ICRAF
Strategy to the year 2000

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International Council for Research in Agroforestry

The Potential of Agroforestry

'Agroforestry is not only the most promising approach to reforestation and the supply of fuelwood, it is also, in yield-boosting forms like windbreaks and alley cropping, the most hopeful avenue for intensifying African agriculture over the next five to ten years, increasing food production and reducing exposure to drought with few or no outside or imported inputs. Agroforestry is arguably the single most important discipline for the future of sustainable development in Africa.'

Paul Harrison, *The Greening of Africa*

What is ICRAF?

The International Council for Research in Agroforestry (ICRAF) is an autonomous, non-profit international research council governed by a Board of Trustees with equal representation from developed and developing countries. ICRAF was founded in 1977 and established its headquarters in 1978 in Nairobi, Kenya. Operational funds are provided through voluntary contributions by bilateral, multilateral and private organizations. The organizations supporting ICRAF in 1990 are listed in Annex 2.

ICRAF, Nairobi CA

International Council for Research in Agroforestry:
ICRAF: Strategy to the Year 2000. Nairobi, Kenya, ICRAF, 1990. 76p.; ill.

ICRAF; agroforestry; suustainable development; programme development; strategy; resources; training; research; information services; networks; institution building.

ISBN: 92 9059 082 3

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INTRODUCTION

Why a strategy for ICRAF?

ICRAF has undertaken a strategic planning exercise for several reasons. First, the importance of worldwide environmental issues has emerged in the late 1980s. Because of the potential of agroforestry to address these issues, their importance directly affects priority setting at ICRAF. In response to these issues, the Council must redouble its efforts to generate agroforestry technologies that conserve natural resources while simultaneously meeting basic human needs. A strategy-development exercise has been necessary to identify the most promising avenues of research in this complex area—one in which ICRAF, given the necessary resources, could make a major impact.

Second, the explosion of interest in agroforestry over the last few years has led to unprecedented pressures on ICRAF. Between 1986 and 1990, requests received by the Council from sources other than its collaborative research partners have increased by about 100% each year. This is 10 times faster than the current rate of increase in the Council's ability to respond to such requests—that is, in its core resources. There is every reason to assume that the first half of the 1990s will see a continuing escalation of the demand for ICRAF's services. Thus, the Council must develop a strategy for deciding which requests it can and cannot meet.

Third, the international status of ICRAF and the complexity of agroforestry both imply that the Council's research and other activities will be long term in nature. This means that programme decisions taken now will have resource and output implications well into the 1990s. Clearly, the three- to five-year planning horizon set by ICRAF since 1980–81 has become too short. We need to look further ahead.

Fourth, the organizational arrangements for international agricultural and forestry research are currently under debate. The Consultative Group on International Agricultural Research (CGIAR) is reviewing some of the 'non-associated centres'—those that deal with resource-management issues relevant to its mandate to increase self-reliance in food production—in terms of their suitability for membership of the group. Simultaneously, several aspects of forestry research are being reviewed for inclusion in the CGIAR system. This review has led to the identification of ICRAF as the institution best placed to take a leading role. Responsibility for these reviews lies with the Technical Advisory Committee (TAC) of the CGIAR, which requested, as a guideline for its assessment of ICRAF, the Council's own view of its role in the 1990s.

The strategy document

This strategy document is organized as follows. Chapter 1 provides an introduction to agroforestry and describes the development of ICRAF. Chapter 2 outlines the international search for sustainable rural development, including an analysis of the potential of agroforestry and an agenda for agroforestry research. Chapter 3 presents ICRAF's mandate, goal and major activities, together with the operational considerations that will shape its future programmes. Chapter 4 describes the eight programmes that ICRAF will implement during the 1990s. Lastly, Chapter 5 outlines how these programmes will be implemented and the resources that ICRAF will require.

Introduction

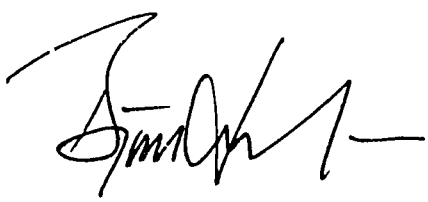
ICRAF's strategy covers the 1990s. The Council has not attempted to look beyond this horizon, believing that the conditions under which it might operate in the next century are too unpredictable to make it worthwhile attempting such a task.

The scope of this strategy document is restricted to agroforestry. It does not review the strategic options for those aspects of forestry research currently under consideration for inclusion in the CGIAR system, since the institutional arrangements for their incorporation are still under debate.

This strategy document is the result of a participatory process that has involved ICRAF's management, staff and Board of Trustees, as well as representatives from institutions collaborating with ICRAF and from the donor community. Guidelines for formulating ICRAF's strategy were provided by the Board at its annual meeting in 1988. ICRAF's second external review team made several recommendations regarding the Council's strategy in the course of its 1989 review. Also in 1989, a five-day brainstorming session attended by two external consultants facilitated the exploration of a wide range of issues. Throughout this period, management and staff provided ideas and background material. A strategy group was formed in early 1990 to coordinate these inputs; its work led to the completion of a first draft in February 1990.

The first draft was sent to a wide circle of representatives from donor agencies and collaborating institutions, many of whom were invited to ICRAF headquarters for three days in March 1990 to discuss its content. This meeting, together with the many written comments received, made extremely valuable contributions to our thinking. A second draft, reflecting these contributions, was prepared and presented to ICRAF's Board at its April 1990 meeting. Subject to a few further modifications, the Board approved the document.

We at ICRAF are confident that this strategy document charts an imaginative but realistic course for ICRAF in the 1990s. It is a course that responds to the needs expressed by national scientists and the resource-poor farmers who are the *raison d'être* of ICRAF. We therefore ask the donor community to endorse ICRAF's strategy and to support the Council in the challenging task of implementing its programme in the years ahead.



Bjorn Lundgren
Director-General

Agroforestry and ICRAF

A NEW SCIENCE

The concept of agroforestry

1.01 It was only in the mid-1970s, through the background work that led to the establishment of ICRAF (see 1.11), that the word 'agroforestry' and the concept behind it were brought to international attention. Several factors led to the emergence of agroforestry as a subject of serious study:

- Environmentalists concerned about the effects of deforestation and tree cutting increasingly called for the protection of remaining forests and for the introduction of more woody perennials into managed land-use systems.
- Ecologists and anthropologists began to explain and quantify the mechanisms behind the positive influence of forests and trees on the stability of natural ecosystems and traditional land-use systems.
- Foresters started to design major programmes for social, village, rural and other forms of forestry, aimed at making the benefits more accessible to local communities.
- Agronomists and soil scientists began to investigate the role of trees and shrubs in maintaining soil fertility and controlling soil erosion in small-scale farming systems.
- Livestock experts began to understand the important role of browse in both mixed farming and pastoral production systems.
- Horticulturists had long realized the benefits of integrating secondary crops with commercial tree crops in order to increase total economic output from land.

1.02 The discussions that led to the establishment of ICRAF contributed to the analysis and synthesis of these seemingly unrelated findings and trends and highlighted the great potential benefits of exploiting the deliberate mixture of trees/shrubs with crops and animals. The concept of agroforestry was born.

1.03 The original report that led to ICRAF's establishment (Bene et al., 1977) and several subsequent statements proposed various definitions of agroforestry. These were often descriptions of what early promoters hoped could be achieved through agroforestry rather than definitions in the strict sense. Indeed, during this early period there was much exaggerated speculation about the potential of agroforestry, epitomized by references to 'miracle trees'. These unsubstantiated claims had the unfortunate effect of alienating a number of serious scientists from early efforts to promote agroforestry.

1.04 It was not until 1982 that ICRAF separated the definition of agroforestry from statements about its aims. The Council's working definition is as follows:

'Agroforestry is a collective name for land-use systems and practices where woody perennials (trees, shrubs, bamboos, vines, etc.) are *deliberately* integrated with crops and/or animals on the *same land-management unit.* The integration can be either in spatial mixture or in temporal sequence. There

must be *both ecological and economic interactions* between the woody and non-woody components to qualify as agroforestry.' (Lundgren, 1982)

This definition was developed for scientific purposes. In terms of development, there is no reason to draw sharp distinctions between agroforestry, horticulture, farm forestry or other uses of land involving trees.

1.05 The aim of a land user practising agroforestry, or of a scientist studying it, is to exploit the positive ecological and economic interactions between the woody and non-woody components in order to achieve higher productivity, sustainability and/or diversity of output than is possible through other forms of land use.

1.06 Fundamental to agroforestry is its potential to address combinations of problems through the same technology. Behind this potential lies the versatility of woody perennials. The same species can serve both productive functions, such as fuelwood, fodder and timber, and service functions, such as soil fertility maintenance, erosion control and microclimate enhancement. For this reason, multipurpose trees and shrubs are central to the concept of agroforestry.

The practice of agroforestry

1.07 The practice of agroforestry is just as varied as that of agriculture or forestry, if not more so. It ranges from simple forms of shifting cultivation to sophisticated hedgerow-intercropping systems; from systems with a low density of trees, such as the widely scattered *Faidherbia (Acacia) albida* seen in sahelian millet fields, to those with a high density, such as the complex multistoreyed home gardens found in the humid tropics; from systems in which trees play a predominantly service role, for example as windbreaks for crops or shade for livestock, to those in which they are the main commercial product, such as rubber plantations in which intercropping is practised. Besides the variability between systems there is also considerable variability within systems—in terms of the species used, the way plants are arranged and managed and the different outputs produced.

1.08 It is difficult to quantify the area of land under agroforestry today or to say how many people practise agroforestry. International and national statistics use the conventional terminology of agriculture, forestry and range management to classify land use, for instance for food grains or commercial crops, plantation or natural forest, ranching or pastoralism. Rarely do the statistics make it possible to determine the agroforestry practices hidden among these terms. However, as a broad generalization, it is likely that some form of agroforestry is practised by about half the rural population in tropical and subtropical regions on about two-thirds of the land area in productive use.

The science of agroforestry

1.09 The science of agroforestry builds heavily on conventional agricultural, forestry, livestock, social and information sciences. The methods and approaches from these disciplines must all be integrated and also adapted to meet the needs of agroforestry researchers. Agroforestry involves the study not of the tree alone, but of the tree in combination with other components. For this reason the study of agro-

forestry requires a broader range of expertise than does pure agricultural or forestry research. In addition, experimental designs in agroforestry research tend to be more complex than in agriculture or forestry.

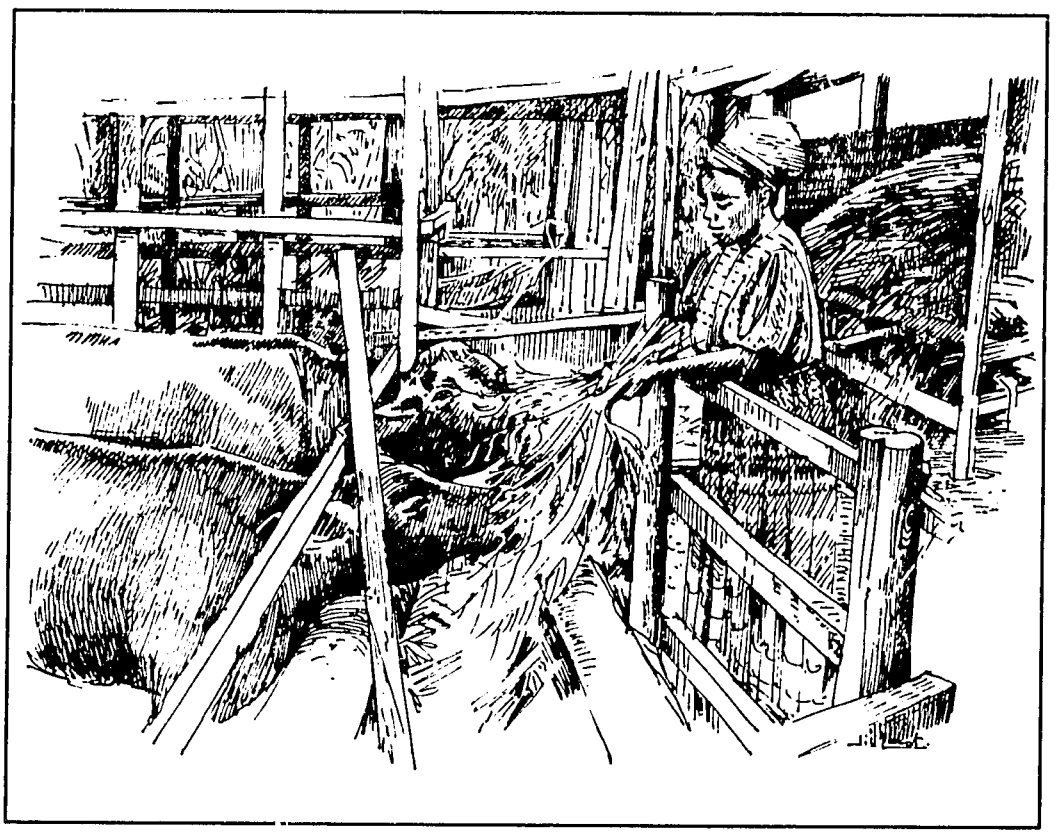
1.10 Like the science of agriculture, that of agroforestry can be subdivided into areas that lie 'upstream' or 'downstream' in the spectrum of research. For example:

- **Strategic research**: understanding the mechanisms and interactions underlying the performance of trees with crops and/or animals; developing methods to diagnose problems in land-use systems or to design field experiments
- **Applied research**: solving practical problems to improve agroforestry production systems, for example, improvement of multipurpose-tree/shrub germplasm, management of mixed tree/crop/livestock systems, development of nursery and transplanting technologies
- **Adaptive research**: adapting technologies to local conditions, assessing the impact of agroforestry technologies.

A NEW INSTITUTION

Foundation and mandate

1.11 In 1975 the International Development Research Centre (IDRC) of Canada initiated a study to identify tropical forestry research priorities for the period up to the end of the century. The chairman of the committee responsible for the study



was the late John Bene. The study began with a strong forestry bias, but as it progressed the emphasis shifted. In Bene's own words: 'Although the initial assignment stressed the identification of research priorities in tropical forestry, the study led to the conclusion that first priority should be given to combined production systems integrating forestry, agriculture and/or animal husbandry...'. The committee's report ends with the recommendation to set up 'an internationally financed council for research in agroforestry, to administer a comprehensive programme leading to better land use in the tropics' (Bene et al., 1977).

1.12 On the initiative of IDRC, potential donors and other interested parties met in Paris in November 1976 and decided to establish ICRAF along the lines proposed in the Bene report. A draft charter was approved and a Board of Trustees was elected in 1977. The overall objective of the Council, as stated in its charter, is 'to increase the social, economic and nutritional well-being of peoples of developing countries through the promotion of agroforestry systems to achieve better land use' (ICRAF, 1979).

The first decade: 1977–86

1.13 Progress during ICRAF's first few years was slow as the young institution tried to find its bearings in a new and complex field. In 1980, ICRAF's four donors requested the Board of Trustees to develop a clear strategy for the Council's future programme. The outcome of this first strategy exercise was that ICRAF should:

- Create a multidisciplinary team of scientists representing all the important fields of expertise required to assess tropical land-use systems
- Develop, through this team, an interdisciplinary methodology for diagnosing the constraints in land-use systems and designing agroforestry technologies to overcome them
- Disseminate this methodology to research and development institutions in developing countries.

1.14 ICRAF pursued these aims during the first half of the 1980s. Some of the achievements of this period are summarized in the section on ICRAF's achievements (1.24–1.35).

A shift of emphasis: 1986–90

1.15 ICRAF's first external review of 1984/85 recommended a shift of emphasis in the Council's programme. During its establishment phase ICRAF had, according to the review, made considerable advances in developing the concepts and methods needed to conduct agroforestry research. It was now time to apply this knowledge in collaboration with other institutions, with the twofold aim of generating appropriate agroforestry technologies and strengthening national research capacity.

1.16 This recommendation represented a logical progression and was in line with the thinking of ICRAF's Board and management at the time. Accordingly, in early 1986 a new programme of work was formally approved incorporating collaborative research with national institutions. With minor changes, this is the programme ICRAF is implementing today.

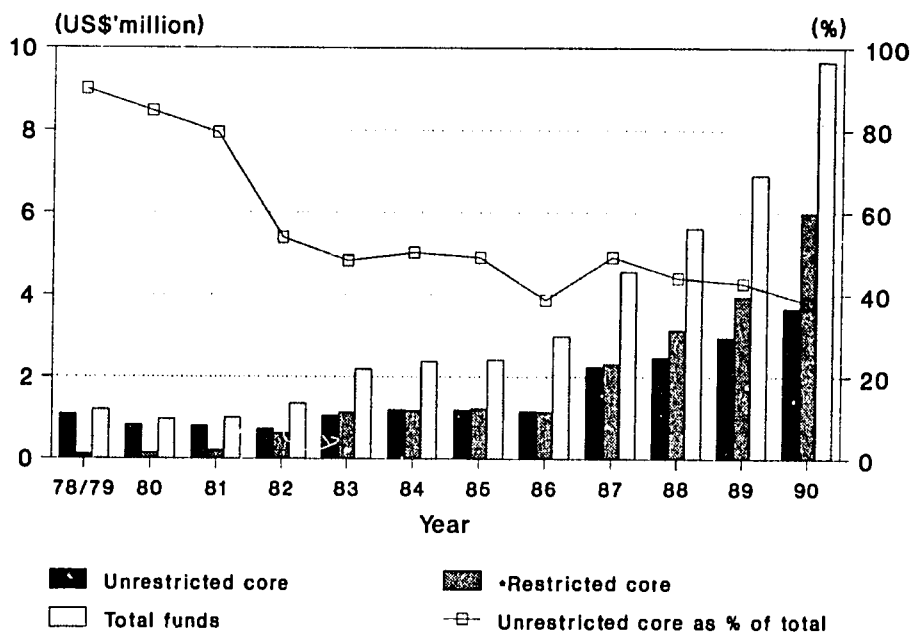
1.17 The formulation and implementation of the new programme were guided by three strategic objectives:

- To continue to develop the science of agroforestry and to maintain ICRAF's ability to provide global leadership in this field
- To collaborate with national institutions in building their capability to design and implement agroforestry research programmes and to work alongside these institutions to generate relevant technologies
- To promote the use of appropriate agroforestry systems and technologies as tools for national development.

1.18 These objectives were reflected in the Council's new organizational structure, which consisted of four divisions:

- The **Research Development Division**, responsible for conducting strategic research including the development of a scientific approach to agroforestry
- The **Collaborative Programmes Division**, responsible for conducting applied research in collaboration with national institutions to develop relevant agroforestry technologies and for building national programmes through training
- The **Information and Communications Division**, responsible for promoting appropriate agroforestry systems and practices as tools for national development
- The **Finance and Administration Division**, responsible for supporting the work of the other three divisions.

Figure 1.1. Development of ICRAF's budget, 1979–89



1.19 ICRAF's collaborative research programme was set up to support agroforestry research at the national level in Africa, using a network approach based on agro-ecological zones. Between 1986 and 1990, the programme launched four Agroforestry Research Networks for Africa (AFRENAs), covering the humid lowlands of West Africa, the semi-arid lowlands of West Africa, the highlands of Eastern and Central Africa (with bimodal rainfall) and the plateau lands of Southern Africa (with unimodal rainfall). Already in 1990, these networks covered areas in 15 countries and included nearly 90 experiments at 14 different sites, in addition to surveys and data analysis. Since these networks are an important element in ICRAF's strategy, their mode of operation is described more fully in Chapter 5 (5.08–5.16).

ICRAF TODAY

Resources

1.20 **Budget.** ICRAF's total budget was nearly US$ 10 million in 1990 (Figure 1.1). Despite rapid growth in funding during the second half of the 1980s, ICRAF remains a small institution by international standards, with a budget only a third the size of a typical 'large' centre in the CGIAR system. Unrestricted core funds account for about 40% of the total budget, reflecting strong donor support through special project funding.

Figure 1.2. ICRAF's professional staff in early 1990

Degrees	Doctor's	Master's	Bachelor's	Diploma
International staff	24	7	2	2
Local staff	—	9	8	5
Other professional staff	2	11	2	—
Total	**26**	**27**	**12**	**7**

Discipline	Agriculture	Forestry	Social Sciences	Other
International staff	10	8	6	11
Local staff	6	1	—	15
Other professional staff	4	5	1	5
Total	**20**	**14**	**7**	**31**

Geographic Origin	Africa	Asia	Europe	North America	South America
International staff	13	1	11	7	3
Local staff	22	—	—	—	—
Other professional staff	1	1	12	1	—
Total	**36**	**2**	**23**	**8**	**3**

Gender	Male	Female
International staff	29	6
Local staff	14	8
Other professional staff	12	3
Total	**55**	**17**

1.21 **Staff.** In early 1990 ICRAF had 35 senior international professional staff, 24 with doctoral degrees (Figure 1.2). These staff represented a wide range of disciplines, reflecting the broad scope of agroforestry research. The majority were agriculturalists and foresters, but the Council had also developed a strong capacity in socio-economics and other disciplines, especially ecology. ICRAF thus had a well balanced, but small, interdisciplinary team. About a third of the senior international professionals were from African countries and most of the rest had considerable experience in Africa. A quarter of all professional staff were women.

1.22 **Facilities.** In 1987 ICRAF celebrated its tenth anniversary by moving to its newly built headquarters just outside Nairobi. Major facilities at the new ICRAF House include a library, which by 1990 contained over 16,000 bibliographic units, and an auditorium, used for training events and meetings. Besides its headquarters, ICRAF has a small field station at Machakos, in the semi-arid uplands of southern Kenya. This station is used for strategic research and for training and demonstration purposes.

1.23 **Conclusion.** ICRAF's current size and resources reflect a belief in the advantages of careful growth. The Council has always been cautious in acquiring its own programmes and facilities, preferring instead to integrate and catalyse the activities of others wherever possible. This approach is vindicated by the substantial achievements of ICRAF's small team during the first 12 years of the institution's life.

Achievements

1.24 Because ICRAF's primary mode of operation is collaborative, the credit for most achievements must be shared with national and other research partners. An important advantage of the collaborative mode of operation is that it allows a multiplier effect, leading to the more rapid dissemination of information and ideas.

1.25 This section will not attempt an exhaustive account of all ICRAF's achievements but will mention only those that provide a basis for the Council's future strategy. The overall impact of ICRAF's work to date is summarized in Box 1.1.

1.26 **Research.** ICRAF's major contribution to agroforestry research has been to develop the 'agroforestry technology development cycle' (Figure 1.3). This is a logi-

Box 1.1. ICRAF's Impact

ICRAF has achieved an impact in four major areas:

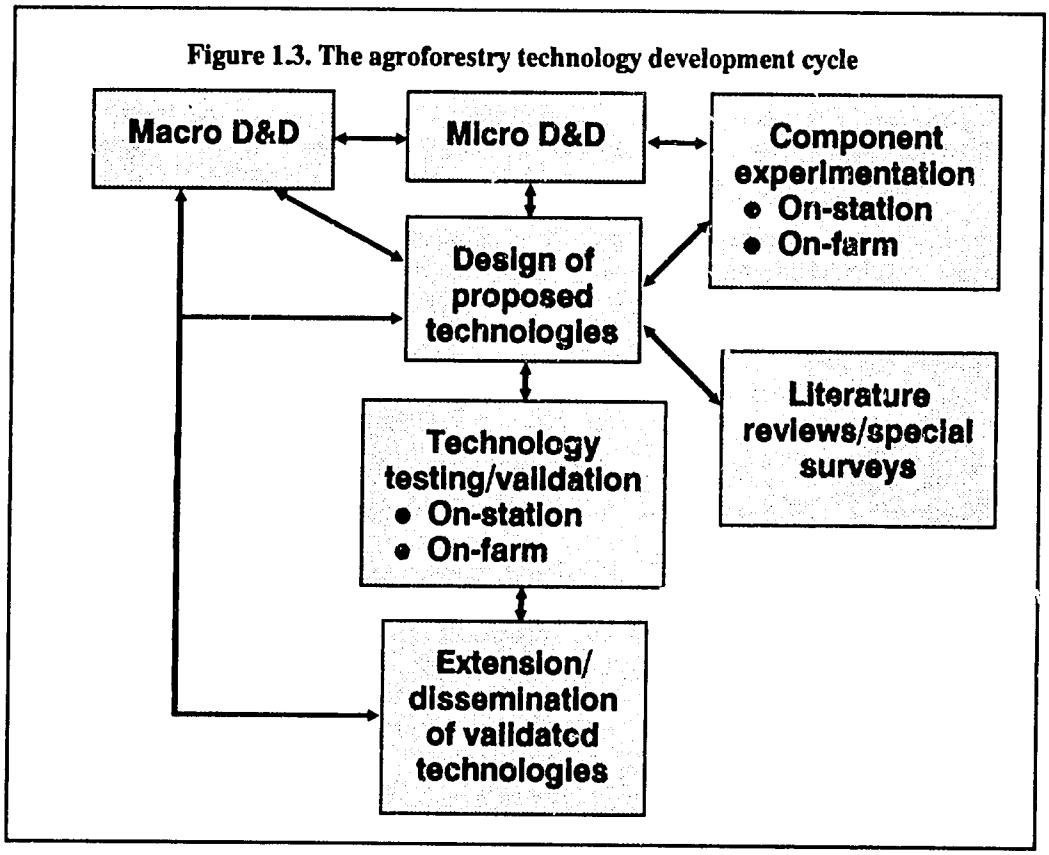
1. It has helped establish a scientific approach to agroforestry.
2. It has contributed to the current high level of awareness of the potential of agroforestry.
3. It has established a unique multidisciplinary capability for dealing with agroforestry land-use issues.
4. It has established a strong collaborative research programme in Africa.

cal, reiterative research process that uses a systems perspective with an interdisciplinary approach. Its essential feature is that it promotes communication among farmers, extensionists, biological and social scientists, development specialists and policy makers—both as decision makers and as key sources of information. The objective is to develop technologies to solve problems in priority land-use systems within specific ecological zones. The pivotal step in the research process is the design of agroforestry technologies.

1.27 The research process begins with what is called a *macro diagnosis and design (D&D) exercise*. This is an assessment of current agroforestry practices, land-use systems, constraints, agricultural policy, the institutional environment, potential agroforestry interventions, and research priorities for technology development—all focused on one ecological zone within a country. The next step in the process is a *micro D&D*, a detailed analysis of one land-use system within the zone, selected by ICRAF's national research partners. From this analysis, specific guidelines are derived for the formulation of a research plan. The D&D exercises should also identify national institutions that have relevant research programmes and can contribute to the implementation of the proposed agroforestry research.

1.28 The research plan typically consists of *component experimentation*, designed to assess the technical potential of multipurpose trees or shrubs through general screening, technology-specific screening and management trials. Such trials are

Figure 1.3. The agroforestry technology development cycle



usually conducted on station but they can also be carried out on farmers' fields, particularly when the agro-ecological conditions of existing experiment stations are not representative of those of the target households and their farming systems.

1.29 A *review of relevant research findings* is essential to avoid wasting resources and time. This contributes directly to the technology-design and component-experimentation phases. In addition to a literature review, special surveys may be organized to enhance the information gained from the D&D exercise.

1.30 The proper specification of an agroforestry technology in the design phase defines the set of hypotheses for *testing and validation* under farmers' conditions. At this stage, adaptations based on household preferences and available farm resources may lead to alterations and refinements in the technology originally proposed.

1.31 Subsequently, agroforestry technologies are monitored and evaluated through *dissemination* programmes with extension agencies. This should also provide essential feedback into the research process.

1.32 ICRAF has developed a number of tools to support the use of this research approach. These include:

- The *D&D User's Manual*: a practical guide to the implementation of D&D exercises
- The *Multipurpose-tree Database*: a global inventory of tree/shrub species and provenances likely to be of use in agroforestry research and development
- The *Multiple Cropping Budget* (MULBUD): a computer program for the economic analysis of farm budgets that takes account of multiple enterprises
- The *Agroforestry Systems Inventory* (AFSI): a classification of global agroforestry land-use systems according to various criteria, including land-use intensity
- *Soil Changes Under Agroforestry* (SCUAF): a computer program for estimating the effects on soils of specified agroforestry systems in given environments
- *Datachain*: a computer program that helps researchers collect and manage their data prior to analysis
- *Source Materials and Guidelines for Agroforestry Researchers*: a 27-part series of booklets describing the methods for a range of agroforestry research tasks
- The tree/crop interface study: guidelines for the design of agroforestry experiments.

1.33 **Training and Information.** Although still being refined, the approach, methods and tools developed by ICRAF are already in widespread use by national institutions, both in Africa and elsewhere. For example:

- Collaborative research based on the agroforestry technology development cycle is in progress in 15 African countries, as well as India and Bangladesh.
- Courses introducing the D&D methodology have been conducted in Peru, Malaysia, India, Zambia, Cameroon and Kenya, as well as at ICRAF headquarters.
- More than 100 copies of the MULBUD program have been distributed worldwide. The program has been used to study the economics of a wide variety of agroforestry systems including taungya systems in Indonesia and Thailand, a silvopastoral system in Costa Rica, a hedgerow-intercropping system in Kenya and home-garden systems in Tonga and Sri Lanka.

- Datachain is now being used by scientists at 62 sites in 32 countries. The collaborating research projects within the AFRENAs are a major group of users. Other users include donor agencies and universities in developed countries as well as national or regional research institutions in Latin America and Asia. Applications cover a broad range of fields including experiments in forestry, horticulture and agronomy, in addition to agroforestry.

1.34 Dissemination activities include ICRAF's training and information programmes. The Council's training programme is well established. Since 1982, more than 300 people have attended ICRAF courses and more than 30 individuals have undertaken residential training. An introductory course on agroforestry is offered every year to a global audience and specialized courses are conducted primarily for collaborating researchers.

1.35 Several specialized information services and products are also offered on request. These include a current-awareness service now reaching more than 175 researchers in Africa, a bimonthly list of library accessions made available to more than 400 institutions and individuals, and a search service currently responding to 500 queries a year. Specialized products include the international scholarly journal *Agroforestry Systems*, the quarterly secondary journal *Agroforestry Abstracts*, the quarterly magazine *Agroforestry Today* and numerous monographs, manuals, bibliographies, proceedings volumes and working papers (see Box 1.2). Recently, ICRAF has also begun to produce and distribute audiovisual materials.

Box 1.2. Achieving impact through information: *Agroforestry in Dryland Africa*

Research on agroforestry systems in Africa has so far concentrated mainly on the continent's relatively favourable highland and humid zones. In 1988, ICRAF published *Agroforestry in Dryland Africa* (Rocheleau et al., 1988), a field guide for those seeking to introduce trees in the continent's drier environments. This book describes traditional agroforestry practices in the semi-arid zone as well as practices in other zones that might prove applicable in dry areas if suitably adapted. It helps readers to select species, arrangements and management regimes and advises on how to plan the introduction of trees jointly with local communities.

The book has been an instant success, both as an educational aid and a practical tool. More than 3600 copies were distributed in the first two years after publication, mostly in Eastern Africa where the Regional Soil Conservation Unit of the Swedish International Development Agency (SIDA), which commissioned the book, is using it to begin building national educational curricula in agroforestry. About 20 universities and training institutions in the region are now using the book in the classroom. The spread of the book among field workers has been even more impressive: Ministries of agriculture in Kenya, Tanzania, Zambia and Ethiopia have issued nearly 2500 copies to their extension staff. Research institutions, development projects and non-governmental organizations have also shown enthusiasm and demand for the book is now spreading beyond the Eastern Africa region. In some countries the book is being used as source material to develop audiovisual materials and information products in local languages.

The search for sustainable development

THE CHALLENGE FOR AGROFORESTRY

Trends in population and cultivated area

2.01 Barring a catastrophe, there is little chance between now and the year 2000 of any substantial decrease in the present world population growth rate. This now stands at about 80 million a year, with 85% in developing countries (World Resources Institute et al., 1989) where some 4.85 billion people will be living by the year 2000 (McLaren and Skinner, 1987). There will be considerable movement into towns and cities, but this will not be sufficient to prevent an absolute increase in the rural population, nor will urbanization reduce the demand for food and other products directly derived from land resources. Increasing population and urbanization provide opportunities to farmers in the form of larger markets, but they also pose severe problems. Since 1980, the number of malnourished people in developing countries is estimated to have increased by 30% (World Resources Institute et al., 1989).

2.02 There are finite limits to any possible increase in the world's cultivated area. Already, the area cultivated per head of population is declining throughout the tropics, falling from 0.28 hectares in 1971 to 0.22 hectares in 1986 (FAO, 1988). Farms are becoming smaller and holdings more fragmented and it has become steadily less possible to increase production by extending the area under cultivation. It is true that cultivated areas are still expanding, but current expansion is mostly onto dry, sloping or other land only marginally suitable for arable farming.

Trends in natural resources

2.03 Closely linked to population growth are trends in the natural-resource base, primarily in soils and vegetation. These trends are for the most part adverse in developing countries, with serious implications for the livelihood of current and future generations. The major forms of resource degradation in rural areas are:

- Soil erosion and compaction
- Decline in soil fertility
- Loss of biological diversity caused by forest clearance
- Destructive land use following forest clearance
- Pasture degradation.

2.04 Together, these lead additionally to hydrological degradation—changes in river regimes, increased salinization and sediment load. On a world scale the same factors may also lead to global warming.

2.05 Soil erosion is the most widely recognized form of resource degradation, since the consequences of severe erosion are visibly apparent and virtually irreversible, at least in the short term. Estimates of the area of cultivable land lost annually through erosion vary widely, but the figure is of the order of 5 million hectares a

year or 0.3% of the total cultivated area in the world (McLaren and Skinner, 1987).

2.06 Decline in soil fertility is far more widespread and arguably more serious in its effects on production. Continuous or nearly continuous use of land for annual cropping without appropriate inputs and management inevitably leads to reduced fertility and lower crop yields. In Africa, it has been estimated that soil erosion could reduce agricultural production by one fourth by the year 2000 if conservation measures are not adopted (Worldwatch, 1990). In more than 60 D&D exercises carried out by ICRAF, low or declining soil fertility was identified by farmers as a major problem. Stopping and reversing this trend is probably the highest priority for current land-use planning in developing countries.

2.07 Forest clearing—the conversion of forest into arable land or pasture—is currently a matter of international concern, particularly in view of the grave consequences for the conservation of biological resources. The rate of clearing of tropical forests and woodlands is currently estimated at 11 million hectares a year (World Resources Institute et al., 1989). In Africa, the area of closed forest and woodland is thought to have fallen by 24% between 1950 and 1983 (Repetto, 1987). The destructive use of land following deforestation leads to flooding, erosion and adverse climatic changes on a local and regional scale, and possibly also globally.

Box 2.1. Global environmental issues

Global environmental issues will continue to command widespread attention throughout the 1990s and probably well into the next century. Among these issues are the possibility of global warming, the disappearance of the world's rain forests, the desertification of grazing and farm land in the semi-arid zone, the pollution of air, water and soil resources, and the growing shortage of arable land.

Agroforestry has both direct and indirect implications for many of these issues. By increasing and diversifying the outputs from arable land, agroforestry may, in the long term, relieve the pressure on the world's dwindling forest resources and overexploited pastures. The introduction of woody perennials increases plant biomass per unit area of land providing, in theory at least, an additional sink for carbon dioxide—one of the major greenhouse gases. Mixing trees and crops can also reduce, though not eliminate, the need for chemical fertilizers, thereby alleviating the pollution of water resources and the production of nitrous oxide, another greenhouse gas.

There are clearly grounds for optimism, but expectations should not be raised unrealistically. Agroforestry systems, as any other land-use systems, involve trade-offs. While the need to ensure sustained production over the long term may be widely perceived by farmers, other, more pressing short-term needs, such as fuelwood, building materials and fodder, tend to take precedence. Environmentally sound production systems will survive and expand only if they also provide commodities and cash incomes for resource-poor farmers. At the same time, if sustainable agroforestry practices are to be adopted on a widespread, lasting basis, they must be supported by sound and effective government policy measures.

2.08 Pasture degradation is the major problem of the semi-arid and arid zones, where livestock represent an important, often the principal, means of livelihood and economic base. Over 60% of the world's productive drylands are believed to have suffered moderate to severe degradation (Bene et al., 1977). Outside the semi-arid zone, and especially in densely populated highland areas, there may also be severe degradation of areas allotted to grazing amid predominantly arable farm land. The underlying causes of pasture degradation are increasing human population and associated growth in livestock numbers without the possibility of expanding the area available for grazing. Indeed, grazing areas are actually shrinking in many places as the areas under cultivation expand. In addition, the fact that grazing areas are often exploited on a communal basis may create special problems. There may be little incentive for individual livestock owners to improve pastures by limiting animal numbers or introducing improved grasses, legumes or trees.

Conclusion

2.09 The interactions between increasing population, pressure on land and degradation of natural resources are obvious. If unchecked, the outcome of this vicious circle is increasing poverty for growing numbers of land users and an irreversible decline in the natural-resource base. These prospects present agroforestry with a formidable challenge.

THE POTENTIAL OF AGROFORESTRY

2.10 To what extent can agroforestry help to meet this challenge? The degree to which agroforestry can contribute to solving global environmental problems remains uncertain, not least because the problems themselves are still poorly understood. The adoption of agroforestry practices on a wide enough scale to make a global impact will depend as much on government policies as on the development of improved technologies (see Box 2.1).

2.11 Agroforestry can contribute to local and regional economies in many ways. An analysis by the Food and Agriculture Organization of the United Nations (FAO) and ICRAF (Raintree and Hoskins, 1988) listed a total of 32 contributions of agroforestry to eight basic human needs (Annex 1). The main contributions can be summarized as:

- Increased and more stable food production, resulting either directly from the introduction of trees (fodder, fruit) or indirectly through the contribution of trees to soil fertility and the sustainability of agriculture
- Higher incomes for small-scale farmers and other land users, resulting from the sale of tree products
- More products and services provided by small-scale farms, with associated benefits to rural and national economies in terms of increased small-scale industry
- Reduced dependence on external sources for key agricultural inputs (fertilizers) and subsistence products (fuelwood, building materials)
- Improved soil structure and fertility, with important effects on crop yields
- Enhanced microclimates through increased standing biomass, with benefits to crops, animals and people

- Reduced pressure on remaining forests, achieved by raising the productivity of existing agricultural land and by increasing the supply of fuelwood and other products from non-forested areas
- Reduced soil erosion and siltation of waterways, achieved through the prevention of runoff on sloping land
- Reduced pressure on grazing lands through the intensification of fodder and animal production.

2.12 In practice, hard evidence on the benefits of agroforestry is still scarce, as the positive effects of trees on crop yields and soil characteristics take years to materialize. Many experiments are still too new for these effects to be measured, but a convincing body of positive results is beginning to emerge (Boxes 2.2 and 2.3). ICRAF's applied research, conducted in the AFRENAs and launched mostly in the late 1980s, will add substantially to this evidence. This work has already begun to show the potential importance of traditional agroforestry practices for income generation (Box 2.4).

2.13 Long-standing agroforestry experiments at the International Institute of Tropical Agriculture (IITA) in Nigeria have shown the advantages of hedgerow intercropping over traditional systems of shifting cultivation. Annual yields of maize cropped continuously for five years between hedges of leucaena were maintained at about 2 tonnes per hectare by adding hedge prunings to the soil, while annual yields on control plots without prunings declined to 0.5 tonnes per hectare or less. The system also produced 5 to 6 tonnes per hectare of stakes for use as fuelwood or for supporting yams (Kang et al., 1984).

2.14 Although these and other on-station experiments have shown that agroforestry can make a substantial contribution to improved productivity, farmers considering the introduction of specific practices must also make a careful evaluation of associated economic costs and labour requirements. In the few cases where cost-benefit analysis has been carried out, the economic advantages of agroforestry appear considerable. At the project level, the internal rate of return for a World Bank project introducing shelterbelts in northern Nigeria was estimated at an encouraging 21% when all the benefits—including soil conservation and increased crop yields as well as wood production—were taken into account (Schuh, 1988).

2.15 There is still a need for more detailed understanding of which agroforestry technologies have a potential in which agro-ecological zones. Nevertheless, it is possible to state some broad generalizations for different areas of the tropics.

2.16 Among the leading problems of the *humid tropics*, or rain forest zone, are the practice of shifting cultivation with reduced fallow periods, the existence of moderate to steep slopes that are prone to erosion, and the presence of acid and strongly leached soils. In this zone, agroforestry has a high potential for controlling soil erosion and maintaining soil fertility. Potential agroforestry technologies include plantation crop combinations, multistoreyed home gardens, improved tree fallows, hedgerow intercropping (especially with hedgerows aligned on the contour of slopes), some systems of taungya and combinations of agroforestry with reclamation forestry on degraded land.

2.17 In the *subhumid tropics*, or savannah (*cerrado*) zone, problems include clearing or overcutting of natural woodland, declining soil fertility, pasture degradation, erosion, shortages of fuelwood and/or fodder, and—especially towards the zone's drier margins—periodic drought. Agroforestry systems with trees on cropland, boundary planting, trees on erosion-control structures, live fences and fodder banks are the most applicable. There appears to be some potential for developing home gardens, which are found in this zone but are not widespread. The apparent potential of hedgerow intercropping is currently under research. The role of trees in maintaining soil fertility has particular relevance in the subhumid zone.

2.18 The *semi-arid tropics and subtropics*, including the sahelian zone in Africa, are dominated by severe problems of drought, pasture degradation and fuelwood shortage. Here, systems with trees on cropland, boundary planting (especially for fuelwood), windbreaks and shelterbelts, live fences, fodder banks, and trees in pastures have a particularly important role. Hedgerow intercropping may be appropriate in the less drought-prone areas although the problem of competition for soil moisture will need special attention.

2.19 In the *tropical and subtropical highlands*, human and animal populations tend to be high and the generally favourable natural-resource base is rapidly deteriorating. Acute problems associated with erosion and declining soil fertility are compounded by drought and fuelwood shortages in areas where degradation is already advanced. However, agroforestry is traditional in many high-potential areas. Technologies such as live fences, boundary planting and mixed intercropping with fruit

Box 2.2. Hedgerow intercropping in Malawi

Research on hedgerow intercropping in Malawi has shown that the use of leucaena leaves as a mulch significantly increases the response of maize to nitrogen fertilizer (Table 2.1). These results suggest that farmers using hedgerow intercropping will be able to economize substantially on the use of commercial fertilizers. In addition, the leucaena will provide them with extra income from the sale of fuelwood. Since Malawi imports commercial fertilizers, cutting down on their use will save the government scarce foreign exchange.

Table 2.1. Maize yields (t/ha) in a hedgerow-intercropping system with and without leucaena foliage used as mulch (Lilongwe, Malawi)

Application of Nitrogen Fertilizer (kg/ha)	Maize yield	
	Without Mulch	With Mulch
0	1.6[d]	2.2[c]
50	3.0[b]	3.7[a]
100	3.1[b]	4.2[a]

Note: Values followed by the same letter indicate nonsignificant differences. Significance level = 1%.
Source: Saka et al., 1989.

trees are relevant, while contour-aligned hedgerow intercropping is needed on sloping land. Trees may also be used on terraces or on grass or stone bunds.

2.20 Two generalizations apply across all these zones. On the one hand, agroforestry has a high apparent potential to help solve land-use problems in a wide variety of environments and socio-economic conditions. However, much of this potential needs to be tested, confirmed or further developed through research. This situation provides the strongest argument for a major programme of agroforestry research.

AN AGENDA FOR RESEARCH

2.21 Many research issues need to be addressed to realize the potential of agroforestry. Here only the main issues will be outlined. These issues are classified as either socio-economic or biophysical, although in reality the two categories are often difficult to distinguish. All the issues discussed here have implications for environmental protection as well as for commodity production and income generation.

Socio-economic issues

2.22 **Understanding agroforestry systems.** The farming-systems approach to research has increased understanding of how small-scale farming works, but the role of trees is still poorly understood. Some useful studies have been conducted at the local level, but geographical coverage needs to be expanded and studies repeated over time to provide a clearer picture of regional trends in land use.

2.23 **Economic impact of agroforestry.** There is an urgent need to determine the potential economic impact of agroforestry – an area in which solid evidence is still largely lacking. As the case of Malawi shows (Box 2.2), agroforestry practices have the potential to generate considerable savings at the farm and national level. The introduction of fruit trees or trees for timber or fuelwood production offers substantial opportunities for increasing the cash income of smallholders. Such economic benefits are badly needed throughout the developing world.

2.24 **Equity issues.** Several equity issues call for further research at the household and community levels. These include the rights of men and women to products and income derived from trees and the rights of landless rural dwellers to collect tree products from communal lands. In many situations, agroforestry interventions may benefit one social group or class at the expense of another. For instance, in the successful Majjia Valley project (Box 2.3) some groups were losers, notably women who raised sheep and goats (Leach and Mearns, 1988). More research is needed to clarify such negative effects and, if possible, avoid them.

2.25 **Land tenure.** Because tree planting is a long-term investment, it may not be attractive to farmers with insecure land tenure. In one area of the Philippines, security of tenure almost doubled the number of trees planted by smallholders, with positive effects on farm income and soil conservation (Rola, 1986). More research is needed to establish the importance of land tenure as a factor in sustainable land use and to determine what governments can do to solve land-tenure problems, especially in pastoral areas.

2.26 **Labour requirements.** Agroforestry systems generally do not require substantial cash inputs, but their additional labour requirements may prove a significant constraint to adoption. Labour shortages are acute in areas where young male labourers tend to leave the land in search of urban employment. More research is needed on the labour required for establishing and managing different agroforestry systems and on the seasonal distribution of labour requirements.

2.27 **Processing agroforestry products.** The area of processing includes a wide range of research tasks with high potential benefits. Examples are the production of furniture or other products from fast-growing woody species and the production of oils, resins, gums and waxes. Special attention should be paid to improving the returns to labour devoted to processing at the farm or community level.

2.28 **Policy issues.** There is an urgent need for research on public- and private-sector policies on agroforestry. As already noted (Box 2.1), environmentally sound farming practices will not be adopted unless they are also economically advantageous. Areas such as pricing policies and the availability of credit, especially during the early years of adoption, will need to be re-examined in this light and new policies will be required to promote the introduction of agroforestry.

2.29 An important aspect of government policy is the support provided to agroforestry through national research and development institutions. Studies are needed on how to build a lasting capacity for agroforestry research in national systems. Because agroforestry is new in many countries, extension methods also require attention and alternatives to government extension services need to be considered, such as the formal education system. Finally, the successful efforts of non-governmental organizations to introduce agroforestry call for expansion.

Biophysical Issues

2.30 **Genetic resources.** Traditional farming systems and natural forests contain a wealth of tree germplasm that urgently requires exploration, conservation and

Box 2.3. Windbreaks in Niger

In many cases it is still farmers' practices, rather than scientists' experiments, that provide the clearest indication that agroforestry has advantages over other forms of land use. The case of windbreaks, used to prevent erosion and increase crop yields in the semi-arid zone, provides an exception.

As early as 1980, studies of a project implemented by CARE in the Majjia Valley of Niger documented a positive impact on cereal production in fields protected by windbreaks. A major evaluation of the project was carried out to confirm these results. Gains in crop yields in protected plots averaged 20 to 23%. In the drought year of 1984, crop yields in protected fields were 18% higher than in unprotected ones. In addition, each kilometre of windbreak yielded on average 110 cubic metres of fuelwood—enough to meet the needs of 250 people for a year (Leach and Mearns, 1988).

evaluation. Steps have recently been taken to launch this conservation task at an international level. Collection priorities need to be identified and activities organized in those countries where the genetic diversity of trees is most threatened. As collections in genebanks expand, the task of evaluation will also demand a rapidly increasing share of research resources.

2.31 Research on the genetic improvement of multipurpose trees and shrubs is at an early stage, similar to that reached for annual crops almost a century ago. There are major opportunities for achieving large gains in tree productivity, first through selection and then through breeding. A few institutions are already engaged in such research, but their work only covers about 10 species. The priority will be to evaluate as many as possible of the species and provenances already used by farmers in order to select a limited number for improved breeding. Tree breeding for multiple uses also imposes important methodological problems that need to be addressed.

2.32 Many tropical multipurpose-tree species are predominantly outbreeding. Classical breeding techniques are appropriate for these species, including phenotypic selection and genetic evaluation through open-pollinated and control-pollinated progeny. Vegetative propagation facilitates the capture and dissemination of desirable genotypes identified in first or second generations. Both seedlings and clonal propagules will be required to estimate genetic parameters and create breeding and seed-producing populations. Research will also be needed on breeding methods and population structures.

2.33 Few annual-crop genotypes have been bred for use in mixed cropping systems involving woody perennials. As research on agroforestry advances, the need for such crop genotypes will also increase. Crop research institutions will need to adapt their breeding programmes to cater for the requirements of crops grown under agroforestry.

2.34 **Management regimes.** The management of agroforestry systems, with their multiple products and services, is more complex than that of monocultural systems. Although research on intercropping is now in progress in many parts of the world, more research is needed on how to manage the tree component. Areas requiring further work include tree spacing, pruning, coppicing and the rotation of trees with other system components.

2.35 **Pests and diseases.** By increasing the diversity of production systems, the introduction of trees and shrubs presents opportunities for reducing the damage caused by pests and diseases, and particularly the economic losses experienced on individual farms. However, trees and shrubs also provide a habitat for several important pests, notably birds and insects. In the humid and subhumid zones of Africa, the presence of trees is associated with tsetse flies, while in semi-arid areas the roots of trees provide food for termites. In addition, the most productive and thus most widely used tree species may be subject to sudden and devastating attack. These and other potential problems indicate the need for a much better understanding of how trees may affect the incidence of pests and diseases.

2.36 **Livestock production.** A few multipurpose-tree species have been evaluated as protein-rich supplementary feed for livestock. Given the high value of livestock products, this work is likely to continue and expand to include a wider range of species and provenances. For example, tree breeding to produce foliage for animal feed might make a major contribution to small-scale dairy enterprises. The trade-offs between the use of foliage for mulch and for feed will need special attention. Ways of enhancing feed utilization and overcoming anti-nutritional factors also need to be further developed.

2.37 The management of livestock in agroforestry production systems is another area requiring further research. Where pressure on land is high, farmers often adopt stall-feeding systems in which animals are closely controlled. In more extensive systems, animals are allowed to roam under levels of supervision that depend on available labour. Crops and young trees are vulnerable to damage by livestock in areas where labour is in short supply. Thus research is needed on the development of agroforestry technologies—notably live fences—that will help to control the movement of livestock.

2.38 **Soil fertility.** The use of tree foliage for mulching, composting and green manuring can make a substantial contribution to the sustainability of agriculture. In the case of green manure, factors such as mode of application (surface or incorporated), timing of application in relation to labour availability and crop growth cycles, and interaction with mineral fertilizers need further investigation.

2.39 Soil phosphorus is an important requirement for woody and other legumes. The behaviour of phosphorus in tropical soils is complex. Small additions of phosphorus to the soil may trigger increased nitrogen fixation by legumes, which in turn can make an important contribution to the production of subsequent or adjacent food crops. These topics are already under widespread study, but more work is

Box 2.4. Fruit trees in Zambia and Malawi

A survey conducted by the Southern Africa AFRENA has revealed the importance of fruit production in the region. Seventy-eight farmers in the Chipata area of Zambia and the Makoka area of Malawi were interviewed. They identified 112 useful plant species, including 52 that provided edible fruits. More than 30 of these were gathered in small quantities and sold or consumed at home. Previous studies on some of these species showed that the fruits were rich in sugars and essential vitamins and that many of the fruit kernels were also rich in vegetable oils and protein. Farmers were enthusiastic about planting these fruit trees in greater numbers, for instance on farm boundaries and around their homesteads, as a potential income-earning opportunity.

Scientists at Makoka have now begun a project to collect the germplasm of indigenous fruit trees, investigate germination requirements, identify suitable nursery techniques for producing seedlings, and assess growth and yield performance. This research will lead to the identification of tree characteristics that are important to farmers and to the design of appropriate management regimes (ICRAF, 1990).

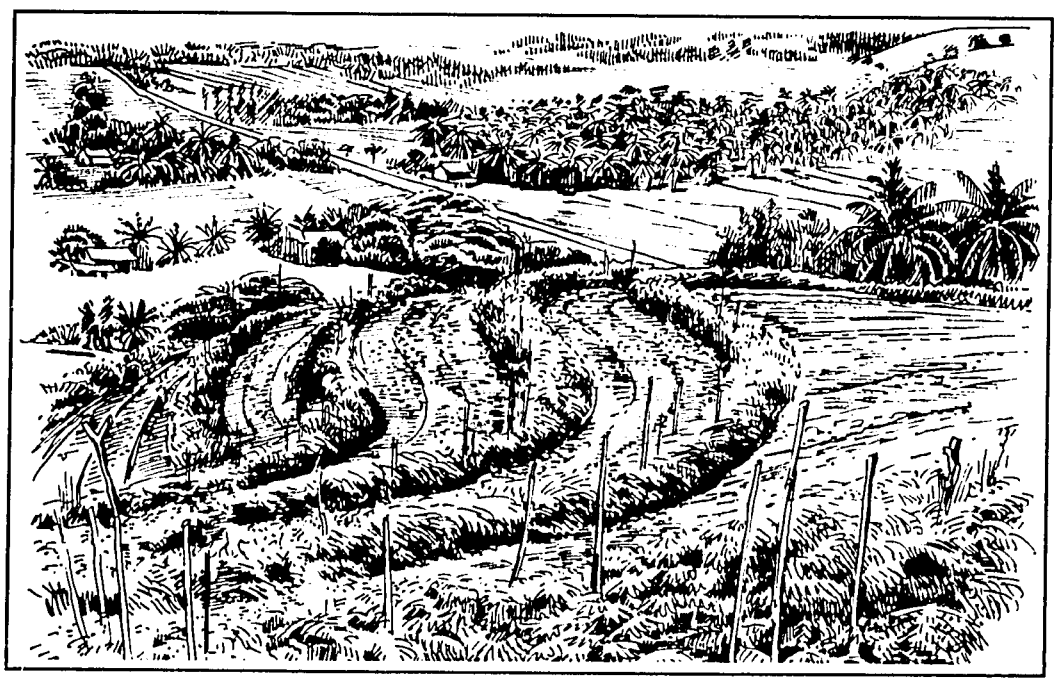
needed that relates specifically to agroforestry production systems. The role of trees in nutrient recycling also calls for further research.

2.40 The development of agroforestry technologies for use on strongly leached acid soils presents a major challenge. Species will be needed that combine tolerance to toxic soil conditions with reasonable growth rates. Some research has already been undertaken in this area but it has so far met with little success. Alternatives to hedgerow intercropping are required for these difficult soils.

2.41 The symbiotic micro-organisms associated with legumes and other plants offer significant opportunities for increasing the overall productivity of intercropping systems. This is an area requiring detailed research to match the right organisms with the right plants and soils and to develop cost-effective ways of introducing and managing them. The enhancement of mycorrhizal associations, which appear critical to the establishment of many multipurpose trees, needs particular attention.

2.42 **Measuring sustainability.** The long-term sustainability of a given production system is a function of three sets of variables: the quantity and quality of the physical resources available (soil, water, vegetation); the management regime, especially the inputs used; and the outputs required from the system, which are normally related to human population density. Because these variables are constantly changing, it is difficult to obtain a clear picture of trends over time. A set of biophysical and economic indicators needs to be developed for measuring sustainability on a periodic basis.

2.43 **Erosion control.** Conventional methods of preventing soil erosion are costly and thus often unattractive to farmers. Agroforestry provides low-cost alternatives. Among the most promising are contour-aligned hedgerow intercropping and



multistoreyed tree gardens. The effectiveness of different arrangements, species and management regimes needs further investigation, with special emphasis on the labour requirements for establishment and on returns during the early years of adoption. Again, new government policies will be needed to promote adoption.

2.44 **Resource competition.** We need to know more about the competition between trees and crops for moisture, especially in the semi-arid zone, and for nutrients and light, especially in the humid zone. The behaviour of tree roots, which may have important effects on crop performance, merits detailed attention. Such research needs to be closely linked with the development of simple but effective management recommendations.

2.45 **The semi-arid zone.** Much of Africa's more profitable agroforestry is found in the wetter and more fertile areas where—as in the highlands of Kenya—agroforestry systems are at their most diverse and productive. If agroforestry is to flourish in the continent's drier areas, a combination must be developed of hardier tree species and low-cost management interventions to make the best use of water. Species will also be needed that are adapted to saline soil conditions—a frequent problem in the irrigated areas of the semi-arid zone. Suitable agroforestry technologies are also lacking, although traditional systems and practices may provide valuable guidelines on promising approaches for future research (see Box 1.2).

Conclusion

2.46 This research agenda is inevitably incomplete. Yet to implement an effective global research programme, even on this limited range of topics, would require resources well beyond those of ICRAF. As the international research institution with a leading role in agroforestry, ICRAF must select a limited number of topics that offer opportunities to make a significant impact. As a coordinating institution, ICRAF also has a special responsibility for encouraging work by others in those areas in which it is unable to undertake research itself.

THE WORK OF OTHER INSTITUTIONS

Activities in agroforestry

2.47 The increased emphasis on sustainable development—brought into focus by the World Commission on Environment and Development (World Commission, 1987)—has led to an explosion of interest in agroforestry over the past few years. As a result of a dramatic increase in funding, mostly by donor agencies and development banks, the number of agroforestry projects in developing countries has multiplied. In this section we briefly outline the various types of institution active in agroforestry. Box 2.5 describes the groups of people who are now working or could work in partnership with ICRAF.

2.48 **National programmes.** The few national programmes with a long-standing interest in agroforestry have built up a substantial research capacity. More recent programmes tend to be weaker (see 2.58). The developing world's largest national programme is in India, where 33 centres collaborate in the All-India Coordinated Research Project on Agroforestry under the umbrella of the Indian Council for

Agricultural Research (ICAR). Several of the larger countries of Southeast Asia and Latin America also have strong national programmes. In Africa, where national programmes are still at an early stage of development, Kenya has made the greatest national commitment, with agroforestry development a major component of government policy. ICRAF and emerging national programmes in Africa have much to learn from the experience of these strong national programmes.

2.49 Several specialized institutions or university departments in developed countries are also actively engaged in research to develop improved agroforestry technologies. These include the Oxford Forestry Institute, the Commonwealth Scientific and Industrial Research Organization (CSIRO), the Centre technique forestier tropical (CTFT) and the Nitrogen Fixing Tree Association (NFTA).

2.50 The agroforestry revolution has also begun to affect national training and educational institutions in forestry, agriculture and the social sciences. In both developed and developing countries, these institutions increasingly offer short-term courses as well as formal graduate and postgraduate programmes in agroforestry. For example, the University of Science and Technology in Kumasi, Ghana, is currently offering a postgraduate diploma in agroforestry and plans to introduce an M.Sc. course in the near future.

2.51 **Regional programmes.** Among regional institutions, the Centro Agronomico Tropical de Investigación y Enseñanza (CATIE) has a well-developed research and training programme based in Central America. Comparable programmes have not yet emerged in Africa and Asia, aside from ICRAF. However, a number of African regional organizations have expressed increased interest in agroforestry and have developed some activities in this area. These include the Southern Africa Centre for Cooperation in Agricultural Research (SACCAR), the Comité permanent inter-Etats de lutte contre la sécheresse dans le Sahel (CILSS), the Club du Sahel and the Consultative Advisory Committee on Semi-arid Food Grains Research and Development (SAFGRAD).

2.52 **International programmes.** The research centres of the CGIAR have now accepted agroforestry as a legitimate activity within their mandates. IITA has conducted original and exciting research on hedgerow intercropping for many years (see 2.13). Several other centres in the group also conduct research on agroforestry, including the International Rice Research Institute (IRRI), the Centro Internacional de Agricultura Tropical (CIAT) and the International Livestock Centre for Africa (ILCA). At the Sahelian Centre of the International Crops Research Institute for the Semi-arid Tropics (ICRISAT), there is a senior core staff position in agroforestry.

2.53 Several agencies of the United Nations have helped to promote agroforestry development. FAO has long been active in developing and applying the concept of 'forestry for agriculture'. The United Nations Educational, Scientific and Cultural Organization (UNESCO) now has a research programme on agroforestry. The United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP) fund and advise national governments and programmes in areas related to agroforestry.

Box 2.5. ICRAF's partners in agroforestry research and development

ICRAF works in partnership with the following major groups:

Land users. Farmers, pastoralists and the rural landless all need the products and services of multipurpose trees and shrubs. These groups, often already well versed in agroforestry practices, have an important contribution to make by participating in research to improve agroforestry technologies for specific locations. As the beneficiaries of ICRAF's programmes, land users are discussed in more detail in paragraphs 3.27 to 3.29.

Scientists. The global community of scientists involved in agroforestry research for development share a common interest in helping land users develop improved technologies. They work in a variety of settings, including national agricultural, livestock and forestry research and development institutions in developing countries whose research is usually targeted to resource-poor farmers. These scientists constitute ICRAF's major client group. A second group of scientists—those who work in regional and international agricultural and forestry research centres and in various specialized research institutions of the developed and the developing world—are also closely associated with ICRAF's work. A third group, scientists who work in universities in developed countries, are concerned mostly with solving land-use problems in the temperate zone, but there may be important spin-offs for tropical regions from their more basic research.

Policy makers. Government policy makers in developing countries are interested in identifying technical and policy options that will help increase and stabilize rural productivity. They also control the flow of funds to national research and development groups. In both capacities they constitute an important audience for ICRAF's dissemination activities.

Rural-development specialists. Rural-development specialists are looking for low-cost, environmentally sound recommendations to benefit farmers and other rural population groups. They are employed mainly by government extension services and non-governmental organizations, both of which are increasingly active in adaptive on-farm research. ICRAF has a special interest in reaching this group with its information and training products and services. In turn, their experiences in agroforestry development, particularly over the last decade, are a vital input to ICRAF's research.

Environmental specialists. Environmental specialists are concerned with issues such as global warming, deforestation and the loss of genetic resources. They work in international and national institutions with a mandate for setting policy, conducting research and/or disseminating information. This group is an audience for ICRAF's information services and can make an important contribution by setting ICRAF's work in a global context.

Donor representatives. Representatives of the bilateral and international agencies and private foundations that fund, or could fund, ICRAF's work are interested in promoting research that will make a rapid and widespread impact on the sustainable production of food and other basic commodities in developing countries. ICRAF maintains close contact with this group, vital to the Council's future activities. The donors to ICRAF in 1990 are listed in Annex 2.

2.54 The increased interest shown in agroforestry by international agricultural organizations is more than matched by the international forestry sector. The Tropical Forestry Action Plan of 1985 (Committee on Forest Development in the Tropics, 1985) contains proposals for a 10-year fuelwood and energy action programme costing US$ 10,153 million, much of which is to be spent on agroforestry. In addition, there are proposals for agrcsilvopastoral development and watershed management amounting to a further US$ 411 million.

2.55 **Non-governmental organizations.** The non-governmental organizations (NGOs) have successfully promoted agroforestry development over the last decade. Particularly in Africa, organizations such as CARE, Environment and Development Action (ENDA) and World Neighbours have played an active role at the community level. The Worldwide Fund for Nature has included an agroforestry component in many of its conservation projects.

2.56 **Environmental organizations.** Several organizations with an environmental focus have played an important part in increasing the availability of information about agroforestry. These include the World Resources Institute, the Panos Institute and the International Institute for Environment and Development (IIED).

2.57 **Networks.** Several networks and professional associations have also contributed to the exchange of information on agroforestry, notably the Information Centre for Low External Input and Sustainable Agriculture (ILEIA). The International Union of Forestry Research Organizations (IUFRO), which has a special programme for developing countries, and the International Society for Horticultural Science have also played important roles. Projects and networks in Southeast Asia also have agroforestry components. These include the Forestry/Fuelwood Research and Development (F/FRED) project funded by the United States Agency for International Development (USAID) and networks coordinated by the Australian Centre for International Agricultural Research (ACIAR), the Ford Foundation and IDRC.

Institutional constraints

2.58 Despite the strong growth of interest in agroforestry, the inherent institutional capacity for agroforestry research and development remains generally low at the national level in developing countries. Many donor-funded national projects use existing staff who lack relevant training and experience. In agroforestry, even more than in conventional agriculture, there is a danger that activities will lapse once donor support is withdrawn because the in-house expertise and resources needed to continue them have not been acquired.

2.59 The main constraint to building national capacities is the fact that, for historical reasons, agroforestry has no institutional 'home' at the national level (Lundgren, 1989). Rather, agroforestry must find a niche within or among ministries or institutions dedicated variously to agriculture, forestry, livestock, the environment or to a particular commodity.

2.60 The systems approach to research represents an important attempt to break down the traditional barriers between disciplines and sectors. Superficially at least, it has

been relatively successful. Gone are the days when agriculturalists, foresters and livestock experts invariably worked in isolation from one another. As we have seen (2.47–2.57), agroforestry research has rapidly gained ground in many institutions where a disciplinary approach was the norm only a few years ago.

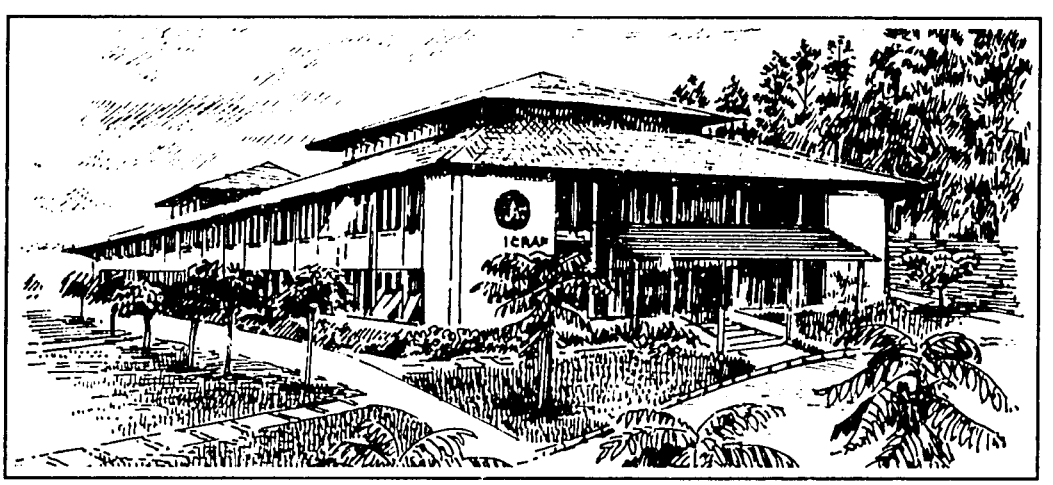
2.61 Yet in many national systems, sectoral barriers remain deeply entrenched. Agriculture and forestry are often not only separated at ministerial level but subject also to different laws and policies and to separate educational arrangements. There are some exceptions, such as francophone countries where forestry and agriculture are frequently united under the same ministry. However, in many countries these barriers are more than just an inconvenient colonial legacy; they have far-reaching implications for sustainable development. As the report of the World Commission on Environment and Development (1987) noted:

> 'Sectoral organizations tend to pursue sectoral objectives and to treat their impacts on other sectors as side effects, taken into account only if compelled to do so.... Many of the environment and development problems that confront us have their roots in this sectoral fragmentation of responsibility. Sustainable development requires that such fragmentation be overcome.'

Clearly, new policies and programmes are urgently needed to tackle this problem at its roots.

Conclusion

2.62 The fact that agroforestry is currently in fashion holds both promise and risks: promise because of the development potential of agroforestry and the willingness of both donor agencies and governments in developing countries to invest in this potential; risks because of the high and unrealistic expectations of quick results and the lack of an institutional capacity to sustain effort without external support. Unless major advances are made within the next five to eight years, enthusiasm may fade. Research must pave the way for such advances by providing clear evidence for the advantages of agroforestry in appropriate circumstances over other forms of land use.



Chapter 3

The decade ahead

ICRAF'S MANDATE

3.01 ICRAF's charter sets out the Council's mandate in some detail. The Board and management have summarized the mandate as follows:

'To increase the economic and nutritional well-being of people in developing countries through the integration of woody perennials in farming and related land-use systems in order to achieve higher productivity, sustainability and diversity of output.'

3.02 This chapter discusses how ICRAF will interpret this broad mandate during the 1990s in the light of the constraints and opportunities outlined in Chapters 1 and 2. First, the goal, strategy, operational principles and major activities of ICRAF are set out. Next follows a discussion of the operational considerations that will shape the Council's future programme. The chapter ends with an overview of ICRAF's changing role as the decade progresses.

ICRAF'S GOAL

3.03 In order to fulfil its mandate, ICRAF's ultimate goal is:

To initiate and assist in the generation and dissemination of appropriate agroforestry technologies for use by farmers.

3.04 ICRAF shares this goal with national institutions in developing countries and it is these institutions, not ICRAF, that bear the primary responsibility for generating and disseminating agroforestry technologies. ICRAF's task is to support their work, not to substitute for it. It follows that the Council's primary mode of operation will be collaborative (see 5.03).

3.05 In developing a strategy to reach this goal, ICRAF must take three factors into account:

- Agroforestry is complex in both technical and institutional terms. Not only does agroforestry present numerous technical options, but it is also being taken up by a rapidly growing number of institutions and yet has no real institutional home.
- Agroforestry technologies are highly location specific, more so than single-commodity technologies. This is because agroforestry is not a single land-use system, but an almost infinite variety of combinations of species and management techniques. The ultimate responsibility for developing locally adapted technologies lies with national institutions.
- ICRAF has a global mandate, but can never hope to acquire the resources needed to make a global impact through directly addressing the generation of location-specific technologies. ICRAF must therefore focus its programme for the 1990s on a few topics of importance in which it has a comparative advantage, while encouraging others to undertake research in other areas.

3.06 ICRAF's strategy is outlined in Box 3.1. The operational principles that will guide its implementation are given in Box 3.2.

MAJOR ACTIVITIES

3.07 ICRAF's two major activities will fall under the broad headings of *research* and *dissemination*. The Council has identified four programmes under each of these activities. These are described in Chapter 4 (4.09–4.63).

3.08 **Approach to research.** ICRAF is committed to playing an active role in agroforestry research for development. Only by being expert research practitioners can ICRAF earn the right to advise and collaborate with other institutions. The purely advisory role originally conceived for the Council has long been complemented by a growing involvement in research. This trend will be further reinforced in the future, with a gradual shift towards meeting strategic research needs identified through applied research conducted by the AFRENAs.

3.09 Agroforestry research must adhere to the same high standards of scientific rigour and quality as other, longer-established applied sciences. This view will guide all of ICRAF's scientific activities—on-farm as well as on-station. At the same time, the Council recognizes the urgency of the problems agroforestry research is required to solve and hence the need to achieve practically applicable results in the shortest possible time.

3.10 ICRAF's approach to research will continue to be systems- and problem-oriented, interdisciplinary, beneficiary-driven and client-responsive (Box 3.2). The combination of these attributes is the hallmark of ICRAF's approach. In general, the Council will undertake research clearly and directly related to the needs of the ultimate beneficiaries. However, since farmers and other land users may not always be aware of the technological advances that research can offer, ICRAF will also be open to other, well-considered areas of research.

3.11 ICRAF recognizes the interdependence of strategic, applied and adaptive research in the pursuit of its goal—the generation and dissemination of appropriate agro-

Box 3.1. ICRAF's strategy

ICRAF's strategy for the 1990s is to:

- Strengthen national capacities to conduct agroforestry research by encouraging interinstitutional collaboration and promoting the dissemination of information on agroforestry through training and other activities
- Encourage and conduct, jointly with national institutions, applied and adaptive research to develop appropriate agroforestry technologies through a careful selection of research priorities based on the needs and potentials of selected land-use systems in the major agro-ecological zones of Africa
- Conduct strategic research on selected topics of global importance in which a need has been recognized through collaborative applied research. ICRAF will encourage its partners and others to undertake strategic research in areas outside its own comparative advantage.

forestry technologies. Recently, organizational changes have been implemented to reflect this interdependence (see 5.22). The Council will also continue to emphasize the integration of information and training at all stages of the research process.

3.12 **Approach to dissemination.** As an international institution, ICRAF will continue to play a major role in the collection, analysis, processing and dissemination of information on research results and methods. The Council recognizes that much of the information it handles will be generated by the work of collaborative partners. In all its dissemination activities, ICRAF will stress the exchange of information rather than its one-way flow.

3.13 Training will be a major channel for the dissemination of research tools and methods. ICRAF's philosophy is that research and training activities conceived and executed jointly with national institutions will be more effective than those planned and implemented in isolation. Much of the Council's training will be inseparable from its research: learning by working together is the primary mode of operation at ICRAF.

DEALING WITH DIVERSITY: OPERATIONAL CONSIDERATIONS

3.14 The challenge facing ICRAF in interpreting its mandate is that of diversity. This diversity is both institutional and technical: not only are there many organizations around the world with an interest in agroforestry, but agroforestry systems themselves are highly diverse in terms of tree and crop species, management practices, and products and services. While remaining responsive to the needs and objectives of land users, ICRAF must also focus its work clearly if it is to succeed. In addition, because agroforestry research overlaps with work carried out by other international institutions, there is a need to define the sphere of operations proper to ICRAF.

3.15 ICRAF responds to the challenge of diversity at two levels. First, the Council makes basic choices that set the boundaries of its work and, second, within these boundaries it is guided by its clients and beneficiaries in formulating a detailed research programme. Figure 3.1 outlines the priorities that emerge from this approach.

Regional coverage

3.16 **Collaborative research in Africa.** Although ICRAF has a global mandate, the Council has so far concentrated its collaborative applied and adaptive research in subsaharan Africa (see 1.19). It will continue to do so until at least 1995: No field research of this type and at this level of intensity will be initiated in other regions before this date.

3.17 The continued emphasis on subsaharan Africa is justified in terms of human need and potential impact, as well as ICRAF's comparative advantage. Africa largely failed to benefit from the 'green revolution', with the result that food production lags behind that of other regions and is failing to keep pace with population growth. Africa's heterogeneous production systems, difficult environments and resource-poor farmers made it unsuited to the approach that characterized the green

revolution, which was geared towards increasing the production of a few major commodities in favourable environments using high levels of inputs.

3.18 Agroforestry, with its focus on multiple products and services, on the sustainability of production and on the needs of resource-poor farmers, constitutes a different but complementary approach to that of the green revolution. As such, it offers considerable hope for making an impact in Africa, although sustained research efforts will be needed to realize its full potential.

3.19 **Global services.** The research approach and methods developed by ICRAF are also applicable beyond Africa (see 1.33). As an international institution, ICRAF has a comparative advantage in providing a range of information products and services to a worldwide audience. For these reasons the Council's service activities, including assistance with research planning as well as information and training, will continue to operate on a global basis. Work of this kind is already in progress in India and Bangladesh, where the need for agroforestry is urgent and where, in the case of India, collaboration with a large and well-established national programme (see 2.48) could have a major impact. These activities will continue and others will be added as resources allow. In order to extend these global services, ICRAF will seek to establish regional offices towards 1995, attached to institutions in Latin America and Asia. Besides providing improved services, these offices will enable ICRAF to learn more systematically from the substantial research and development work already in progress in these regions.

Zones and land-use systems

3.20 **Zonal networks.** ICRAF and its national partners are already conducting collaborative research in four agro-ecological zones of subsaharan Africa. Details of these zones are provided in 1.19. Research in a fifth zone—the subhumid lowlands—will begin in the mid-1990s. At the outset, this research will be conducted as a subprogramme of ICRAF's network for the humid zone but, in the longer term, the Council may establish a separate network for the subhumid zone in view of its distinct problems and potential (see 2.17).

3.21 Within each zone, the choice of priority land-use systems for more detailed study resides with ICRAF's national research partners, with the provisions noted in 3.24–3.26. The criteria for this choice include the kind of farming practised (commercial or subsistence), the likelihood of finding suitable entry points for agrofore-

Box 3.2. ICRAF's operational principles

ICRAF's programme will be built on three overriding principles:

- The approach to research and institution building will continue to be systems- and problem-oriented, interdisciplinary, beneficiary-driven and client-responsive.
- The mode of operation will continue to be collaborative.
- Priority setting will continue to be based on the needs of land users and the relevance of agroforestry to address those needs.

stry interventions, the size and population density of the system, and the urgency of the need to increase productivity and sustainability.

3.22 During the first half of the 1990s, ICRAF will gradually expand and consolidate its collaborative zonal research activities. The number of land-use systems studied within each zone will probably increase along with the number of participating countries. By 1995, when these zonal networks are expected to be fully operational, about 24 countries will be involved in collaborative research at approximately 50 field sites. Within Africa, ICRAF will not seek further growth beyond these approximate limits.

3.23 **Sloping land.** Sloping land presents special problems that cut across ecological zones. Agroforestry offers considerable promise for preventing soil erosion and improving soil fertility in such areas. ICRAF will ensure that sloping land is adequately represented among zonal research sites and that suitable technologies developed for sloping land in one zone are transferred for adaptation and testing in others.

3.24 **Forest areas.** Within the humid lowland zone, there are a few remaining forest areas in which gathering is the only form of land use. These will be excluded from ICRAF's site-specific collaborative research since they fall within the mandate of forestry research institutions. However, forest areas constitute a rich source of

Figure 3.1. ICRAF's research priorities

	High Priority	Medium Priority	Low or No Priority
Regions	Africa	Asia, Latin America	–
Zones	humid, subhumid, semi-arid, highland plateau	–	arid, montane –
Beneficiaries	smallholders	landless	commercial farmers, ranchers
Clients	national research institutions	extension services, non-governmental organizations	–
Benefits	sustainability, income, subsistence	–	–
Products and Services	fodder, building materials, fruit, live fencing, fuelwood, soil fertility, erosion control	–	–

genetic material for use in multipurpose-tree breeding and ICRAF will maintain close contact with institutions conducting plant-exploration missions in such areas.

3.25 **Pastoral systems.** Within the semi-arid lowland zone, purely silvopastoral land-use systems, without a crop component, offer little opportunity for increasing output through agroforestry practices, given current socio-economic and environmental constraints (see 2.08). ICRAF will not normally include such systems in its site-specific collaborative field research. However, changes in factors such as land tenure and pricing policies could substantially improve the prospects for agroforestry in pastoral systems and for this reason these systems will continue to be included in ICRAF's research on policy. Studies on the interactions between silvopastoral and agrosilvopastoral systems will also continue.

3.26 **Arid and montane areas.** ICRAF will not conduct collaborative field research in arid or montane areas, at least for the next five years. These harsh and underpopulated environments offer little potential for significant impact through agroforestry in the short term. The crop component is typically absent, except under irrigation in the arid zone, but trees and shrubs could play an important role in halting desertification. The Council will therefore undertake a watching brief for the arid zone.

Beneficiaries

3.27 ICRAF's research is directed primarily towards resource-poor land users. Agroforestry development is particularly suited to the needs of this group because it reduces the requirement for costly chemical inputs. Larger, more commercially oriented farmers and ranchers may benefit from ICRAF's research but are not the primary targets. ICRAF emphasizes resource-poor land users because in tackling the needs of this group research is directed towards the the problems of poverty, resource degradation and insufficient production of basic commodities.

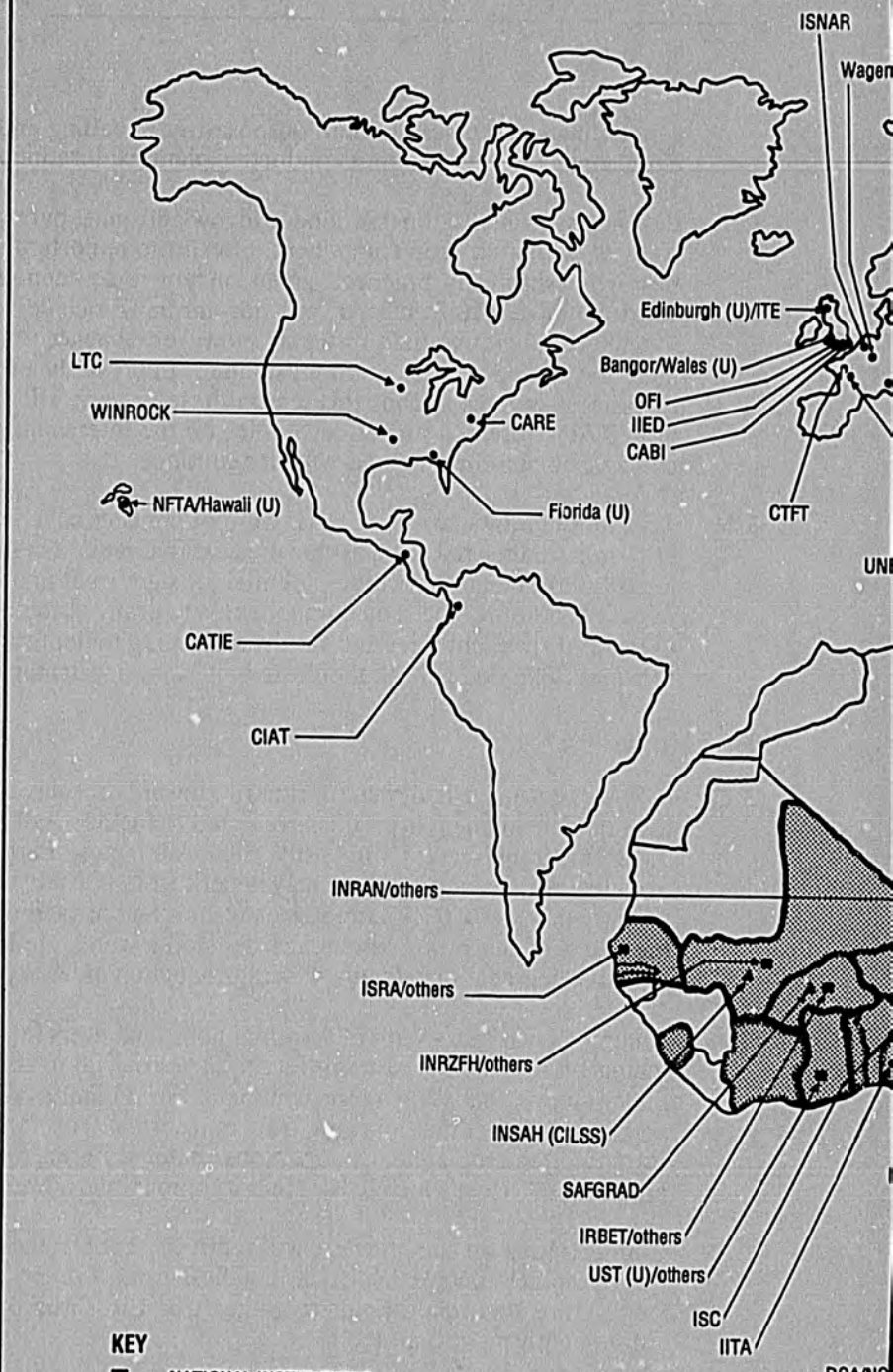
3.28 Among the various groups of resource-poor land users in Africa, ICRAF will focus mainly on smallholder farmers. Family farms of 0.75 to 10 hectares account for the bulk of food production on the continent. Farm families need a variety of products and services from multipurpose trees and shrubs. This range of needs calls for the study of tree/crop/animal interactions under different management regimes, an area of research in which ICRAF has a comparative advantage.

3.29 Concentrating on smallholders will indirectly benefit the small but growing number of landless people in Africa. Landless rural dwellers often provide labour on small farms and retain rights to gather tree and shrub products, which they may subsequently process and sell.

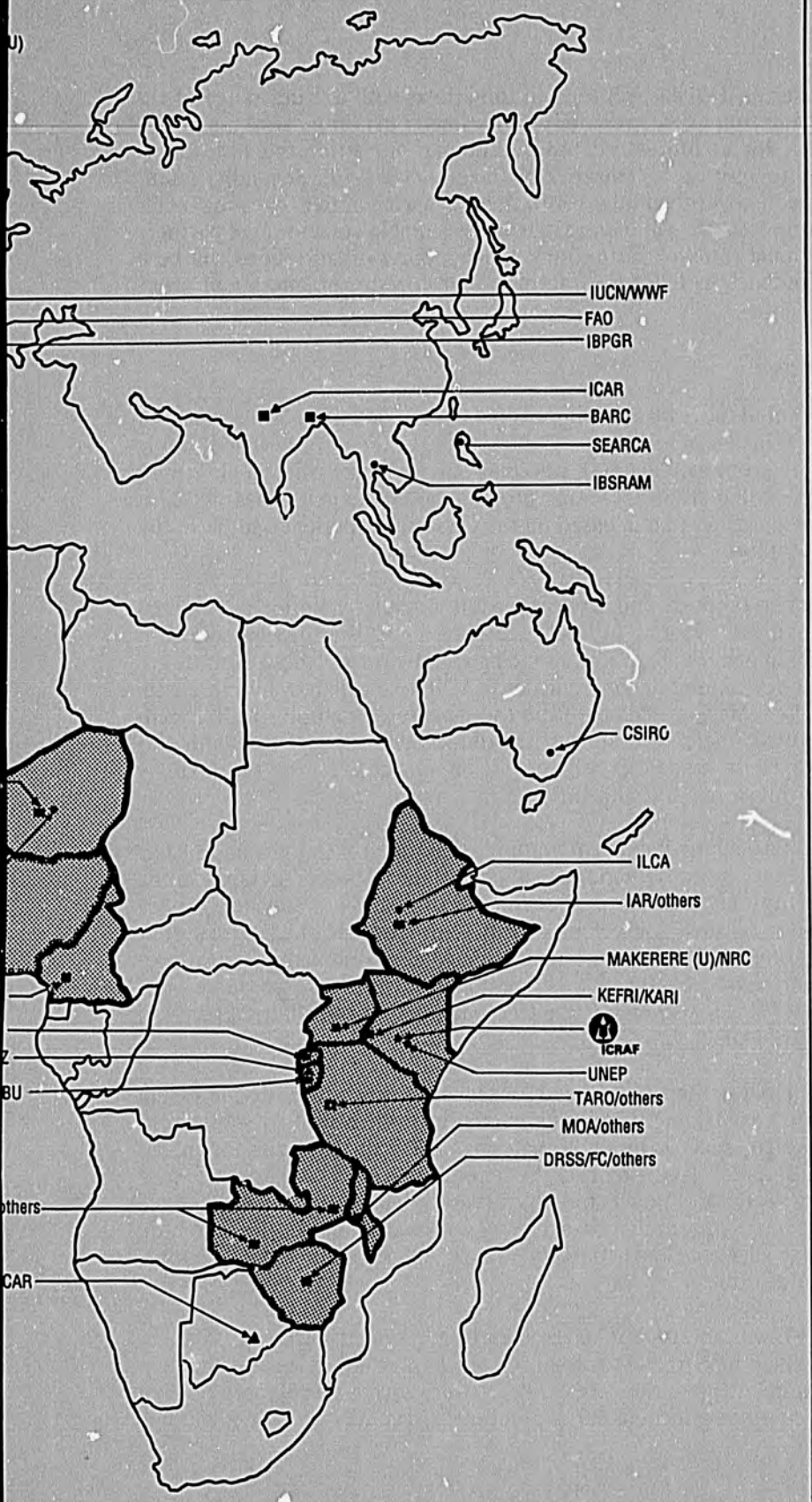
Research partners

3.30 ICRAF's choice of research partners is guided primarily by the need to strengthen national agroforestry research capacities in developing countries. The Council's main partners in applied and adaptive research will therefore be national research institutions in these countries. ICRAF's partners in strategic research will be selected from a range of specialized institutions in both developed and developing countries (see Figure 3.2).

Figure 3.2. ICRAF's current a



ned collaborative partnerships



3.31 For two major reasons, ICRAF will tend to forge links with a wider range of research partners than some other research institutions. First, in most national systems responsibility for agroforestry is divided among ministries and institutions devoted variously to agriculture, livestock or forestry (see 2.59). Secondly, extension services and non-governmental organizations, by virtue of their growing involvement in on-farm research, will increasingly make suitable collaborative partners alongside the national research institutions. Indeed, these organizations will be a vital source of feedback to ICRAF on farmers' agroforestry practices and problems.

Products and services

3.32 ICRAF's user-oriented focus makes it impossible to set a definitive list of research priorities to the exclusion of all others. Choices will continue to be made jointly with ICRAF's clients and beneficiaries, who must have a major voice in determining the aims of the collaborative research programme. Some guidelines on these choices can nevertheless be stated, based on the Council's experience so far in the use of the D&D method.

3.33 **Major priorities.** The products and services most frequently identified as research priorities by farmers participating in D&D exercises are soil fertility/erosion control, fodder, building materials, fruit, live fencing and fuelwood. These outputs are therefore likely to remain the major priorities of ICRAF's collaborative research. Since several of them may be available from the same tree or shrub species, managed in different ways, the choice of specific products and services frequently involves trade-offs. These trade-offs will be an important area for research by ICRAF and its partners (see 4.17 and 4.22).

3.34 **Sustainability.** A particularly important 'output' of multipurpose trees and shrubs is their contribution to the conservation of soil and water resources and thus to the sustainability of crop and livestock production. Quantifying and enhancing these benefits will be an important research task for ICRAF (see 4.16–4.23). Yet sustainability alone is not enough, for species and management systems must also provide tangible, short-term benefits if they are to be attractive to resource-poor farmers. Thus ICRAF will also emphasize tree outputs that contribute directly to the livelihood of rural land users.

3.35 **Income generation.** All farmers feel a need for higher incomes. The products from agroforestry systems contribute, if only indirectly, to cash as well as subsistence needs. Some products, such as building materials and fruit, have substantial income-generating potential (see Box 2.4). In general, ICRAF's research will concentrate primarily on those products for which there is widespread demand, since they offer the greatest opportunity for achieving substantial impact. Research on problems related to specialized agroforestry outputs will be conducted in collaboration with other institutions.

3.36 **Processing.** ICRAF will not undertake research on the processing of agroforestry products. The Council nevertheless recognizes certain key areas, such as the production of furniture and chemicals (see 2.27), in which increased research on processing might open up new income-earning opportunities. ICRAF will encourage

other institutions to carry out such work, especially when research on processing might have important implications for tree-improvement programmes.

3.37 To ensure the relevance of research aimed at developing suitable animal feeds, ICRAF will maintain close links with institutions specializing in livestock production. However, the Council will not undertake research on livestock feed utilization, an area in which it lacks the necessary facilities and expertise and which is in any case covered by other international institutions.

Technologies and components

3.38 **Arrangements.** Selection, breeding and management are linked to the ways in which multipurpose trees are arranged in the landscape. Although there are many thousands of agroforestry systems, all differing from one another in detail, they can be classified into about 20 agroforestry technologies – distinctive arrangements of trees and other components in space and time (Annex 3).

3.39 ICRAF's field research will concentrate mainly, but not exclusively, on those arrangements in which trees and shrubs are closely associated with agricultural crops and/or animals. Spatial arrangements of this kind include trees on cropland, multistoreyed tree gardens (including home gardens) hedgerow intercropping (also called alley cropping or alley farming), boundary planting, windbreaks and trees on erosion-control structures. Combinations of multipurpose trees with perennial plantation crops such as cocoa or coffee will be included where such systems are locally important. Rotational (temporal) arrangements include improved tree fallows, in which fast-growing trees are planted in succession with annual crops, and the taungya system, in which food crops are planted on forest land in the initial stages of plantation establishment.

3.40 Among arrangements of trees in pure stand, the most important to ICRAF will be fodder banks and fuelwood or pole production in mixed farming systems. Other monocultural arrangements, such as forest plantations and woodlots for single use, will not normally be included in ICRAF's research programmes since these fall within the mandate of forestry research institutions. A great deal of applied and adaptive research on such arrangements has already been carried out by these institutions.

3.41 **Species and provenances.** ICRAF's multipurpose-tree database contains information on more than 1000 species with potential candidates for use in agroforestry. Little is known about most species and still less about the highly variable performance of different provenances. Nevertheless, there are several guidelines for choosing the species and provenances on which to conduct research.

3.42 The products and services required of a multipurpose tree and its place in the landscape must both be adequate before a species is chosen for a screening or breeding programme. In the selection process, trees must be viewed in terms of the farming systems within which they will be introduced.

3.43 About 20 multipurpose-tree species are already fairly widely used in research. These have been selected for their obvious potential and therefore form a useful

basis for bringing about early improvements in production systems. Where their performance characteristics are already well understood, they can be introduced without initial screening and evaluation.

3.44 The potential of these relatively well-researched species should not obscure the fact that many less well-known species and provenances may hold considerable promise. There are two additional reasons to study a broad range of species and provenances. These are the importance of maintaining or improving resistance to pests and diseases and of ensuring the current wide variety of products and services available from trees. A major task for ICRAF will be to identify promising genetic material, test it more widely and ensure that sound selection and breeding programmes are conducted, either collaboratively or independently by other institutions (see 4.24–4.30).

3.45 In support of this work, it will be important to preserve the existing diversity of tree and shrub species and provenances in genebanks. To this end, ICRAF will continue to collaborate with the relevant specialized institutions in identifying collection priorities and organizing plant-exploration missions. In the short term, the Council itself will not undertake the task of germplasm conservation, since genebanks have already been established at a number of national and regional institutions in Africa and elsewhere. However, in the longer term ICRAF may become more involved in this area if the task is not adequately addressed through existing arrangements.

3.46 Shade-tolerant grasses and annual crops will be needed to accompany trees in improved agroforestry systems. As already noted (2.33), few of the widely planted annual crop varieties are adapted for agroforestry. ICRAF will encourage crop-research institutions to broaden their breeding programmes in view of the requirements of agroforestry systems.

TOWARD 2000: ICRAF'S CHANGING ROLE

3.47 The major directions for ICRAF during the 1990s are outlined in Box 3.3. In this section we explore ICRAF's changing role through the decade.

3.48 On entering the 1990s, ICRAF approaches the end of a period in which considerable resources were devoted to developing tools and methods for agroforestry research. Although the Council will continue to play a significant role in this area, the share of resources devoted to methodology development will decline in the 1990s.

3.49 Collaborative applied and adaptive research is now in progress in a growing number of African countries. This research will gain even more importance during the first half of the 1990s. During this period, evidence should emerge for the potential of large and rapid productivity gains in agroforestry systems, due largely to the matching of multipurpose-tree species and provenances with the appropriate environments and functions. These early gains should be followed towards the end of the decade by a second wave of equally spectacular gains resulting from tree-improvement research. However, for species with a longer generation time, gains from this type of research will not materialize until well into the next decade.

3.50 Two additional outcomes are likely from this phase of intensive collaboration. The first will be the increasing ability of national institutions to conduct applied and adaptive research independently, with less direct involvement by ICRAF. The second will be a growing understanding of the potential benefits from strategic research. Research on basic processes will gain in importance during the 1990s, focusing on topics such as resource competition between trees and crops, pest and disease management, root symbionts and vegetative reproduction. Towards the end of the decade, biotechnology will increasingly be used as a tool to shorten the research process and make research more productive.

3.51 As new agroforestry technologies become available, it will be important to ensure that the necessary policies and institutional structures are in place to support adoption by land users. The share of ICRAF's resources in this area is likely to grow during the decade, with special emphasis on constraints related to land tenure.

3.52 Throughout the 1990s information-dissemination activities will be closely tied to the needs of ICRAF's national research partners, but information dissemination will also play a broader role in synthesizing and guiding the work of the global agroforestry community. As agroforestry research expands and at the same time becomes more specialized, ICRAF's support through training, information and communications activities will need to grow. For example, by the end of the decade agroforestry curricula should be well established in the national universities collaborating with ICRAF's education programme (see 4.46–4.51). In addition, national institutions should enjoy enhanced access to a global information network (see 4.52–4.57).

CONCLUSION

3.53 In conclusion, ICRAF's work is likely to expand during the coming decade as the world turns increasingly to agroforestry as an approach to sustainable development. As the pressures on ICRAF increase, the Council will undoubtedly need to grow in size, yet in so doing retain the advantages of being small. If this process is successful, we may envisage an ICRAF in the year 2000 that, despite its larger size, retains the informality and adaptability that characterize the Council today. In a field as complex as agroforestry, ICRAF's strategy must emphasize collaboration with others, including a stress on communication and linkage activities as core responsibilities equal in importance to research.

Box 3.3. Major directions for ICRAF in the 1990s

During the 1990s ICRAF will aim to:

- Strengthen applied and adaptive research through the AFRENAs
- Increase research on multipurpose-tree improvement
- Increase strategic research on issues related to sustainability
- Increase research on policy and economic issues
- Build agroforestry education programmes at national universities
- Provide more support to research in Asia and Latin America
- Reduce the relative emphasis on developing research methods.

Proposed programme

RESEARCH ACTIVITIES

4.01 ICRAF conducts three types of research:
- Strategic research
- Applied research
- Adaptive research.

4.02 This research will be organized in four major programmes:
1. Agroforestry and Land-Use Systems
2. Component Interactions in Agroforestry Systems
3. Multipurpose-Tree Improvement for Agroforestry Systems
4. Agroforestry Policy and Institutional Issues.

4.03 Each of the four programmes will integrate strategic, applied and adaptive research, carried out either at ICRAF or through the zonal AFRENAs (Figure 4.1). Programmes 2 and 3 reflect ICRAF's commitment to sustainable development through the generation of improved agroforestry technologies. They will be ICRAF's largest programmes in terms of professional staff. Programmes 1 and 4 will support this work by providing the knowledge base for planning technology development and by increasing the likelihood that technology will reach land users and be accepted.

4.04 The Council will be directly involved in applied and adaptive research through its collaboration with national institutions, largely in the context of the AFRENAs. The objectives of each AFRENA are twofold: to generate agroforestry technologies suitable for specific land-use applications and to strengthen national agroforestry research capacities.

4.05 In its collaborative activities, ICRAF's primary objective is to develop and apply the necessary approaches, methods and tools for generating agroforestry technologies and strengthening national institutional capacities. A further objective is to set priorities for strategic research in agroforestry.

4.06 Chapter 5 describes in detail how the AFRENAs operate (5.07–5.16). Box 4.1 provides an example of the type of research in progress.

4.07 ICRAF's four programmes should not be regarded as immutable. They will be subject to modification as research progresses and new areas of work become important. Three important new research areas have already been identified—soil fertility, pest and disease management, and fruit production. Research in these areas will be conducted initially as projects crossing programme boundaries, but these or other projects may be reorganized as separate programmes at a later date.

4.08 The sections below describe each of the four ICRAF programmes in terms of objective, justification, approach, research topics and mode of operation.

Programme 1: Agroforestry and Land-Use Systems

4.09 **Objective.** To contribute to sustainable increases in the output of land-use systems by understanding how such systems operate and assessing their potential for development through agroforestry.

4.10 **Justification.** Land-use systems must first be understood if they are to be improved through agroforestry (2.22). The elements of such an understanding include the role played by multipurpose trees and shrubs, the problems experienced by land users and the opportunities for solving them, as well as the trends in productivity and sustainability over time. Given the global issues outlined in Box 2.1, it is especially important to understand these long-term trends, together with their environmental and policy implications.

4.11 ICRAF's comparative advantage in conducting research on agroforestry and land-use systems is twofold. First, the Council is in a position to correlate information about similar systems from different countries and so to form a picture of regional trends and priorities. Second, ICRAF has access to a range of tools and databases that facilitate the task of assembling and managing information.

Figure 4.1. Matrix approach to ICRAF's operations

PROGRAMMES	LOCATIONS: S/Africa AFRENA	EC/Africa AFRENA	Humid W/Africa AFRENA	Semi-arid W/Africa AFRENA	South Asia	SE Asia	Latin America	ICRAF/ Global
Research								
1. Agroforestry and land-use systems								
2. Component interactions in agroforestry systems								
3. Multipurpose-tree improvement for agroforestry systems								
4. Agroforestry policy and institutional issues								
Dissemination								
5. Training								
6. Education								
7. Information and documentation								
8. Communications								

Note: Work is planned in all boxes of the matrix and is already in progress in most. See text for details.

4.12 **Approach.** This programme will gather, analyse and synthesize information on agroforestry technologies and systems. Studies of how systems function will lead to the identification of specific problems for more detailed research in other programmes. The results of work on specific aspects of agroforestry systems will be synthesized and applied to the development and improvement of systems as a whole. The approach will be multidisciplinary, covering both the biophysical and the socio-economic aspects of agroforestry.

4.13 The programme will apply and refine the D&D methodology already developed by ICRAF. It will use the multipurpose-tree database and other tools that have also been developed as well as tools and information, such as remote-sensing data, available from other organizations. A geographic-information system will provide a basis for assessing the transferability of technology and identifying recommendation domains. An important output of this programme will be a computerized 'technology register' for recording research results and field experience, grouped by technology. The development and dissemination of research methods will also be important.

4.14 **Research topics.** It is not possible to specify all the research topics for this programme over the next decade since these will evolve according to changing needs. However, the following topics will be included:

- Effects of land and tree tenure laws and customs on the adoption of agroforestry technologies
- Evaluation of the uses made of multipurpose trees (including their food-production potential)
- Identification of the most beneficial agroforestry systems for specific environmental and socio-economic conditions
- Study of adoption of agroforestry systems in relation to population density
- Measurement of the long-term sustainability of land-use systems
- Assessment of the contribution of trees to family farm income
- Significance of agroforestry for forest clearance in the humid zone
- Potential of agroforestry for decreasing pressure on grazing lands in the semi-arid zone
- Effects of agroforestry on the global carbon cycle.

4.15 **Mode of operation.** A multidisciplinary team of both socio-economic and biophysical scientists will be responsible for implementing this programme. A major activity will be D&D exercises, carried out in collaboration with ICRAF's national research partners. Field surveys will be combined with more sophisticated techniques to obtain a picture of longer-term and/or regional trends. The expertise of specialized institutions, such as the University of Bangor (UK) and the Land Tenure Center (USA), will be sought where necessary. FAO and UNEP may also be important research partners.

Programme 2: Component Interactions in Agroforestry Systems

4.16 **Objective.** To contribute to sustainable increases in the output of agroforestry systems by understanding and improving the biophysical and socio-economic interactions between system components with a view to increasing the management options available to resource-poor farmers.

4.17 **Justification.** Agroforestry has considerable potential for contributing to the sustainability of production systems. However, its contribution may be radically affected by the offtake of other outputs such as fuelwood, building materials and fodder (see 3.33–3.34 and Box 2.1). Ultimately, it is farmers who decide what combinations of products and services they want from their trees in the long and short term, but ICRAF can help by providing information for better decision making and methods for more efficient use of resources. Both strategic and applied research are needed to understand the interactions between system components in order to enhance the positive and reduce the negative interactions.

4.18 ICRAF's comparative advantage in conducting this research lies in its capacity to marshal the resources needed to carry out a complex, long-term, multilocational programme that would be beyond the means of individual national institutions operating in isolation. These programmes will be complex because the interactions between the many components in agroforestry systems are complex and little understood, long-term because the effects of agroforestry on sustainability take many years to accrue, and multilocational because agroforestry research is highly site specific, implying a need for extensive cross-site comparisons. A further important advantage is the expertise ICRAF has acquired in the development of methods for on-station and on-farm research in agroforestry, including the design of experiments and surveys and the analysis of data (see 1.26–1.33).

4.19 **Approach.** This programme will use a combination of on-station and on-farm research supported by data analysis and other services provided at ICRAF headquarters or at other locations as appropriate. It will continue to refine and apply the research tools and methods already developed by ICRAF, using these to support the applied research carried out through the AFRENAs and by other institutions. The emphasis in strategic research will shift gradually away from the development

Box 4.1. Research in the Eastern and Central Africa AFRENA

The countries participating in the Eastern and Central Africa AFRENA in 1989 were Rwanda, Burundi, Kenya and Uganda, with 15 ICRAF and national scientists collaborating in research to develop improved agroforestry technologies. D&D exercises conducted in these countries identified soil-fertility and erosion problems as major constraints affecting farmers, together with shortages of animal feed, fuelwood and building and fencing materials. The two major technologies selected initially to address these constraints were hedgerow intercropping and grass/tree strips on bunds. Recently, other technologies have been added, including the use of multipurpose trees in coffee and banana plots and on grazing land.

Screening trials and experiments to test agroforestry technologies are now in progress at six sites at different altitudes in the four countries. About 30 multipurpose-tree species and 60 provenances are being screened at Maseno in Kenya, the major site selected for multipurpose-tree improvement research. Screening includes several well-known species—such as leucaena, calliandra, sesbania and grevillea—and also a number of others, less well known. Studies also include alternative management regimes for hedgerow intercropping and other agroforestry technologies.

of methods towards research on basic processes, which will account for a growing share of this programme's resources as the decade progresses (see Box 3.3).

4.20 On-station research at the Machakos field station and at other sites under ICRAF control will focus on strategic issues arising from the applied research process. During the next few years, the emphasis will be on completing the development of appropriate experimental designs, a task that is now approaching its final phase. Thereafter, research on basic processes, and especially below-ground tree/crop interactions, will assume increasing importance. On-station research at other locations will tend to focus more on applied research to develop appropriate arrangements and management regimes for different technologies and site conditions. An important input to all on-station research in the longer term will be the development of improved germplasm under Programme 3.

4.21 On-farm research will make an important contribution to the development and testing of research methods that simultaneously ensure scientific rigour and the active participation of farmers. On-farm research will also be used to test the improved germplasm developed under Programme 3. It is difficult enough to obtain reliable experimental results from on-farm research where the concern is purely with annual-crop production. It is doubly difficult in agroforestry research with more complex interactions between system components. Yet farmer participation is especially important in agroforestry research for at least two reasons: first, because local expertise can often make a substantial contribution to the research process and, second, because acceptability to farmers is an important issue since the benefits of agroforestry technologies are often not apparent for several years.

4.22 **Research topics.** It is not possible to specify all the topics that will be covered under this programme over the next decade since these will evolve according to changing needs. However, the following topics will be included:

- Competition between trees and annual crops for soil nutrients, moisture and light
- Trade-offs between different outputs of agroforestry systems
- Efficiency and management of root symbionts, especially mycorrhizal associations
- Management of pests and diseases in agroforestry systems
- Fertilizer/green manure interactions
- Impact of agroforestry on family farm income
- Labour requirements of agroforestry interventions
- Design of agroforestry experiments
- Statistical treatment of on-farm research data.

4.23 **Mode of operation.** A strong multidisciplinary core team will interact with ICRAF's research partners in national institutions to implement this programme. Work will be conducted at the Machakos field station in addition to a wide range of network sites for on-station and on-farm research. An additional research station under ICRAF control will also be sought in a more humid environment. Links with a wide range of specialized institutions will be used to complement the expertise available at ICRAF and in national institutions. In addition, ministerial departments, universities, non-governmental organizations and extension services will continue to participate in applied and adaptive research. Visiting scientists and

seconded experts already make a significant contribution to this programme. In order to hold down ICRAF's core costs, specialists in these categories will be used to an even greater degree in the 1990s.

Programme 3: Multipurpose-Tree Improvement for Agroforestry Systems

4.24 **Objective.** To contribute to sustainable increases in the output of agroforestry systems by improving multipurpose-tree germplasm and silviculture.

4.25 **Justification.** Large gains in productivity are possible through the improvement of multipurpose-tree germplasm and silviculture, particularly in those species that have not yet been subject to intensive research (see 2.31). Research is urgently needed for the identification of promising provenances, followed by breeding within and between provenances. In addition, a variety of techniques, such as rhizobia inoculation, can be applied to enhance tree growth. ICRAF is one of the few institutions anywhere in the world already engaged in multipurpose-tree improve-

ment, as most other tree-breeding programmes are geared towards species for application in large-scale plantation forestry.

4.26 ICRAF's comparative advantage in undertaking this research is threefold. First, through the D&D methodology the Council has acquired considerable understanding of the needs of multipurpose-tree users. Second, the Council has developed an extensive database on the characteristics of multipurpose trees (see 1.32) that is already serving as a valuable tool for research. Third, ICRAF's status as an international institution allows access to advanced breeding techniques developed elsewhere in the world.

4.27 **Approach.** This programme will conduct multipurpose-tree screening and evaluation trials in locations throughout subsaharan Africa. As wide a range of species as possible will be tested, striking a balance between trees already in widespread use by farmers and lesser-known species. During the first years, work will focus on screening and evaluation. In the medium term, it should be possible to identify a few promising species for genetic improvement and this aspect will account for a growing share of resources during the second half of the decade. Silvicultural research will also be conducted, aimed at improving tree establishment and growth rates.

4.28 Tree-improvement research will be supported in a variety of ways. Information on the roles and characteristics of multipurpose trees and the species and traits preferred by farmers will provide valuable guidance in selecting genetic material for different locations and technologies, as well as in setting breeding objectives and selecting parent material. Advanced techniques will be applied to shorten the breeding cycle and overcome specific problems such as outbreeding. The programme will develop methods for setting multi-trait breeding objectives, leading to comprehensive breeding plans for selected species. Tools such as the multipurpose-tree database will continue to serve as an invaluable resource for ICRAF and its research partners. Their further refinement will be an important output of this work.

4.29 **Research topics.** It is not possible to specify all the topics that will be covered under this programme over the next decade since these will evolve according to changing needs. However, the following topics will be included:

- Genotype-by-environment interactions of selected tree provenances
- Constitution of advanced-generation breeding populations
- Heritability of key traits
- Enhancement of tree growth through rhizobia inoculation
- Use of tissue-culture techniques to increase the efficiency of vegetative propagation
- Phenology of flowering and fruiting.

4.30 **Mode of operation.** A strong multidisciplinary core team will support ICRAF's research partners in the AFRENAs in conducting this programme. This support will be complemented by inputs from a wide range of specialized institutions (see 5.20). Subject to national plant-quarantine regulations, the AFRENAs will exchange multipurpose-tree germplasm with each other, with ICRAF and with other agencies, and will screen germplasm in a wide variety of locations. To support the

AFRENAs, the programme will seek to establish four regional centres equipped with the necessary facilities for this kind of work. One of these will be the Maseno field station in western Kenya where research has already started. Others will be located in Southern Africa, the humid zone of West Africa and the Sahel.

Programme 4: Agroforestry Policy and Institutional Issues

4.31 **Objective.** To contribute to sustainable increases in the output of agroforestry systems by helping to develop more effective policies in the agroforestry sector and better ways to organize and manage agroforestry research and development.

4.32 **Justification.** The adoption of agroforestry technologies is critically influenced by government policies (Box 2.1) and particularly by the support provided through national research and development systems. Agroforestry has the potential to contribute to sustainable land use, but new agroforestry technologies by themselves will not be enough to guarantee this contribution. Appropriate policies in areas such as pricing and land tenure will also be needed. Devising and implementing such policies is a difficult task, especially in countries where the pressure on natural resources is growing rapidly. In addition, the fact that agroforestry has no institutional home (see 2.59) has complicated the organizational arrangements for conducting agroforestry research. The support provided to agroforestry development suffers as a result.

4.33 ICRAF's comparative advantage in conducting research on policy and institutional issues lies in its close contacts with policy makers and the leaders of both forestry and agricultural research and development in Africa. Devising solutions to agroforestry policy and institutional problems is the responsibility of national governments, but ICRAF can assist them by comparing experiences in different countries and extracting relevant lessons.

4.34 **Approach.** A wide range of policies is already in place in developing countries aimed at supporting and encouraging sustainable development. National governments are also trying various models for incorporating agroforestry research into national systems. ICRAF's programme will focus on analysing and synthesizing experience in different countries with a view to applying the lessons learned in Africa and elsewhere.

4.35 **Research topics.** It is not possible to specify all the topics that will be covered under this programme over the next decade since these will evolve according to changing needs. However, the following topics will be included:

- Effect of the availability and price of mineral fertilizers and other inputs on the adoption of agroforestry and on its economic and environmental impact
- Effect of different land-tenure laws and customs on tree planting and harvesting
- Role of credit in the adoption of agroforestry practices
- Effect of commodity prices on offtake from agroforestry systems
- Development of private- or public-sector services to control pests and diseases
- Use of different extension channels for promoting agroforestry development
- Development of effective interinstitutional mechanisms for planning and implementing agroforestry research

- Use of different linkage mechanisms to integrate agroforestry research in national systems.

4.36 **Mode of operation.** This programme will be carried out through desk studies at ICRAF headquarters and missions to national policy and research institutions. Experience in the AFRENAs will serve as a major source of case-study material and collaborative research will be undertaken with national agroforestry steering committees and specialized institutions in participating countries. Through regional coordinators, close links will be maintained with policy makers in these countries. The involvement of the International Service for National Agricultural Research (ISNAR) and of the International Food Policy Research Institute (IFPRI) will also be sought.

DISSEMINATION ACTIVITIES

4.37 ICRAF will have four major programmes devoted to dissemination:
5. Training
6 Education
7. Information and documentation
8. Communications.

4.38 All four programmes reflect ICRAF's commitment to strengthen national research capacities and support global agroforestry research and development efforts.

4.39 The sections below will outline each programme in terms of objective, justification, current activities, future trends and mode of operation.

Programme 5: Training

4.40 **Objective.** To increase the skills and knowledge of agroforestry scientists and others by offering a range of training opportunities at ICRAF and elsewhere.

4.41 **Justification.** One of the most severe limitations on the establishment of a lasting capacity for agroforestry research and development in developing countries is a shortage of staff with the necessary multidisciplinary knowledge and skills (see 2.58). Because agroforestry is a new science, the shortage of trained manpower is more acute than in established areas such as agriculture and forestry.

4.42 ICRAF has a comparative advantage in offering training opportunities by virtue of its expertise in the development of research approaches, tools and methods (see 1.26–1.33) and its wide range of contacts with universities and specialized institutions. Training can be carried out cost-effectively at the international level because the same course can meet the needs of more than one country or region.

4.43 **Current activities.** ICRAF's training programme currently offers short- and medium-term courses and a variety of individual training opportunities including internships and fellowships. Meetings, field trips and other events are also organized under this programme. Training activities are held in a variety of locations, supported by written and audiovisual materials, staff inputs and other resources. The training programme emphasizes support to ICRAF's collaborative research net-

works, but courses and materials are available to a global audience including those not collaborating directly with ICRAF. The main beneficiaries are scientists and technicians, although trainers, policy makers, research managers and extension specialists are also important audiences. Courses of a more general nature, as well as some specialized courses, are offered in French as well as English.

4.44 **Future trends.** As ICRAF's collaborative research gathers pace, training will gradually become more specialized and will increasingly include contributions from other institutions. Additional courses will be offered in French, especially as work in West Africa intensifies, and there may also be an attempt in the longer term to organize courses in Spanish and Portuguese. There will be more emphasis on the development of training materials, which will be tested and modified in cooperation with selected training institutions. A policy of 'training the trainers' will allow a multiplier effect, enabling ICRAF gradually to relinquish its direct role in training in favour of providing support to training activities carried out by national institutions. Thus training will become increasingly decentralized, although conferences and workshops will continue to be an important activity at ICRAF headquarters.

4.45 **Mode of operation.** The training programme will work closely with ICRAF's scientists who will continue to have primary responsibility for course instruction and assistance to individual participants. Links will be established with universities and other institutions as training needs become more specialized.

Programme 6: Education

4.46 **Objective.** To increase the supply of professional agroforesters by helping institutions of higher learning to incorporate agroforestry into their curricula.

4.47 **Justification.** Agricultural, forestry and livestock scientists are often educated in separate disciplines, although they are increasingly expected to work together during their subsequent careers (see 2.60–2.61). Partly as a result of this, sectoral and disciplinary differences continue to thwart the integrated development of rural areas in developing countries. Incorporating agroforestry into national educational curricula would help solve this problem and could be achieved without costly additions or drastic restructuring. By helping to shape the attitudes and approaches of young scientists at the outset of their careers, ICRAF could achieve a considerable impact on the future productivity of agroforestry research and development.

4.48 ICRAF's comparative advantage in undertaking this programme lies in its worldwide contacts with institutions of higher education and the tools, methods and approaches already produced for agroforestry research and development. This work will increasingly be supplemented by the development of instructional materials. In the longer term, the introduction into national education systems of the basic techniques and methods of agroforestry research will make it possible for ICRAF's own training activities to become more specialized.

4.49 **Current activities.** In 1989, ICRAF conducted a survey of 25 universities in 14 African countries to assess the extent to which agroforestry was already taught. Following the survey, consultations were held in five countries to discuss possible institutional arrangements and resource requirements for introducing agroforestry at undergraduate and postgraduate levels. Two new degree courses were designed and are now being offered to students at the University of Science and Technology (UST) in Ghana and at Moi University in Kenya. General guidelines for curriculum development are being prepared.

4.50 **Future trends.** During the 1990s, ICRAF's education programme will concentrate on agroforestry curriculum design and instruction, on the development of teaching materials for degree courses and on the exchange of information on agroforestry education programmes and training opportunities. The major focus will be on Africa. The support of educational institutions in developed countries will be enlisted where possible.

4.51 **Mode of operation.** This programme will be carried out in collaboration with a limited number of universities and other educational institutions in Africa and other regions. Courses and workshops for lecturers and teachers will be an important means of standardizing curricula and teaching methods. These will be complemented by an 'Agroforestry Education Network' or similar mechanism to facilitate the exchange of information and resources. A database on agroforestry education and training opportunities will also be created.

Programme 7: Information and Documentation

4.52 **Objective.** To contribute to agroforestry research and development through the collection, analysis and dissemination of relevant information.

4.53 **Justification.** Relevant, up-to-date information is a vital prerequisite for planning and implementing agroforestry research and development (see Box 1.2). Much of this information is not widely available and the audiences for it are highly diverse

(see Box 2.5). For these reasons ICRAF has made special efforts to locate and classify information related to agroforestry and to identify and serve the appropriate audiences. The Council also has a special role in helping national programmes and institutions gain access to this information.

4.54 ICRAF has a comparative advantage in implementing this programme because its international status makes it possible to act as a global clearing-house for agroforestry information. Relying on the use of up-to-date information technology to acquire, store, manipulate and provide rapid access to information, the Council is able to reach a wide audience of researchers and others with specialized information drawn either from its own library or from other sources (see 1.35).

4.55 **Current activities.** ICRAF information staff monitor the world literature on agroforestry and acquire selected titles for storage and rapid retrieval in the library. Library-based services include the specialized dissemination of information (SDI) to research partners, a current-awareness service, a bimonthly list of library accessions and a search service (see 1.35). This work is supported by research on terminology, including English and French language equivalencies, on the demand for agroforestry information and on information technology. A major activity is the compilation of specialized bibliographies. In addition, ICRAF pursues exchange agreements with other libraries, organizes access to other databases, provides journal subscriptions and conducts joint information-retrieval activities with other international research centres and agencies. Major emphasis is placed on strengthening the ability of national institutions to acquire and disseminate agroforestry information. To this end, the Council trains information professionals from national institutions and has helped to establish a network of information officers in Eastern and Southern Africa. Funding proposals are also prepared for upgrading staff and equipment in national institutions.

4.56 **Future trends.** ICRAF will continue to develop services and products to meet the global demand for specialized agroforestry information, with special emphasis on the needs of its collaborative research partners. In this context, the use of computerized services is likely to expand and diversify. The Council will explore the use of new technologies such as CD-ROM, e-mail and computer-based teaching aids in the belief that these will gradually become more accessible to national institutions in developing countries. ICRAF will continue to strengthen the ability of national institutions to obtain and use information on agroforestry, both by providing training and advice directly and by helping to arrange training and assistance from elsewhere. The long-term aim is to provide all users in national institutions with user-friendly access to relevant information through a global agroforestry information network that is fully integrated with existing agriculture and forestry information networks.

4.57 **Modes of operation.** This programme will collaborate closely with institutions such as CAB International (CABI), the Technical Centre for Agricultural and Rural Cooperation (CTA) and FAO/AGRIS, with a view to increasing the access of national institutions to information services and products. ICRAF will continue to cooperate in information retrieval and dissemination with regional and international agricultural and forestry research centres. Direct collaboration with national institutions will ensure the implementation of effective information programmes

at national level. ICRAF may also decide to host workshops and short training courses for national information staff.

Programme 8: Communications

4.58 **Objective.** To contribute to agroforestry research and development by producing and disseminating relevant information.

4.59 **Justification.** ICRAF needs a communications programme to ensure that the results of its own and others' research reach the global community of scientists and other specialists concerned with agroforestry research and development. In addition, ICRAF has a number of audiences—such as national policy makers and training-course participants—who require information in forms specially tailored to their needs (see Box 2.5).

4.60 ICRAF has a comparative advantage in undertaking this programme because existing staff and facilities make possible the analysis and synthesis of information from a range of sources and the production and distribution of publications and other information products. Its international status allows the Council to establish relationships with other research institutions and with commercial publishers in pursuit of these aims. Located in Nairobi, ICRAF also enjoys excellent communications and support facilities.

4.61 **Current activities.** ICRAF's communications programme meets the information needs of a variety of audiences, including scientists and technicians, trainers and educators, and development specialists and policy makers. Some of the publications produced for these audiences are listed in Annex 4. Besides producing publications independently, ICRAF reaches a wider audience by copublishing with commercial publishers or specialized agencies. Activities of the communications programme include editing, writing, translating, audiovisual production and distribution. Publications and audiovisual materials are translated into French as resources allow, with priority given to those titles of interest to a francophone audience.

4.62 **Future trends.** During the 1990s, ICRAF's communications programme will support the expanding needs of the collaborative research and training programmes. Increased resources will be devoted to the production of training manuals and audiovisual materials, and publications describing the results of network research are also likely to become more important. Publications will continue to be directed towards a global and more general audience. In response to demand, the Council may increase its promotional activities, including news releases and articles written for science magazines. There will be an effort to publish key titles in Spanish and Portuguese as well as increasing the number of titles appearing in French.

4.63 **Mode of operation.** This programme will work closely with ICRAF's research, training and information programmes. Collaborative links will continue with commercial publishers, specialized institutions such as CABI and CTA, and other international agricultural research centres.

Implementation and organization

MODES OF OPERATION

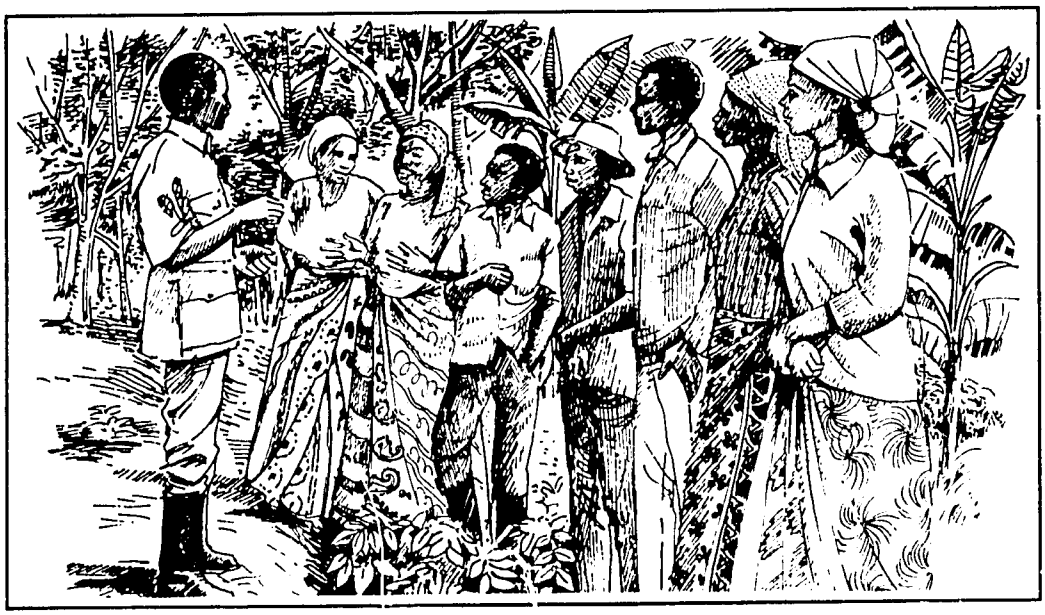
Multiple roles

5.01 This section outlines the roles ICRAF will play in the global research community.

5.02 **Research implementer.** ICRAF will build and maintain a lead in key areas of strategic research as identified through the process of collaborative applied research. In some cases, ICRAF will have the facilities and staff to conduct strategic research independently. In others, ICRAF will contribute staff and facilities to collaborative research efforts in which some tasks are implemented by ICRAF and others by its partners.

5.03 **Research collaborator.** As already indicated (3.04), collaboration is ICRAF's primary mode of operation. All applied and adaptive research will be conducted in partnership with national institutions in developing countries. Some strategic research will also be carried out collaboratively, drawing on the expertise and facilities of national programmes and other, specialized institutions and universities. Through these partnerships, ICRAF aims to build a lasting capacity for agroforestry research in the national research systems of developing countries.

5.04 **Research contractor.** Some strategic research will be carried out on a contractual basis. This will occur whenever research needs arise for which ICRAF does not have the necessary expertise or facilities, but which are recognized as central to the solution of a given problem. Special-project funding will normally be sought in such instances.



5.05 **Research promoter.** As the lead international institution, ICRAF will play an important role in enabling and encouraging other institutions to conduct agroforestry research. This will be a 'matchmaking' role, in which ICRAF helps to secure funds, facilities or expertise from donors or specialized institutions to support research conducted in developing countries. In the short term, the research agenda outlined in 2.21 to 2.45 will serve as a basis for identifying priority research topics. This will be updated as new needs arise.

5.06 **Research supporter.** In developing countries outside Africa, ICRAF will help plan national agroforestry research but will not become involved in its implementation (see 3.19). ICRAF will undertake D&D exercises jointly with national task forces and will support subsequent research by providing tools and methods as well as information and training.

African research networks

5.07 Section 3.22 outlines the projected size of AFRENA operations in Africa. This section will describe how the AFRENAs operate and how ICRAF's role will change over time.

5.08 The AFRENAs are based on agro-ecological zones. They are not technology-specific networks, but rather address a range of problems in priority land-use systems identified by national scientists and farmers (see 1.26–1.31 and 3.20–3.22). Their objectives are to ensure that appropriate agroforestry technologies are developed and adopted and that agroforestry research becomes permanently established within national research systems (see 4.02).

5.09 **Current activities.** Work in a given country begins when the national government expresses an interest in starting an agroforestry research programme. ICRAF staff visit senior policy makers and research managers to brief them on agroforestry in general and on ICRAF's approach. A national steering committee and multidisciplinary task force are established to plan the research programme. These mechanisms also promote discussion across sectoral and disciplinary barriers, laying the foundation for a permanent interinstitutional commitment to agroforestry research and development. Next, a D&D exercise is carried out at zonal or 'macro' level to assess research needs in broad terms (see 1.29). A zonal planning workshop is then held, to agree on a priority land-use system for more detailed research and to make the necessary institutional arrangements.

5.10 The next step is a micro D&D exercise, analysing in more detail the land-use system selected as a result of the macro D&D. This leads to the preliminary design of promising agroforestry technologies and to the identification of research priorities. Specific research projects at the zonal and national levels are then formulated with the objective of refining and testing technologies on station and on farm in preparation for their extension to farmers.

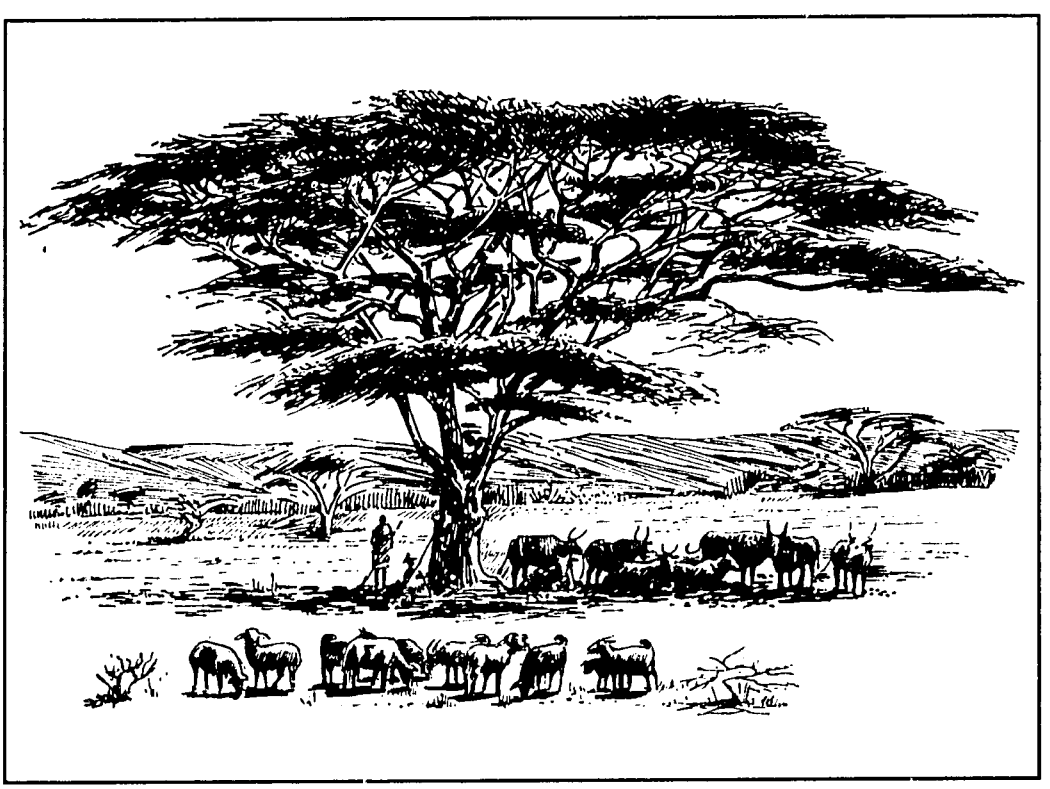
5.11 Research is implemented by national scientists seconded to the project with the support of an ICRAF staff member posted to the country or region. The types of trial conducted include the general screening of tree species and provenances for their establishment and growth rates in local environments, technology screening

to assess the productivity of promising agroforestry technologies using different species and planting arrangements, management trials to identify the most promising management regimes, and prototype trials to validate technologies before extending them more widely to farmers. During implementation of this research process, longer-term research needs may be identified. Steps are taken to initiate this research using resources from within the network wherever possible, with support from ICRAF.

5.12 This combination of the network approach with the use of the D&D methodology to plan research ensures that the needs of farmers are taken into account, that the multidisciplinary requirements of agroforestry research are met and that the limited human and financial resources of national institutions are shared on a cost-effective basis.

5.13 Two types of project are conducted in the AFRENAs—zonal and national. Zonal (or regional) projects focus on research that will be relevant across more than one country, while national projects address more site-specific problems. ICRAF conducts research jointly with national institutions at some sites, while at others research is implemented entirely by national institutions, although ICRAF may help with research planning and may provide logistical and other forms of support.

5.14 **Future trends.** The AFRENAs are currently at an early stage of development. Trials now in progress will produce substantial amounts of information, leading to a need for increased analytical capacity. New research priorities will emerge and



topics requiring strategic research will be identified. The exchange of germplasm and information among participating countries will also assume greater importance.

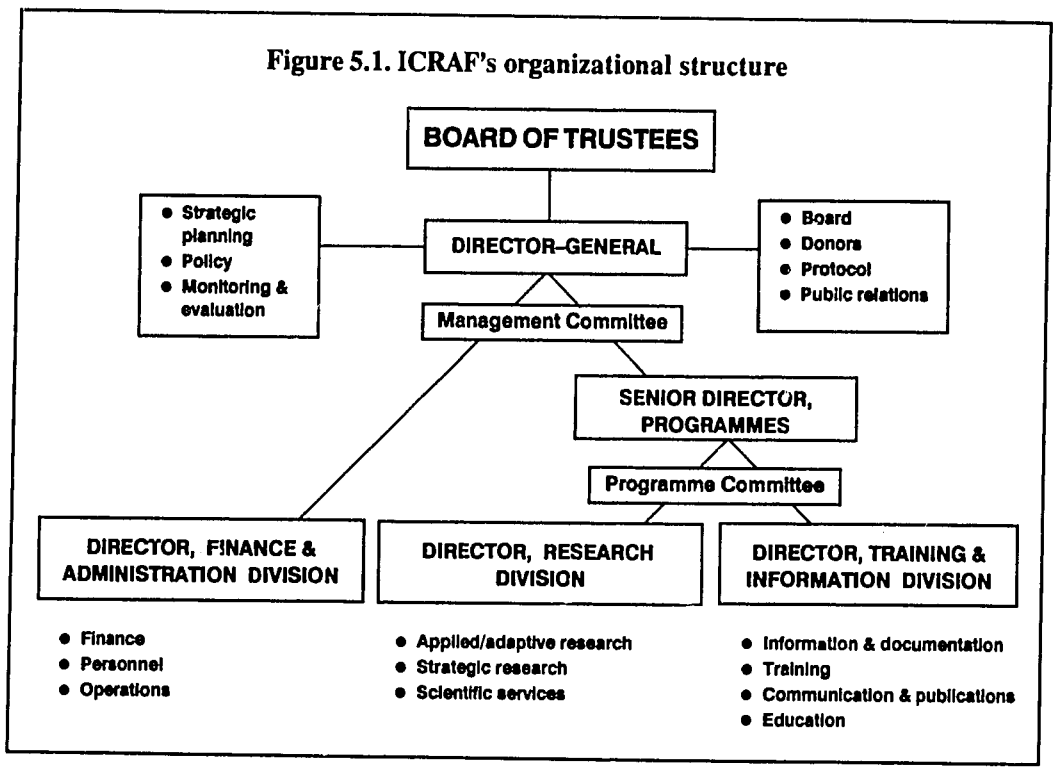
5.15 The primary focus of the AFRENAs will continue to be research to generate new or improved agroforestry technologies. ICRAF's specific contributions will be: to develop appropriate research methods, tools and approaches; to offer training; and to provide support through information, education, research planning and a range of other services.

5.16 The role of ICRAF in each network will gradually change over time. At the early stages, ICRAF has been, and will continue to be, directly involved in planning, formulating and implementing research within national programmes. This level of involvement will probably continue for at least 10 years in each network. After this, ICRAF will begin to disengage from the direct implementation of research, focusing attention increasingly on support activities. During the second half of the decade, results from strategic research will become an increasingly important input into national programmes.

Other research partners

5.17 In addition to national institutions, ICRAF may form closer working relations with a number of international, regional and specialized organizations over the coming decade. This discussion will only cover those partnerships that are either central to ICRAF's programme or that raise specific operational issues.

Figure 5.1. ICRAF's organizational structure



5.18 **International centres in Africa.** Three of the international agricultural research centres based in Africa will be especially important research partners for ICRAF. All three not only conduct agroforestry research, but also operate in agro-ecological zones in which ICRAF has a major commitment. They are: ICRISAT's Sahelian Centre, with extensive research on mixed farming systems in the semi-arid zone; ILCA, conducting research on livestock production in all except the arid zone; and IITA, responsible for developing sustainable production systems for the humid zone (see 2.13). ICRAF will collaborate with ICRISAT in the development of agroforestry technologies for the semi-arid zone, with ILCA in the use of tree foliage as animal feed and with IITA in testing hedgerow intercropping. ICRAF will also conduct joint research with IITA and ICRISAT on the improvement of multipurpose-tree germplasm and will continue to coordinate the Alley Farming Network for Tropical Africa (AFNETA) with IITA and ILCA.

5.19 **ICRAF and the CGIAR.** As already noted in the introduction, the organizational arrangements for international agricultural and forestry research are currently under review. In view of the CGIAR's growing involvement in research on resource management, ICRAF believes that closer association with the group would be mutually beneficial. The Council already shares goals and activities (see 3.03–3.07) and clients and beneficiaries (see 3.27–3.31) with many of the centres in the CGIAR, particularly those involved in commodity research in Africa. ICRAF's governance, strategy, programmes and organizational structure are also broadly similar to those of CGIAR centres, facilitating integration within the group. In addition, ICRAF's client-responsive approach to conducting collaborative research with national institutions could make a valuable contribution to the search for effective models for cooperation in agricultural research.

5.20 **Multipurpose-tree improvement.** A number of international, regional and specialized institutions, based mostly in the developed countries, will be important research partners for ICRAF in the conservation and improvement of multipurpose trees. The International Board for Plant Genetic Resources (IBPGR), which has recently launched collection activities for these species, will conduct joint plant-exploration missions with ICRAF. As noted above, breeding work will be undertaken jointly with IITA and ICRISAT. The Oxford Forestry Institute will provide training in advanced breeding techniques, starting in the Southern Africa AFRENA. ICRAF will also exchange multipurpose-tree germplasm from Africa and other parts of the world with several institutions, including the Centre technique forestier tropical (CTFT), CSIRO, the FAO/CILSS Tree Seed Programme and the Regional Tree Seed Centre in Southern Africa. Germplasm for leucaena species and provenances will be exchanged with NFTA and germplasm suitable for use as fodder will be exchanged with ILCA.

ORGANIZATIONAL STRUCTURE AND MANAGEMENT

5.21 ICRAF's organizational structure as of mid-1990 is shown in Figure 5.1. A Senior Director, reporting to the Director-General, is responsible for the overall coordination of programmes within and between the Research and the Training and Information Divisions, while the Director of Finance and Administration continues to report directly to the Director-General. A Programme Committee plans and coordinates the institution's eight programmes. Responsibility for implementing

these programmes lies with the two divisional directors and eight programme co-ordinators—four in each division.

5.22 The previously separate Research Development and Collaborative Programmes Divisions are now merged in a single Research Division containing the four research programmes plus staff outposted to the AFRENAs. Training and education have moved from their former position in Collaborative Programmes to the new Training and Information Division along with information and communications.

5.23 A new Planning Unit in the Director-General's office helps with strategic planning and monitoring, including developing a set of indicators for gauging the impact of ICRAF's activities. Another unit in the Director-General's office addresses donor and Board relations, public relations and protocol in the host country.

5.24 The Director of Research is responsible for the technical and scientific quality of the research programme, including research conducted in the AFRENAs. Initially at least, responsibility for institutional relationships will be shared between the Senior Director and the regional network coordinators.

5.25 In addition to the four programmes in the Research Division, a service unit will be attached to the director's office with the following functions:

- Statistical support for the design and analysis of experiments and surveys
- Programming and modelling
- Soil and plant analysis
- Workshop facilities
- Geographic information systems
- Cartographic services.

5.26 In the Training and Information Division, the Communications Unit will be responsible for ICRAF's audiovisual products and services, including the maintenance of audiovisual equipment. The Training and Information Division is also responsible for the management of workshops, study tours and conferences.

5.27 The four programmes in each division are conducted by multidisciplinary teams of professional staff. In addition to headquarters staff in the Research Division, staff members posted at field sites within the AFRENAs are also associated with one of the four research programmes. Although professional staff members have major responsibilities within a single programme, they contribute to other programmes as appropriate, ensuring that ICRAF maintains its multidisciplinary character. In particular, professional scientific staff are expected to be involved in training and information activities as well as research.

5.28 In addition to the eight research and dissemination programmes, work is conducted within projects that cross programme boundaries. Each project has a leader responsible for planning, implementing and reporting on project activities. Some staff members lead more than one project. Each programme has a full-time coordinator, responsible for supervising all the project leaders within the programme.

5.29 The zonal programmes of the AFRENAs continue to be organized and managed by regional coordinators, reporting to the Director of Research. These programmes are also subdivided into projects, which may be specific to particular countries.

5.30 Activities and plans for all programmes and projects are discussed at an annual programme review meeting. Budgets are then prepared and funds allocated to those projects that have been approved. Project leaders are responsible for managing project funds under the supervision of the respective programme coordinators and divisional directors.

RESOURCES

Human resources

5.31 **International professional staff.** To implement the programme outlined in Chapter 4, international professional staff positions will need to expand from their current level of 35 to approximately 100 by 1995 and 125 by the year 2000. The rapid growth projected for the first half of the decade reflects ICRAF's increased commitment to strategic research in Programmes 2 and 3—Component Interactions in Agroforestry Systems and Multipurpose-Tree Improvement for Agroforestry Systems—as well as continued growth of the AFRENAs. Expansion during the second half of the decade includes the establishment of three regional offices—in Latin America, South Asia and Southeast Asia. Staff allocations among organizational units are shown in Table 5.1.

5.32 **Combination of disciplines.** Details of the disciplinary mix in each research programme are given in Annex 5.

5.33 About 25% of professional staff in the Research Division will be social scientists. During the 1990s, ICRAF will aim to recruit a similar proportion of social scientists for AFRENA positions. Socio-economic factors affecting the adoption and impact of agroforestry will also be emphasized in ICRAF's training programme. This emphasis on social science is intended to ensure that ICRAF's currently strong orientation towards users' needs will continue through the 1990s. Areas of

Table 5.1. International professional staff allocations at ICRAF: 1990, 1995 and 2000

	1990	1995	2000
AFRENA staff	16	35	44
Regional office coordinators	0	1	3
Research Division	14	32	38
Training and Information Division	7	19	26
Director-General's office	1	4	4
Senior management	8	8	10
Total	**46***	**99**	**125**

*Includes seconded staff and new staff members recruited during 1990.

socio-economics in which additional expertise will be needed include macro-economics, policy analysis and land tenure.

5.34 Among the biological sciences, ICRAF will need to build up expertise in tree breeding, silviculture, tree physiology, microclimatology, soil physics, soil fertility, pest management, microbiology, seed technology and animal science. Ecology will continue to be strongly represented.

Financial resources

5.35 The strategy and programme outlined here will require a rate of growth in ICRAF's funding during the 1990s similar to that experienced in the latter part of the 1980s. Although all the programme activities presented in this document are core activities, funding will continue to consist of a mixture of core funds, restricted core funds, special-project funds and staff secondments. ICRAF will continue to seek restricted-core or special-project funding for specific activities as appropriate. The core budget will be used to support core activities and also to meet the requirements of special projects as required – as 'funds of last resort'.

5.36 **Total budget.** Assuming an annual cost of US$ 250,000 per international staff member to cover salary and the costs of associated support staff, services and facilities, but not major capital expenditures, then ICRAF will need a budget in the year 2000 of US$ 31 million (1990 dollars). This represents a threefold increase over the 1990 level (see 1.20). If the rapid growth in funding of the last few years is maintained, the projected doubling of ICRAF's resources to US$ 25 million should be achieved by 1995.

5.37 **Relative allocations.** The current allocation of ICRAF's financial resources is approximately 20% to strategic research, 50% to applied research, 20% to training and information and 10% to management and administration. In line with the directions of ICRAF's programme discussed in Chapter 3, the allocations in the year 2000 should be as follows: 30% to strategic research, 38% to applied and adaptive research, 21% to training and information, and 11% to management and administration. Within strategic research, there will be a shift of resources away from methodology development to research on basic processes (see 3.48–3.50).

Physical resources

5.38 The rapid growth of ICRAF's decentralized, collaborative activities in recent years has created an immediate need for some additional central facilities to carry out important research tasks. In the longer term, the expansion of strategic research may require increased investment in more sophisticated facilities.

5.39 Immediate needs include laboratories for soil and plant analysis, an additional building at headquarters and more land for research at the Machakos field station. An additional research station for the humid zone will be needed soon and some additional facilities will also be needed for the four decentralized regional support units (see 4.30). Within the next five years, ICRAF plans to open three regional offices – in South Asia, Southeast Asia and Latin America. Finally, tissue-culture facilities will be required to serve the needs of the tree-improvement programme.

Potential roles of trees and shrubs in satisfying basic human needs

Food

1. Human food from trees – fruits, nuts, leaves, cereal substitutes, honey, mushrooms
2. Livestock feed from trees
3. Enhanced food and feed production from crops associated with trees – through nitrogen fixation, better access to soil nutrients brought to the surface from deep tree roots, improved availability of nutrients due to higher soil cation-exchange capacity and organic matter, and mycorrhizal associations
4. Enhanced sustainability of cropping systems – through soil and water conservation by arrangements of trees to control runoff and erosion
5. Microclimate improvement associated with arrangements of trees in croplands and grazing lands – shelterbelts, dispersed shade trees

Water

1. Improvement of soil moisture retention in rainfed croplands and pastures through improved soil structure and microclimatic effects of trees
2. Regulation of streamflow, reducing flood hazard and a more even supply of water through reduction of runoff and improvement of interception and storage in infiltration galleries
3. Protection of irrigation works by hedgerows
4. Improvement of drainage from waterlogged or saline soils by trees with high water requirements

5. Increased biomass storage of water for animal consumption in forage and fodder trees
6. Purification of drinking water

Energy

1. Fuelwood for direct combustion
2. Pyrolytic conversion products—charcoal, oil, gas
3. Gas produced from wood or charcoal feedstocks
4. Ethanol produced from fermentation of high-carbohydrate fruits
5. Methanol produced from woody feedstocks by destructive distillation or catalytic synthesis
6. Oils, latex, other combustible saps and resins
7. Augmentation of wind power using tree arrangements to create venturi effects

Shelter

1. Building materials for shelter construction
2. Shade trees for people, livestock and shade-loving crops
3. Windbreaks and shelterbelts for protection of settlements, croplands, pastures and roadways
4. Fencing—living fences, fence posts, cut brush fences

Raw materials for local industries

1. Wood for a variety of crafts
2. Fibre for weaving
3. Fruits, nuts and other products for drying or other food-processing industries
4. Tannins, essential oils and medicinal ingredients

Cash

1. Direct cash benefits from sale of tree products
2. Indirect cash benefits from increased productivity or savings on inputs

Savings and investment

1. New savings/investment enterprises
2. Improvement of existing savings/investment enterprises, such as fodder for cattle

Social production

1. Production of any of the above goods for socially motivated exchange, such as bride price or dowry, funerals or other ceremonial occasions, political expenses
2. Increased cash for social expenses, such as ritual expenses, development levies, political contributions

Source: Raintree and Hoskins (1988).

Donors to ICRAF in 1990

African Development Bank (ADB)
Australian Centre for International Agricultural Research (ACIAR)
Australian International Development Assistance Bureau (AIDAB)
Canadian International Development Agency (CIDA)
Finnish International Development Agency (FINNIDA)
Ford Foundation
Government of the Federal Republic of Germany
Government of France
Government of Kenya
International Development Research Centre (IDRC)
International Fund for Agricultural Development (IFAD)
Ministry of Development Cooperation of The Netherlands
Ministry of Foreign Affairs of Japan
Norwegian Agency for International Development (NORAD)
Overseas Development Administration (ODA)
Rockefeller Foundation
Royal Norwegian Ministry of Development Cooperation
Swedish Agency for Research Cooperation with Developing Countries (SAREC)
Swedish International Development Authority (SIDA)
Swiss Development Cooperation
United States Agency for International Development (USAID)
World Bank (IBRD)

Agroforestry technologies

Mainly agrosilvicultural (trees with crops)

Rotational
- Shifting cultivation
- Improved tree fallow
- Taungya

Spatial mixed
- Open: Trees on cropland
- Dense: Plantation crop combinations, multistoreyed home gardens

Spatial zoned
- Hedgerow intercropping (alley cropping, barrier hedges)
- Boundary planting
- Windbreaks and shelterbelts
- Trees on erosion-control structures

Mainly or partly silvopastoral (trees with pastures and livestock)

Spatial mixed
- Open: Trees on rangeland or pastures
- Dense: Plantation crops with pastures

Spatial zoned
- Live fences
- Fodder banks

Tree component predominant (see also taungya)

- Woodlots with multipurpose management
- Reclamation forestry leading to multiple use

Source: Adapted from Young (1989).

ICRAF's major publications

Periodicals

- *Agroforestry Today*: quarterly magazine
- *Agroforestry Systems*: primary journal, copublished with Martinus Nijhoff
- *Agroforestry Abstracts*: secondary journal, copublished with CABI

Books

- **Carlowitz, P.G. von (1986).** *Multipurpose tree and shrub seed directory.* Nairobi: ICRAF, 265 pp.
- **Nair, P.K.R., ed. (1989).** *Agroforestry systems in the tropics.* Dordrecht, The Netherlands: Kluwer and ICRAF, 676 pp.
- **Raintree, J.B., ed. (1989).** *D&D user's manual: an introduction to agroforestry diagnosis and design.* Nairobi: ICRAF, 110 pp.
- **Rocheleau, D., Weber, F. and Field-Juma, A. (1988).** *Agroforestry in dryland Africa.* Nairobi: ICRAF, 312 pp.
- **Steppler, H.A. and Nair, P.K.R., eds. (1987).** *Agroforestry: a decade of development.* Nairobi: ICRAF, 250 pp.
- **Young, A. (1989).** *Agroforestry for soil conservation.* Wallingford, UK: CABI and ICRAF, 284 pp.

Bibliographies

- **Harwood, C., comp. (1989).** Grevillea robusta: *an annotated bibliography.* Nairobi: ICRAF, 124 pp.
- **Labelle, R., Majisu, L. and Munyua, H., comps. (1988).** *Agroforestry literature: a selected bibliography.* Nairobi: ICRAF, 276 pp.
- **Müller, E.U. and Scherr, S.J., comps. (1989).** *Technology monitoring and evaluation in agroforestry projects: an annotated bibliography.* Nairobi: ICRAF, 176 pp.
- **Munyua, H., Bondole, B.M. and Majisu, L., comps. (1989).** *Agroforestry literature: a selected bibliography on subsaharan Africa.* Nairobi: ICRAF, 120 pp.

Source Materials and Guidelines

- 27 since 1983

Reprints (articles or chapters by ICRAF staff members)

- 65 since 1983

AFRENA Reports

- 20 since 1988

ICRAF Working Papers

- 58 since 1983

Annual Reports

- 7 since 1983

International professional staff needs, 1990–2000

The staff needs described in this annex refer to international professional staff, each of whom will require support staff in the form of associates, assistants and technicians.

Research

From 1995 until shortly after the turn of the century, ICRAF will be directly involved in implementing research at about 50 network sites in 24 countries of subsaharan Africa (see 3.22). These network operations will require 34 outposted scientists, 5 network coordinators and 5 scientists responsible for multipurpose-tree germplasm improvement. Thus, a total of 44 ICRAF scientific staff will be attached to the AFRENAs. This number will start to decrease after the year 2000 as ICRAF gradually disengages from research implementation in the networks.

Towards 1995, ICRAF will establish three regional offices—in Latin America, South Asia and Southeast Asia. Each office will be staffed with three professional staff: one in research planning, another in information/documentation and a third in training. The Latin American office will also have an English/Spanish translator.

Throughout the 1990s, ICRAF will build its capability in strategic research in line with the programmes and priorities outlined in Chapter 4 (4.09–4.63).

Programme 1, Agroforestry and Land-Use Systems, will remain a small multidisciplinary group including specialists in the following areas: land-use evaluation, plant science (agriculture, forestry or horticulture), economics, social science and ecology. It is expected that this programme will be fully staffed by 1995 and will remain at the same level until 2000.

Programme 2, Component Interactions in Agroforestry Systems, will be ICRAF's largest research programme, including 7 staff members in 1990 and increasing to 11 by 1995 and 15 by 2000. The team will include specialists in agronomy, soil physics/fertility, plant physiology, microclimatology, animal science, pest management, forestry, horticulture, economics and sociology. Some areas, such as agronomy, will be represented by more than one scientist.

Programme 3, Multipurpose-Tree Improvement for Agroforestry Systems, will be a major new activity in the 1990s, expanding from its current level of 3 scientists in 1990 to 11 by 2000. The team will include specialists in tree breeding, silviculture, seed technology, microbiology, botany, tree physiology and database management. Two specialists will be required in breeding and also in silviculture. In addition, a specialist in tree breeding, genetics or silviculture will be assigned to each AFRENA.

Programme 4, Agroforestry Policy and Management, will remain ICRAF's smallest research programme, but will receive considerable input from senior management and from network coordinators. The programme will expand to include three professional staff by 1995, covering the fields of institutional management, policy analysis and planning.

Attached to the Research Division will be a Research Support Services Unit, undertaking activities as outlined in 5.25. By 1995, this unit will consist of three international professional staff in the areas of modelling, statistics and data analysis plus a relatively high proportion of local professional staff.

Dissemination

Programme 5, Training, will include eight international professional staff by the year 2000. Each member of this team will work closely with one of the AFRENAs to design, implement, monitor and evaluate ICRAF's training courses. This programme will also be responsible for the development and testing of teaching materials. By 2000, each of the three proposed regional offices will also include a training officer.

Programme 6, Education, currently includes one senior fellow responsible for establishing a framework for the programme. One full-time professional staff member is expected to join this programme in 1991. By 1995, there will be three professional staff, responsible for curriculum development in anglophone universities, francophone universities and diploma- and certificate-level institutions. By 2000, a fourth professional staff member will be responsible for curricula in Spanish-speaking countries.

Programme 7, Information and Documentation, will grow from one international professional in 1990 to six by the year 2000. In 1991, an international professional will be recruited to head the library and documentation units. Information specialists will also be assigned to each of the regional offices – in Latin America by 1995 and in South Asia and Southeast Asia by 2000.

Programme 8, Communications, currently has three international professionals. This will increase to six by 1995, with the addition of a second English/French translator, an editor and an audiovisual producer. By the year 2000, an English/Spanish translator will be attached to the Latin American regional office, making a total of seven in the programme.

Management

Senior management will consist of the Director-General, the Senior Programme Director, the two Divisional Directors, the Director of Finance and Administration and professional staff in the Finance and Administration Division – making a team of eight. This will remain at the same level until 1995 and rise to 10 by 2000.

Within the Director-General's office there will be two units: one dealing with policy, planning and evaluation; and the other with donor and Board relations and public relations and protocol. The first unit will have two professional staff dealing with socio-economic and biophysical issues. A few scientists on sabbatical with ICRAF will also be based in this unit, together with other visiting scientists or consultants. The second unit will have one professional staff member from 1991 onwards. By 1995, an internal auditor will also be based in the Director-General's office.

References

Bene, J.G., Beall, H.W. and Côté, A. (1977). *Trees, food and people: land management in the tropics.* Ottawa: IDRC, 52 pp.

Committee on Forest Development in the Tropics (1985). *Tropical forestry action plan.* Rome: FAO, 170 pp.

FAO (1988). *FAO production yearbook: 1987.* Rome: FAO, 360 pp.

ICRAF (1979). *Charter of the International Council for Research in Agroforestry (ICRAF).* Nairobi: ICRAF, 11 pp.

ICRAF (1990). *Annual report 1989.* Nairobi: ICRAF, 100 pp.

Kang, B.T., Wilson G.F. and Lawson, T.L. (1984). *Alley cropping: a stable alternative to shifting cultivation.* Ibadan, Nigeria: IITA, 24 pp.

Leach, G. and Mearns, R. (1988). *Bio-energy issues and options for Africa.* A report to the Royal Norwegian Ministry of Development Cooperation. London: IIED, 224 pp.

Lundgren, B. (1982). Introduction. *Agroforestry Systems* 1(1): 3–6.

Lundgren, B. (1989). The potential of agroforestry. In A.M. Kilewe, K.M. Kealey and K.K. Kebaara, eds. *Agroforestry development in Kenya: proceedings of the Second Kenya National Seminar on Agroforestry.* Nairobi: ICRAF, pp. 29–38.

McLaren, D.J. and Skinner, B.J., eds. (1987). *Resources and world development.* Chichester, UK: John Wiley, 940 pp.

Raintree, J.B. and Hoskins, M.W. (1988). Appropriate R&D support for forestry extension. In *Planning forestry extension programmes.* Report of a regional expert consultation. Bangkok: FAO, pp. 24–48.

Repetto, R. (1987). Managing natural resources and sustainability. In T.J. David and I.A. Schirmer, eds. *Sustainability issues in agricultural development.* Proceedings of the Seventh Agriculture Sector Symposium. Washington, DC: World Bank, pp. 167–81.

Rocheleau, D., Weber, F. and Field-Juma, A. (1988). *Agroforestry in dryland Africa.* Nairobi: ICRAF, 312 pp.

Rola, W.R. (1986). *An impact assessment of the Jala-Jala agroforestry area: a multi-dimensional approach.* Los Baños, Philippines: University of the Philippines at Los Baños, 50 pp.

Saka, A.R., Bunderson, W.T. and Phombeya, H.S.K. (1989). *Annual report of the agroforestry commodity team for 1988/89.* Lilongwe, Malawi: Chitedze Agricultural Research Station.

Schuh, G.E. (1988). Policy and research priorities for agroforestry. In *The potential of agroforestry.* Nairobi: ICRAF, pp. 70–80.

World Commission on Environment and Development. (1987). *Our common future.* Oxford, UK: Oxford University Press, 400 pp.

World Resources Institute, IIED and UNEP (1989). *World resources 1988–89.* New York: Basic Books, 380 pp.

Worldwatch Institute (1990). *State of the world: 1990.* New York: Norton, 268 pp.

Young, A. (1989). *Agroforestry for soil conservation.* Wallingford, UK: CABI and ICRAF, 284 pp.

List of acronyms

ACIAR: Australian Centre for International Agricultural Research (Canberra, Australia)
ADB: African Development Bank (Abijan, Côte d'Ivoire)
AFNETA: Alley Farming Network for Tropical Africa (Ibadan, Nigeria)
AFRENA: Agroforestry Research Networks for Africa (coordinated from ICRAF)
AFSI: Agroforestry Systems Inventory
AGRIS: International Information System for the Agricultural Sciences and Technology (Rome, Italy)
AIDAB: Australian International Development Assistance Bureau (Canberra, Australia)

BARC: Bangladesh Agricultural Research Council (Dacca, Bangladesh)
BMZ: Bundesministerium für wirtschaftliche Zusammenarbeit (Bonn, FRG)

CABI: CAB International (Wallingford, U.K.)
CATIE: Centro Agronomico Tropical de Investigación y Enseñanza (Turrialba, Costa Rica)
CD-ROM: Compact disk read-only memory
CGIAR: Consultative Group on International Agricultural Research (Washington, DC, USA)
CIAT: Centro Internacional de Agricultura Tropical (Cali, Colombia)
CIDA: Canadian International Development Agency (Hull, Quebec, Canada)
CILSS: Comité permanent inter-Etats de lutte contre la sécheresse dans le Sahel (Ouagadougou, Burkina Faso)
CSIRO: Commonwealth Scientific and Industrial Research Organization (Canberra, Australia)
CTA: Technical Centre for Agricultural and Rural Cooperation (Brussels, Belgium)
CTFT: Centre technique forestier tropical (Nogent-sur-Marne, France)

D&D: Diagnosis and design
DC: District of Columbia (USA)
DOA: Department of Agriculture (Lusaka, Zambia)
DRSS: Department of Research and Specialist Services (Harare, Zimbabwe)

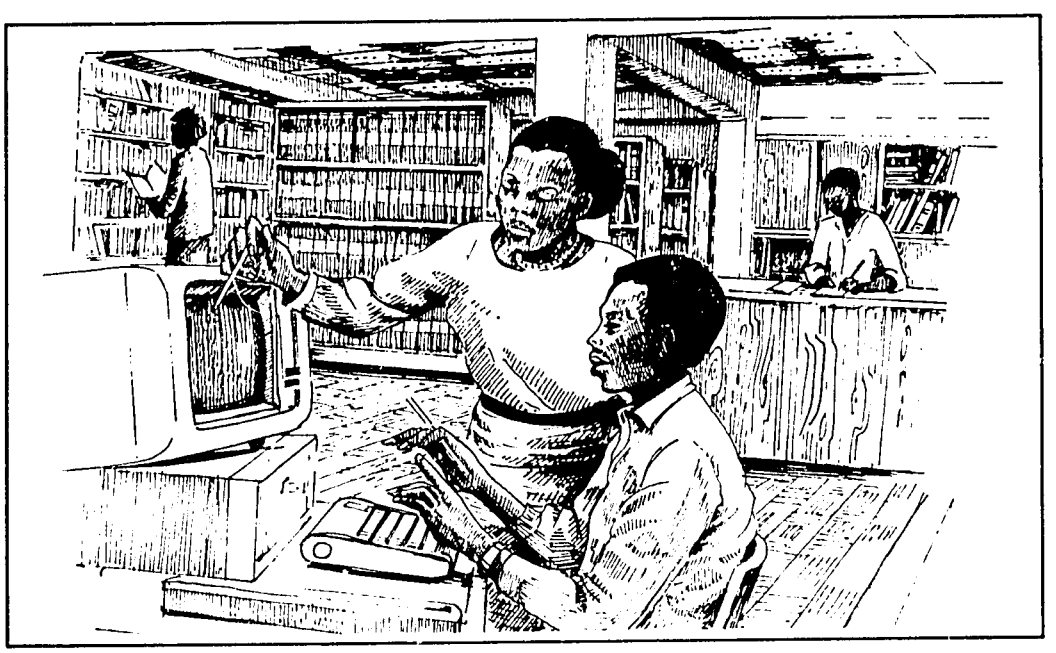
ENDA: Environment and Development Action (Dakar, Senegal)

FAO: Food and Agriculture Organization of the United Nations (Rome, Italy)
FC: Forestry Commission (Harare, Zimbabwe)
F/FRED: Forestry/Fuelwood Research and Development, Winrock International (Washington, DC, USA)
FINNIDA: Finnish International Development Agency (Helsinki, Finland)
FRG: Federal Republic of Germany

GTZ: Gesellschaft für technische Zusammenarbeit (Eschborn, FRG)

IAR: Institute of Agricultural Research (Addis Ababa, Ethiopia)
IBPGR: International Board for Plant Genetic Resources (Rome, Italy)

IBRD: International Bank for Reconstruction and Development (World Bank) (Washington, DC, USA)
IBSRAM: International Board for Soil Research and Management (Bangkhen, Bangkok, Thailand)
ICAR: Indian Council of Agricultural Research (New Delhi, India)
ICRAF: International Council for Research in Agroforestry (Nairobi, Kenya)
ICRISAT: International Crops Research Institute for the Semi-arid Tropics (Hyderabad, India)
IDRC: International Development Research Centre (Ottawa, Canada)
IFAD: International Fund for Agricultural Development (Rome, Italy)
IFPRI: International Food Policy Research Institute (Washington, DC, USA)
IIED: International Institute for Environment and Development (London, UK)
IITA: International Institute of Tropical Agriculture (Ibadan, Nigeria)
ILCA: International Livestock Centre for Africa (Addis Ababa, Ethiopia)
ILEIA: Information Centre for Low External Input and Sustainable Agriculture (Leusden, The Netherlands)
INRAN: Institut national de recherches agronomiques du Niger (Niamey, Niger)
INRZFH: Institut national de recherches zootechniques, forestières et hydro-biologiques (Bamako, Mali)
INSAH: Institut du Sahel (Bamako, Mali)
IRA: Institut de la recherche agronomique (Yaounde, Cameroon)
IRAZ: Institut de recherche agronomique et zootechnique (Gitega, Burundi)
IRBET: Institut de recherches en biologie et écologie tropicale (Ouagadougou, Burkina Faso)
IRRI: International Rice Research Institute (Los Baños, Philippines)
IRZ: Institute of Animal Research (Yaounde, Cameroon)
ISABU: Institut des sciences agronomiques du Burundi (Bujumbura, Burundi)
ISAR: Institut des sciences agronomiques du Rwanda (Butare, Rwanda)
ISC: ICRISAT Sahelian Centre (Sadoré, Niger)



ISNAR: International Service for National Agricultural Research (The Hague, The Netherlands)
ISRA: Institut sénégalais de recherches agricoles (Dakar, Senegal)
ITE: Institute of Terrestrial Ecology (Cambridge, UK)
IUCN: International Union for Conservation of Nature and Natural Resources (Gland, Switzerland)
IUFRO: International Union of Forestry Research Organizations (Vienna, Austria)

KARI: Kenya Agricultural Research Institute (Nairobi, Kenya)
KEFRI: Kenya Forestry Research Institute (Muguga, Kenya)

LTC: Land Tenure Centre, University of Wisconsin (Madison, Wisconsin, USA)

MOA: Ministry of Agriculture (Lilongwe, Malawi)
MULBUD: Multiple-Cropping Budget – computer program

NCSR: National Council for Scientific Research (Lusaka, Zambia)
NFTA: Nitrogen Fixing Tree Association (Waimanolo, Hawaii, USA)
NGO: Non-governmental organization
NORAD: Norwegian Agency for International Development (Oslo, Norway)
NRC: National Research Council (Kampala, Uganda)
ODA: Overseas Development Administration (London, UK)
OFI: Oxford Forestry Institute (Oxford, UK)
SACCAR: Southern Africa Centre for Cooperation in Agricultural Research (Gaborone, Botswana)
SAFGRAD: Consultative Advisory Committee on Semi-arid Food Grains Research and Development (Lagos, Nigeria)
SALWA: Semi-arid Lowlands of West Africa (AFRENA programme)
SAREC: Swedish Agency for Research Cooperation with Developing Countries (Stockholm, Sweden)
SCUAF: Soil Changes Under Agroforestry – computer model
SDI: Selective dissemination of information
SEARCA: Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (Laguna, Philippines)
SIDA: Swedish International Development Authority (Stockholm, Sweden)

TAC: Technical Advisory Committee, CGIAR (Rome, Italy)
TARO: Tanzania Agricultural Research Organization (Dar es Salaam, Tanzania)
TSBF: Tropical Soil Biology and Fertility programme (Nairobi, Kenya)

UK: United Kingdom
UNDP: United Nations Development Programme (New York, NY, USA)
UNEP: United Nations Environment Programme (Nairobi, Kenya)
UNESCO: United Nations Educational, Scientific and Cultural Organization (Paris, France)
USA: United States of America
USAID: United States Agency for International Development (Washington, DC, USA)
UST: University of Science and Technology (Kumasi, Ghana)

WWF: World Wildlife Fund (Gland, Switzerland)