the multi-disciplinary resources required to attempt integrated investigations in an entirely unbiased, problem-oriented way.

Among the approximately 600 forest research organizations and more than 1000 agricultural research institutes and agencies involved in tropical and subtropical land use research identified in a recent study by the World Bank/FAO (1981), less than 90 are currently conducting research on agroforestry or have the capacity to do so.

In spite of this fact, a fair amount of research is under way concerning agroforestry technology components and systems. The latter, however, tends to be of a descriptive, qualitative nature, and the former, though often aiming at generating new technologies, does so for the most part in an ad hoc, piecemeal way without a clear prior analysis of the specific local land-use problems which the new technology is supposed to solve. The reservations aside, much of this research is of considerable potential value. It simply remains debatable whether the studies which have been begun are the most relevant to their respective situation.

Some international institutions, i.e. those either based in developed countries or supported more or less entirely by funds from developed countries and working on problems common to more than one country, are doing agroforestry research, or working on information and training in support of such research:

1. ICRAF in Nairobi is the only institution conceived expressly to perform agroforestry research on a global basis;
2. the international tree crop institutes (U.K., U.S.A. and Australia) are primarily occupied with data compilation relevant to multipurpose trees;
3. the Nitrogen-Fixing Tree Association (Hawaii, U.S.A.) is studying the assessment and development of leguminous trees;
4. the National Academy of Sciences (U.S.A.) collects information about fuelwood and legume tree species;
5. the Commonwealth Forestry Institute (U.K.) is involved with information, research, and training;
6. the East-West Centre (Hawaii, U.S.A.) includes agroforestry in its program of publications, meetings, and training;
7. the United Nations University is arranging workshops on agroforestry;
8. some components of UNESCO's research program include agroforestry;
9. some agroforestry projects are initiatives of universities in developed countries, e.g., the University of Arizona's Office of Arid Land Studies (U.S.A.), Wageningen Agricultural University (The Netherlands), the University of Hamburg and Freiburg (Federal Republic of Germany), and the University of Montpellier (France);
10. some CGIAR centers are engaged in technology-generating research of an agroforestry nature, e.g., IITA on alley cropping (*Leucaena*-maize), CIAT on *Leucaena* (acid soil-tolerance and mimosine content), and ILCA on browse trees and shrubs; an increasing awareness of the role of trees in the farming systems of their mandate areas has also become noticeable at IRRI, ICRISAT, and ICARDA, but it has not yet led to specific research activities;
11. FAO's Panel of Experts on Forest Gene Resources works in conjunction with IBPGR on data collection and assessment of information about arboreal species for the improvement of rural living, particularly in arid/semi-arid areas.

In addition valuable information of direct and indirect relevance to agroforestry is stored and, in many cases, systematically updated in former colonial agriculture and forestry institutions, such as the Tropical Products Institute (U.K.), various commonwealth institutes and bureaus (U.K. and Australia), The Royal Tropical Institute (The Netherlands), and CTFT, IRAT, and IEMVT of France (for tropical forestry, agriculture, and animal husbandry, respectively). Although this cumulative list may seem impressive, it is not likely that in budgetary terms the total volume of work in progress directly related to agroforestry exceeds US$10 million per year.

At regional and national levels an increasing number of institutes are adding agroforestry-related research to their programs. Some of the more long-standing and interesting research efforts have originated, not surprisingly, in the South and Southeast Asian regions.

In India several of the Indian Council for Agricultural Research institutes are involved in refining technologies and systems of direct relevance to agroforestry, particularly the:

1. Grassland and Fodder Research Institute (IGFRI) in Jhansi—multipurpose (fodder) trees;
2. Central Arid Zone Research Institute (CAZRI) in Jodhpur—*Prosopis cineraria* and other dry-land multipurpose species;
3. Central Plantation Crops Research Institute (CPCRI) in Kasaragod—multi-story, mixed cropping;
4. Central Soil and Water Conservation Research and Training Institute in Dehra Dun — the use of multipurpose trees for conservation.

Other Indian institutions partially involved in agroforestry include:

1. the Forest Research Institute and Colleges at Dehra Dun—taungya and other tree establishment methods and fuelwood;
2. the Indian Institute for Management in Allahabad—social aspects of village and rural use of trees;
3. the Xavier Institute in Bihar—sociological and institutional aspects of agroforestry;
4. several agricultural universities at scattered locations throughout India.

As in India, a number of institutes elsewhere in Southeast Asia are actively engaged in research technologies:

1. in Indonesia—the Organization for Tropical Biology (BIOTROP), the Forest and Forest Products Research Institutes of the Agency for Agricultural Research and Development in Bogor, the Institute of Ecology in Bandung, the Forestry Faculty of the Gadjah Maja University in Yogjakarta, and Perum Perhutani in Jakarta;
2. in the Philippines—the Forest Research Institute, College, Laguna, the Paper Industries Corporation (PICOP), the University of Los Banos, and the Visayas State College of Agriculture at Leyte;
3. in Malaysia—the Malaysia Agricultural Research and Development Institute, the Forest Research Institute at Kepong, the Palm Oil Research Institute of Malaysia, and the University of Malaysia at Kuala Lumpur;
4. in Thailand — the University of Chiang Mai and Kasetsart University;
5. in Papua New Guinea—the University of Papua New Guinea at Lae.

This list, which is incomplete, suggests the variety of institutions engaged in some form of research on agroforestry-related subjects. In Southeast Asia, SEARCA has recently taken the initiative to create a Regional Agroforestry Research and Education Network in which many of the institutions mentioned above will, it is hoped, take part. A series of research projects are planned in which ICRAF will share in the project formulation phase.

ICRAF's role and program

The International Council for Research in Agroforestry (ICRAF) was set up in 1977 at the Royal Tropical Institute in Amsterdam. It moved to its present headquarters in Nairobi, Kenya in 1978. ICRAF's mandate is to stimulate, initiate, and support research for the development of sustainable and productive land-use systems (in the developing world) based on the integration of woody perennials with crops and/or animals.

The Council, governed by an international board of trustees, is entirely independent from all supra-national bodies, and receives its operational funds principally from various bilateral donor agencies and private foundations.

ICRAF spent some initial years searching for an identity and a strategy to fulfil its mandate. This was no easy task in a new and exciting field, one full of temptations in the form of a practically unlimited number of challenging and interesting problems and activities. ICRAF set to work, moreover, in an atmosphere charged with enormous international expectations, but it was endowed with extremely modest funds. At its 1981 and 1982 meetings ICRAF's Board of Trustees finally agreed upon a comprehensive work plan for the coming four-year period. This plan had three foci.

1.The development within ICRAF of an interdisciplinary capacity and appropriate methodologies to assess constraints in land-use systems and to identify agroforestry solutions to overcome these constraints. In order to achieve this end, after systematically identifying the expertise and knowledge required in the field of agroforestry, ICRAF recruited a multidisciplinary core team of scientists and land-use experts. The team consists of an agronomist, a horticulturist, a forester, an animal husbandry expert, a social anthropologist, a farm economist, a bio-climatologist and a physical land evaluation expert/soil scientist Both in Kenya and elsewhere through collaboration with international, regional, and national institutions, the team is now working on the development of a diagnostic and design methodology.

2.The systematic collection and evaluation of existing knowledge about agroforestry technologies, and the development of methods for the appropriate study of such information.

3. The establishment of an efficient program for disseminating information about agroforestry methods and technologies to scientists, development planners, and institutions in developing countries.

These objectives are to be achieved through seven mutually supportive programs within which all ICRAF projects and activities will be carried out:

1. management and administration—this component deals with program planning and coordination, fund raising, public relations, and general administration;
2. information services — ICRAF will offer an information request service and assemble documentation files on agroforestry, particularly on various

agroforestry systems and on multipurpose trees. It will have a library for in-house and external use and produce publications on agroforestry. An IDRC information specialist, a documentalist, a. library assistant, and a publications officer make up the staff, with disciplinary inputs provided by other staff where necessary;

3. training and education—ICRAF will mount training courses in agroforestry research and development methods and in material development. Fellowships and on-the-job training will be available. This program, supported by USAID and the Ford Foundation and led by a recently recruited training officer, is expected to get under way in 1983;
4. agroforestry systems research and evaluation — the development of interdisciplinary methods to study and develop agroforestry systems, e.g., the diagnostic and design (D&D) methodology, economic evaluation of agroforestry systems, and methods of assessing systemic sustainability. This program will also be responsible for a global inventory and evaluation of existing agroforestry systems;
5. agroforestry technology research and evaluation — ICRAF will review the potential role of agroforestry technologies for enhancing food, fuel, and fodder production, soil conservation, and socio-economic well-being; and develop methods to study and evaluate agroforestry technologies, particularly those which involve multipurpose trees;
6. field station -- a small (40 ha) field station, 70 km outside Nairobi, is being developed as a support for other ICRAF programs. It will include agroforestry demonstration plots for training and public relations. It will also be a site for field research in connection with methodology development;
7. collaborative and special projects — the creation of an international network of agroforestry research and development projects in developing countries will facilitate the dissemination and testing of the Council's interdisciplinary diagnostic and design methodology. Projects are under way with institutions in Peru (INIPA, CIAT, North Carolina State University), Philippines (SEARCA, VISCA), Costa Rica (CATIE), and Kenya (National Dryland Farming Research Station at Katumani). Preliminary contacts have been made with ICARDA in Syria, IITA in Nigeria, CAZRI (ICAR) in India, and EMBRAPA in Brazil.

It must be stressed that ICRAF is not set up as an institute to generate locally adapted agroforestry technologies or whole systems through field research. This can only be done by local institutions with the facilities required to carry out long-term field research. Nor is ICRAF able to fund the work of other institutions. It is a Council, housed in a mid-city office building in Nairobi, with a modest annual budget and a senior scientific and administrative staff of 15. It is, however, the only institution established expressly to work with agroforestry research issues on a global scale. It is one of the few organizations in the world with the professional competence to deal with practically all aspects of land development: physical, biological, social, and economic. The fact that ICRAF's scientists retain and cultivate working relations with outside colleges and institutes has led to a situation where the Council's network of contacts not only crosses international and language barriers, but also transcends disciplinary and institutional boundaries. This situation, in combination with the Council's own institutional independence, makes it possible for ICRAF not only to collaborate with any type of institution, but also to initiate cooperation between scientists and institutes in both developing and developed countries.

How to identify relevant agroforestry research—ICRAF's diagnostic and design approach

Research towards development of locally adapted agroforestry technologies and systems attempts to address the real problems of farmers and other land users. In so doing it invariably encounters difficulties at many different levels:

1. how to identify relevant research topics;
2. how to ensure a sufficiently multi-disciplinary input;
3. how to cope, in field research and trials, with the complexity (interactive components) and periodization (rotation of trees/shrubs) inevitably involved in agroforestry technology validation research;
4. how to develop, evaluate, and rate, in quantitative terms, the germplasm of multipurpose trees/shrubs.

The second question has been partially answered in the previous text. The third has been discussed in several papers by Huxley (1979, 1981a 1981b, 1982a, and 1982b). The fourth is the subject of an ongoing joint project between ICRAF and the Commonwealth Forestry Institute (CFI), financed by the U.S. National Academy of Sciences. This project will draw up guidelines for an international network of national research projects aimed at developing fast-growing nitrogen-fixing trees. THe problem of genetic development of multipurpose trees and of agroforestry combinates of trees and herbaceous crops has also been discussed by both Burley (1979) and Pickersgill (1931) and will be the subject of an ICRAF/IBPGR/CFI workshop in mid-1983.

The remaining question, the first one, how to identify relevant research topics, will be considered here. If agroforestry is to live up to the world's expectations with regard to its problem-solving capabilities, it will have to significantly improve its ability to choose research topics and embark on development efforts which accord with the actual needs and potentials of tropical land-use systems. ICRAF's research strategy places a major emphasis on the development of a diagnostic and design methodology to guide agroforestry research and development (R&D) toward relevant and practical solutions to location-specific land-management problems. A sketch of the principal features of this evolving methodology appears below together with an explanation of their internal logic and rationale.

Why diagnosis is necessary

Our ultimate aim is to develop land-management systems and technologies with specific capabilities to solve land-use problems in areas where agroforestry is deemed to have a role. When confronted with an ailing land-use system, agroforestry planners and practitioners must identify and prescribe relevant problem-solving treatments. The nature of their task is analogous in many respects to that of a doctor who confronts a diseased human organism.

It is a cardinal rule in the medical profession that diagnosis should precede treatment. In practice there are exceptions to this rule, of course, but it would be unthinkable for doctors ever simply to ignore the diagnostic process altogether, and prescribe treatment without due regard for the specific nature of the patient's illness. We would hardly tolerate a haphazard, hit-or-miss approach to treatment from professions dealing with human pathologies. How strange then that we have come to accept such an approach when it comes to treating pathologies arising from man's use of the earth. Is this not in fact what happens in many cases when a traditional agricultural or forestry research station develops a new technology and recommends it for dissemination? In how many instances is the treatment preceded by an adequate diagnosis of the actual and perceived problems which confront the majority of land users in the recommendation domain? The answer of many researchers, that they "already know what the problems are" without having to bother with the complications of a formal diagnostic procedure, is analogous to a doctor's making either the patently absurb assumption that all patients are the same, or his claiming arrogantly that a well-trained practitioner is able to treat patients without recourse to an examination.

No wonder the cure rate for land-use problems is so low! Technologies developed for conditions which prevail on research stations, high farms (Rolling, 1980), and forest management units are often abysmally inappropriate when extended to the majority of land users in an agroecological zone. The problem is not that the bio-physical parameters of the zone have not been taken into account. On the contrary, these are usually well understood. What goes wrong is that single discipline-oriented researchers too often fail to perceive that the "patient" in the final analysis is the existing land-use system, which has its own internal organization and its own unique set of operational constraints and potentials.

The problem with an ad hoc approach to technology generation is that researchers are rarely capable of taking the full set of relevant design criteria into consideration. It was never a very effective strategy to design technology on the basis of only a partial set of design criteria and then to treat the failure of farmers to adopt the resulting technology as an extension problem. It will almost always be more useful to place the onus of responsibility for unsuccessful transfer of relevant technology squarely on technology development professionals, recognizing that the problem is, in the first instance, a design problem. There is simply no substitute for good design. To achieve this objective will usually require coordinated inputs from an interdisciplinary team of professionals, as well as from the intended users of the eventual technology product.

A problem-oriented diagnostic approach to agroforestry design is felt to be the most direct and logical route to effective and transferable agroforestry technologies and land-management systems. In developing its diagnostic and design methodology, ICRAF recognizes that a quick turnaround on diagnostic and design activities is absolutely necessary in order to have a timely influence on the project planning cycle. It is not envisaged that a long drawn-out survey process will be either necessary or useful. Rather, the Council's aim is to develop a practical, effective, and quickly realizable D&D protocol which can prove its utility in a wide range of environments around the world.

The logic of agroforestry diagnosis and design

The logic of any methodology must be compatible with its aims, and the aims of ICRAF's D&D methodology are eminently practical. In the final analysis the success of the methodology will be judged not by the number or by the elegance of resultant agroforestry technologies, but by the impact of the methodology on the total landscape, i.e., how effective it has been in the transformation of human landscapes into more productive and sustainable land-use systems. A successful D&D methodology must somehow guide potential users to agroforestry technologies which embody three essential attributes: productivity, sustainability, and adoptability.

The first two criteria are virtually axiomatic. Agroforestry has been almost universally defined as an approach which seeks to improve the productivity and sustainability of land-use systems. Plenty of technologies are capable of increasing productivity, but are they also sustainable? Likewise, there are numerous technologies for resource conservation, but are they productive? Agroforestry has demonstrated significant potential for achieving both objectives simultaneously. This combination of goals is not, of course, an automatic feature of every conceivable agroforestry system, but it is indeed part of good agroforestry design, where measurable production and conservation benefits are, or ought to be, two sides of the same coin.

With regard to the adoptability of new agroforestry programs, it is perhaps not superfluous to point out that any technology, no matter how efficient or elegant in its problem-solving capabilities, will have little impact unless it is acceptable to a significant percentage of its intended users.

Nutritionists refer to an analogous fact of life when they note that the nutritional value of food that is not eaten is zero, regardless of its chemical composition. The practical point for agroforestry diagnosis and design is that many factors other than gross technological irrelevance may limit the adoptability of an otherwise promising technology. These factors must somehow be identified, and dealt with by the D&D process.

Most possible adoption constraints have to do with the level of available resources and management skills in a given system, or with the incompatibility of a candidate technology with either existing practices and/or cultural norms and values associated with the general technological tradition of the area. It may be difficult, or even impossible, to diagnose all of the potential adoption constraints before undertaking farm trials of candidate technologies. The D&D process can, however, be guided initially by a certain psychological corollary to basic problem-solving techniques: it is not the solution of problems per se which is of greatest interest to potential technology-adopters, but the solution of perceived problems. The core of ICRAF stategy is the common-sense assumption that the ability to solve a problem begins with the ability to define it. Such an orientation advances us half-way towards our goal, inasmuch as technologies capable of solving local problems are more likely to be adopted than those which are not. The most common error of the R&D/extension process is the local introduction of technologies which solve problems which exist somewhere else, e.g., on a reseach station or in some other land-use system.

For an adoption-oriented, impact-maximizing strategy which focuses R&D attention on the solution of perceived problems in existing land-use systems, two practical implications stand out. The first pertains to the diagnostic phase, a time when it is absolutely essential to involve the land user in the R&D process, for only he or she can shed light on perceived problems. This realization explains the importance in ICRAF's D&D methodology which is placed on analyzing perceived management problems and strategies at the household or unit management level. The second implication pertains to the design phase. It arises from the fact that not all problems which constrain the productivity and sustainability of a household land-management system are necessarily perceived by the manager. This is particularly likely to be true with sustainability problems. Even when such a problem is perceived, its solution may not rank high in the farmer's priorities so that technologies designed to solve the problem fail to awake user interest. Many people may regard this as an extension education problem, but it can clearly also be considered a problem of technology design.

Where research scientists and land managers may not share similar perceptions of land-use problems, in certain instances the multifunctional nature of many potential agroforestry technologies may come to the rescue. The challenge for the technology designer is to find an attractive way to link an unwanted conservation function, for example, to some desirable production function of a well-chosen multipurpose technology. One might then obtain sustainability benefits as a by-product of a farmer's decision to adopt the proposed technology for its production incentives, i.e., for the help it gives him in solving some high-priority household supply problem.

By way of illustration, in our D&D work in Kenya we have encountered farmers with little or no present interest in erosion control, a severe problem in dry hill areas. The farmers, nevertheless, appear very interested in planting hedgerows of fast-growing leguminous trees to satisfy their household fuelwood needs. By planting dense hedgerows of coppicing fuelwood trees on the contour with row spacings selected for effective erosion control, we can achieve two ends with a single, appealing design. Such design tactics lend themselves well to the incorporation of flexibility for future functional expansion. Other farmers in Kenya, for example, have been identified as having a definite, present interest in erosion control, but no immediate, perceived problem with fuelwood supply. Where trend analysis indicates a future fuelwood problem such farmers can be induced to plant dense hedgerows with fuelwood potential in order to hold down the soil. Presently the farmers can begin to manage the hedgerows for fuelwood once the anticipated crunch does come.

Productivity and sustainability, then, are the criteria we apply in analyzing existing land-use systems in order to diagnose constraints which limit the performance of the system. Productitivy, sustainability, and adoptability are the criteria we use to identify corresponding agroforestry potentials and to evaluate candidate technologies and land-use system designs. In our analyses it is necessary to distinguish between two distinct levels or orders of constraints and potentials: those pertaining to the performance of output sub-systems in existing land-use systems, and those pertaining to the appropriateness of candidate agroforestry technologies.

Thus two orders of evaluation, each dealing with constraints and potentials of a different type, are required for thorough research. These two orders of evaluation are embedded in the following sequence of analytic activities which progresses from diagnosis to design:

1. characterize essential features of structure and function sub-systems;
2. evaluate the performance of the sub-systems (identify problems);
3. determine what constraints limit the performance of the sub-systems;
4. identify general potentials for performance-improving (constraint-removing) interventions of an agroforestry nature (candidate technologies);
5. determine constraints which may impair the appropriateness of candidate agroforestry technologies (components and practices);
6. identify remaining potentials for specific agroforestry technologies (existing or to be developed).

With the foregoing as a general conceptual background, let us look a little deeper now into the logic of agroforestry diagnosis and design and consider what is necessary at each of the above-listed steps if we are to do the job well.

Identification of output sub-systems

We have said that we shall give priority to the household land-management unit, or its functional equivalent, as the primary decision-making unit and reference system for our analysis of land-use patterns and problems. This is because the household is ordinarily the primary decision-making unit with respect to specific land-use practices. Of all the possible ways to define sub-systems, we have opted for a definition in terms of output sub-systems because: a) this is the least restrictive of the modeling possibilities; b) it is the most compatible with various useful techniques of input-output analysis; and c) it is the most consistent with the way land users actually manage their land, i.e., to produce desired outputs. A major output sub-system, then, may be defined as the set of all activities, resources, and other land-use factors which are involved in the generation of an output intended to satisfy one of the basic production objectives of the household.

In deciding specifically what output categories to consider as basic, it is important, if we are to develop a practical methodology, to satisfy two general requirements: a) the need for general applicability, and b) the need for adequate representation of the idiosyncracies of local land-use systems. To satisfy both these requirements and to facilitate ready linkage with standard categories of agroforestry technologies, we have found it fruitful to follow what we call "a basic needs approach." There are six output categories which we consider basic to the economic well-being of households everywhere: food, energy, shelter, raw materials for home industry, cash, and community integration.

Items 1, 2 and 5 are self-explanatory. Item 3 is intended to include all forms of shelter (housing for people and livestock, shade, windbreaks, etc.) and enclosures (fences, kraals, boundary markers, etc.). Item 4 is a catch-all category meant to accommodate all raw materials for household or village manufacture of everything from clothes and kitchen implements to medicinal preparations, i.e, all locally manufactured consumer items, whether for home consumption or sale. Item 6 is another broad category including all forms of "social" production and consumption, e.g., feasting, gift-giving, bridewealth, patronage, taxes, education, etc.

Underlying this sub-system approach are the assumptions that a) the basic needs in the list are universal; b) local systems may display great variety with respect to the forms in which these needs are ideally satisfied (food and fuels preferences, shelter types, etc.), but essentially the same themes are valid everywhere; and c) local and regional land-use systems, whatever else they may do, are organized to produce goods aimed at satisfying these basic needs. The way in which various land-use systems fulfil this function, of course, will differ. In commercialized land-use systems, cash crop production for income to purchase basic commodities will be the predominant household strategy. In subsistence-oriented economies, the household land-use system will be organized to meet needs more directly.

The use of basic needs terminology should not be understood to imply any restriction whatsoever on the level of economic development. The needs we have distinguished may be basic in type, but they admit many levels of satisfaction. We are interested in laying a foundation for the development process, not in constructing a ceiling.

Problem identification

Once basic needs sub-systems have been identified, we may proceed directly to problem identification. The objective of this step, to particularize problems which exist vis-a-vis the productivity and sustainability of the basic land-use systems, is first approached through intensive interviews with representative farmers to ascertain what difficulties they experience in supplying their basic consumption needs. The following example, from Kathama, Machakos District, Kenya illustrates the application of the methodology to a semi-arid-zone mixed farming system in the midlands of East Africa.

Problems identified in household basic-needs supply sub-systems:

1. food sub-system — seasonal shortages of staple foods are normal, deficits must be made up by purchases; drought-related crop failure requiring famine relief occurs, on an average, once every five years; low milk and meat production results from dry-season feed shortage for livestock;
2. energy sub-system — there is an insufficient production of fuelwood from farmers' own lands; they must purchase fuelwood for household and cottage

industry use. A lack of large trees for firing bricks also exists;

3. shelter sub-system — the lack of construction quality timber and poles means that farmers must purchase expensive supplies. There is a shortage of large trees for firing bricks, and an inadequate supply of fencing and shade trees. Wind dessication of crops is potentially a problem;
4. raw materials sub-system — farmers must purchase expensive fuelwood supplies for butchery and brick-making enterprises;
5. cash sub-system — low net household income can be attributed, in part, to the cash outflow for staple foods, fuelwood, and construction wood (see above); the earning and saving potentials of livestock enterprises are limited by the dry-season feed gap;
6. community integration — there are difficulties in meeting expectations for cash contributions to numerous harambee self-help projects, as well as educational expenses.

Identification of problem-ridden sub-systems prior to a detailed analysis of the land-use system as a whole is an economical measure. Thereafter diagnostic attention can focus on sub-systems which appear to be in especial trouble.

Analysis of land use constraints

Once vulnerable sub-systems have been recognized and the general nature of household supply problems has been ascertained, the stage is set for an analysis of the land-use system designed to trace the etiology of supply problems. To continue with the Kathama example:

Antecedent causal factors:

Crop land:

1. low fertility and declining yields;
2. lack of manure;
3. oxen too weak for dry-season plowing and planting as recommended for efficient use of limited soil moisture;
4. soil erosion and water loss from poor infiltration and heavy runoff of rain water;
5. waterlogging on low spots;
6. labor bottleneck at plowing and weeding times;
7. pigeon pea pests.

Grazing land:

1. small grazing area;
2. insufficient dry-season feed production;
3. overgrazing and soil erosion.

The first step of this analysis involves intensive discussions with farmers to probe their perception of the causes of these problems, while the interviewer conducts a visual inspection of their farms. Additional objective measures are being developed to supplement the interview and observation data in order to arrive at a more quantitative appreciation of land-use problems. The output of this step is twofold: a spot diagnosis, and sufficient information for drafting a structural model of problem etiology. Indeed, a causal network diagramming technique has been found useful in analyzing the interrelationships among land-use problems and in identifying the critical constraints which limit the productivity and/or sustainability of the system.

Identification of potentials for problem-solving agroforestry interventions
The resulting model or models of problem etiology then serve as the basis for identifying points in the system where potentials exist for interventions designed to remove, reduce, or avoid specific constraints. The procedure for this analysis is, in principle, quite straightforward: the analyst simply studies the causal diagram(s) and, for each node in the causal network, asks himself the question, "Is there anything trees could do to solve or mitigate this problem?" Ideally, this exercise should be conducted as an interdisciplinary brainstorming session with the intention of opening up thinking about possible land-use alternatives.

While the primary aim is to emerge from the exercise with a set of design specifications for hypothetical problem-solving technologies of an agroforestry nature, non-agroforestry alternatives should also be considered. Where these are incontestibly superior to an agroforestry alternative, they should be recommended. If, after careful consideration, there appear to be no promising agroforestry approaches, then the agroforestry exercise should be terminated and the problem referred to appropriate non-agroforestry specialists. Agroforestry does not have a solution to offer for every land-use problem, and there is simply too much real agroforestry work to be done in the world to waste time trying to force agroforestry technologies into land-use systems where they have no clear and significant role to play.

At present the state of our knowledge about agroforestry technology is so limited, however, and we have little hard information, that it is perhaps better to err on the side of optimism regarding the potential of hypothetically appropriate agroforestry land-use systems. Such optimism should seem justified in order to stimulate further national development and R&D of hypothetical agroforestry technologies. One desirable output from such R&D would be the data necessary to evaluate, objectively and quantitatively, the comparative performance of agroforestry and non-agroforestry land-use alternatives.

Minimally, when the agroforestry diagnosis and design team has completed this step of the analytical process, it should have a clear picture in mind of what general kinds of agroforestry technologies, by addressing specific end-use or service potentials in the system, might have a role to play in solving land-management problems. In Kathama, to return again to our previous example, the following specific problem-solving agroforestry alternatives were identified:

1. alley cropping/mulch farming with leguminous and other suitable trees to control erosion, increase rain water infiltration, reduce runoff, conserve soil moisture, improve soil fertility and structure, reduce the traction requirements for tillage (or the tillage requirement in general by minimum tillage management), diminish the labor requirement for weeding, and possibly provide some measure of pest control through the use of insect-repelling mulch species;

2. multi-purpose fodder trees in grazing areas to reduce or eliminate the dry-season feed gap, and as hedge-rows, in and around crops with concommitant erosion control and windbreak benefits and fuelwood and mulch coproduction possibilities; the improved feed situation should allow dry-season plowing and planting;
3. hedgerows and living fences of high-yielding fuelwood species and fruit-producing thorn bushes for better livestock control; appropriate plantings can also function as protection against famine in bad years and as a source of supplementary livestock feed in average years;
4. multi-story fruit tree plantings with undersown grass/legume pasture;
5. cut-and-carry fodder trees for increased pen-feeding of livestock to improve dry-season nutrition and increase the amount of collectable manure.

Identification of constraints on potential agroforestry interventions

The next step is to evaluate which of the generally appropriate and functionally relevant agroforestry technologies recently identified remain specially promising in the context of a detailed analysis of site constraints. The order of analytical procedures is here again intended to be economical, for the gathering of detailed data on site and land-management characteristics can now be limited to whatever is necessary to evaluate technological hypotheses.

Before making a final screening of candidate technologies (components and practices), we must ascertain what constraints might interfere with their adaptability to site conditions and/or their adoptability in the context of local farming practices. First we reject those components which are rendered inappropriate by climatic, edaphic, and/or biotic constraints. In Kathama, for example, the biotic constraint of high termite populations in the semi-arid zone of Kenya excludes from consideration any mulch species which provides a good habitat for these pests. We are left, then, with those potential mulch species which have at least the hypothetical ability to repel or discourage termite infestation (e.g., *Adzadirachata indica, Adhatoda vasica, Derris indica).* This is a good illustration of notional agroforestry technology with an unknown potential which could prove rather high. This fact alone would appear to justify its further research and development.

After a screening of components on grounds of natural adaptability, the rejection process shifts to the identification of practices which are unlikely to be adopted by farmers because the practices conflict, for one or more reasons, with the local farming system, e.g., infeasible resource requirements, labor bottlenecks, management incompatibilities, etc. To refer again to Kathama, here the establishment techniques initially used to plant out the first round of alley-cropping farm trials were found to be incompatible with the local practice of plow weeding which buried the young mulch tree seedlings under a heavy layer of soil. It may, however, be possible to modify local farming practices somewhat to accommodate the new technology (e.g, local farmers seem to have no objections to a change in their time-honored plow-weeding practice). Otherwise it may prove necessary to search for an acceptable agroforestry alternative.

Finally, having eliminated various suggested components and practices along the way, we arrive at a set of feasible agroforestry alternatives which must be compared with each other, with existing land management practices, and with non-agroforestry alternatives to determine which, if any, of them offer promising potential for incorporation into site-specific, problem-solving agroforestry designs.

Follow-ups and conclusion

The "rapid appraisal" diagnostic and design procedures outlined above are merely the beginning of the technology R&D cycle. For project development appraisal should be followed, depending on the state-of-readiness of the technology in question, by immediate on-farm trials of the more promising agroforestry technologies (existing off-the-shelf solutions, so to speak, from the current inventory of agroforestry technology), and/or by on-station R&D to develop notional or candidate technologies for later incorporation into on-farm trials. These activities entail their own methodological needs. In the fullness of time ICRAF intends to collect, develop, and disseminate information and methodologies relevant to the full range of biophysical and socio-economic research questions involved in the development of agroforestry's potential to provide solutions to global land-use problems.

In conclusion, what has been described in a brief and sketchy form above is the core logic of an evolving diagnostic and design methodology which, in its totality, is intended to serve as a reliable tool for arriving at effective agroforestry solutions to local land-use problems the world over. Successful completion of this decidedly ambitious undertaking will be possible only with the full and active participation of the international community of agroforestry research workers. ICRAF eagerly solicits comments on and contributions to the methodology outlined in this paper.

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