PN-ABE-227

64570

Working Paper No.

Working Papers are made available in limited numbers for comment and discussion and to inform interested colleagues about work in progress at the International Council for Research in Agroforestry. Comments and suggestions are invited, and they should be directed to the author(s).

ICRAF

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY
CONSEIL INTERNATIONAL POUR LA RECHERCHE EN AGROFORESTERIE
CONSEJO INTERNACIONAL PARA INVESTIGACION EN AGROSILVICULTURA

P.O. Box 30677, Nairobi, Kenya, Tel: 29867. Telex: 22048 Cable: ICRAF

46

AGROFORESTRY
GENERAL CONCEPTS, EARLY WORK AND CURRENT INITIATIVES

A REVIEW OF THE LITERATURE

Richard Labelle

January 1987

International Council for Research in Agroforestry (ICRAF)

P.O. Box 30677, Nairobi, Kenya

AGROFORESTRY

GENERAL CONCEPTS, EARLY WORK AND CURRENT INITIATIVES

A REVIEW OF THE LITERATURE

Richard Labelle
Programme Coordinator
Information & Documentation
ICRAF, Nairobi

September 1986

Contents

	page
Acknowledgement	i
List of Tables, Figures and Appendices	ii
Agroforestry	1
Definition	2
Terminology	2
Early work	3
Work during the colonial period: Africa and Asia	4
Latin America	5
Perennial tree crops	5
Institutional setting	5
Classification and Characterization of Agroforestry Systems	6
Concepts of Agroforestry	8
Agroforestry and the tropical forest model	8
Relevance of multiple cropping to agroforestry	9
Current Status of Agroforestry Knowledge and Research	11
ICRAF	11
The wasted lands	11
Diagnosis and design	11
Characterizing agroforestry systems	12
Woody plants for agroforestry	13
Research methods for agroforestry	15
Economic analysis	15
Information and training	15
Agroforestry Initiatives Worldwide	16
CGIAR	16
World Bank	16
FAO	17
National and regional scales	18
International research on multipurpose trees	19
Crops for agroforestry	20
Animals for agroforestry	22
Conclusion	24
References	45

		page
Table 1	Products (outputs) and services rendered by agroforestry	26
Table 2	Major approaches in the classification of agroforestry systems (and practices)	27
Table 3	Classification scheme for agroforestry information	28
Table 4	Beneficial effects of trees on soils (from Young, 1986)	29
Figure 1	Categorization of agroforestry systems	30
Appendix 1	Publications from the Agroforestry Systems Inventory (AFSI) project along with the agroforestry systems register (June 1986)	31
Appendix 2	List of publications prepared for or resulting from meetings on agroforestry held from 1978 to 1986	42

Acknowledgement

This review of the literature on agroforestry is based in large part on the activities surrounding the operation of a question and answer service on agroforestry and on the work attendant to the organization of the ICRAF bibliographic information resources that was required as part of the question and answer service ~~since~~ and in order to meet the information needs of ICRAF.

Support for this work has been provided by the International Development Research Centre (IDRC) of Canada since July 1981. The continued interest and support for the development of agroforestry information resources and services by the Information Sciences Division of IDRC, in particular, and by IDRC in general, is gratefully acknowledged.

AGROFORESTRY

Agroforestry is a collective term for land use systems that have been in existence long before the term itself was coined. Shifting cultivation and other fallow based systems of agriculture, farming systems based on perennial crops, tree or forest gardens, including home gardens, practices such as the use of shelterbelts and windbreaks, taungya afforestation, and many other systems and farming practices with trees are forms of agroforestry. They have been in use for centuries ... at least 100 years in the case of the taungya system ... and in most cases, much longer. Their main characteristic is the deliberate role played by woody perennials in agricultural production, and they span the spectrum of socioeconomic circumstances, from subsistence cropping to cash cropping systems with perennials.

Several factors had a role to play in leading some members of the international community to support research in agroforestry. The energy crisis of the early 1970's made the purchase of fertilizers an expensive proposition in many countries, especially the poorest, and limited the benefits of the Green Revolution (Ehrlich, Ehrlich & Holdren, 1977).

The drought in the Sahel underlined the fragility of this ecosystem and helped to point out the need for more stable and sustainable forms of agriculture that were also reconciled to local circumstances and needs (UNEP, 1977). The destruction of the natural forest in the tropics pointed out the need for conservation of this resource (Ehrlich, Ehrlich & Holdren, 1977).

The global increase in population and the resulting pressure on arable land along with an attendant move to marginal agricultural land for food, fuelwood, fibre and pastures for livestock led the search for more intensive and sustainable forms of land use.

Against the difficult background, the International Development Research Centre (IDRC), a Canadian public corporation, set up a project to identify tropical forestry research priorities which, among other things, would

> 'assess the interdependence between forestry and agriculture in the low-income tropical countries and propose research leading to the optimization of land use.'
> (Benc, Beall & Cote, 1977)

The result of this project was the promotion of agroforestry through the creation in 1977, of the International Council for Research in Agroforestry (ICRAF).

Definition

Several definitions of agroforestry have been proposed (Agroforestry Systems, 1982). For this review, the following definition is used.

> Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, either in the same form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components.
> (Lundgren & Raintree, 1983)

For social scientists, this definition may be too biological. From the point of view of an economist, agroforestry is '... defined broadly as those farming systems in which farm resources are allocated to raising crops as well as trees.' (Shapiro, 1984).

Terminology

The term 'agroforestry' is not without its linguistic difficulties, whether in English (Stewart, 1981), French or Spanish (Combe & Budowski, 1979). However, the term has gained wide acceptance, irrespective of these problems (Nair, 1985), and is now used in French (Depommier & Goudet, 1983) and in Spanish (Combe & Budowski, 1979). The ICRAF library presently contains over 280 indexed books and articles and other documents in which the term agroforestry appears in the title. Many more articles based on papers presented at several conferences that have been held on agroforestry have also been published.

To complicate this issue even further, agroforesters speak of agroforestry systems and agroforestry practices.

For the purposes of this discussion, an agroforestry system is a farming enterprise in which "... several activities are closely related to each other by the common use of the farm's labour, land and capital, by risk distribution and by joint use of a farmer's management capacity." (Ruthenberg, 1980).

Agroforestry practices '... denote a specific land management of operation of an agroforestry nature on a farm or other management unit.' (Nair, 1985). Agroforestry farming systems may include one or more agroforestry practices.

Agroforestry farming systems have been known under different names until just recently. Ruthenberg, in his important work on farming systems, describes the use of trees or woody plants in agricultural production systems in the tropics. Thus agroforestry practices appear under several system headings: shifting cultivation, fallow systems, combining annuals with perennials in which agroforestry with *Acacia albida* (see below) is a cropping principle under the chapter dealing with 'systems with permanent upland cultivation', and systems with perennial crops. (Ruthenberg, 1980).

Early work

Significant scientific research and reviews of knowledge on some aspects of the subject had taken place in the 1960's and earlier, in particular if one refers to the literature of the colonial administrations (see below).

Noteworthy is the work on shifting cultivation which demonstrated the value of trees in restoring soil fertility after a period of fallow.

Under moist tropical forest conditions in particular, trees can restore soil fertility to previously cropped parcels of land through litter deposition and subsequent humus formation. Nye & Greenland in their classical work on the subject have estimated that once fallow has been established, litter production can reach up to '... 10,000 lb. per acre per annum'. This is without counting the simultaneous addition from dead roots, root slough and exudate. Under drier conditions, in savannas for instance, the increase is estimated to be about one half to one quarter of this. (Nye & Greenland, 1960)

King, in his landmark study of the taungya system of afforestation in Nigeria, presented evidence for the combination of crops and forest trees on the same piece of land. King also suggested some biological and other properties of trees and crops for agroforestry (King, 1968).

Acacia albida is a leguminous tree indigenous to the drier parts of Africa. In parts of West Africa, farmers have traditionally incorporated this tree in their fields of millet and groundnuts. Intercropping is possible because the tree, contrary to the practice of most plant species, loses its leaves in the wet season and remains evergreen during the dry season (Wickens, 1969).

In West Africa, research on Acacia albida demonstrated the role of this species in ameliorating soil fertility through nutrient recycling and by the direct improvement of soil biological , physical and chemical properties (Charreau & Vidal, 1965; Jung, 1967), the result of which is translated in increased yields of millet and groundnuts (Giffard, 1974).

To this day, the work on Acacia albida stands out as some of the most conclusive in demonstrating without any doubt the beneficial role of a tree species in support of agricultural production, and, although it has not been proved, it has been suggested that '... Acacia albida has made it unnecessary to clear and fallow land thus permitting sedentary, permanent agricultural settlements.' (Felker, 1978).

Farmers in Senegal believe that Acacia albida stands accumulate enough soil fertility when livestock shelter beneath their canopies during the dry season that there is no need for a fallow period (Pelissier, 1966).

Work during the colonial period : Africa and Asia

Considerable evidence of agroforestry research is also to be found in the important bibliographies undertaken during the period of European colonization of the tropical lands. Of particular relevance (because the information has been brought together) is the vast body of forestry literature from the Dutch colonization of Indonesia. Over 6000 publications have been abstracted from Dutch mostly to English, and these contain interesting and revealing references mostly to taungya with teak, and other forms of agroforestry (PUDOC, 1982; Beekman et al., 1982). Similarly, the 'Centre d'Informatique appliquee au Developpement et a l'Agriculture tropicale' (CIDAT) in Belgium has compiled three extensive volumes of bibliography on agriculture in Zaire, Rwanda and Burundi that contains over 8000 references, most of which are directly available from the compilers as microfiche copies of the original documents (Halleux, Ergo & Haes, 1973).

Jurion & Henry (1969) have summarized much of the Belgian experience of what would now have been called agroforestry, including the 'corridor system' of cultivation, as an unsuccessful alternative to shifting cultivation.

Both of the bibliographies mentioned above contain valuable references to trees that are used for agroforestry.

The British experience is documented in the various publications of the Imperial Agricultural Bureaux, now the Commonwealth Agricultural Bureaux (CAB). The French experience is published in the various monographs, journals, 'cahiers', 'fiches techniques' and other publications of the Office de la Recherche Scientifique et Technique d'Outre Mer (ORSTOM) and of the Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD). Several departments of the CIRAD, previously known as the Groupement d'Etudes et de Recherches pour le Developpement de l'Agronomie Tropicale (GERDAT), continue to contribute actively to research in agroforestry.

Noteworthy among the results of this research is the review on fodder trees undertaken by the Imperial Agricultural Bureaux (Whyte, 1947) and accompanied by a 265-page bibliography.

In the French literature, one title is of particular significance. The monograph of Giffard summarizes much of the early work that is relevant to agroforesters from francophone West Africa (Giffard, 1974).

Depommier & Goudet (1983) review the experience in agroforestry of the Centre Technique Forestier Tropical (CTFT), a department of the CIRAD. The Institut de Recherches en Agronomie Tropicale (IRAT), another CIRAD institution, has produced a bibliography on agroforestry that will be helpful in locating titles dealing with the subject in general, and from the perspective of research undertaken in francophone Africa in particular (IRAT, 1982).

Latin America

Unfortunately, the early experience of research on shifting cultivation and other forms of agroforestry systems in Latin America is not as well documented in comparison to the experience in Africa and parts of Asia and the Pacific (Sanchez, 1977). However, it is clear that traditional forms of agroforestry have been in existence (Budowski, 1979). In a bibliography on agroforestry produced by Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE), a regional agricultural research institution located in Costa Rica, there are references predating 1975 that deal with the practice of shading coffee and cacao with trees. Many of these references appear as articles in the journal Turrialba (Combe, Jimenez Saa & Monge, 1981).

Perennial tree crops

The literature on intercropping with rubber (Hevea brasiliensis) contains early references to agroforestry practices, in association with this perennial crop (Soosai & Kaw, 1975). Other perennials have also been known to lend themselves to agroforestry : cacao (Theobroma cacao), (Martinez & Enriguez, 1981; Wessel, 1985); oil palm (Hartley, 1977) and coconut (Nair, 1979). Cacao requires shade for early growth (Wessel, 1985; Wood, 1985; Wood & Lass, 1985) and coffee occurs naturally as an understory shrub in Ethiopian highland forests. Many of these perennials are grown in agroforestry combinations by small holder farmers who depend on the food crops for subsistence (Hartley, 1977).

Quite independently, individuals have also shown considerable interest in trees for agriculture. Sholto Douglas and Hart (1984) document the biological benefits of trees in agriculture and list some practices, including the choice of trees and the products or benefits that accrue. The first edition of this book was published in 1976. In it, the authors refer to a book by Russell Smith printed in 1929 entitled 'Tree Crops - A permanent agriculture' in which the author hypothesizes that '... certain crop yielding trees could provide useful substitutes for cereals in annual feeding programmes, as well as conserving the environment.' The same source is reported to have spoken of 'three dimensional forestry 'as early as 1967 (Sholto-Douglas, 1967).

Institutional setting

Given the present level of enthusiasm for agroforestry, it is notable that interes in the subject was so long in coming. This may in part be due to the complexity of agroforestry systems. Experimental designs and the statistical analysis of results are not simple when intercropping trees with crops. Time frames are variable and plant interactions are three dimensional. Scientists have not been trained to deal with complex land-use systems, instead they specialize in restricted fields (Budowski, 1981). Put another way, agroforestry has been neglected because of the historical and institutionalized separation of agronomists and foresters; agroforestry lacks an institutional niche (Lundgren, 1982).

CLASSIFICATION AND CHARACTERIZATION OF AGROFORESTRY SYSTEMS

Agroforestry systems and practices can be classified in several ways. Classification by components leads to three main types of agroforestry :

1. agrisilviculture, which is the combination of woody perennial plants with crops, including tree crops

2. silvopastoral systems, which integrate livestock with woody perennials

3. agrisilvopastoral systems, which combine all three components

Some authors (King, 1979, Nair, 1980) also add a further category: 'multipurpose forest tree production systems', from which diverse outputs are obtained. However, Combe & Budowski (1979) do not consider 'multipurpose forestry' as agroforestry, although both systems have the forest in common.

Agroforestry systems can be characterized by the outputs and services they render. Possible outputs and services are listed in Table 1. The objective of agroforestry is to stabilize agricultural production over time, while at the same time improving production, i.e. sustainable agricultural production while conserving environmental resources. The balance between improving the productive features of the farming system and management interventions emphasizing the ameliorative or restorative qualities of agroforestry will depend on the objectives of the land manager and the site conditions of the farm.

It is possible to classify the system on the basis of function, that is, on the basis of products or services rendered. Classification schemes can be devised in this way (Combe & Budowski, 1979), but they are complicated because agroforestry involves multiple outputs and benefits. Factors of time and space can also form the basis of a classification system. The arrangement of trees and crops over time can be complex. Just as in multiple cropping, different trees and/or crops can be grown sequentially over time or crops can be mixed or grown together. Borrowing from the classification of multiple cropping already in existence increases complexity because the tree adds a third dimension, the vertical, and extends the time dimension. Beets' classification of multiple cropping systems (Beets, 1982) can thus be applied to agroforestry, but it does not simplify the matter in a way in which a classification system should, although it does show the variety of agroforestry combinations that are possible with crops alone.

Agroforestry systems can also be classified by the level of management and inputs used, and on the basis of the economic goals intended. These systems can also be distinguished by the tenurial status of the farmer.

On this basis, Lundgren (1982) distinguishes between commercial, intermediate and subsistence systems. In commercial systems, one crop is usually the intended output. These systems are typical of the perennial tree crop plantation systems of coffee and cacao in Latin America (see articles in Workshop on agroforestry systems in Latin America; Las Salas, 1979); taungya systems can also be grouped here (King, 1968).

Intermediate systems are characterized by the combined production of subsistence and cash crops, the latter being of economic importance in the market place. Examples of smallholder production systems for the major tropical plantation crops are well documented.

In 1960, Malaysian rubber smallholders contributed 43% of the total production of rubber, that is, 29 000 tonnes on sites that are less than 100 hectares in area (Hutson, 1960). Today, small holdings account for 76% of the total area of the country under rubber and 56% of the total national production (Tajuddin, 1986).

Coffee and cacao in parts of Latin America, especially in Central America, are grown on small holdings (Budowski, 1979).

In subsistence systems such as shifting cultivation and tree-based fallow systems in general, the landowner seeks to satisfy basic needs. Village or forest gardens, for example in Indonesia, have been well researched and fall under this category (Michon, 1983, 1985; Michon et al., 1986; Mary, 1985).

In reviewing the various approaches that have been taken, Nair (1985) emphasizes the importance of the structural composition of an agroforestry system as the main criterion for classification. Other attributes can be qualifiers. Thus, one can talk of agrisilvicultural forms of agroforestry for food production. Table 2 summarizes the basic approaches to classification which are useful in outlining the possible management options and attending complexities of agroforestry. Figure 1 breaks down the various systems on the basis of components, and this corresponds largely to the main headings used to classify information about agroforestry (Table 3).

CONCEPTS OF AGROFORESTRY

Agroforestry and the tropical forest model.

Shifting cultivation is a traditional farming system that has supported man in humid tropical forests for ages, apparently without upsetting the environmental balance of this ecosystem (Nye & Greenland, 1960).

It is an efficient farming system in terms of the use made of environmental resources as long as the fallow period is long enough. During the fallow period, nutrients are recycled and soil fertility in the cleared patch of forest is restored to 'levels comparable to that of the adjoining forest.'

In bush fallowing systems and in other intensive forms of subsistence agriculture that use woody perennials, the nutrient cycling dynamics of the climax tropical rainforest are mimicked. The result is a farming system that is inherently and ecologically more stable and efficient because the environments above and below ground level are being exploited at many levels and soil fertility is preserved through nutrient cycling.

These multistoried cropping systems capture sunlight at different levels in the canopy and nutrient cycling occurs in a more or less closed system. The root systems exploit the subsoil horizons efficiently and nutrients are cycled to the above-ground biomass (Okigbo, 1980). Whatever loss of forest land occurs as a result of clearing patches in the forest and allowing a period of secondary forest regrowth is insignificant. The tropical forest, under conditions of low population density, is resilient enough not to suffer any loss or degradation and fallow plots , in time, revert to the original tropical forest.

The situation at present is different. Increases in population density and the attendant pressure on agricultural land have caused an inevitable reduction in the fallow period. In some cases, there is no fallow, and fertility maintenance in these intensive subsistence systems depends on various organic manures and animals, household wastes, composts and rotations of leguminous cover crops (Okigbo, 1980).

The stability and the sustainable production inherent in fallow based forms of cultivation is lost and tropical forests are suffering irreversible declines as a result of improper or short rotation shifting cultivation. According to the FAO, shifting cultivation is responsible for the loss of considerable amounts of natural forests in the tropics, being the main factor in Africa (20% of the deforestation) and exercising a considerable effect in tropical Asia (49%) and tropical America (35%) (FAO, 1982 a, FAO, 1982 b).

The need is for a cropping system that can counter the requirement for shifting or rotating fallows while maintaining ecological stability. Sanchez (1977) and Grinnell (1977) have recognized the potential benefits of such a system, and work on alley cropping at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria has yielded some positive results in this direction (IITA, 1984).

Forms of agroforestry, in particular alley cropping and multistorey cropping, although further research is needed to determine their adoptability, are considered as possible solutions to the problems posed by fallow agriculture (FAO, 1984). Multistorey cropping is the system of agroforestry that mimics most closely the tropical forest model, both in terms of the intensity of land use and management inputs (Raintree, 1981).

The beneficial effect of trees on soil fertility and the process by which trees exert their influence are summarized in Table 4 (Young, 1986). The evidence of their role is presented in the same source (Young, 1986). Thus, concepts of agroforestry are derived in part from the amelioration and regenerative biological features of trees.

Relevance of multiple cropping to agroforestry

Agroforestry systems involve multiple cropping with trees. The literature on multiple cropping in agriculture is applicable here because many of the benefits of multiple cropping, as well as some of the arrangements, are relevant to agroforestry (Beets, 1982; American Society of Agronomy, 1976).

'Multiple cropping describes forms of cropping practices where total production from a unit of land in a farming year is achieved through growing crops simultaneously, sole crops in sequence, or a combination of mixed and sole crops in sequence' (Andrews & Kassam, 1976). Two forms are distinguished: intercropping where crops occupy the same space at the same time and sequential cropping where crops are grown in sequence. Multiple cropping systems offer certain advantages. Beets (1982) cites the following:

i. better utilization of environmental factors

ii. greater yield stability in variable environments

iii. soil protection

iv. in general, a higher yield and greater gross return per unit area

v. regularity of food supply

All of these factors or objectives are compatible with agroforestry, although the tree components add many considerations of their own to be taken account of. These include biological, managerial or socio-economic ones, (Huxley, 1983 a), as well as those concerning the cropping period, the sequence and succession of trees and crops, the arrangement of trees and crops, etc. (Huxley, 1983 b; 1983 c).

Similarly, the tree-crop interface will need special attention in view of the complexity of the association when intercropping with trees (Huxley, 1986). Bio-economic considerations in intercropping with trees are particularly important in dealing with an agroforestry intercrop (Raintree, 1983). Information on these points, and on plant biological aspects related to agroforestry have already been reviewed (Huxley, 1983 d). A thorough scientific analysis of many of the factors and concepts discussed above, especially the efficient use of resources by appropriate management of constituents as they apply to multiple cropping with coconuts, has also been done (Nair, 1979).

The biological basis for agroforestry centres on the role the woody component can play in assisting and sustaining crop and/or animal production in a farming system. By using trees, the idea is to create a multistoried cropping system that imitates the climax tropical rainforest and that helps to ensure the recycling of nutrients as well as the optimal use of solar energy and other resources while affording multiple outputs and services to the farmer or land manager (Torres, 1983).

CURRENT STATUS OF AGROFORESTRY KNOWLEDGE AND RESEARCH

ICRAF

With the establishment of ICRAF, the systematic promotion of agroforestry started and a concerted effort began to document knowledge about agroforestry.

Little information existed on the extent and variation of agroforestry systems and practices around the world. Very little quantitative information existed about agroforestry. Apart from a lack of knowledge at the system level, there was little systematic and species-specific information about the woody components of agroforestry - the multipurpose trees.

Finally, methods for doing research on agroforestry, whether on the plant aspects or concerning economic analysis of agroforestry systems, still had to be worked out.

The wasted lands

In the early stages, ICRAF focused its efforts on the application of agroforestry to overcoming the problems of the 'wasted lands' (King & Chandler, 1978). These problems include those posed by shifting cultivators encroaching on the tropical forest, unproductive soils in Latin America, desertification in the Sahel, etc.; in short, areas that were suffering from environmental degradation and for which agroforestry was perceived as a possible solution.

Diagnosis and design

In 1981, there was a change in emphasis and a more systematic research programme was initiated, in which a method for diagnosing land-use systems and identifying appropriate agroforestry interventions was elaborated (Steppler, 1982). The systems approach and the importance of a location-specific approach resulting from the intimate plant/environment associations implicit in agroforestry were emphasized (Steppler & Raintree, 1983). This programme of work has continued and within this context, agroforestry is considered a general form of land use that offers solutions not only in restoring degraded agricultural landscapes, but which has a role to play in stabilizing and improving established agricultural practices in general (Lundgren, 1982; Lundgren & Raintree, 1983).

ICRAF has devoted a considerable amount of time to developing the 'Diagnosis and Design' methodology (ICRAF, 1983 a; 1983 b), as well as testing it in selected case studies undertaken around the tropics (Raintree, 1983; Rocheleau & van dan Hoek, 1983; Torres & Raintree, 1984; Hoekstra, 1984). The method is an adaptation of various rapid rural appraisal techniques and is based on recognizing bottlenecks affecting production (the diagnosis stage) and identifying agroforestry interventions that have the greatest potential for

overcoming the bottlenecks or problems identified (design stage). The possible agroforestry interventions are subsequently tested using on-farm assessment, as well as by undertaking on-station experimentation. National, regional and international institutions with a mandate to undertake experimental research then set to work with ICRAF in undertaking the research (Raintree & Torres, 1986).

ICRAF is not mandated to undertake primary research on the model of the international agricultural research centres, but it is responsible for helping, through collaborative activities, including training, national and other institutions and organisations to develop the expertise to undertake research on appropriate agroforestry interventions. The experience acquired by applying the 'Diagnostic & Design Methodology' in cooperation with over 19 institutions from the agricultural, forestry and academic sectors has resulted in its application and adoption, with modifications in some cases, by several international and other organizations (Raintree & Torres, 1986).

This experience also forms the basis for more extended and systematic collaborative activities in Africa in particular, where the problems of food and fuelwood production and desertification are most acute (Torres, 1985; Raintree & Torres, 1986).

Characterizing agroforestry systems

Since 1977, several national and international conferences and workshops dealing with agroforestry have taken place (see Appendix 2). However, the literature generated from the proceedings of these meetings is largely qualitative and does not answer the question, 'What agroforestry systems and practices are recommended for given biophysical, socio-economic and socio-cultural circumstances?'

In order to assess the state of agroforestry in the world, a project was initiated at ICRAF. With support from the USAID, and with the assistance of five coordinators located in different regions of the tropics, the 'Agroforestry Systems Inventory' (AFSI) project systematically surveyed agroforestry systems and practices on the basis of a common format of specifications. The objective was to gather as much quantitative data as possible on the nature, constituents, extent and perceived strengths and weaknesses of these systems so that they could be compared and evaluated, and gaps in knowledge identified. Research priorities could be determined on the basis of the survey and 'best-bet' recommendations could be made quickly available by querying the computerized data base that contained the results (ICRAF, 1983 c).

Over 150 agroforestry systems have been entered into an agroforestry systems register as of August 1987. Twenty-six system descriptions have also been published in the journal Agroforestry Systems, and three more are in press. Fifteen miscellaneous publications have also been printed. This information is presented in Appendix 1. Much more research is still needed to characterize with quantitative data subjected to statistical analysis the benefits of agroforestry interventions.

Woody plants for agroforestry

Like agroforestry, woody perennial plants for agroforestry, better known as multipurpose trees, have received many definitions (Burley & von Carlowitz, 1984).

Participants from the UN, the CGIAR, academic, donor and other organizations from around the world meeting at a 'Planning Workshop to Discuss International Cooperation On Multipurpose Tree Germplasm,' held in Washington, D.C., in June 1983, agreed on the following definition :

> 'Multipurpose trees and shrubs are those which are deliberately grown or kept and managed for preferably more than one intended use, usually economical and/or ecologically motivated major products and/or services in any multipurpose land-use system, especially agroforestry systems' (Burley & von Carlowitz, 1984).

Within this definition, the term 'tree' is not limited by the biological meaning of a woody perennial plant characterized by the xylem tissue that is eventually to become wood and that is produced annually by a persistent cambium. Some palms and a variety of other plants that are usually characterized by a tree-like growth habit are also considered to be multipurpose trees (Burley, 1985).

It is worthy of mention that this workshop was the first of its kind, and the first attempt to systematically examine the question of germplasm of multipurpose trees (Burley and von Carlowitz, 1984).

Similarly, a directory of seed sources for multipurpose trees has been published as a result of another initiative of ICRAF. (von Carlowitz).

The technical, managerial and socio-economic considerations for the selection of woody species for agroforestry have been described in detail (Huxley, 1983 a). The selection of ideal species for planted fallows, alley cropping and multistoried cropping have been described (Raintree, 1981).

In the case of species that can substitute for natural bush fallow vegetation as well as yield firewood or other by-products, the following characteristics of 'ideal' candidates, as well as suggested species for further testing, are worth noting (Raintree, 1981) because they provide an idea of what constitutes an 'ideal' multipurpose tree and because these features could be helpful in selecting species that could potentially be suitable for agroforestry.

Raintree (1981) distinguishes the following characteristics of ideal species:

1. High N-fixation capacity

2. Fast growing

3. Capable of restoring soil fertility and suppressing weeds in a shorter time than natural bush fallow

4. Able to provide good erosion control

5. Easy to establish rapidly and economically

6. Easy to get rid of

7. By-product yields provide significant additional economic incentives (e.g., food, forage, firewood, fiber, building materials, staking, etc.)

8. Special adaptive characteristics (e.g. promiscuous nodulation; tolerance of drought, acid soils, high altitudes; cultural acceptability, history of previous local use, etc.)

The same author also notes the following promising species for trial and evaluation:

1. Cajanus cajan
2. Acacia auriculiformis
   Albizia falcataria
   Calliandra callothyrsus
   Cassia spp.
   Crotolaria juncea
   Damanthus spp.
   Desmodium spp.
   Enterolobium cyclocarpum
   Leucaena leucocephala
   Mimosa scabrella
   Sesbania grandiflora
   Tephrosia candida

Other candidate leguminous species for agroforestry have been suggested (Nair, Fernandes & Wambugu, 1985).

Unlike agroforestry systems, multipurpose trees have not received recognition because of the emphasis placed on trees for industrial use, ... the commercial timber species. However, some work predating 1970 had been undertaken. A search of the ICRAF library data base for references dealing with multipurpose trees revealed 15 references published before 1970. These references emphasize the multipurpose uses that can be made of the species in question. Many of these were published by the CTFT in their series 'Fiche techniques.' Undoubtedly, many other references are to be found in the colonial literature mentioned above.

Research methods for agroforestry

Apart from the basic work of collecting and organizing information about agroforestry systems and their components, research has focused on the question of experimental design and spacing of trees & crops (Huxley, 1985; 1986). Fast-growing nitrogen fixing trees are of particular interest to agroforesters because of the central role they can play in sustaining and assisting agricultural production by their rapid growth and their ability to fix atmospheric nitrogen and to recycle nutrients to the benefit of the system as a whole. A thorough documentation of the research considerations and the present state of knowledge along with theoretical aspects of plant research with trees as intercrops is being compiled with special reference to fast-growing nitrogen fixing trees (Huxley, 1984).

Economic analysis

Agroforestry systems involve perennial crops which have a life of more than one year. From an economic point of view, a decision by a land manager to introduce agroforestry practices means making a long-term investment in the use and allocation of on-farm resources.

Traditional methods of economic analysis applied to cropping systems based on annual crops are not appropriate. Appropriate methods of economic analysis permitting this have been derived. MULBUD is a computerized tool for the economic analysis of agroforestry systems that handles multiple enterprises, products and time periods and provides farm budgets (Etherington & Mathews, 1985). An application of this package to a simulated alley-cropping system in a semi-arid district of Kenya indicates a net economic benefit (Hoekstra, 1983).

Information and training

Work on the nature of information in agroforestry has resulted in an information classification scheme for the subject (Table 3) and the development of computerized information methods for managing bibliographic information on the subject (Labelle, 1986). A preliminary thesaurus of terms for agroforestry has also been derived (Labelle, 1983), along with a glossary (Huxley, 1984). Over 8750 documents of relevance to agroforestry have been collected from around the world and are stored in the ICRAF library. A conference on professional education in agroforestry took place in late 1982 (ICRAF, 1983) and training materials have been developed for short courses lasting three weeks each (ICRAF, 1985) that have so far been held in Kenya, Malaysia, Peru and India.

AGROFORESTRY INITIATIVES WORLDWIDE

Since 1977, there has been considerable interest in agroforestry. Many international conferences, expert consultations and other meetings of a regional nature or dealing with a particular aspect of agroforestry have been held. Some of these meetings have been organized with ICRAF, but many more have been organized independently. Meetings, around which proceedings or other publications been published, are listed in Appendix 3. Many of these meetings are regional or national assessments of agroforestry and also make recommendations about research policies and priorities.

CGIAR

Within the international development community, agroforestry received mixed interest at first. The Consultative Group on International Agricultural Research (CGIAR) originally perceived agroforestry as a form of forestry and thus excluded it from its mandate, a clear example of the artificial institutional separation of agriculture and forestry (Lundgren, 1982; Lundgren & Raintree, 1983; Office of Technology Assessment, 1984). This has now changed considerably.

Several agricultural research institutions within the CGIAR system have adopted agroforestry research programmes. The International Institute for Tropical Agriculture (IITA), located in Ibadan, Nigeria has been carrying out experimental research on the potential of alley cropping as a substitute for the bush fallow system in the lowland humid tropics (IITA, 1984; Kang et al., 1984).

IITA and the International Livestock Centre for Africa (ILCA), the latter located in Addis Ababa, Ethiopia are collaborating on research or alley-cropping for the production of feed from pastures and browse for small ruminants (Terkuile & Kang, 1986).

ILCA has also hosted a very important meeting to review the state of knowledge about feed trees and shrubs in Africa. These feed trees and shrubs are important examples of African dryland agroforestry practices (Le Houerou, 1980).

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), with headquarters in India, has several on-going experimental agroforestry research projects, to study alley-cropping, cropping under shade trees, pigeon pea in agroforestry systems, land management systems with perennial plants and observing tree growth with an agroforester's bias (ICRISAT, 1986).

World Bank

The World Bank recognized the importance of a specific form of agroforestry, farm forestry, as far back as 1978 (World Bank, 1978) and has funded agroforestry projects, or what are termed farm forestry projects, which have produced a rate of return that is

considerably higher (10-30%) than the return from conventional industrial forestry projects. In some cases, cash market incentives have provided the stimulus, but lower investment costs compared to government plantations have also had a role to play in these large-scale schemes (Spears, 1985). Not everyone shares this enthusiasm and the poorest farmers do not always benefit from farm forestry on this scale (Foley & Barnard, 1984).

The World Bank applies a narrow definition to agroforestry. In the case of farm forestry, the World Bank has subsumed agroforestry under the forestry sector and assigned outputs to agroforestry that are associated with the production of wood from trees. There has been little indication in the World Bank reports that agroforestry can have a role to play in agricultural production in more ways than by just placing trees on farms or giving farmers incentive to grow wood for fuel or industrial products. There has been little appreciation for the role of agroforestry in food production except in more general statements about the potential of agroforestry as a sustainable form of land use in Africa in particular (World Bank, 1984).

Recently, a more holistic approach to crop production along with an appreciation of the effect of the institutional separation of agriculture and forestry at the field level in the Sahel has been recognized, and some agroforestry techniques useful to assist agricultural production have also been identified, along with research orientations (World Bank, 1985).

FAO

Within the United Nations system, the Food and Agricultural Organization (FAO) is the institution which is most concerned with agriculture, although many others (UNEP, UNDP) have an interest in sustainable forms of land use.

The FAO does not use the term 'agroforestry' in the title of its publications that are related to subject. Of the 266 titles attributable to the FAO and found in the ICRAF library, the word groforestry appears in the title of only two of them. Forestry for local community development or community forestry or farm forestry are used by FAO, and this terminology shares a measure of common meaning with agroforestry.

'Community forestry has been defined ... as any situation which intimately involves local people in a forestry activity. It embraces a spectrum of situations ranging from woodlots in areas which are short of wood and other forest products for local needs, through the growing of trees at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industry level to generate income, to the activities of forest-dwelling communities ... (FAO, 1978 a).

The forestry for local community development programme of the FAO is thus broadbased and is characterized by the emphasis it places on the community and on forest products, especially wood-based forest products, i.e. fuelwood, charcoal, poles, etc. By 1978, seventeen community forestry projects had been described by the FAO (FAO, 1978a). By 1984, more than 130 community forestry programmes had been started in over 50 countries with a total funding level in excess of $ 750 million (Foley & Barnard, 1984).

As is the case with agroforestry, terminology as well as definitions concerning this concept are a problem. In India, social forestry shares a similar meaning with community forestry, farm forestry, urban forestry, recreation forestry, environmental forestry, vanamahotsava, arboriculture, tree farming, forest farming, small scale forestry, village woodlots, bio-aesthetic plantations, energy plantations, three-dimensional forestry, tree crops and livestock forestry, forestry for 4-F (fuel, forage, fodder, fertilizer), agroforestry, etc. (Tiwari, 1983 b).

In general, social forestry emphasizes tree growing on common lands, sometimes in association with villages, as it has been done traditionally in India (Tiwari, 1983 a).

For the purpose of this review, social forestry and community forestry are deemed to be more or less equivalent and are based on the use of common lands (the 'commons') for tree growing (Tiwari, 1983 a; Foley & Barnard, 1984). For some, community forestry is the preferred term because it does not mean that any form of tree growing brings social benefits as 'social forestry' implies (Foley & Barnard, 1984).

Farm forestry is applied to programmes '... which aim to encourage commercial tree growing by individual farmers on their own land'. In these programmes, trees are regarded as a cash crop, and farmers are provided with assistance in growing them (Foley & Barnard, 1984). Farm forestry is contrasted with social or community forestry on the basis of individual as opposed to community involvement.

Other forms of farm or community forestry include tree growing for family uses and land allocation schemes (Foley & Barnard, 1984).

Much development work has gone into these tree-growing activities that share some common ground with agroforestry, and they have been criticially analysed on the basis of the experience acquired (Shepherd, 1985; Foley & Barnard, 1984).

National and regional scales

The many regional and national initiatives in agroforestry are documented in the proceedings listed under Appendix 2. Notable among these is the concerted effort by the Indian Council for Agricultural Research (ICAR) which initiated the 'All India Coordinated Research Project on Agroforestry' in 1983. This project is a very systematic national endeavour in agroforestry and presently involves twenty-two participating research centres in India. With the assistance of ICRAF, three core projects have been developed in 1982 (Singh, 1986).

These include :

1 - diagnostic exercises and the identification of Indian agroforestry systems in order to determine the potential for improving them.

2 - collection and evaluation of germplasm of trees most often used in native agroforestry systems.

3 - studies to determine the best combination of agroforestry components, their arrangements and to undertake economic feasibility analysis of these systems.

Similar activities, but on a regional scale, are under way in Africa (Torres, 1985).

International research on multipurpose trees

In 1979, the Forestry Department of the FAO initiated a project on the conservation and better utilization of the genetic resources of arboreal species for the improvement of rural living (FAO, 1981). Emphasis has been placed on multipurpose fuelwood species from the dry zones, in particular selected species of the genera Acacia, Prosopis and Eucalyptus, as well as a few others. Priority has been given to the exploration, collection and conservation of these species.

Updates documenting the progress of this project have appeared in various issues of 'Forest Genetic Resource Information' published by FAO. (See, Palmberg, (1983), for example).

Similarly, several handbooks on dry-zone species have been published by the FAO to provide technical information on these little known but potentially useful species. (Brenan, 1983; Ffolliott & Thames, 1983 a, 1983 b; Johnson, 1983; Southgate, 1983).

In 1980, the Ad Hoc Panel of the Advisory Committee on Technology Innovation of the National Academy of Sciences of the USA published the first of two reports on the selection of species suitable for deliberate cultivation as firewood crops in developing countries (NAS, 1980, 1983 a). Particular emphasis was placed on the multipurpose nature of the species, ease of establishment and adaptation to the local site conditions, ability to fix atmospheric nitrogen, ability to grow rapidly and to coppice and ability to produce wood of high calorific value, among others.

A questionnaire was sent to researchers, institutions and a selection of most suitable candidate species was made. The results were first published in 1980 and described sixty tree species or groups of species (NAS, 1980). Twenty-seven more species were described in a companion volume published in 1983 (NAS, 1983 a).

The multipurpose qualitites and adaptability of these species is of considerable interest for agroforestry applications, and several of the species have been used for this purpose. Companion volumes on other candidate agroforestry species, namely, Leucaena leucocephala, Acacia mangium and other Acacia species native to the tropical rainforest of Australia, Calliandra callothyrsus, eighteen Casuarina species, have also appeared (NAS, 1977, 1983 b, 1983 c, 1984).

Other NAS panels, one on underexploited tropical plants and another to identify leguminous plants that are little known or underutilized also produced reports that contained useful information on selected species as candidates for agroforestry (NAS 1975, 1979). Once again, the National Academy of Sciences sought the views of respected plant scientists in selecting and researching these topicss.

The Australian Centre for International Agricultural Research (ACIAR) '... has given high priority to the evaluation of lesser known Australian trees and shrubs with potential to meet the diverse needs of forestry and agroforestry programmes in developing countries ...' (Turnbull, 1986).

100 Australian species have been described using the format of the Natural Academy of Sciences publication 'Firewood Crops'.

Australian Acacias with potential for developing countries have also been described in another ACIAR monograph (Turnbull, 1987).

Together, these publications of the National Academy of Sciences and of the Australian Centre for International Agricultural Research represent the most systematic collection of organized and readily accessible, if sometimes general, information on multipurpose woody plants for agroforestry.

The Nitrogen Fixing Tree Association (NFTA) of Hawaii in the USA publishes periodically a collection of short technical reports on research, demonstration and utilization of trees that fix nitrogen (NFTA, 1985 a) and on the genus Leucaena (NFTA, 1985 b). They have also summarized useful information about the genus Leucaena, one dealing with wood production (NFTA, 1985 c) and another on Leucaena for animal feed (NFTA, 1985 d).

The species researched by the NAS and the NFTA are most promising candidates for further research on their role as constituents of agroforestry systems and for their role as producers of firewood.

The published proceedings of an international conference on Casuarinas, convened by the Commonwealth Scientific Industrial Research Organizations (CSIRO) of Australia presents an in-depth and very useful review of scientific knowledge about this genus, along with an extensive bibliography (Midgley, Turnbull & Johnston, 1983).

Eucalypts are another genera of mostly Australian trees (over 600

species) with potential for agroforestry, because, like Casuarinas, they are fast growing, highly adaptable and offer many benefits. However, the genus Eucalyptus stands out because of the reputation that trees of the genus have for degrading the environment. A review of this controversy suggests that site specific considerations and the objectives of land management will decide how best to use or not to use eucalypts (Poore & Fories, 1985).

Crops for agroforestry

In agroforestry research, more attention is currently devoted to the woody component in the farming system than to either the crop or animal components. This is because the tree, the conditional constituent of agroforestry, is considered the underexploitedcomponent with greatest promise to yield applicable results to help overcome problems of land management in an environmentally conservative and ecologically sustainable fashion.

However, crops and animals must also be selected properly in order that the optimal mix of components is achieved. The selection, suitability and cultivation of crops for agroforestry has been reviewed (Nair, 1980). Some research on this subject has been undertaken for plantation crops. It has been suggested to interplant rubber with perennial crops, with particular attention to minimizing biological or economic competition (Allen, 1955).

According to this source for an intercrop to be successful,

- it should not grow as tall as the rubber and its root system should be different;
- it should be tolerant of partial shade;
- it should not be more susceptible than rubber to the diseases they have in common;
- its harvest should not damage the rubber roots or induce soil erosion or deterioration of soil structure;
- it should not be slow maturing or have a longer economic life than rubber.

To this are added the further considerations that :

- the soil should be suitable to both crops; (from Hartley, 1977)
- the combined yield of both crops shall be greater in monetary terms than that of the main crop when grown alone;
- when the subsidiary crop comes to the end of its bearing life, the yield of the main crop shall continue at an economic level unaffected by the previous presence of the subsidiary crop.

The oil palm does not lend itself to intercropping with food crops, except possibly at the establishment stage (Hartley, 1977). Work in India on multiple cropping with coconuts has demonstrated that this species can be intercropped with different root and tuber crops, grain legumes, upland rice and other food crops, and that the perennial crop cacao can also be grown in a mixed cropping arrangement with coconuts (Nair, 1979). Coconut has the interesting property of casting less shade as the crop matures and the canopy rises above the ground (Nair, 1979).

A list of crops with potential for agroforestry along with notes has been prepared (Nair, 1980).

Animals in agroforestry

The selection of which animal to introduce in agroforestry systems depends on the objective of land management and on local animal husbandry practices.

In general terms, ruminants are preferred because they are more efficient and less demanding in their nutritional requirements and because they compete less than other animals for land (Zandstra & King, 1982).

In Nepal, as in many other countries in Asia, livestock in general and buffaloes in particular are kept as a source of fertilizer, meat, milk, draft power and for cultural reasons. Agroforestry practices must take this into consideration. Here, feed trees and shrubs, from either private land or forest areas, play an important role in animal production (Panday, 1982).

Grazing livestock under tropical plantation crops is sometimes done for practical purposes, such as suppressing weeds and to maintain or improve soil nutrient status, especially if a leguminous cover crop is introduced (Thomas, 1978). However, research with rubber and oil palm shows that, generally speaking, cattle grazing may have adverse effects, i.e., soil compaction from trampling, upsetting latex collection cups (rubber), rubbing off or chewing bark, browsing young trees, etc. (Thomas, 1978).

Grazing cattle under coconuts is possible because of the light penetration under plantations less than five years old or those that are over twenty years old, the time beyond which the amount of light reaching the ground increases, to the benefit of any sown pasture (Reynolds, 1980).

The selection of animals to grow under perennial crops will depend on the pasture crops that are adapted to particular conditions. Under coconut, the most suitable grass species have the following properties (Reynolds, 1980) : they

- are tolerant of reduced light conditions
- have stoloniferous growth habit
- form short to moderate height swards
- provide moderate carrying capacity
- do not compete excessively with coconut production
- allow fallen nuts to be located easily

Much of the literature on this subject deals mainly with cattle. When research is aimed at the selection of animals, work with rubber has shown that sheep are preferable to buffalo, cattle or goats, and that poultry rearing and bee keeping are also possible (Tajuddin, 1986).

While in many cases, it would be preferable to use smaller ruminants, such as sheep, which are less destructive in plantations, larger ruminants, such as buffaloe or cattle, are preferred because they produce more meat, fertilizers and milk.

In Ecuador, tropical lowland sheep have been selected because of their adaptation to the climate and their resistance to disease and because they cause little soil compaction and erosion as is the case under continuous cattle grazing on less fertile lands and because they accept less palatable forage than cattle. Studies to intensify land use under shifting cultivation have shown that sheep, which produce high-quality food, can be grazed on a legume cover forage of Desmodium ovalifolium intercropped with Inga edulis, a fast-growing nitrogen fixing tree species, and produce three times as much as cattle . while intensifying land use and accelerating the rehabilitation of cleared forest land (Bishop, 1983).

In general, research on animal selection for agroforestry is lacking. Research programmes to determine the most nutritious and palatable feeds from woody plants will need to be undertaken and interventions at the farming system level are required that will call not only for modifying the plant components of mixed farming systems, but for breeding animals that are best adapted to ecological, socio-cultural and economic circumstances. This is an area where much more research is needed.

CONCLUSION

Agroforestry is generating much interest and research. Each quarter, the documentation service of the International Council for Research in Agroforestry identifies over 300 titles that are broadly relevant to the subject from the Commonwealth Agricultural Bureaux journals alone.

Current research emphasis continues to be placed on identifying and characterizing agroforestry systems and practices, as well as trees for agroforestry systems and practices, as well as trees for agroforestry, and developing methods of agroforestry research and project design, implementation and analysis.

Selection of promising technologies and multipurpose trees for further research is already under way. Propagation of species and dissemination of information, knowledge, research methodologies, certified germplasm of known provenance, etc., are steps that are at various stages of accomplishment. Interesting questions lie in the future. Of the many agroforestry combination of trees, crops and animals, which are likely to be the most promising and under which conditions? Those that can intensify fallow-based cultivation systems to either reduce or eliminate the need for fallow completely, while being adoptable; more efficient plantation-based systems where nutrient cycling is efficient enough to considerably reduce the need for fertilizer applications; permanent tree crop farming systems in the Sahel that can improve production, conserve soil, fee livestock and improve and maintain soil fertility indefinitely; and many others.

All of these possibilities do exist. The choice has to be made as to how the scant resources of the developing countries and of the development community are to be used for research on these topics. Obviously, it will not be possible scientifically to examine the two thousand-odd potential multipurpose species (von Carlowitz, 1985).

However, it is interesting to speculate on the benefits that intensive research could bring to agroforestry considering that plant breeders have been able to increase the crude rubber yield of this plantation crop, a tree of the Amazonian rainforest, ten-fold in one hundred years (Oldfield, 1984). More interesting yield increase, between 300-800 per cent, have been reported for Eucalyptus camaldulensis through the selection of the best adapted provenances for given situations (Palmberg, 1981).

Given these responses, the question can be posed, 'What is the genetic potential of some of these more promising species?' If such gains can be obtained by simply selecting the best-performing provenances, then surely this approach merits more effort, and not simply with a view to improving the plant ideotype.

Yield is not the only concern in agroforestry. Plant combinations, i.e., tree and crop associations do not lend themselves to the crop 'ideotype' model of breeding which emphasizes yield improvement. Perhaps breeding for tree crop associations is needed as well (Sinha & Swaminathan, 1984).

Other areas of research have not been explored. Work on integrated pest management under agroforestry is an example. If there are the resources and the cooperation necessary to undertake this research and to involve farmers and extension workers in this effort, then the next few years will promise to be very interesting for agroforestry, as a tool for development.

Table 1 - Products (outputs) and services rendered by agroforestry

Products

Fuelwood, charcoal
Timber - poles
- construction materials (wood)
- wood for tools
Bark - tannin, fibre, rope dyes, etc.
Thatch - roofing
Food - fruits, nuts, leaves, cash crops, honey, etc.
Feed for animals - pods, husks, seeds & leaves for protein banks,
- supplemental feeds,
- fodder gap resources
- bee fodder
Medicinal products
- traditional
- pharmaceutical
Industrial products
- oils, waxes, exudates (damar), gums (gum arabic), resins (lac)
Public health
- water clarifiers

Services

Soil conservation
- trees on bunds, vertical risers (terrace cropping)
- contour hedges and anti-erosion strips
- shelterbelts
- sand dune fixation

Soil amelioration
- nutrient assimilation by deeper roots resulting in litter deposition, humus formation
- soil fertility enhancement by improved fallows without need shifting (alley cropping)

Moisture conservation
- mulching

Microclimate modification
- shelterbelts
- shade for livestock, plantation crops or other crops

Nitrogen fixation & cycling
- decreased dependence on chemical fertilizers

Hedges
-livestock fencing (non-palatable bushes), live fences

Conservation
- of genetic resources, by increasing diversity of plants used in cropping systems
- of forest and other protected lands (by creation of bufferzones, i.e., agroforests, see Michon, 1985)

Table 2 - Major approaches in classification of agroforestry systems (and practices)

Categorization of systems (based on their structure and function)			Grouping of systems (According to their spread and management)	
Structure (Nature and arrangement of components, especially woody ones)		Function (Role and/or output of components, especially woody ones)	Agro-ecological/ environmental adaptability	Socio-economic and management level
Nature of components	Arrangement of components			
Agrisilviculture (crops and trees incl. shrubs/trees and trees Silvopastoral (pasture/animals and trees) Agrosilvopastoral (crops, pasture/animals and trees) Others (multipurpose tree lots apiculture with trees, aquaculture with trees, etc.)	In space (Spatial) Mixed dense (e.g.: Home garden) Mixed sparce (e.g.: most systems of trees in pastures Strip (width of strip to be more than one tree) Boundary (trees on edges of plots/fields) In time (Temporal) Coincident Concomittant Overlapping Sequential (separate) Interpolated	Productive function Food Fodder Fuelwood Other woods Other products Protective function Windbreak Shelterbelt Soil conservation Moisture conservation Soil improvement Shade (for crop, animal, and for man)	Systems in/for Lowland humid tropics Highland humid tropics (above 1,200 m a.s.l; e.g.: Andes, India, Malaysia) Lowland subhumid tropics (e.g.: savanna zone of Africa, Cerrado of South America) Highland subhumid tropics (Tropical highlands) (e.g.: in Kenya, Ethiopia)	Based on level of technology input Low input (Margina Medium input High input Based on cost/bene relations Commercial Intermediate Subsistence

Source: Nair (1985) Classification of Agroforestry Systems. Agroforestry Systems 3:97-128

Table 3 - Classification scheme for agroforestry information

Agroforestry in general

- history
- definition
- classification
- concepts from other land-use systems
- potential

Agroforestry systems

- Agrisilviculture
- Sylvopastoral systems
- Agrosylvopastoral systems
- Other systems

Agroforestry components and processes

- Multipurpose trees (definition, choice of species, genetics, seeds, breeding and other biological aspects)
- Animals for agroforestry (ditto)
- Crops for agroforestry (ditto)
- Production aspects (fuelwood, food, industrial, feed, etc.)
- Service aspects (soil and water conservation, shelterbelts, nutrient cycling, etc.)
- Human ecology and social, economic aspects (including cultural aspects, economics of production)
- Agroforestry development issues (including extension, education and training)
- Agroforestry research and methodology (including information resources)

Table 4 - Beneficial effects of trees on soils (from Young, 1986)

Processes which augment additions to the soil:

- Photosynthesis: fixation of atmospheric carbon and its transfer to the soil.
- Nitrogen fixation, both symbiotic and non-symbiotic.
- Nutrient retrieval: the taking up of nutrients released by rock weathering in deeper layers of soil, and their release by litter decay on the surface (not specifically demonstrated).
- Providing favourable conditions for input of nutrients by rainfall and dust (not demonstrated).

Processes which reduce losses from the soil, making the plant/soil system more closed:

- Protecting the soil from erosion (water and wind), thereby from loss of carbon and nutrients.
- Trapping and recycling nutrients which would otherwise have been lost by leaching (not demonstrated).

Improvement of soil fertility through physical conditions

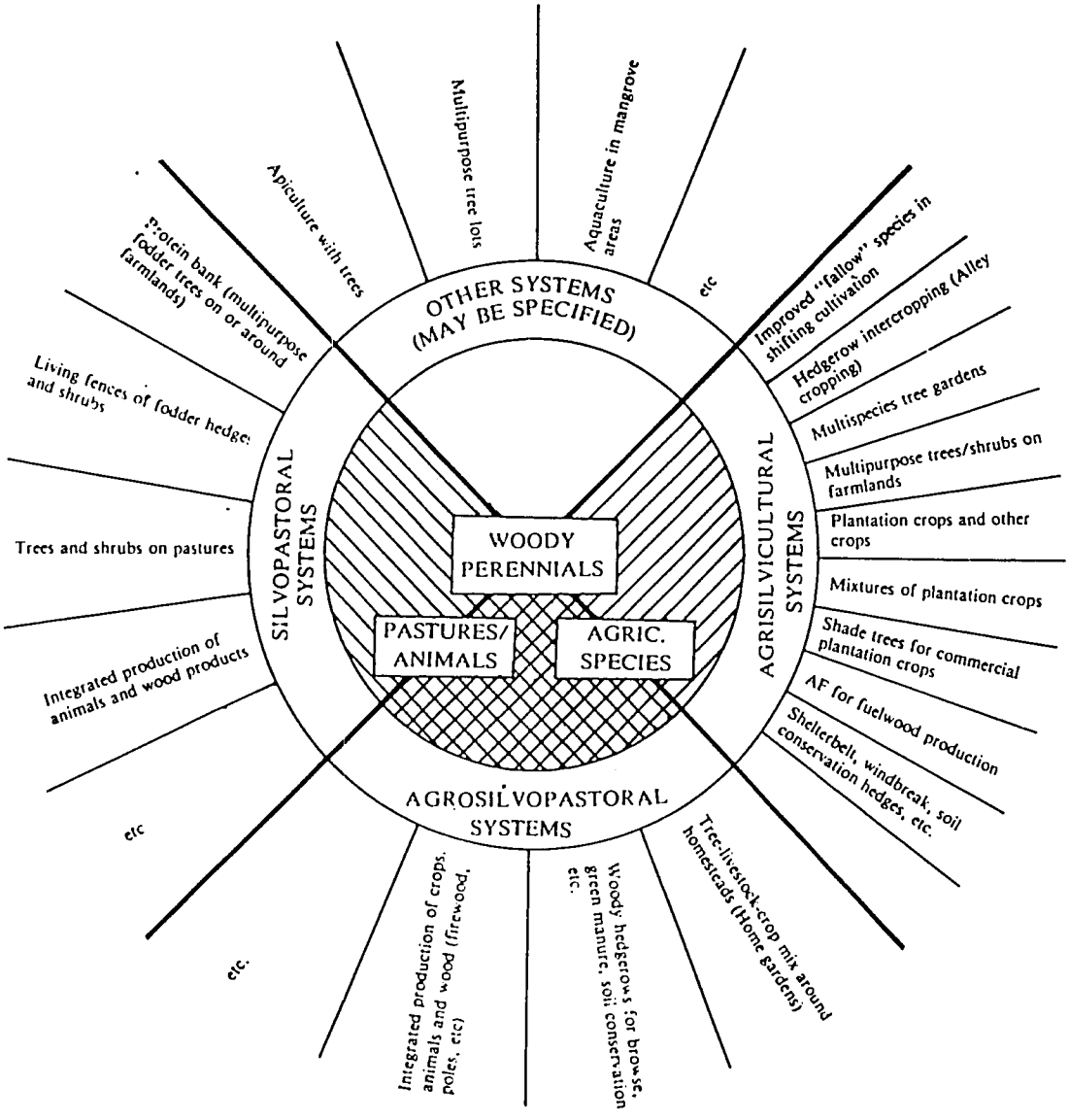
- Soils under trees generally have better physical conditions, including a higher water-holding capacity combined with good permeability and drainage, and greater erosion resistance.

Processes which affect the quality of plant residues and the timing of their transfer to the soil:

- Promotion of a range of different qualities of plant litter, through supplying a mixture of woody and herbaceous litter (TSBF hypothesis).
- Favourable effects of roots: growth-promoting substances in the rhizosphere (demonstrated in some cases) possibly also provision of a range of root-litter quality (TSBF hypothesis).
- Timing of nutrient release. Under natural conditions, the provision of a steadily-decaying nutrient store in the form of soil organic matter. Under management, the potential to control timing further, e.g. through decisions on when to prune (basic TSBF hypothesis).
- Effects of shading on microclimate, thereby on soil climate and rate of mineralisation (demonstrated in some cases; TSBF hypothesis).

Note: TSBF : Tropical Soils Biology and Fertility Programme

Figure 1 - Categorization of agroforestry systems based on the nature of components (Nair, 1985)



PUBLICATIONS FROM THE AGROFORESTRY SYSTEMS INVENTORY PROJECT

I. AGROFORESTRY SYSTEM DESCRIPTIONS

August 1987

This series of Agroforestry System Descriptions is edited by Dr. P.K.R. Nair and published by Martinus Nijhoff/Dr. W. Junk Publishers in the journal Agroforestry Systems.

AFSD-1 1984 Fernandes, E.C.M., A. O'Kting'ati and J. Maghembe. The Chagga home gardens: a multistoried agroforestry cropping system on Mt. Kilimanjaro (N. Tanzania). Agroforestry Systems 2: 73-86.

AFSD-2 1984 Boonkird, S.-A., E.C.M. Fernandes and P.K.R. Nair. Forest villages: an agroforestry approach to rehabilitating forest land degraded by shifting cultivation in Thailand. Agroforestry Systems 2: 87-102.

AFSD-3 1984 O'Kting'ati, A., J.A. Maghembe, E.C.M. Fernandes and G.H. Weaver. Plant species in the Kilimanjaro agroforestry system. Agroforestry Systems 2: 177-186.

AFSD-4 1984 Fonzen, P.F. and O. Oberholzer. Use of multipurpose trees in hill farming systems in Western Nepal. Agroforestry Systems 2: 187-197.

AFSD-5 1984 Evans, P.T. and J.S. Rombold. Paraiso (Melia azedarach var. "Gigante") woodlots: an agroforestry alternative for the small farmer in Paraguay. Agroforestry Systems 2: 199-214.

AFSD-6 1984 Bourke, R.M. Food, coffee and casuarina: an agroforestry system from the Papua New Guinea highlands. Agroforestry Systems 2: 273-279.

AFSD-7 1984 Liyanage, M. de S., K.G. Tejwani and P.K.R. Nair. Intercropping under coconuts in Sri Lanka. Agroforestry Systems 2: 215-228.

AFSD-8 1984 Johnson, D.V. and P.K.R. Nair. Perennial crop-based agroforestry systems in Northeast Brazil. Agroforestry Systems 2: 281-292.

AFSD-9 1985 Allen, B.J. Dynamics of fallow successions and introduction of Robusta coffee in shifting cultivation areas in the lowlands of Papua New Guinea. Agroforestry Systems 3: 227-238.

AFSD-10 1985 Escalante, E.E. Promising agroforestry systems in Venezuela. Agroforestry Systems 3: 209-221.

AFSD-11 1985 May, P.H., A.B. Anderson, J.M.F. Frazao and M.J. Balick. Babassu palm in the agroforestry systems in Brazil's Mid-North region. Agroforestry Systems 3: 275-295.

AFSD-12 1985 Vergara, N.T. and P.K.R. Nair. Agroforestry in the South Pacific Region - An overview. Agroforestry Systems 3: 363-379.

AFSD-13 1986 Alvim, R. and P.K.R. Nair. Combination of cacao with other plantation crops - an agroforestry system in Southeast Bahia, Brazil. Agroforestry Systems 4: 3-15.

AFSD-14 1986 Tajuddin, I. Integration of animals in rubber plantations. Agroforestry Systems 4: 55-66.

AFSD-15 1986 Jambulingam, R. and E.C.M. Fernandes. Multipurpose trees and shrubs on farmlands in Tamil Nadu State, India. Agroforestry Systems 4: 17-32.

AFSD-16 1986 Miehe, S. Acacia albida and other multipurpose trees on the Fur farmlands in the Jebel Marra highlands, Western Darfur, Sudan. Agroforestry Systems 4: 89-119.

AFSD-17 1986 Poschen, P. An evaluation of the Acacia albida-based agroforestry practices in the Hararghe Highlands of eastern Ethiopia. Agroforestry Systems 4: 129-142.

AFSD-18 1986 Nair, M.A. and C. Sreedharan. Agroforestry farming systems in the homesteads of Kerala, Southern India. Agroforestry Systems 4: 339-363.

AFSD-19 1986 Balasubramanian, V. and A. Egli. The role of agroforestry in the farming systems in Rwanda with special reference to the Bugeresa-Gisaka-Migongo (BGM) region. Agroforestry Systems 4: 271-289.

AFSD-20 1986 Oduol, P.A. The Shamba system: an indigenous system of food production from forest areas of Kenya. Agroforestry Systems 4: 365-373.

AFSD-21 1986 Michon, G., F. Mary and J. Bompard. Multistoried Agroforestry garden system in West Sumatra, Indonesia. Agroforestry Systems 4: 315-338.

AFSD-22 1987 Shankarnarayan, K.A., L.N. Harsh and S. Kathju. Agroforestry in the arid zone of India. Agroforestry systems 5: 69-88.

AFSD-23 1987 Jacob, V.J. and W.S. Alles. Kandyan gardens of Sri Lanka. Agroforestry Systems 5: 123-137.

AFSD-24 1987 Okafor, J.C. and E.C.M. Fernandes. Compound farms of southeastern Nigeria: a predominant agroforestry homegarden system with crops and small livestock. Agroforestry Systems 5: 153-168.

AFSD-25 1987 Leuschner, W.A. and K. Khalique. Homestead agroforestry in Bangladesh. Agroforestry Systems 5: 139-151.

AFSD-26 1987 Joffre, R., J. Vacher, C. de Los Llanos and G. Long. The Dehesa: an agrosilvopastoral system of the Mediterranean region with special reference to the Sierra Norte area of Spain (in press).

II. MISCELLANEOUS PUBLICATIONS

A. Book

Nair, P.K.R. (ed.). Agroforestry Systems in the Tropics. Martinus Nijhoff, The Hague (in preparation).

B. Papers

1. Nair, P.K.R. and E.C.M. Fernandes. 1984 Agroforestry as an alternative to shifting cultivation. In: Improved Production Systems as an Alternative to Shifting Cultivation, FAO Soils Bulletin 53, 169-182. FAO, Rome.

2. Nair, P.K.R., E.C.M. Fernandes and P.N. Wambugu. 1984 Multipurpose leguminous trees and shrubs for agroforestry. Agroforestry Systems 2: 145-163. (Also published in Pesquisa Agropecuaria Brasileira, Vol. 19 S/N - Junho 1984, pp. 295-313).

3. Nair, P.K.R. 1984 Fruit trees in Agroforestry. Working Paper, East-West Center, Honolulu, Hawaii (also published as ICRAF Working Paper No. 32, 1985).

4. Nair, P.K.R. 1985 Classification of agroforestry systems. (ICRAF Reprint No. 23, 1985). Agroforestry Systems 3, 97-128.

5. Nair, P.K.R. 1985 Agroforestry. Paper presented to the "Conference of Agricultural and Rural Development Officers of the Asia Missions of USAID"; International Rice Research Institute, Los Banos, The Philippines; 22-26 April 1985.

6. Nair, P.K.R. 1985 Agroforestry in the context of land clearing and development in the tropics. Paper presented to the "International Workshop on Land Clearing and Development, IBSRAM"; Jakarta, 26 August - 03 September 1985. (ICRAF Working Paper No. 33, 1985).

7. Nair, P.K.R. 1986 Alternative and improved landuse systems to replace resource-depleting shifting cultivation. In: Strategies, Approaches and Systems in Integrated Watershed Management, pp. 61-84. FAO Conservation Guide 14. FAO, Rome.

8. Nair, P.K.R. 1987. Agroforestry and firewood production. In: D.O. Hall and R.P. Overend (eds). Biomass: Renewable Energy, pp. 367-386. John Wiley and Sons, Chichester.

9. Nair, P.K.R. (forthcoming). Tropical agroforestry systems and practices. In: Furtado, J.I. and K. Ruddle (eds) Tropical Resource Ecology and Development, Chapter 14. Wiley Chichester (in press).

10. Fernandes, E.C.M. and P.K.R. Nair. 1986. An evaluation of the structure and function of some tropical homegardens. Agricultural Systems 21: 179-210.

11. Nair, P.K.R. 1986. Agroforestry systems and practices: their application in multiple use of forests. Keynote speech to V Brazilian Forestry Congress, Recife, Brazil; November 1986.

12. Nair, P.K.R. (forthcoming). Soil Productivity under agroforestry. In: H. Gholz (ed.) Agroforestry: Realities, Potentials and Possibilities; Martinus Nijhoff, The Hague. (in press).

13. Nair, P.K.R. 1987. Agroforestry systems in major ecological zones of the tropics and subtropics. Paper for the ICRAF/WMO Workshop on the Application of Meteorology to Agroforestry; ICRAF, February 1987. (ICRAF Working Paper No. 47, April 1987).

14. Nair, P.K.R. 1987. Agroforestry systems inventory. Agroforestry Systems (Special Issue for ICRAF's Tenth Anniversary, 1987) (in press).

15. Nair, P.K.R. 1987. Use of perennial legumes in Asian farming systems. Paper for the International Workshop on Sustainable Agriculture, Intern. Rice Res. Inst, Los Banos, The Philippines; 25-29 May 1987.

Appendix 1 b - Agroforestry Systems Register
(Computerized Data Sheets Available on the
Following Systems: Dated 06/12/86

No	System Name	Country
1	Cereal cultivation in Butyrospermum parkii and Parkia biglobosa tree parks practised by the Mossi	Burkina Faso
2	Integration of Crop and Livestock production in West African Savannah (Southern Fulani Farming system)	Burkina Faso
3	Acacia albida - sorghum - livestock system on compound and village fields	Burkina Faso
4	Acacia albida and Butyrospermum parkii tree gardens	Burkina Faso
5	Acacia albida and cattle on village fields in Dagari country, Burkina Faso (formerly Upper Volta)	Burkina Faso
6	Butyrospermum parkii (karite), Parkia biglobosa (nere), cereals & nomadic livestock on village fields	Burkina Faso
7	Acacia albida - cereal system with cattle practised by the Birifor in S. B. Faso	Burkina Faso
8	Acacia albida - Sorghum - Livestock system in compound fields as practised by the Massa tribe	Cameroon
9	Acacia albida systems practised by "refugee" tribes of the Mandara mountains	Cameroon
10	Oasis system: Phoenix dactylifera (date palm) - cereals - livestock	Chad
11	Cordia alliodora (laurel) - shade and timber tree in cocoa (Theobroma cacao) plantations	Costa Rica
12	Oil palm system (Elaeis guineensis) with Rice (rainfed) & livestock in Western Gambia	Gambia
13	Mixed garden - Fruit trees - Livestock - Vegetable farming system in Guam	Guam
14	Acacia albida with cattle as practised by the Brame and Mandjak in Guinnea Bissao	Guinnea-Bissao
15	Intercropping under poplars (Populus deltoides) in Uttar Pradesh, India	India
16	Multiple cropping with Arecanut (Areca catechu) in India	India
17	Gunehr village terraced cropping, fodder tree and cattle production system	India
18	Shifting cultivation in North East India	India
19	Multiple cropping with coconuts in India	India
20	Farm forestry in the Western Himalayas	India

No	System Name	Country
21	Kumri cultivation in Deccan plateau of India	India
22	Farm forestry in the Rajasthan desert	India
23	Agroforestry systems in the Homestead of Kerala, India	India
24	Rattan-swidden system	Indonesia
25	'Damar' (resin) tree gardens: Shorea-javanica - rice - coffee - cloves - fruit trees	Indonesia
26	'Shamba' system of forest plantation establishment - Kenya highlands	Kenya
27	Acacia albida - millet - livestock system on piedmont and plateau fields	Mali
28	Multipurpose shade trees (Erythrina poeppigiana & Diphysa robinoides) for cacao	Mexico
29	Coconut, star grass, bovine system	Mexico
30	Multipurpose shade trees (Inga edulis, Erythrina fusca, Samanea sama) for cocoa	Mexico
31	Multipurpose shade trees (Gliricidia sepium & Diphysa robinoides) for cacao and vanilla	Mexico
32	Coconut, breadfruit, mango, papaya system	Mexico
33	Multipurpose live fence tree species (Diphysa, Pachira, Salix sp.) around pastures	Mexico
34	Laurel (Cordia alliodora) multipurpose shade tree on pastures	Mexico
35	Multipurpose shade trees (Cedrella, Tabebuia, Ceiba sp.) on pastures	Mexico
36	Multipurpose fruit trees (mango & citrus) for animal shade on pastures	Mexico
37	Samanea saman: multipurpose shade tree for cocoa	Mexico
38	Multipurpose live fence trees (Gliricidia sepium & Tabebuia rosae) around pastures	Mexico
39	Fruit trees (avocado, sapodilla) as shade for perennial woody shrub and herbaceous crops	Mexico
40	Multipurpose trees (fuelwood, poles) as live fences around pastures	Mexico
41	Trees, maize and beans system	Mexico
42	Living fences: Bursera, Brosimum and crops system	Mexico
43	Trees, apiculture	Mexico
44	Trees, coffee system	Mexico
45	Grevillea, coffee system	Mexico

No	System Name	Country
46	Inga, coffee system	Mexico
47	Acacia, paspalum, bovine system	Mexico
48	Multipurpose tree/shrub strips on hill farms of Western Nepal	Nepal
49	Hill farming Western Nepal	Nepal
50	Date - Palm Oasis system of the Southern Air/Niger	Niger
51	Date palm system: Regional development programme for oases and related systems in the Air/Niger	Niger
52	Compound farms (homegardens): multistoried agroforestry system in the humid zone S.E. Nigeria	Nigeria
53	Cropping by Fulani Agropastoralists in Nigeria	Nigeria
54	Mixed homegardening in the Pacific Islands	Pacific Islands
55	Mixed gardens: Casuarina oligodon and bananas as shade for coffee	Papua New Guinea
56	Multipurpose shade trees for coffee (coffea arabica)	Papua New Guinea
57	Alyura basin forest fallow system	Papua New Guinea
58	Timber trees (Cedrella tubiflora, Cordia trichotoma, Balforodendron sp.) as shade for bananas	Paraguay
59	Forest plantation trees (Cobralea oblongifolia, Pterogyne nilens	Paraguay
60	Melia azedarach (timber) & Leucaena leucocephala (fuelwood, poles) intercropped with maize	Paraguay
61	Eucalyptus (poles, essential oils) intercropped with maize and cassava	Paraguay
62	Experimental system involving Cordia trichotoma (timber) intercropped with peas and groundnuts	Paraguay
63	Melia azedarach (for timber) intercropped with bananas	Paraguay
64	Ilex paraguarensis (tea made from leaves) as shade tree on pastures	Paraguay
65	Citrus species (oranges, tangerines, grapefruit) intercropped with maize and soyabeans	Paraguay

No	System Name	Country
66	Ilex paraguarensis (tea made from leaves) intercropped with maize and soyabeans	Paraguay
67	Melia azedarach (for timber) intercropped with maize and soybean	Paraguay
68	Paraiso (Melia azedarach var. gigante) woodlots on farmland	Paraguay
69	China berry, maize system	Paraguay
70	Trees, food crops system	Paraguay
71	Pinus, maize and watermelon system	Paraguay
72	Trees, maize and watermelon system	Paraguay
73	China berry, mate and maize system	Paraguay
74	China berry and cotton system	Paraguay
75	China berry, cordia and maize system	Paraquay
76	Paulownia and maize system	Paraguay
77	Aleuritis and soybean system	Paraguay
78	Paulownia and soybean system	Paraguay
79	Aleuritis and maize system	Paraguay
80	Palm, banana and pineapple system	Paraguay
81	Leucaena leucocephala (soil conservation, fuel, fodder) with crops & livestock - a resettlement project	Philippines
82	Multistorey cropping involving fruit trees, tree crops (coffee) and field crops (maize, cassava)	Philippines
83	Leucaena leucocephala (fodder, soil conservation, fuelwood) in an Upland Development Programme	Philippines
84	Ikalahan kaingin system	Philippines
85	Nasipit Lumber Company Silvopastoral sytem with exotic & indigenous timber species & cattle	Philippines
86	Grazing under forest plantations: an experimental system by the Nasipit Lumber Company, Philippines	Philippines
87	Traditional subsistence tree/crop system in Ponape	Ponape
88	Leguminous trees as shade trees for cocoa in Samoa	Samoa

No	System Name	Country
89	Taungya system - Taro cultivation and timber trees	Samoa
90	Traditional system: Yam cultivation with live tree supports in Samoa	Samoa
91	Acacia senegal - millet, groundnuts, cowpeas - livestock: a development project in Senegal	Senegal
92	Acacia albida - millet system with cattle integration practised by the Serer	Senegal
93	Grazing in forestry plantations in the Solomon Islands	Solomon Islands
94	Kandy homegardens: multistorey cropping with multipurpose trees, tree and shrub crops, and field crops	Sri Lanka
95	Intercropping under coconuts in Sri Lanka	Sri Lanka
96	Tea under shade in Sri Lanka	Sri Lanka
97	Gum gardens: Acacia senegal - millet - bush fallow	Sudan
98	Establishment of Tectona grandis (teak) plantations by the taungya method in southern Sudan	Sudan
99	Chagga homegardens: coffee-banana-multipurpose trees/shrubs and stall-fed livestock	Tanzania
100	Forest village system: agroforestry on forest land	Thailand
101	Thailand forest village system	Thailand
102	Intercropping under coconut in Tonga	Tonga
103	Shifting cultivation in Vanuatu	Vanuatu
104	Trees - Guinea - Brachiaria - Bovine	Venezuela
105	Spanish cedar - Brachiaria - Bovine	Venezuela
106	Cedar - Napier grass - Bovine	Venezuela
107	Teak - Guinea grass - Napier grass - Bovine	Venezuela
108	Avocado - Papaya	Venezuela
109	Mango - Papaya	Venezuela
110	Avocado - Mango - Food crops	Venezuela
111	Orange - Star grass - Bovine	Venezuela
112	Avocado - Mango - Banana - Papaya - Cassava	Venezuela

No	System Name	Country
113	Orange - food crops	Venezuela
114	Coconut - Guinea grass - Bovine	Venezuela
115	Trees - Caprine	Venezuela
116	Mahogany - Cacao - Pineapple - Vigna	Venezuela
117	Trees - Natural grasses - Caprine - Ovine	Venezuela
118	Trees - Banenas - Cacao	Venezuela
119	Trees - Bananas - Coffee	Venezuela
120	Avocado - vegetables	Venezuela
121	Cedar - plantain	Venezuela
122	Gmelina - beans	Venezuela
123	Gmelina - maize	Venezuela
124	Gmelina - Guinea grass - Bovine	Venezuela
125	Gmelina - Grasses - Bovine	Venezuela
126	Mahogany - Star grass - Bovine	Venezuela
127	Raintree - Grasses - Bovine	Venezuela
128	Cedar - Grasses - Bovine	Venezuela
129	Cordia - Cacao	Venezuela
130	Raintree - Brachiaria - Bovine	Venezuela
131	Cedar - Brachiaria - Bovine	Venezuela
132	Raintree - Guinea grass - Bovine	Venezuela
133	Spanish cedar - Guinea grass - Bovine	Venezuela
134	Cedar - Guinea grass - Bovine	Venezuela
135	Mahogany - Star grass - Bovine	Venezuela
136	Cedar - Star grass - Bovine	Venezuela
137	Raintree - Star grass - Bovine	Venezuela
138	Raintree - Napier grass - Bovine	Venezuela

No	System Name	Country
139	Mahogany - Napier grass - Bovine	Venezuela
140	Citrus - Food crops	Venezuela
141	Coral tree - Banana - Cacao	Venezuela
142	Coconut - Cacao - Cassava	Venezuela
143	Trees - Bovine - Caprine - Ovine	Venezuela
144	Raintree - Grasses - Buffalo	Venezuela
145	Avocado - Sorghum - Pineapple - Vigna/Guaniapa	Venezuela
146	Avocado - Pineapple	Venezuela
147	Avocado - Sorghum - Vigna	Venezuela
148	Mango - Vigna - Sorghum	Venezuela
149	Mango - Pineapple	Venezuela
150	Cashew nut - Brachiaria - Bovine	Venezuela
151	Conuco	Venezuela
152	Natural forest - Manaca Palm	Venezuela

Appendix 2 - List of publications prepared for or resulting from meetings on agroforestry held from 1978

1978 Royal Tropical Institute. Agroforestry Proceedings of the 50th 'Tropische Landbouwdag' (Symposium on tropical agriculture), 1978.
Bulletin 303, Royal Tropical Institute, Amsterdam. 47 pp

1979 De Las Salas, G - Proceedings of a Workshop - Agroforestry systems in Latin America, Turrialba, Costa Rica, March 26-30, 1979
United Nations University/CATIE, Turrialba, Costa Rica. 220 pp

Indian Council of Agricultural Research. Proceedings of the agroforestry seminar. Imphal, India, May 16-18, 1979.
ICAR, New Delhi. 268 pp

Mongi, H O & Huxley, P A - Soils research in agroforestry. Proceedings of an expert consultation, Nairobi, March 26-30, 1979
ICRAF, Nairobi. 585 pp

Serravo, R & Rodriguez, M L - Agroforestry in perspective: proceedings of the agroforestry symposium-workshop, December 19-21, 1979.
PCARRD Book No. 5, Philippines Council for Agricultural and Resources Research, Los Bonos, Laguna, Philippines. 81 pp

1980 Chandler, M T & Spurgeon, D - International Cooperation in Agroforestry. Proceedings of an international conference.
DSE/ICRAF Conference on international cooperation in agroforestry, Nairobi, Kenya, July 16-22, 1979. 469 pp

Ives J D, Sabhasir, S & Voraurai, P - Conservation and development in northern Thailand : Proceedings of a programmatic workshop on agro-forestry and highland - lowland interactive systems held at Chiang Mai, Thailand, November 13-17, 1978.
United Nations University, Tokyo, Japan. 114 pp

Le Houerou - Browse in Africa. The current state of knowledge.
ILCA, Addis Ababa, Ethiopia. 491 pp

1981 Buck, L - Proceedings of the Kenya National Seminar on Agroforestry - ICRAF/University of Nairobi, November 12-22, 1980.
ICRAF/University of Nairobi, Kenya. 679 pp

1981 Central Arid Zone Research Institute. Proceedings of the summer institute on agroforestry in arid and semi-arid zones. June 15 - July 14, 1981, Jodhpur, India.

Satjapradja, O et al. Seminar agroforestry dan pengendalian perladangan (Seminar on agroforestry and shifting cultivation control), Jakarta, Indonesia, November 19-20, 1981

1982 Hoekstra, D A & Kuguru, F M - Agroforestry systems for small-scale farmers : Proceedings of the ICRAF/BAT Workshop held in Nairobi.
ICRAF, Nairobi. 283 pp

Macdonald, L H - Agroforestry in the African humid tropics: Proceedings of a workshop held in Ibadan, Nigeria, April 27 - May 1, 1981.
UNU, Tokyo. 163 pp

1983 Huxley, P A - Plant Research and agroforestry. Proceedings of a consultative meeting, Nairobi, April 8-15, 1981.
ICRAF, Nairobi. 617 pp

Obel, E et al. - Proceedings of an agroforestry workshop for high-potential areas in Kenya : Seminar held in Bukura, Kakamega, March 1983.
KENGO, Nairobi. 68 pp

SECID - Comptes-rendu du Seminaire sur l'Agroforesterie au Sahel, Niamey, Niger du 23 mai au 11 juin, Vol I : Syllabus (et documents d'appui).
CILSS/Club du Saehl /AID, Washington, D.C., South Eastern Consortium for International Development. 65 pp

1984 Bilbrough, G W - Proceedings of a technical workshop on Agroforestry, Ministry of Agriculture & Fisheries, Wellington, New Zealand. 98 pp

Burley, J F & Carlowitz, P G Von - Multipurpose germ plasm. Proceedings of a planning workshop to discuss international cooperation, Washington D.C., June 1983.
ICRAF, Nairobi. xvi +. 298 pp

Heuveldop, J & Lagemann, J - Agroforestry: Proceedings of a Seminar held in CATIE, Turrialba, Costa Rica, February 23 - March 3, 1981.
Agroforesteria Actas del Seminario realilzado en el CATIE, Turrialba, Costa Rica 23 de Febrero - 3de Marzo de 1981, CATIE. 112 pp

Linnartz, N E - Agroforestry in the southern United States - 23rd Annual Forestry Symposium, 1984.
Louisiana State University. 183 pp

1984 Schirmer, A - The role of agroforestry in the Pacific, DSE, Fed. Republic of Germany. 103 pp

1985 Fortmann, L & Riddell, J - Trees and tenure. An annotated bibliography for agroforesters and others. Nairobi : ICRAF/Madison, Wisconsin, USA.
Land Tenure Center. xviii + 135 pp
(In preparation for a conference 'Tenure issues in agroforestry', held in Nairobi, May 27-31, 1985).

New Zealand Ministry of Agriculture & Fisheries. Proceedings. Ruakara farmer's Conference, 1985 : 37A Conference, Hamilton, New Zealand, Ministry of Agriculture & Fisheries. 154 pp

REFERENCES

Allen E F (1985) Cultivating other crops with rubber. Plant Bull. No.16. Rubber Research Institute of Malaysia. pp 10-21

American Society of Agronomy (1976) Multiple cropping. American Society of Agronomy (ASA) Special Publication No 27. Wisconsin, USA. 378 p.

Andrews D J, Kassam A H (1976) The importance of multiple cropping in increasing world food supplies. In: Multiple cropping. pp 1-10, ASA Special Publication No 27. Wisconsin, USA

Beekman F, Wiersum K F, Wouters F (1982) Bibliography on forest ecology, forestry management, agroforestry and timber characteristics for Indonesia 1950-1980. Rapport nr 285. Prepared for project 'Strengthening Forest Research in Indonesia'. Bogor, Indonesia, Forest Research Institute & Wageningen, Netherlands, Research Institute for Forestry and Landscape Planning. 112 p.

Beets (1982) Multiple cropping and tropical farming systems, Great Britain, Westview Press. Gower Publishing. 156 p.

Bene J G, Beall H W, Cote A (1977) Trees, food and people: Land management in the tropics. Ottawa, Canada. International Development Research Centre (IDRC)

Bishop J P (1983) Tropical forest sheep on legume forage/fuelwood fallows. Agroforestry Systems 1:79-84

Bishop J P (1983) Tropical forest sheep on legume forage/fuelwood fallows. Agroforestry Systems 1:79-84

Brenan J P M (1983) Manual on taxonomy of Acacia species: present taxonomy of four species of Acacia (A. albida, A. Senegal, A. nilotica, A. tortilis). Rome, Italy. FAO

Budowski G (1979) National, bilateral and multilateral agroforestry projects in Central and South America. In: Chandler T, Spurgeon D, eds, International cooperation in agroforestry. pp 149-160. Nairobi, Kenya. German Foundation for International development (DSE) and International Council for Research in Agroforestry (ICRAF)

Budowski, G (1981) Agroforestry in Central America. In: Agroforestry. Proceedings of a seminar held in CATIE, Turrialba, Costa Rica 23 Feb.- 3 March,1981. Turrialba, Costa Rica. CATIE

Burley J (1985) Global needs and problems of the collection, storage and distribution of multipurpose tree germplasm. Science and Practice of Agroforestry No 2. Nairobi, Kenya. ICRAF 179 p.

Burley J, Carlowitz P von, eds. (1984) Multipurpose tree germplasm. Proceedings of a planning workshop to discuss international cooperation, Washington D.C., USA, June 1983. Nairobi, Kenya. ICRAF 298 p.

Carlowitz P von (1985) Some considerations regarding principles and practices of information collection on multipurpose trees. Agroforestry Systems 3:181-195

Charreau C, Vidal P (1965) Influence de l'Acacia albida Del. sur le sol, nutrition minerale et rendements des mils Pennisetum au Senegal. Agron. Tropicale. 20:600-626

Combe J, Budowski G (1979) Classification of agroforestry techniques. In: Workshop agroforestry systems in Latin America, Turrialba, Costa Rica, 1979. Proceedings. Ed. G. de las Salas. CATIE, Turrialba, Costa Rica, 1979. pp 17-47

Combe J, Jimenez Saa H, Monge C (1981) Bibliography on Tropical agroforestry. Turrialba, Costa Rica, CATIE. 67 p.

Depommier D, Goudet J P (1983) Agroforesterie: foresterie et systèmes de production, étude de cas. Document de travail. Nogent-sur-Marne, France, Centre technique forestier tropical (CTFT). 71 p. + bibliographie

Ehrlich P R, Ehrlich A H, Holdren J P (1977) Ecoscience, population, resources, environment. San Francisco, USA. Freeman. 1051 p.

Etherington D, Matthews P (1985) Mulbud user's manual. 16-bit DOS version. A computer package for the economic analysis of multi-period and multi-enterprise farm budgets. Canberra, Austra lia. Australian National University. 96 p + exercises.

FAO (1978 a) Forestry for local community development. FAO Forestry Paper No.7. Rome, Italy. FAO 114 p.

FAO (1981) FAO/IBPGR project on genetic resources of arboreal fuelwood species for the improvement of rural living. Forest Genetic Resources Information. No 10: 31-32. Rome, Italy. FAO

FAO (1982 a) Conservation and development of tropical forest resources. FAO Forestry Paper No.37. 122 p. Rome, FAO

FAO (1982 b) Tropical forest resources. FAO Forestry Paper No 30. Rome, FAO. 106 p.

FAO (1984) Changes in shifting cultivation in Africa. Forestry paper 50. Rome, Italy, FAO. 59 p.

Felker P (1978) State of the art: Acacia albida as a complementary permanent intercrop with annual crops. University of California, Riverside, Mimeo, 143 p.

Ffolliott P F, Thames J L (1983 a) Handbook on taxonomy of Prosopis in Mexico, Peru and Chile. Rome, Italy. FAO 31 p.

Ffolliott P F, Thames J L (1983 b) Collection, handling, storage and pre-treatment of Prosopis seeds in Latin America. Rome, Italy. FAO 45 p.

Foley G, Barnard G (1984) Farm and community forestry. Technical Report No.3 London, United Kingdom. Earthscan 236 p.

Giffard P L (1974) L'arbre dans le paysage sénégalais. Sylviculture en zone tropicale sèche. Dakar, Centre technique forestier tropical (CTFT). 431 p.

Grunell H R (1977) A study of agri-silviculture potential in West Africa. IDRC, Ottawa, Canada, 1977. 30 p.

Halleux B, Ergo A B, Haes W, Bal A G (1972) Bibliographie analytique pour l'agronomie tropicale, Zaire, Rwanda, Burundi. Volume 1 (1972), Volume 2 (1973). Tervuren, Belgique. Centre d'Informatique appliquée au Développement et à l'Agriculture Tropicale (CIDAT)

Hartley C W S (1977) The oil palm. 2nd edition. Tropical Agriculture Series, London & New York, Longman. 806 p.

Hoekstra D A (1983) An economic analysis of a simulated alley cropping system for semi-arid conditions, using micro-computers. Agroforestry Systems 1:335-346

Hoekstra D A (1984) Agroforestry systems for the semi-arid areas of Machakos District, Kenya. ICRAF Working Paper No.19. Nairobi, Kenya. ICRAF 28 p.

Hutson V M (1960) Le rôle du petit planteur dans la production de caoutchouc en Malaisie. RGC 37:1096-1102

Huxley P A (1983 a) Some characteristics of trees to be considered in agroforestry. In: Huxley P A, ed. Plant research in agroforestry pp 3-12, Nairobi, Kenya. ICRAF.

Huxley P A (1983 b) Comments on agroforestry classifications: with special reference to plant aspects. In: Huxley P A, ed. Plant research in agroforestry. pp 161-172. Nairobi, Kenya. ICRAF

Huxley P A (1983 c) The role of trees in agroforestry: some comments. In: Huxley P A, ed. Plant research and agroforestry. pp 257-271. Nairobi, Kenya. ICRAF

Huxley P A (1983 d) Plant research in agroforestry. Proceedings of a consultative meeting held in Nairobi, 8-15 April 1981. Nairobi, Kenya. ICRAF. 617 p.

Huxley P A (1985) Systematic designs for field experimentations with multipurpose trees. Agroforestry Systems 3:197-207

Huxley P A (1986) Tree/crop interface or simplifying the biological/environmental study of mixed cropping agroforestry systems. Agroforestry Systems 3:251-256

Huxley P A ed. (1984) A manual of research on methodology for the exploration and assessment of multipurpose trees: source materials and guidelines. Nairobi, Kenya. ICRAF 1404 p.

ICRAF (1983 a) Guidelines for agroforestry diagnosis and design. ICRAF Working Paper No.6. Nairobi, Kenya. ICRAF 25 p.

ICRAF (1983 b) Resources for agroforestry diagnosis and design. ICRAF Working Paper No 7. Nairobi, Kenya. ICRAF 383 p.

ICRAF (1983 c) A global inventory of agroforestry systems: a project announcement. Agroforestry Systems. 1:269-274

ICRAF (1983) Report on the ICRAF/DSE international workshop on professional education in agroforestry. Nairobi, 6-10 December, 1982. Nairobi, Kenya ICRAF. 29 p.

ICRAF (1985) Reports (various) of ICRAF Agroforestry courses, On-the-job training and research fellowships. Nairobi, Kenya. ICRAF

ICRISAT (1986) Agroforestry research in the semi-arid tropics. Report on working group meeting, 5-6 August 1985, ICRISAT Center, India. Patancheru, India. ICRISAT 59 p.

IITA (1984) Farming systems program. In: IITA, Annual report 1983. pp 139-196. Ibadan, Nigeria, IITA

IRAT (1982) Bibliographie sur l'agroforesterie. Nogent-sur-Marne, France, Institut de recherches agronomiques tropicales et des cultures vivrières (IRAT). 131 p. + index

Johnson C D (1983) Handbook on seed insects of Prosopis species. Rome, Italy, FAO 55 p.

Jung G (1967) Influence de l'Acacia albida (Del) sur la biologie des sols Dior. Rapport intérieur. Dakar-Hann, Office de la Recherche scientifique et technique Outre-mer (ORSTOM). 63 p.

Jurion F, Henry J (1967) De l'agriculture itinérante à l'agriculture intensifiée. Hors série. Bruxelles, Institut National pour l'Etude Agronomique du Congo (CINEAC). 498 p.

Kang B T, Wilson G F, Lawson T L (1984) Alley cropping. A stable alternative to shifting cultivation

King K F S (1968) Agri-silviculture. The taungya system. Bulletin No 1 Ibadan, Nigeria, Dept. of Forestry, University of Ibadan. 101 p.

King K F S (1979) Agroforestry and the utilization of fragile ecosystems.

King K F S, Chandler M T (1978) The wasted lands. The programme of work of the International Council for Research in Agroforestry (ICRAF). Nairobi, Kenya. ICRAF 36 p.

Labelle R (1983) A preliminary agroforestry word list, with definitions. ICRAF Working Paper No 8. Nairobi, Kenya. ICRAF 30 p.

Labelle R (1986) Bibliographic information management using microcomputers: the experience of the International Council for Research in Agroforestry (ICRAF). Pan African Development Information System (PADIS), German Foundation for International Development (DSE). Padis training workshop, April 1986, Nairobi, Kenya (In press)

Las Salas G (1979) Workshop. Agroforestry systems in Latin America. March 1979. Proceedings. Turrialba, Costa Rica. United Nations University, CATIE.220 p.

Le Houerou H N (1980) Browse in Africa. The current state of knowledge. Papers at an international symposium on browse in Africa. Addis Ababa, 8-12 April 1980. Addis Ababa, Ethiopia. ILCA 491 p.

Lundgren B O (1982) The use of agroforestry to improve the productivity of converted tropical land. Prepared for the Office of Technology Assessment of the United States Congress. 82 p.

Lundgren B O, Raintree J B (1983) Sustained agroforestry. In: Agricultural research for development: potentials and challenges in Asia. Report of a conference held 24-29 October 1982, Jakarta, Indonesia. pp 37-49. The Hague, ISNAR

Lundgren B O, Raintree J B (1983) Sustained agroforestry. In: Agricultural research for development: potentials and challenges in Asia. Report of a conference held 24-29 October 1982, Jakarta, Indonesia. The Hague, International Service for National Agricultural Research (ISNAR). pp 37-49

Martinez A, Enriguez G (1981) La sombra para el cacao. Turrialba, Costa Rica, CATIE. 93 p.

Mary F (1985) Agroforêts et sociétés. Etude comparée de trois systèmes agroforestiers indonésiens. Thèse. Ecole nationale supérieure agronomique de Montpellier. Volume 1. Document de synthèse. 160 p. Volume 2. Trois exemples d'agroforesterie en Indonesie. 350 p.

Michon G (1983) Village forest gardens in West Java. In: Huxley P, ed. Plant research and agroforestry. pp 13-24. Nairobi, ICRAF

Michon G (1985) De l'homme de la forêt au paysan de l'arbre. Agroforesterie indonésienne. Thèse de doctorat. Académie de Montpellier, Université des Sciences et Techniques du Languedoc

Michon G, Mary F, Bompard J (1986) Multistoried agroforestry systems in West Sumatra, Indonesia. Agroforestry Systems (in press).

Midgley S J, Turnbull J W, Johnston R D (1983) Casuarina ecology, management and utilization. Proceedings of an international workshop, Canberra. Australia, 17-21 August 1981. Commonwealth Scientific and Industrial Research Organization (CSIRO), Melbourne, Australia 286 p.

Nair P K R (1979) Intensive multiple cropping with coconuts in India. Principles, programmes and prospects. Berlin & Hamburg, Verlag Paul Parey. 147 p.

Nair P K R (1980) Agroforestry species: A crop sheets manual. ICRAF, Nairobi, Kenya, 1980. 336 p.

Nair P K R (1985) Classification of agroforestry systems. Agroforestry Systems 3:97-128

Nair P K R, Fernandes E C M, Wambugu P N (1985) Multipurpose leguminous trees and shrubs for agroforestry. Agroforestry Systems 2:145-163

NAS (1975) Underexploited tropical plants with promising economic value. Washington, D.C., USA. National Academy of Sciences (NAS) 187 p.

NAS (1977) Leucaena: promising forage and tree crop for the tropics. Washington, D.C. USA. National Academy of Sciences (NAS) 115 p.

NAS (1979) Tropical legumes: Resources for the future. Washington, D.C., USA. National Academy of Sciences (NAS) 331 p.

NAS (1980) Firewood crops: Shrub and tree species for energy production. Washington, D.C., USA. National Academy of Sciences (NAS). 237 p.

NAS (1983 a) Firewood crops: Shrub and tree species for energy production. Washington, D.C., USA. National Academy of Sciences (NAS). 92 p.

NAS (1983 b) Mangium and other fast growing Acacias for the humid tropics. National Academy of Sciences (NAS) 63 p.

NAS (1983 c) Calliandra: a versatile small tree for the humid tropics. Washington, D.C., USA. National Academy of Sciences (NAS) 56 p.

PUDOC (1982) Indonesian Forestry Abstracts. Dutch literature until about 1960. Wageningen, Netherlands. Center for Agricultural Publishing & Documentation (PUDOC) 658 p.

Raintree J B (1981) Conservation farming with multipurpose tree legumes: An underdeveloped branch of tropical agroforestry research. In: Buck L, ed. Proceedings of the Kenya National Seminar on Agroforestry pp 107-121 Nairobi, Kenya. ICRAF

Raintree J B (1983) Bioeconomic considerations in the design of agroforestry cropping systems. In: Huxley P A, ed. Plant research in agroforestry. pp 271-290. Nairobi, Kenya. ICRAF

Raintree J B (1983) Preliminary diagnosis of land use problems and agroforestry potentials in Northern Mbere Division, Embu District, Kenya. ICRAF Working Paper No.1. Nairobi, Kenya. ICRAF 16 p.

Raintree J B, Torres F (1986) Agroforestry research in a farming systems perspective: the ICRAF approach. ICRAF Working Paper No 39. Nairobi, Kenya. ICRAF 30 p.

Reynolds S G (1980) Grazing cattle under coconuts. World Animal Review 35:40-45

Rocheleau D, den Hoek A van (1983) The application of ecosystems and landscape analysis in agroforestry diagnosis and design: a case study from Kathama sub-location Machakos District, Kenya. ICRAF Working Paper No 11. Nairobi, Kenya. ICRAF 92 p.

Ruthenberg H (1980) Farming systems in the tropics. 3rd Edition. Oxford, Clarendon Press. 424 p.

Sanchez P A (1977) Soil management under shifting cultivation. In: A review of soils research in tropical Latin America. pp 46-67. Ed. P A Sanchez. Technical Bulletin NO.219. North Carolina Agricultural Experiment Station, Raleigh, North Carolina, USA

Shapiro K H (1984) Agroforestry in developing countries: selected policy issues. In: Agroforestry in developing countries pp 1-28. Michigan, USA. Center for Research on Economic Development, University of Michigan

Shepherd G (1985) Social forestry in 1985: lessons learnt and topics to be addressed. Network Paper 1a. London, United Kingdom. Overseas Development Institute (ODI) 33 p.

Sholto-Douglas J (1967) 3-D forestry. World Crops 19:20-24

Sholto-Douglas J, Hart R A J (1984) Forest farming. London. Intermediate Technology Publications. 207 p.

Sinha S K, Swaminathan M S (1984) New parameters and selection criteria in plant breeding. In: Vose P B, Blixt S G eds, Crop Breeding. A contemporary basis, pp 1-31 Pergamon Press

Singh G B (1986) The ICAR program. In: ICRISAT. Agroforestry research in the semi arid tropics. A report on the Working Group Meeting held at ICRISAT Center, India, 5-6 August 1986. pp 25-27, ICRISAT,India.

Soosai J S, Kaw H W (1975) Fifty years of natural rubber research 1926-1975. A bibliography of contributions from the Rubber Research Institute of Malaysia. Kuala Lampur, Malaysia, Rubber Research Institute of Malaysia (RRIM). 319 p.

Southgate B J (1983) Handbook on seed insects of Acacia species. Rome, Italy. FAO 30 p.

Spears J (1985) Deforestation issues in developing countries. The case for an accelerated investment programme. Commonwealth Forestry Review. 64:313-344

Steppler H A (1982) An identity and strategy for agroforestry. In: Macdonald L H, ed. Agroforestry in the African humid tropics. pp 1-5. Proceedings of a workshop held in Ibadan, Nigeria, 27 April - 1 May 1981. Tokyo, Japan. United Nations University

Steppler H A, Raintree J B (1983) The ICRAF strategy in relation to plant science research in agroforestry. In: Huxley P A ed. Plant research and agroforestry. pp 297-308. Nairobi, Kenya. ICRAF

Stewart P J (1981) Forestry, agriculture and land husbandry. Common. For. Rev. 60:29-34

Tajuddin I (1986) Integration of animals in rubber plantations. Agroforestry Systems 4:55-66

Terkuile C H H, Kang B T (1986) Farming systems to prevent soil degradation in the Humid and Subhumid tropics. In: Farming systems principles for improved food production and the control of soil degradation in the arid, semi-arid, and humid tropics. Summary proceedings of an experts meeting, 20-30 June, pp 31-34, Patancheru, India. UNEP, ICRISAT 36 p.

Thomas D (1978) Pastures and livestock under tree crops in the humid tropics. Tropical Agriculture 55:39-44

Tiwari K M (1983 a) Social forestry for rural development, Dehra Dun, India. International Book Distributors. 108 p.

Tiwari K M (1983 b) Social forestry in India. Dehra Dun, India. Natraj Publishers. 296 p.

Torres F (1983) Agroforestry: concepts and practices. In: Hoekstra D A, Kuguru F M, eds. Agroforestry systems for small-scale farmers. Proceedings of the ICRAF/BAT workshop held in Nairobi in September 1982. pp 27-42. Nairobi, Kenya. ICRAF

Torres F (1985) Networking for the generation of agroforestry technologies in Africa. ICRAF Working Paper No.31. Nairobi, Kenya. ICRAF 85 p.

Torres F, Raintree J B (1984) Agroforestry systems for smallholder upland farmers in a land reform area of the Philippines: the Tabango case study. ICRAF Working Paper No 18. Nairobi, Kenya. ICRAF 25 p.

Turnbull J W (1986) Multipurpose Australian Trees and Shrubs. ACIAR Monograph No. 1, 316 p.

Turnbull J W (1987) Australian Acacias in developing countries: proceedings of an international workshop held at the Forestry Training Centre, Gympie, Qld., Australia, 4-7 August 1986. ACIAR Proceedings No. 16, 196 p.

UNEP (1977) Desertification - an overview. In: Secretariat, UN Conference on Desertification, eds. Desertification: its causes and consequences. pp 1-64. Oxford, England. Pergamon Press.

Wessel M (1985) Shade and nutrition. In: Wood G A R , Lass R A, eds. Cacao. pp 166-194. 4th edition. Tropical Agriculture Series, London & New York, Longman

Whyte R O (1947) The use and misuse of shrubs and trees as fodder. pp 94-109. Commonwealth Bureau of Pastures and Field Crops. Publication No 10.

Wickens G E (1969) A study of Acacia albida Del. (Mimosoideae). Kew Bulletin 23:181-207

Wood G A R (1985) Establishment. In: Wood G A R, Lass R A, eds, Cacao. pp 119-165, 4th edition. Tropical Agriculture Series, London & New York, Longman

Wood G A R, Lass R A (1985) Cocoa, 4th edition. Tropical Agriculture Series, London & New York, Longman. 620 p.

World Bank (1978) Forestry, Sector policy paper. Washington, D.C, USA. World Bank 64 p.

World Bank (1984) Toward sustained development in sub-Saharan Africa. A joint program of action. Washington, D.C., USA. World Bank 102 p.

World Bank (1985) Desertification in the Sahelian and Sudanian zones of West Africa. Washington, D.C., USA. World Bank 60 p.

Young A (1986) Effects of trees on soils. In: Amelioration of soils by trees. Proceedings and recommendations of a planning workshop. Lucknow, India, 2-9 March 1986. London, United Kingdom. Commonwealth Science Council.

Zandstra H G, King D J (1982) Technology and livestock development in Asia. In: Fine J C, Lattimore R G eds. Livestock in Asia. Issues and policies, pp 167-174. Ottawa, Canada. International Development Research Centre (IDRC)