Agroforestry in the Sahel

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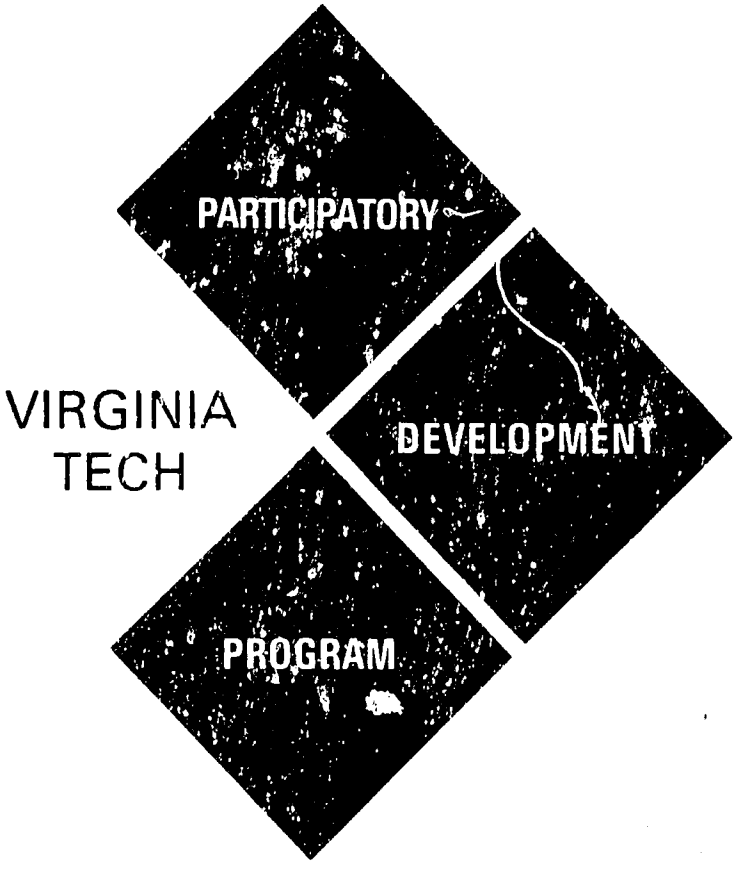

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AGROFORESTRY IN THE SAHEL

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TABLE OF CONTENTS

page

INTRODUCTION 1

OVERVIEW 1
DEFINITIONS 4
AGROFORESTRY AS A CONCEPT 5

TRADITIONAL AGROFORESTRY 7

OVERVIEW 7
TRADITIONAL SAHELIAN AGROFORESTRY SYSTEMS 8
Acacia albida 9
Karite (Shea nut tree) Butyrospermum parkii . . 15
Nere, Parkia bigolbosa (P. clappertoniana) . . 17
Tamarind 17
Borassus, Run palm (Borassus aethiopum) French: ronier 18
Other traditional agroforestry species 20
AGRICULTURAL EFFORTS AND FARMING SYSTEMS 22
FORESTRY EFFORTS AND SOCIAL FORESTRY 24

MODERN AGROFORESTRY TECHNIQUES 27

OVERVIEW 27
THE ROLE OF AGROFORESTRY IN THE SAHEL 32
AGROFORESTRY TECHNIQUES IN THE SAHEL 33

SITUATION ANALYSIS 37

PRESENT DAY PROBLEMS 37
LESSONS LEARNED 39
General 39
Specific Points Discussed at the Seminar . . . 41
CRITERIA FOR FURTHER AGROFORESTRY ACTIVITIES IN THE SAHEL 43

PROPOSED AGROFORESTRY STRATEGY 46

STRATEGY FRAMEWORK 46
BASIC APPROACH 49
THE NEXT STEPS 51
THE CRITICAL QUESTION: WHO? 53
THE SPECIAL ROLE OF VOLUNTEERS AND PVOS 55
MOST REASONABLE COURSE FOR DONORS AND RECIPIENTS . 57

page

Annex I Bibliography, References cited 60

Annex II Bibliography, general 62

Annex III, Technical details on Agroforestry techniques in the Sahel 66

Revegetation, controlled use of rangeland 66

Dune stabilization 72

Trees in Vegetable gardens 76

Acacia albida 79

Windbreaks 83

Live Fences 86

Farm-Park species 90

Village Woodlots 93

Taungya on Public Land 95

Vegetation strips 99

Shade trees 101

Reforestation of depleted farmland 102

INTRODUCTION

OVERVIEW

Agroforestry has become one of the more recent buzz-words in the development world. A number of international efforts highlighting this subject have increased the awareness of donors and recipients alike. Some examples of these efforts are as follows:

1. In 1979 CATIE arranged a workshop on agroforestry systems in Latin America at Tourrialba, Costa Rica (Proceedings available through CATIE, Tourrialba, Costa Rica).

2. The International Centre for Research on Agroforestry (ICRAF), Nairobi, has been established and has made a number of important conceptual contributions. In December of 1982, ICRAF sponsored a worldwide seminar on the training aspects of Agroforestry (ICRAF, PO Box 30677, Nairobi, Kenya).

3. In June of 1982, the UN University held a seminar on Agroforestry in Germany which attracted participants from around the world (The proceedings are in press).

4. The private sector has also become involved. A paper in French "Introduction aux systemes agrosylvicole" has been prepared by R.C. Zimmermann of Associates in Rural Development Inc. (available from ARD, 362 Main Street, Burlington, VT 05401). (17).[1]

5. Part of the recent analysis of tropical forestry with recommendations to Congress on ways to sustain tropical forests was developed by the

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[1] Number in parenthesis refers to specific references listed under "References Cited" (Annex 1).

Office of Technology Assessment emphasises agroforestry. (Papers available from OTA, US Congress, Washington D.C. 20510).

In Africa, interest in agroforestry has been strong for a number of years and is growing.

1. In 1981 a workshop, "Agroforestry system in the African Humid Tropics", was sponsored by the UN University and held in Ibadan, Nigeria (Proceedings available from UNIPUB, New York City, NY).

2. State of the art papers are being produced including one focusing on agroforestry in the Sahel which the NAS recently published (12).

3. An overview paper on the usefulness of Acacia albida in the Sahel has recently been prepared by M. Wentling at Cornell University (16).

4. In July 1983 the U.S. Peace Corps organized an agroforestry workshop in Ouagadougou (Upper Volta) bringing together from various countries forestry volunteers with their counterparts.

5. Another Sahel-specific effort was an agroforestry curriculum development seminar organized by CILSS for its member countries. This seminar was held in Niamey in June 1983 with funding provided by AID's program for Environmental Training and Management in Africa (ETMA), and inputs from various other donors (France, Switzerland, Belgium, Canada, etc.) and international organizations (Club du Sahel, ICRAF, FAO, World Bank). (Proceedings in preparation by SECID, Chapel Hill).

This paper is in part an elaboration of the information presented and issues participants raised and discussed during the above mentioned June regional CILSS country seminar.

Originally the idea was to increase new capabilities and interest in agroforestry activities in the member countries by obtaining funding to develop a special agroforestry syl-

labus to be introduced into the different government training institutions across the Sahel.

However, the basic U.S. seminar staff[2] insisted that a more complete overview of the basic components (traditional tree and crop mixtures, and socio-economic as well as legal and administrative supports and constraints, etc.) should first be identified and discussed. In light of these components, a plan of action could be established which might well, at some priority level, include new syllabi. A compromise was reached in which a plan of action was to be framed and then an appropriate syllabus written.

Subsequent discussions during this seminar were based on introductory papers on Sahelian ecology, land tenure, experience with past forestry projects and benefits, use rights of trees, etc. Participants then assessed the future of agroforestry in the Sahel and identified changes, including those in training, which will have to take place before agroforestry can take a dynamic role in project activities.

Some of the issues, e.g. lessons learned from past efforts or potentials for various technologies, could not be covered in depth during the two and a half weeks of presentations and group sessions. What follows is an attempt to summarize the seminar's basic findings and to expand on pre-

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[2] (F. Weber and M. Hoskins of VPI)

sented information in order to provide basic reference points for effective planning, analyzing and implementing future agroforestry activities in the Sahel.

Additional reading will be required for a comprehensive background and a bibliography is attached for that purpose (Annex 2).

DEFINITIONS

According to John B. Raintree of ICRAF (International Council for Research in Agroforestry), "Agroforestry is the new interdisciplinary science dealin with the age old practice of combining trees, in space or time, with herbaceous crops and/or animals on the same unit of land."

The recent NAS paper "Agroforestry in the West African Sahel" (12), using P.K.R. Nair (ICRAF) as the source, says agroforestry is a land-use system that integrates trees with crops and/or animals to get higher productivity, more economic returns, and better social benefits on a sustained basis, than are obtainable from monoculture on the same unit of land; even for marginal areas and under conditions of low level of technological inputs.

During the Niamey seminar on agroforestry Sahelian participants, with assistance from R. Labelle (ICRAF) wrote the following version to adapt the meaning of agroforestry to Sahelian conditions:

> Agroforestry is a general term encompassing land-use systems in which perennial, ligneous vegetation (trees, bushes, palms, bamboos) are deliberately cultivated (planted or protected) on plots of land, also used to raise crops or livestock, either simultaneously or successively on the same areas. In agroforestry systems, ecological, economic, and socio-cultural aspects are interrelated (original in French).

To which they added:

> Agroforestry is included in forestry for rural development but all forestry for rural development is not agroforestry.

AGROFORESTRY AS A CONCEPT

Regardless of which version is used or how it is interpreted, the common denominator lies in the fact that agroforestry covers a variety of land-use systems combining some form of forestry activity with crop raising or animal production on the same piece of land.

The concept of agroforestry has been used indiscriminantly and perhaps too freely by development technicians. Many peripheral activities have been included in this new movement. For instance, small woodlots, though they do not contain efforts to combine crop or animal raising with forestry, are called agroforestry.

On the other hand, farmers may be encouraged to raise crops inside a recently reforested project perimeter. The basic purpose is to reforest. Raising peanuts or cowpeas,

around freshly planted young trees eliminates the need for weeding and encourages farmers to keep out their animals. The trees are better protected with the crops growing between them, and the chance for fires is reduced.

However, after trees have grown to a certain height, this type of protection is no longer needed, the trees produce too much shade and farming operations cease. From then on, a forest has been established with the major and often only accent on the production of wood either for fuel, poles or timber. When farming activities at the outset are merely a tool to provide needed maintenance and protection in an effective and economic manner, in our opinion, the activity should not be called agroforestry.

Though it is true that converting farm land to forest should normally not be called agroforestry, the principle of alternating trees with crops to retain or restore soil productivity does amount to combining forestry efforts with crop raising and therefore, at least in the long run, the effort could qualify as "agroforestry".

It is not easy to determine the exact limits of the term. The important thing is that in planning agroforestry one should realize that trees depend on people and vice versa.

TRADITIONAL AGROFORESTRY

OVERVIEW

Contrary to many other parts of arid or semi-arid Africa, throughout the entire Sahel the relatively recent term "agroforestry" fits well with the existing typical, savannah-park landscape. Farmers in a belt reaching from Senegal to Chad have always preserved selected trees in their fields and they continue to do so as long as changing circumstances and increasing land pressure permit.

Across the Sahel the tree cover is disappearing at a continuously high rate. Comparison of older and more recent aerial photos provide proof of a significant loss of natural tree cover. For instance, in a forest reserve near Niamey losses range from 60% to 10% in 20 years. Local residents are forced to trim and cut individual branches from nearby trees more frequently as firewood from the open brush areas becomes increasingly scarce.

It is very important to note, however, the only large-scale, completely treeless farm areas found today in the cereal belts of the Sahel, are development projects sites where trees were removed because they were judged by "experts" to be superfluous or obstructing heavy modern farm equipment and machinery.

In order to make up for these losses, a considerable number of reforestation efforts have been undertaken in recent years. Many of them have fallen short of expectations. According to the series of "bilan programme" papers (3) recently completed by the Club du Sahel and CILSS, the costs of large scale, industrial type government plantations are far too great for the yields actually obtained. Moreover, many plantations have created major social and political problems where traditional cultivating or grazing rights were cancelled by government agencies to provide land for project efforts.

Some smaller community oriented forestry schemes have not fared much better due to lack of management skills and the persistent repressive orientation of field level forestry personnel.

TRADITIONAL SAHELIAN AGROFORESTRY SYSTEMS

Ample evidence exists across the Sahel that many different species of trees, in different farming or grazing systems have been deliberately managed and protected by the local people as part of their way of using the land. This practice was established long before the important contribution of trees to crops yields or range conditions were recognized and given full credit by development or government agencies.

A wealth of local knowledge exists about ecologic relationships between plant life and human activities, about local tree species which complement each other in a farm-park landscape (French: savanne-parc) or on rangeland. Local farmers and herders also have a good "feel" for which species are increasers, decreasers, or invaders.

Selection of species and their harmonious incorporation into local farming/herding practices depends mainly on soils and rainfall. Hardly any traditional farming systems exist in the Sahel where the significant contribution of trees in terms of both production and protection, is not one of the elements determining the way land is used. The most important of these different systems are recapped in Figure 1 and described in the following section:

Acacia albida

The feature which makes this tree especially valuable to farming is that it looses its leaves during the rainy season, thus allowing unhindered crop cultivation even underneath its canopy. Several other aspects add to its value:

1. As a member of the legume family, the tree has the ability to fix nitrogen through its root system, though the magnitude of this contribution to soil nutrients available to farm crops has not been firmly established (16).

2. Competition[3] for available moisture in the soil with farm crops is believed to be rather small.

a) The tree develops a very deep tap-root system which draws water at levels far below those penetrated by the roots of field crops. A three year old A. albida excavated near Kano, Nigeria in 1964, already had a vertical root shaft over 30 feet long!

b) Water intake of this species is at a low during most of the cropping cycle since the tree is leafless during this period and therefore in a period of physiological rest.

3. During the hot season, the fully developed crowns of these tall trees provide important shade for livestock. Manure accumulates where the animals rest and results in increased soil fertility near the trees.

4. The relatively thin and fragile leaflets decompose readily once they have reached the ground, adding additional organic material in the areas around the tree.

5. Where a minimum cover of approximately 40 trees per ha exists, significant protection and conservation functions take place:

a) Soil surface temperatures are greatly reduced which is extremely important to biologic soil forming activities, especially during the hottest part of the year.

b) the hot and dry winds of the harmattan are broken up somewhat by crowns and branches which further mitigates adverse soil surface conditions.

On the production side, the tree provides a number of items important to local populations.

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[3] A possible disadvantage of associating A. albida with farming efforts as cited by Felker (4).

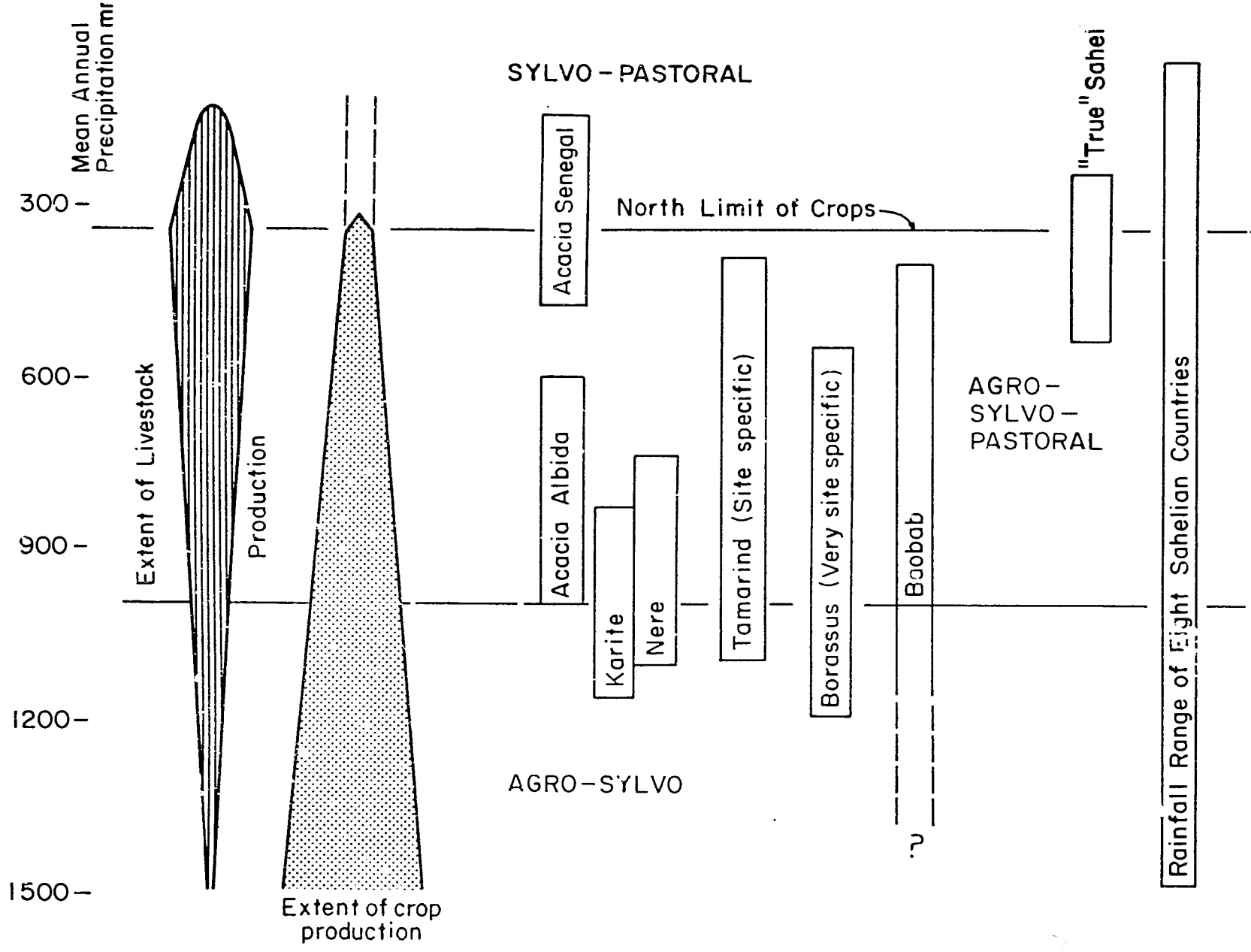

Figure 1. Range of Agroforestry Species & Systems

1. From the onset of the dry season until the first rains, trees (from an age of ten years on) produce a fair quantity of pods important in the diet of many tree gazing animals. These pods are collected systematically by local farmers and herders alike; frequently they are offered for sale in the local markets. In some parts of the Sahel, it has been reported that they are used for human consumption in times of severe food shortages. Standard nutritional value of these pods has been reported to be relatively high (approximately equivalent to oats or barley), however actual digestability and absorption of nutrients is questioned by some due to tannin and other components (16).

2. Branches with their small, strong and sharp thorns are ideal for construction of local branch-fences (zeribas).

3. Although "pruning" (or mutilating, depending on extent of the intervention) is traditionally frowned upon and against modern laws in most Sahelian countries, A. albida does provide high quality firewood. In addition, due to the relative high density of the wood, trunks and stems are often used to make tools or utensils including mortars, indispensable to local food preparation.

Respect and appreciation for this tree across the Sahel is well documented as part of the cultural heritage of the local people. This species, for instance, is used as the coat of arms of the century old city of Tombouctou. One of the Sultans of Zinder reportedly dealt harshly with anyone needlessly mutilating or cutting an A. albida in the old days; if caught cutting a branch the offender's hand was cut, if found cutting a tree the culprit's head was cut!

Across the Sahel, folklore, stories, proverbs and sayings describe these acacia trees as protectors and conservators of farm fields and soils. These are examples which leave no doubt that it's extraordinary value as an "agroforestry" species has long been recognized.

Many Sahelian foresters relate the presence of this tree to the activity of man. Some authors believe that this species, originally present only in Tanzania, was indeed spread into other parts of Africa by farmers, or - perhaps more precisely - by their domesticated livestock. As experience in modern nurseries has amply proven, the seeds are well protected by a hard coat and germination undoubtedly is greatly enhanced by their passage through animals before being deposited, sometimes miles away from where they grew. We cannot, however, agree with those who feel that animals are essential to its reproduction. Quite satisfactoy germination is achieved with special techniques in nurseries (13).

Except for some few specific project efforts, all of the A. albida growing today originated as natural regeneration. Careful observation reveals that in many fields a continued supply of young trees is produced each year. In other areas natural regeneration may be sparse or absent due to lack of nearby seed trees. Even where seed sources are present, however, young or middle-aged trees may be absent.

The main problem, and one of great concern to local farmers, is the present lack of regeneration. More livestock grazing in farm fields after harvest or more intensive and perhaps less careful clearing and weeding are the main causes for interrupting this natural sequence. Measures which could bring about a natural increase of young trees are clear:

1. Either protect recently germinated seeds against grazing, clearing (including fire) and indiscriminate weeding and cultivating; or

2. Plant young A. albida at specific locations and subsequently protect them, mainly against animals.[4]

Other than occasional fears expressed by farmers that these trees attract crop eating birds, efforts to re-introduce Acacia albida in farm fields have been welcomed without hesitation. High farmer acceptance rates of these type of projects are reported from Senegal to Chad.

Although the specie's site requirements are not too specific, the best results so far have been observed in loose, sandy soils in the 500 - 700 mm. rainfall range. Pilot A. albida plantations, however, have also been successful on heavy soils in seasonally flooded riverbottom land (Logone River South of Ndjamena) or on much drier sites in approximately 350 mm. (North of Filingue, Niger).

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[4] Experience in Niger and Chad has shown that A. albida need protection for 3 to 5 years.

Several locations exist across the Sahel where fully covered A. albida park landscapes provide almost unbroken shade of farming areas covering hundreds of hectares at each site. Bambey, Senegal; N'Dounga, Niger; or, Yagoua, Cameroun (just across the Mayo Kebi in Tchad) are examples. Here, local farmers claim that A. albida permits continued cropping as opposed to a long term shifting/fallow pattern necessary in areas lacking A. albida cover.

Karite (Shea nut tree) Butyrospermum parkii

Karite is second in importance to A. albida as a farm tree, particularly in Upper Volta, and Mali, and to a lesser extent in Chad, Senegal and Niger. The farm-park landscape surrounding the Upper Volta capital of Ouagadougou is typical. The pattern repeats itself elsewhere and may be seen as far away as South-central Chad. The common feature is the almost systematic distribution of large and well-formed trees found scattered throughout farm fields, seemingly unaffected by field boundaries, cropping patterns or different farm management practices.

Contrary to A. albida, these trees keep their heavy foliage during both rainy and dry seasons. Thus they affect crop yields adversely in the areas immediately underneath their crowns. Yet, like the A. albida, they are highly ap-

preciated by the local farmers (and their husbands). The main asset and product of these trees is the seed which furnishes a vegetable oil, traditionally used as general purpose cooking butter. This butter, as well as the fresh seeds, are traded in local markets on a year-round basis.

Reports from Upper Volta indicate that Karite seeds have been exported in commercial quantities during the last five to ten years to Europe and in more limited quantities to Japan.

Generations of experience with this highly valued (and priced) seed has led to a wide variety of processing techniques and uses of by-products. Even the residue left after extracting the oil is used as a high-grade cooking fuel.

Basic processing of oil to use as a multipurpose shortening involves the following steps:

- pounding or grinding the seeds;
- mixing with water and boiling;
- adding with water of various temperatures at differing points of the process (tepid, boiling, cool) as the oil is stirred; and, finally,
- whipping the oil as it becomes thick and turns into the consistency of a soft shortening or "butter".

Stands of Karite are normally associated with production of a multitude of sorghum varieties, millet, and some corn in Southern areas. Secondary or supplemental associated crops may be cowpeas (niebe), peanuts, Bambara groundnuts or vegetable/garden crops like tomatoes, peppers, oseille, okra or a form of indigenous eggplant.

Nere, Parkia bigolbosa (P. clappertoniana)

The large bean-shaped pods of this tree are fermented and made into a sauce ("soumbala") which provides protein, vitamin and mineral supplement to the traditional cereal based diet.

As with Karite, there are many different products or by-products derived from this tree including medicines made from its bark. It is the sum of these values that has made this a key agroforestry species across the Sahel.

Recent experience in Niger and Upper Volta has shown that propagation, outplanting and protecting in farmfields is straight forward. Its re-introduction is often actively solicited by local farmers. Where this tree has disappeared from the landscape, as reported in some areas in East-Niger, the loss is highly regretted by the local population (J. Thomson).

Tamarind

The juice of the fruit of this tree is fairly well known not only in Africa but also in Europe and the US. It is one ingredient of Hawaiian punch. Tamarind requires more specific site conditions than other trees mentioned so far. Though it is also found in the north of the Sahel, it is limited to deep sandy loams with favorable groundwater con-

ditions mainly along permanent water sources like rivers (Niger) or around lakes located in depressions without outlets (French: mares).

Apart from its pleasant tart taste, tamarind juice plays a critical role in the preparation of the local traditional staple foods. Due to the acid content, when the juice is added to the water in which the course millet flour is cooked it helps break down the starches rendering the mixture more digestable and at the same time keeping the product from souring as quickly or harboring bacteria.

Recent inquiries have shown that this is one of the farm tree species most often requested by local people when they are given a chance to help decide which trees should or could be introduced.

Borassus, Run palm (Borassus aethiopum) French: ronier

Roniers occur in widely separated areas of the Sahel from Senegal to Chad. They are, however, rather demanding and require sites characterized by fluctuating groundwater tables at the right depth. Dense stands of this species are found along all major rivers of the Sahel as well as along mares or in other areas where the right combination of soils and groundwater occur.

Farming activities are often closely associated with roniers even where these trees form dense stands. Studies over the years have indicated that regeneration is enhanced by cultivation around the young trees. Where roniers have been planted (by placing the cantaloupe-sized seeds directly into the ground), they do especially well when properly weeded and protected against free grazing livestock (3).

In one part of the Sahel, farmers say "ronier is millet", meaning that where roniers occur, there is food to eat. Various parts of the fruit are used during different stages of ripening. In addition, the sa and the young under-ground shoots which develop in the initial phase of germination are consumed as delicacies. The tree's large fronds provide material for fencing, partition walls, and roofing. Its trunk produces one of the area's best natural material for rafters which is used throughout the Sahel in traditional flat-roof adobe (Fr: banco) buildings.

During the sixty plus years of the tree's life cycle, farming and grazing activities follow the different growth stages of the tree:

1. From germination to approximately age five, intensive farming around young shoots is possible and even beneficial to the tree (protection, cultivating, elimination of fire hazards, etc.).

2. From age five to about age 25, crowns develop at or near ground level, and farming becomes handicapped or impossible unless the trees are spaced far apart. At this stage, however, controlled

grazing (with careful trimming, stocking with the correct type and number of animals, etc.) can be advantageous to the trees by reducing the grass cover and associated fire hazards. Although these trees are fairly fire-resistant, periodic fires around their trunks will weaken them prematurely.

3. After the age of 25 or 30, the trees are sufficiently tall and the trunks reasonably free from fronds, so that room is again available for farming. Although some light is retained by the crowns, crops seem to grow well, even under dense stands. According to farmers in Gaya (Niger) crops do even better near these trees than in associated open fields.

This tree can provide the local population considerable economic benefit as long as government rules and regulations do not shifts profits away from the people living in the area. Farming patterns and cultivating practices among ronier are astonishingly similar at the various sites throughout the Sahel although sites are often hundreds of miles apart.

Other traditional agroforestry species

Acacia senegal and its close relative, *Acacia laeta* are tree species associated with and actually limited to the low rainfall livestock raising and herding areas north of the cultivated or cereal belt.

They produce the valuable gum arabic, often the only cash income available to herder, transient or nomadic populations. In addition, together with a large number of other

tree and bush species, they produce a very important portion of browse during seasonal prolonged dry periods. Wood from these trees is medium quality firewood. Gum, browse and firewood together provide an important source of revenue in an area where other natural resources are scarce.

Baobab (Adansonia digitata) is another farm-tree species typical of West Africa. It is of substantial value to the local population and has been protected and "managed" in farm fields together with the crops. Some of its uses are:

1. Young leaves are picked (sometimes all the leaves on the entire tree) for use in soups or sauces. Dried leaves are used when fresh leaves are not available. Forest Service Reports from Maradi (Niger) indicate that a family recently sold the rights to pick the leaves of one grown tree to neighbors for FCFA 20,000 per year (approx. 80$).

2. The seeds are imbedded in a fibrous but sweet tissue high in Vitamin C. The dried fruit has the texture of hard marshmallows and is eaten or soaked in water to use as a drink.

3. Outer layers of the trunk are removed in strips and turned into good quality rope, an important item in an area where people and their animals seasonally depend on water drawn by hand from wells. This fibre also has special qualities making it valued for use on ritual masks.

4. The fruit, complete with seeds, can be used to produce a cough syrup and the pods are reported to be used in the production of a traditional glue used in leather-work.

Moringa oleifera, a relative newcomer, is valued for its tender leaflets used in sauces or as a salad. Although this

tree has been introduced into the general area (probably by the Arabs), it is widely grown in and around vegetable gardens in areas with as little as 250 mm rainfall (Department of Tahoua, Niger) where it can be irrigated together with winter vegetable crops. Even in the most remote traditional gardens it is grown from seed by local gardeners. Where women and men farmers are given a voice in what species of trees they would like to see grown in their village nurseries, Moringa is often one of the favorites (World Bank Forestry project, Niger).

AGRICULTURAL EFFORTS AND FARMING SYSTEMS

Agricultural extension in the Sahel has long focused on maximizing production of cash crops. There are some basic problems with this approach. Although agricultural programs have been designed for farmers to use on their own land, the farmers themselves have seldom been involved with the design. Some introduced programs are not adopted because farmers in this fragile environment focus on minimizing risk rather than maximizing production. In regions such as the peanut basin of Senegal where introduced programs were adopted, production has begun to decline as removal of trees for the purpose of increasing production space has led to soil impoverishment.

The new approach of first analyzing existing farming systems and the various family member roles within them has a possibility of overcoming many weaknesses in the agricultural programs. First, by looking at available land and other resources with the whole farming or herding family unit, the objectives, needs, advantages and constraints can be identified as a system, and better planning can be done. In practice, however, some of the farming systems projects have focused on cropping systems (ignoring the interaction with livestock). Plans may be developed by the technical experts themselves after short visits with only the men in farming families ignoring the fact that the women are often the most active farmers.

To offer Sahelians a useful and effective new planning tool will require several steps: 1) the inventory of resources will have to include trees; 2) local needs will have to include fuel, building materials, and other essential products traditionally provided by trees; 3) objectives will have to include long term sustainability; and, 4) all active family members (female and male) will have to be involved in the planning process. The fact that women make many of the resource decisions will have to be recognized and ways devised to encorporate them into decision-making roles within the evolving systems.

It follows from this that agroforestry (old or new) is directly tied to farming systems. Agroforestry (as opposed to pure forestry) requires interaction of trees with farming or livestock raising. In the Sahel farming systems is a useful technique for foresters; foresters are needed on farming system teams.

FORESTRY EFFORTS AND SOCIAL FORESTRY

Forestry efforts in the Sahel have generally focused on planting trees in reserves and protecting them from the local populations. In response to both increasing agricultural pressures for land and resources and the need of local populations for forestry products, foresters have developed a new approach to forestry. This is called by various names -- community forestry, forestry for local community development, rural forestry, farm forestry and social forestry. The common theme in this approach is the use of trees as a development tool to help improve living conditions for local residents. The involvement of residents in selecting, planning, carrying out and benefitting from tree related activities is a major thrust as is the integration of trees as a component of the total socio-economic and physical environments of participants.

All agroforestry is social forestry. Certainly all attempts to combine the use of trees with crops and livestock would focus on local benefits and as such fall into the category of social forestry. Not all social forestry is agroforestry, however. Industrial uses or processing of trees for the benefit of local populations, energy focused woodlots or other raising of tree plantations for local cash benefits are oriented toward trees and may not integrate agricultural production activities.

In a region where growing conditions for trees and crops are difficult and pressure on land able to support any vegetation is as great as it is in the Sahel, forestry activities can not be accorded the luxury of occupying large tracts of land. Local people are hard pressed to meet their daily needs from the few scarce natural resources that are available. Here, trees depend on people more directly than they do in many other areas and people depend very much on trees. The dramatic dependence of the local population on trees for their fuelwood is, to outsiders, the most obvious part of a complex net of tree-people relationship, but it is just one small part.

It is this dependence, and the experience and knowledge Sahelian people have for trees that have not been mobilized in most of the past government-donor forestry efforts. Yet

it is this base of understanding upon which "agroforestry," if placed in a framework of collaboration between farmers and technical experts, could develop into more satisfying land-use systems across the Sahel.

MODERN AGROFORESTRY TECHNIQUES

OVERVIEW

General donor response at the onset of drought relief activities was to counteract desertification with massive government-managed "industrial" type tree plantations, based on exotic species (either eucalyptus or neem). Large tracts of land were set aside for these activities, sometimes in existing forest reserves. However, farm or grazing land was often used for plantations regardless of its previous local use. Some preliminary sampling has revealed that the benefits foregone to the local residents from this land are of major magnitude (6). Even where residents suffered greatly by being prohibited from using this land, these losses were not considered significant by project organizers.

Plantations have proven to be much more costly than originally anticipated and have produced less wood than predicted. Some few large scale plantations worked out well from both sociological and economic viewpoints, but most of these relative successes are located in the better endowed southern areas of the Sahel (The Gambia, Southern Upper Volta, Southwest Mali). Most plantation projects offered few if any benefits accruing to the local population other than employment as labor, sometimes on what had been the farmer's

own farmland. After evaluating results, donor emphasis began to shift to village woodlots.

Many woodlots did not fare much better than larger scale plantations. Again, exotics were used, often species that required much more rainfall and/or soil moisture than was available at the site. Many were "government mini-plantations" without anymore input or consideration of the local people's choice of areas, species or organizational format than found in the larger schemes. Initial costs did not go down as predicted. In one instance, an analysis revealed that over $2400 per ha were spent to establish neems in enclosed areas belonging to chiefs of selected villages. Success was still the exception.

Social forestry became the focus when a number of organizations and donors identified "working with the people" as the essential basis for the few crucial forestry success stories. If trees can be grown by the people and for the people it did matter whether specific surfaces were planted. "Social forestry" developed a focus on offering local residents planting stock to fit perceived needs even where people requested shade or fruit trees for individual compounds or market places or trees for windbreaks or hedge rows. A landscape full of trees seemed much better than costly blocks of forest land that yielded little and caused anta-

gonism among local populations. The number of trees planted and/or protected became the key measure, not the hectares of forest surface established or identified in records as forest reserves. This new focus opened to branch out into agroforestry.

Initial steps were greatly assisted by local farmers (and herders) who valued trees as part of their living space. "Social forestry" possibilities discussed with local population of several Sahelian countries revealed that re-introducing Acacia albida in farm field or Acacia senegal on range land or establishing wind-breaks were ideas of particular interest.

Since the drought, donors have spent $160,000,000 throughout the Sahel in the forestry sector (Club du Sahel, 3). Although many of these activities have fallen far short of the original goals, there are some marked (and often overlooked) successes.

In Senegal, efforts to introduce Acacia albida started in the late thirties and have been continued on an off and on basis with comparatively little outside assistance.

Other farm-tree type activities were undertaken in the Sahel before the term agroforestry was coined. According to one Club country review, Borassus planting efforts in Mali required associated farming (by local farmers) for the first

three to five years in order for the growth to be successful.

Other small-scale examples exist throughout the Sahel which contain important lessons for the future. Unfortunately most of them are practically unknown except to a few older local agents. Hardly any case studies have been made or documented. Where they have been, the texts normally remain unpublished or can be found in appendixes of project papers, reviews, or other seldom read technical-administrative documents. Outside the working level network of technicians, little of this information is known.

Most of the more successful efforts have been small-scale and scattered in places difficult to reach. Some have been brushed aside by development planners as insignificant in scale. Some examples which deserve close attention in terms of lessons to be learned are as follows:

> A CARE Acadia albida project in Chad, in which trees were planted on 3000 hectares of farm field in 3 years. (Average survival rate: 50%).
>
> A windbreak project in Niger funded primarily by CARE (AID matching grants were also used during the last two years), in which a total of 250 km of windbreaks were planted in 8 years. Just under $1,000,000 were spent protecting a total of 250 hectares of prime millet land with measured increases over 15% in farm yields. (1).
>
> A winter vegetable gardening project in Niger, in which Lutheran World Relief introduced live-fencing (Prosopis and local species) in twelve different sites. In only 4 years the fencing is

doing well enough that the major input needed now is to show gardeners how to properly trim the plants.

A national village woodlot, program in The Gambia (funded by AID) consisting of planting and intercropping (taungya principle) has been successfully begun.

Agroforestry efforts in Northern Senegal which are funded by West Germany have introduced trees in conjunction with livestock raising and some farming over several hundred hectares. Plans are to apply the same approach to several other sites.

In summary, trends have continued along the following course:

1. Large scale, government (top-down) plantations of exotics for timber and firewood

2. Village woodlots (mostly still top-down) exotics with some few local species, all to produce more wood.

3. Early social or communal forestry with some forays into basic local participation using some local species for a variety of forest products including food and forage.

4. Later social or communal forestry providing local people with the resources to create a tree-rich landscape where agroforestry plays an important role together with shade and fruit trees, individual woodlots and protective measures, such as soil and water conservation (15). These activities select the best adapted and suitable species for a variety of production and conservation purposes and include help in processing and marketing.

Again, the most important difference in social or agroforestry focus is that it is no longer the forest surfaces which count (in terms of acres or hectares), rather, the ac-

cent is on the number of individual trees, regardless of where they grow. Since, in the Sahel, farm fields occupy more and more of the general terrain, trees in agricultural fields (together with trees in open rangeland) are the key element to future tree-covered landscapes. Former and current local efforts to retain farm-park management land units can provide valuable guidance.

Agroforestry can operate on a level easily managed by individual families without much outside help, to do two things at the same time:

Protect; (conserve; or, restore)	-AND-	Produce; (furnish; and, provide)

Seminar participants confirmed without reservation, that these benefits are only possible if the proper social, economic and administrative framework exists. Where this framework does not exist, it must be established before agroforestry can provide its potential benefits.

THE ROLE OF AGROFORESTRY IN THE SAHEL

The importance of agroforestry in the Sahel to the well-being of its 80% rural population becomes quite clear, if the following points are reviewed together:

1. Trees in farm fields and on rangeland are vital to the area's ecologic balance. The local people are well aware of this and have been for generations. A Sahel without trees is dead, regardless

of how well all other rural efforts (wells, irrigation, intensive crop or animal production, etc.) may succeed.

2. Shortage of wood (mainly for fuel) and other forest products is becoming more severe. Prices for firewood are climbing faster than other agricultural products; "bush foods" which play a key role in the population's nutritional chain are disappearing. To date efforts to reverse these trends by reforestation and plantations have failed to bring even minor relief.

3. Agroforestry is based on traditional knowledge. If it is properly encouraged, expanded and promoted can gain ready acceptance by the local people. With local support small scale interventions can produce significant results for residents in terms of increased wood and crop and/or animal production and at the same time add important conservation element of the area's natural resource base (soil, water, natural vegetation).

AGROFORESTRY TECHNIQUES IN THE SAHEL

During the course of the recent seminar on agroforestry in the Sahel, a number of interventions were discussed, experiences in different countries compared among participants and summarized in a short state of the art paper. Based on this information the different, specific interventions are outlined here.

The Sahelians, using their own definition, place a number of activities under the heading agroforestry that stricter definitions would exclude. For this reason activities such as shade plantation, restoration of depleted farm soils, or dune stabilization are included in this section.

The Swiss funded Village Woodlot Project in Upper Volta carried out an analysis of different existing agroforestry interventions. This analysis produced a classification procedure which was adopted for use by the seminar.[5] It is similar to the "diagnostic analysis" proposed by ICRAF.

This classification system contains the following elements:

1. Description of type indicating whether crop raising, livestock production, or both are involved:
   A. stands for "agro" (crop farming)
   P. stands for "pastoral" (livestock raising)
   S. stands for "sylvo" (pertaining to forestry)

2. A determination whether the effort's major accent is on Protection (Prot.) or Production (Prod.).

3. Whether the trees are spaced in a regular, systematic (geometric) pattern or are planted (or regeneration protected) in an irregular setting (R or I).

4. Whether the presence of trees is temporary (T) or permanent (P).

Eleven different forestry/agricultural mixes or patterns are recapped in Figure 2, which can be expanded for crops and livestock.

A certain amount of practical experience has been gathered during the past few years in connection with different type of interventions. Some of the basic, practical elements are described in Annex 3, "A Field Guide to Agrofores-

[5] The original presentation "Quelques Applications Possibles de l'Agroforesterie en Haute-Volta" by J.M. Samyn will be published in the seminar proceedings.

try Activities in the Sahel."

Type of Intervention	Traditional	Introduced	General Rainfall Range	Major Specie(s)	Secondary Species	Accent on P Production C Conservation R Restoration	Classification See Text
Revegetation of Range Land		X	100-500	Acacia senegal Prosopis juliflora	A. Raddiana Balanites Commiphora	R = Vegetation Cover	S.P. or A.S. Prot I T or P
Dune Stabilization		X	Under 500	Prosopis juliflora Euphorbia Balsamifera	A. raddiana A. scorpioides Balanites Eucalyptus	R: Sand Stabilization	A.S. Prot. I.P.
Trees in Vegetable Gardens	X		Anywhere	Dates Prosopis Moringa Fruit Trees	Numerous Depending on Site Conditions	C = Improve Micro-climate Organic Matter	A.S. Prot. I.P.
Acacia albida	X		300-800	Acacia albida	-	C = Micro-Climate Organic Matter Nitrogen	A.S.P. Prot. R. or I, P.
Wind-breaks		X	250-700	Neem Acacia scorpioides Eucalyptus	Prosopis Other Acacias Sclerocarya ziziphus, Etc.	C = Reduce Evapo-transpiration, wind velocities	A.S.P. Prot. R.P.
Live-Fences	X	X	Anywhere	Prosopis A. scorpioides Ziziphus mauritiaca	Parkinsonia Euphorbia Commiphora	C = Access Control	A.S. Prot. R.P.
Farm-Park Species	X		600-1100	Nere Karite Baobab Ronier	Tamarind Prosopis africana Daniela Isoberlinia	C and P: Microclimate Food Production	A.S.P. Prot. and Prod. R. or I. P.
Taungya on Public Land		X	400-1000	Nere Karite Baobab	Many others depending on sites	P. Crops and Trees together	A.S.P. Prod. R. or I. P.

Figure 2a Forestry component of agroforestry interventions.

Type of Intervention	Traditional	Introduced	General Rainfall Range	Major Specie(s)	Secondary Species	Accent on P Production C Conservation R Restoration	Classification See Text
Vegetation Strips		X	500-1200	Acacias Prosopis Leguminous Exotics	Combretacae Other Natural Vegetation	C = Erosion Control, Soil Improvement	A.S.P. Prot. and Prod. R, T or P
Shade Trees	X		100-800	Neem Prosopis Gmelina Acc. to Site		C = Shade P (some) Poles, Branches	Prot. and Prod. R or I P.
Reforestation of Depleted Farmland		X	350-900	Acacias Prosopis Leguminous Exotics	Desirable Local Species	R: Soil Restoration Vegetation Cover	A.S.P. R or I, T.

Figure 2b Forestry component of agroforestry interventions. (Continuation of Figure 2a)

SITUATION ANALYSIS

PRESENT DAY PROBLEMS

Much has been said, studied and reported about "desertification" or "deforestation." An extensive summary will soon be available through OTA in a report to Congress. In addition, a recent NAS publication on environmental change in the Sahel gives an excellent overview (10). However, these discussions and documents have caused little improvement in the condition of the local farmer or herder. Demographic pressures steadily increase and soil, water, and vegetation resources continue to be overused.

The single most important factor underlying all these unfortunate trends in the grain raising area of the Sahel is the decrease of fertility of traditional farm land. Sahel specialists believe all other factors including overgrazing, overcutting for firewood or excessive burning could eventually be reduced to tolerable levels if yields in existing, traditional farm areas could be brought back to and maintained at rates that existed twenty or thirty years ago.

Many of these leading specialists (Charraud, von Meydell, LeBeau, and numerous others) point to the direct linkage between farm yields and water retention capability of the soils, which, in turn, depend mainly on the organic content.

If organic content could be increased and maintained at higher levels, more water would be retained in the soil layers utilized by the roots of crop plants. Although better crop protection, more efficient farming practices, improved millet or sorghum varieties, etc., would help increase yields, it is the water retention capability of farm soils upon which success of any of these activities would rely. For range as well as for areas a second serious factor is the general low nitrogen forage production.

North of the cultivated areas, the problems causing declining range productivity are different but the problems are intermingled. One of the factors eroding overall natural forage production is over use exacerbated by expanding farm land area. In Niger, documents show a shift north of farming activities of over 50 km in 20 years as a result of the need for more farm land. Part of these increasing land demands reaching into the north are directly linked to the drop in yields from traditional farmland in the areas further south.

Other factors causing large scale deterioration of vegetation on rangeland include: overstocking in specific areas especially around large boreholes wells; massive tree dying as result of the last drought; extensive soil losses due to water- or wind erosion; and, a first-come-take-what-he-wants grazing patterns (Labo, PAF evaluation, USAID-FLUP, Niger).

A closer look at both range and farm areas reveals that some of the following major site-specific factors all affect the production capacity of the area's soils and natural vegetation:

- decreasing soil fertility,
- wind- and/or water erosion
- loss of (tree) vegetation cover, worsening of the micro-climate
- decrease in availability or quality of water, or
- other problems such as salt, dune encroachment, etc.

LESSONS LEARNED

General

A rich information base from local people combined with past project activities and experiences can provide important insights for making project design and programming more effective.

Agroforestry is only one of the options for using an areas' natural resources. It is an attempt to realistically combine present-day local needs for food, fuel, water, shelter, fibre, etc. with the existing natural production limits with the goal of preserving (and possibly enhancing) the available natural resource base for the future.

Agroforestry is more than simply another technique of resource management, development or increasing the agricultural production base of an area. It entails an entire philosophy combining purely technical and economic considerations with social, political and cultural values.

The average technician, regardless of his or her background in agronomy, soil, animal science or forestry, may be overwhelmed by the need to consider all these other factors together. Yet, it is precisely the global and empiric or holistic "feel" for this interrelatedness that forms the traditional base which local people use to make their resource management decisions.

Agroforesty may appear to be too complex, involving too many objectives and goals at the same time. However, in the Sahel there is no viable option. In more temperate zones, a given land surface can be divided into separate farm pasture and woodland areas where intensive single-purpose forestry (wood, biomass or protection) can be carried out without concern over competitive uses. However, the Sahel is located in the arid tropics where options are more limited. What works in the temperate areas will not necessarily work in the Sahel. Resource use, grazing patterns or traditional farming systems that have been successful in the Sahel have always been based on closely interweaving technical, economic, social and cultural considerations.

What is now called agroforestry, old or new, forces the development "industry" to use a new mix of moderation, humbleness, patience and of respect for both the environment and the local people. Before agroforestry is featured as another potential development break-through (like: cooperatives, community development, appropriate technology, women, improved stoves, etc.), it must be understood that agroforestry is not a simple technical solution. It requires a basic interest and commitment to people, to their culture and their environment which cannot be short-circuited by superimposing technologies or money.

Specific Points Discussed at the Seminar

1. The notion of closely integrating trees for production and conservation benefits into all aspects of agriculture (crop- as well as animal raising) in the Sahel not only works, but makes good sense economically, socially and ecologically.

Trees have always been an important and closely integrated part of Sahelian life. Farmers as well as herders are well aware of the use and value of trees, depend on them for many things beyond just fuel. Sahelian living standards, in part, depend very much on an ongoing presence of trees in compounds, villages, on crop land and in the open bush.

2. Incorporating trees into agricultural systems contribute greatly to lower risks. The ever-present danger of another year of below normal rainfall or another period of prolonged drought has taught farmers to protect themselves from downside risks. Trees provide an indispensable emergency reserve of food and forage.

3. An overriding reason why Sahelian farmers and herders do not actively assure the establishment or continuity of trees is that many (modern) government laws and regulations (and the manner of their enforcement) discourage or even forbid rational use and management of tree resources.

One major issue is the lack of guarantees of future benefits to those who make improvements. Ownership rights to trees or to continued use of improved parcels of land are often ambivalent. Individual and family initiative to undertake long-term improvements, in the form of tree planting, or soil conservation activities like contour farming, terracing or wind erosion control is limited by lack of confidence in being able to profit from these initiatives.

4. Agroforestry in the Sahel without local participation is impossible. However, most techniques of agroforestry require active changes in herding or farming family's use of their natural resources. Obviously these families must be involved in planning potential changes. In the past, where donors, often through PVOs or Volunteers, have tried to work directly with the local people, they have run across rigid host country government regimentation; accents continue to be placed on large-scale, "modern" agricultural development using heavy equipment, massive land clearing and relocation. It is obvious that local governments must also be part of the team before agroforestry can be successfully supported and expanded.

5. It is difficult and ineffective to promote agroforestry working with only one or a few farmers or herders here and there. The available natural resources of an area are limited; a new use and management concept must encompass a minimum unit of land and of people who use it. If one group of farmers plan gardens around mares without considering cattle routes to the water, if emphasis is placed on certain produce without considering transportation and marketing, if new techniques are introduced in part of a watershed to protect the land and if the areas above and below are not also protected, positive effects can be lost. It is most important to realize that agroforestry involves "rational" resource management schemes based on the concept of sustainability.

Governments need to commit themselves to the principles of sustained yields, not just for their forestry efforts, but for all farm- and rangeland. Exploitation plans for maximum short-term benefits, letting those who come later beware, are simpler and cheaper. Planning for long-term requires a commitment, a will and strength that is difficult for host countries to pursue while current priorities include raising revenue to keep the national governments operable and providing enough food and water to meet urgent, daily needs.

CRITERIA FOR FURTHER AGROFORESTRY ACTIVITIES IN THE SAHEL

A composite review of the long history of traditional agroforestry patterns, experience gained introducing new techniques, and a state of the art synthesis was carried out by the participants of the recent seminar. The following basic criteria for future agroforestry efforts in the Sahel emerge:

1. Success of agroforestry interventions begin with peoples' participation. Agroforestry projects without local participation will not work; funding them will be a waste of money.

As self-evident as this statement may be, experience has shown that in reality, project implementators (host country agents as well as expatriate technicians, administrators, and donors) often lose sight of original project concepts. Progress in developing local confidence may be slow, which may be compounded by late arrival of equipment, and long drawn out administrative paperwork. When project "targets" must be met, short-cuts are tempting. Local people may then be left out of the decision making processes with the results that they become disinterested or antagonized bystanders compelled to watch someone trying to do something they do not understand, that will not work or will cause more harm than good.

2. Agroforestry activities must be designed so that locally perceived economic, socio- cultural, technical and political-administrative as well as ecologic realities are in balance.

This requires indepth knowledge of the local situation, not just technical factors. The agroforestry activities, must make sense to the local people, as well as the project designers, planners and programmers.

Seminar participants came to the conclusion that landscapes "full of trees" are needed (and possible) in addition to scattered woodlots and government forest reserves. In contrast, they warned that "Sahelian farm and rangeland without trees is dead". In order to reverse the existing trend of trees disappearing throughout the region, agroforestry is the practical and most rational approach. It also answers most directly the CILSS' overall objective of increased food production while re-establishing the ecologic balance.

3. Benefits which ultimately accrue from investments made by local people must be guaranteed to them by the government. Planting trees without being sure to profit from them once they are grown is nonsense to the Sahelian farmers. Laws, decrees or revision of existing regulations must be made to guarantee benefits. The manner in which texts have been enforced, vis a vis the population also has to change. Until these changes are made, agroforestry efforts will be seriously jeopardized.

4. Agroforestry efforts should be part of a larger cooperatively designed resource management package. Protection and conservation of natural resources based on widely dispersed land surfaces controlled by a few cooperating individuals or families is highly ineffective. Some form of overall resource management or landuse plan should be developed on at least the scale of a village, a rural community, a valley or watershed. Other conservation and protection efforts, for instance soil and water conservation, should be integrated. An entire conservation plan could thus be conceived in simple, but compelling terms. A further step would be to combine overall development plan-

ning with resource conservation needs and balance the two.

CRITERIA SUMMARY

Further agroforestry projects therefore should:

1. be based entirely on local participation;

2. balance economic, socio-cultural, administrative-political and technical considerations and realities;

3. contain guarantees that future benefits will belong to those who invested in the change; and,

4. be part of an overall resource-use plan in which development and conservation are balanced and the areas' soil, water, vegetation, are managed on a sustainable basis.

PROPOSED AGROFORESTRY STRATEGY

STRATEGY FRAMEWORK

Certain agroforestry techniques practiced by farmers and herders in the Sahel are well established and time tested. Others have been introduced more recently, some with considerable success.

Past experience shows what type of agroforestry efforts could or should be undertaken. Eleven separate types of interventions are described in the annex of this report, each responding to different needs, each having its range and limits of application. Some can be combined with others or made part of larger conservation or management packages.

The question of what could be technically effective on which site can be answered with relative ease. Exactly how these efforts are to be carried out, and what conditions must first be met, is another matter.

Experience has shown that serious constraints exist over a wide area:

1. Agroforestry, inspite of the fact that it has been an integral part of rural Sahelian life for hundreds of years is difficult to administrate. Host country government executing institutions find agroforestry a complex concept which includes responsibilities of different technical services and ministries but belongs to none. No service is adequately prepared or duly authorized to carry out the needed integrated activities.

2. Agroforestry is based on locally productive, ecologically sound and conservation oriented activities. This focus runs at cross purposes to some general development strategies with accents on immediate production increases, using water and land more intensively.

3. Agroforestry can only be done by the local people themselves. It cannot be carried out by government project interventions or punitive enforcement of laws. Unfortunately forest service personnel are not prepared or rewarded for the new people-and service-oriented approach which is needed. Assisting the population to plant their own trees is a new, sometimes strange and threatening concept to many agents.

4. Constantly increasing pressure on the region's natural resource base has reached levels where traditional efforts and outlooks no longer suffice to keep trees in balance with agriculture and livestock production. More locally designed and implemented discipline and a deliberate move to more managed control of what used to be a common good are pre-requisites to successful agroforestry efforts.

5. Although a solid practical base exists which permits introduction of more trees into the landscape, the "technical package" needs further improvement. Testing new and more productive species, improving the existing ones, a better understanding of the relationship between trees and crops and better understanding of local management and farming systems would be extremely useful.

Agroforestry strategies must address an unusually broad range of issues and constraints. Common technical and economic considerations must be related to issues of overall planning, rural development policy making, administration and local social and cultural environments.

Thinking, discussing and option-development which took place at the Agroforestry seminar in Niamey is reflected in the proceedings (in preparation by SECID). The following are elaborations of points made by participants:

What is needed first is for governments to formulate and adopt across-the-board policies which favor agroforestry and contain the following elements:

1. Revise laws and regulations to better reflect, protect, and guarantee the interest of local people willing to make investments in long-range improvements on "their" land (trees, soil conservation, etc.).

2. Re-orient technical agencies (forest, agriculture and livestock services) to adopt a more interdisciplinary and management oriented planning and implementing approach.

3. Promote (plan, finance and seek outside assistance for) practical and result oriented research and experimentation, innovative pilot activities, strengthen infrastructure and inter-service collaboration, and develop appropriate formal and informal training.

4. Adopt and apply resource-use planning procedures designed to manage the available land "more rationally". Local participation in the decision making and formulation of these plans is of vital importance for local cooperation and also for socio-political reasons.

BASIC APPROACH

If such an approach is adopted, the strategy then would consist of initiating action simultaneously in three areas:

1. adopt new policy, laws and regulations

2. carry out a minimum of administrative (executive) restructuring (including training and recycling)

3. improve the technical package

Four additional points are important:

1. Absent from the above three points are issues and concerns in regard to the local population. The assumption, based on experience in the field, is that people would take more initiative if laws were changed in the right direction. Training activities would naturally include intermediaries from the villages as well as the technical services. If government services would provide such inputs as information helping residents make land-use decisions and plans as well as providing planting stock of higher quality and of both valued native varieties and some productive exotic trees, local participation would be much more probable.

This assumption can be challenged and deserves close scrutiny. Great differences exist from one area to the next, some ethnic groups may be more conservation minded than others, etc. Local people have, however, responded at locations throughout the region indicating that under the right set of circumstances residents will take the initiative.

2. Host country strategies relating to trees and other resources lend themselves unevenly to donor support: national policy changes, modification of laws and regulations and administrative restructuring can hardly be accelerated through massive outside financing.

Training needs, however, can sometimes be successfully supported through donor inputs, although it is not always easy to find adequate training centers and appropriate candidates.

3. The technical package will attract donors more than other available options. Experience in the field, however, strongly suggests considerable caution. Government technical agencies are severely limited in personnel. Even where local, qualified people are available, chances are that they are already extremely busy. Hiring more people is often limited by budget constraints and where project funds temporarily hire more personnel they cannot be retained after outside funds are depleted.

4. A wide-sweeping call for new government policies, changes of laws, administrative restructuring and an increase in research, educational and development efforts may seem too ambitious.

However, in most Sahelian countries, some of these changes are already under way. Forestry and, to some extent, more general land use laws, are already in the process of being revised and re-written. Several countries are reorganizing the way technical agents operate in the field and are stressing a more interdisciplinary approach. Training (or re-training) of agents has already begun to reflect social forestry including agroforestry concepts at different educational levels. Therefore, the above suggestion is less ambitious or revolutionary than it might first appear.

It is clear that a great deal of work lies ahead. New programs must be based upon new criteria: ideas previously held on what effective development is or should be must be abandoned.

THE NEXT STEPS

New agroforestry strategies will take considerable time to effectively influence what is happening in the field. Yet, governments and donors are not compelled to inactivity in the meantime.

Types of activities that are possible and which can or should be carried out now have been described. The question is, how could such work be implemented. Several basic options have been used in the past, each of which the seminarists examined: and cons:

1. Government intervention

The standard government project approach (with or without outside support) has been to conceive some project, then to inform local people what will take place, on who's land, who will do the work, etc.

This model is "expedient", for the first stages of a project, is the least complex to develop and can be implemented through a staff of field technicians. However, seminarists rejected this model for agroforestry. The top-down approach does not allow local people to become involved, and generally fails at the point where local people are expected to take over the maintenance and upkeep of the initial investment.

2. Community action based on modern power structures

In this model government services collaborate with the local leadership of rural communities (such as district development councils). Together they discuss and decide upon specific interventions. A great deal of discussing and participating in the original decision making can take place since it is essentially the local community body that will be the implementing party. Individuals,

family or other units to be included, future benefits and their distribution, labor and other required inputs, etc. can be discussed on a local level with both residents and representatives of the political structur

This approach has the advantage that government services are committed to make the project as successful as possible. Local people, provided they are actually reasonably well represented in the community or district councils, do have a say and have a chance to voice their ideas and objections or doubts and to share their knowledge and experience at the specific sites.

The success of this model appears to depend upon the effectiveness of local leadership. It depends in part on how well and in whose behalf residents feel local governmental bodies are functioning and how much support the national government gives to the decentralized approach.

3. Community action based on traditional power structures

This approach has the advantage of directly involving local traditional power structures in areas where these structures are well organized and capable of carrying out projects of considerable size. Through this approach, a total of several hundred hectares of land were improved by a water conservation scheme in Upper Volta (late sixties, early seventies). As is sometimes the case with modern community structures, the strength of traditional power structures is not always continuous: when an important village chief dies it may be months before new leadership is functional and the new leader(s) may have entirely different priorities.

The power base of traditional leadership may or may not represent the broad and sometimes conflicting interests of various groups in the community. Under this model government support may be less committed. At the onset community action without governmental support can be very effective. However, as success becomes greater, local projects may well require government assistance in the form of special seed stock, aerial photogra-

phy, soils maps, survey crews or marketing supports etc. The type of local organization to use at each locale depends upon attitudes of residents, of governmental agencies and of estimates of potential effectiveness of local leadership.

4. Working with individuals and families

Working directly with the people on an individual or family basis can be immensely satisfying for development agents but can also be extremely limiting in the magnitude of project activities. Selected efforts in vegetable gardening in the driest parts of the Sahel, erosion control projects in extremely remote locations, etc. have started this way and have resulted in remarkable successes. The nature of agroforestry, however, is such that the impact of individual farmers would be more effective if neighbors, as a group, would participate together. One family on their 2.5 hectares could never establish an effective windbreak system, and a few farmers in a village could not protect their freshly planted farm-trees if locally owned animals continue to roam freely.

THE CRITICAL QUESTION: WHO?

If some government organization is to provide the leadership in promoting intensified agroforestry activities, which one should it be?

By tradition, the forest services have the mandated responsibility to conserve and protect the country's natural resources. In reality, their allocation in funds and personnel is so small that they cannot begin to do their job well. This has placed them at a disadvantage vis a vis other technical, more production oriented services. An infusion of money, equipment and training can not quickly over-

come basic needs in personnel, in infrastructure and in reorientation.

Agroforestry efforts also could be spearheaded by the agriculture or livestock services. But the nature of the work to be carried out is such that the average field agent of any of these services simply does not have the technical background, experience and knowledge to provide the guidance and input for agroforestry.

Important contributions in the field of agroforestry have been made in some countries through para-statal or other associations. Such a para-statals can request transfers for agents from existing technical services. Although this does work on a short term basis, its success is at the cost of reducing technical capabilities of already overtaxed existing government services.

Unfortunately, in several countries forest services, which were formerly attached to the ministries of Rural Development together with agriculture and livestock, have recently been made part of other ministries. The magnitude of the communication problems has thus increased from inter-service to inter-ministerial levels. Working together as a team becomes very difficult. Everybody can readily articulate and agree upon what is needed: technicians from different disciplines must work more closely with each other and

with the local populations. The question remains, "how?" And - more important - who is going to do the organizational work that is necessary?

Forming "task forces" under one or the other of the technical agencies involved in rural development may be one solution. This idea is so new that when it was discussed among the seminar participants it encountered a mixture of vague approval and uncertainty.

Difficulty in communications and coordination is one reason why the seminar participants placed such emphasis on a need for policy changes. Once government officials have really decided to focus national efforts on agroforestry, ways to establish better ties between different government units would take place much more easily than is possible at present.

THE SPECIAL ROLE OF VOLUNTEERS AND PVOS

By their very nature, PVOs often become the research and development arm of the development world. They are often more flexible, less tied to mandates from the home office, and can begin (and end) project activities faster and with less official protocol than larger public assistance organizations. As such, they can respond more rapidly and more effectively to either new small scale emergency situations

or new opportunities. Individual volunteers have similar attributes and advantages.

It is, therefore, not surprising that most of the foreign assistance experience in the field now called "agroforestry" was initiated by volunteers and PVOs. US Peace Corps Volunteers in Upper Volta, for example, have worked with farmers planting Nere, Baobab and other local species since 1970, which was before many larger donor organizations had programs in the Sahel. Similarly, PVOs (US as well as Europeans) have long been active in small scale, communal tree planting and soil or water conservation efforts. Much of the experience gained was discussed during the seminar. Except for the World Bank sponsored "mini-nursuries," all site visits during the field trip were to projects which were assisted by Volunteers and/or PVOs.

Some larger donor organizations have made important contributions researching and developing new approaches as well. Bilaterial efforts have been made by West Germany, Canada and USAID in North Senegal, USAID's "model-sites" in Niger, the forestry education project in Upper Volta, and its forestry project in Mali. Some of these activities have incorporated Volunteers.

As the introductory papers of the seminar clearly show, PVOs and Volunteers have carried the weight of trying new

approaches, techniques, methods of establishing dialogues with farmers and herders and experimenting with different project administration models to meet the requirements of the host country governments.

It seems, therefore, that especially in the field of agroforestry, PVOs and volunteer organizations could play an increasingly valuable role in the future. Their effectiveness could be enhanced by involving them more closely when future general plans and strategies are discussed on country or international levels: (CILLS/ Club etc.).

MOST REASONABLE COURSE FOR DONORS AND RECIPIENTS

The three basic elements or prerequisites for a meaningful agroforestry "strategy" which were seen by the Sahelian and the outside advisors alike were:

1. New policies, laws and regulations,

2. Some administrative restructuring and institutional building, and

3. Technical improvements (including R and D efforts).

An ideal formula would appear to be for donors and recipients to form a small collaborative "agroforestry team" that would divide the task of working on these three priorities in a well coordinated manner.

While host country governments would take the required steps for required changes in the first item, donors, in concert with each other, and with PVOs and volunteer agencies, would develop an action plan designed to bring about the needed technical improvements (the third item). As the necessary administrative restructuring is being accomplished (clearly the responsibility and prerogative of the host countries), donors should assist in training and re-training including participatory action research methods, in order to pass the changes into the field as rapidly as possible (the second item).

Enough experience has been accumulated to know the extent to which planning and design efforts could and should be carried out on a regional basis using CILSS and the offices of the Club du Sahel. The topics and issues which could be addressed at this level have become evident.

Meanwhile, progress at the field project level not only should continue but should be expanded, basing activities on previous experience and on insights presented at the seminar. Interventions such as re-introducing A. albida, windbreaks, farm trees into fields, can now be accelerated on the basis of techniques presently in use, while experimentation with other less tested techniques should also be increased.

Certainly, the idea of placing accents on more trees in the landscape, instead of only concentrating them in standard forest plantations, can be supported. Agroforestry could become an important component, if not the guiding principle of many on-going, and all future development efforts in the entire agricultural sector.

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ANNEX III

TECHNICAL DETAILS ON AGROFORESTRY TECHNIQUES IN THE SAHEL

Observations and experience gathered in implementing the more common techniques in the Sahel are recapped in this annex. Objectives, range of application, notes on local participation and literature references are listed under each activity heading.

Revegetation and Controlled Use of Rangeland

Brief Description

Pastoralists holding traditional grazing rights in an area collaborate in selecting, protecting (fenced and/or guarded) and/or planting parcels varying in size between 50 and 500 ha. Major species used are Prosopis juliflora and Acacia senegal (gum tree); secondary species include Acacia raddiana, Balanites aeggyptiaca, Commiphora africana and others of particular interest to local people.

The clearing and weeding around the trees is combined with grass cutting operations, permitting the collection, harvesting and storing of dry grass-hay to be used by the local herders during the dry season where natural or introduced grass species are suitable for dry feed. Where soil

and/or cowpeas) are grown between the trees during the first few years.

Once trees have reached a certain size (normally three to five years), cropping is abandoned and a select number of animals are permitted to graze inside these perimeters. Tree and range conditions are carefully monitored to make sure that the trees and other vegetation are not exposed to too much grazing. In the case of Acacia senegal, as trees develop further, gum is systematically harvested using appropriate cutting and collection techniques.

Once trees have reached maturity (none of the on-going projects have reached this stage yet), under one option the shortlived gum trees are cut, producing valuable fire- and some utility wood. Under one option this cycle can be repeated. Under another, the areas, now stocked by an optimum number of trees and bushes, can be managed as small grazing or range units or be set aside as vegetation and range reserves for periods of severe drought.

Objectives

The primary purpose is to establish a permanent system to rationally utilize available (or re-introduced) natural vegetation where the major accent is on livestock raising. The ultimate objective, controlled grazing on a sustained

basis, the elusive goal of most range and livestock projects in the Sahel is pursued in such a way that the local herders are managing the range.

Secondary objectives are: income generation through well managed and organized gum collection, production of firewood, temporary dryland staple crop farming (where feasible) and fodder production (grass cutting and collecting).

Though originally high-risk in nature and totally dependent on adequate rains during the first few years, after trees are established this scheme has a good potential for lowering drought risks of local herders through range rehabilitation, soil and range conservation, general anti-desertification, and income enhancement.

Range of Application

This technique is applicable for the grass and tree steppe zones across the Sahel north of the usual limit of cultivation, in the range of 150 and 450 mm. mean annual precipitation.

Local Participation

The key difference between these schemes and other revegetation and range rehabilitation efforts is that the local residents are the key actors in project identification

design and implementation. Areas are set aside for these activities by specific families or family-groups who hold the locally recognized, traditional grazing rights. These rights must be recognized and supported also by modern government regulations.

Criteria for project success require not only that residents put a priority on potential benefits but that the benefits indeed go to participants. Among the participants must be those free to plant during planting season and those who are able to stay near the site to provide year round protection. If penning or stall feeding animals is suggested the added labor of carrying water and feed must be carefully weighed. Since benefits from labor or other inputs will not be realized for several years, some incentive or advance for future returns may be needed by very poor families. Land which is selected for revegetation must not be essential for current survival of participants and their animals. All current uses of this land for household needs must be identified. Alternatives for fodder, fuel, or other benefits which are foregone because of the project may be needed. If this land has been in general use and will now be restricted to the family or groups with "grazing rights," the needs and concerns of those with former informal use-rights will need to be identified and addressed. In one

project, in order to avoid potential conflicts over access and grazing rights among local residents of differing ethnic groups, separate areas were simultaneously established so each group could have its own activity.

However, limiting use of a formerly common good is often filled with unexpected difficulties. For example, in one area of the Ferlo region of Senegal, residents had agreed to limit the number of animals to the carrying capacity of the land. The activity had a serious set-back when drought hit Mauritania and Mali. Herders, many of them distant relatives of the Senegalese, came with their animals for life saving forage and water. The Senegalese residents found it socially and/or ethnically impossible to refuse.

Successful tree planting with herders may require considerable extension inputs. Although herders generally value trees, few have had the experience of planting them. Herders have often had conflicts with governmental agencies and may need a longer period to build up confidence in technical agents. A large number of healthy seedlings of desired species will need to be produced and delivered to the rangeland areas in a timely fashion.

An example of successful tree planting comes from Lagbar (Senegal). Although residents themselves identified the drought related loss of gum trees as a major problem, they

had to be taken to a nearby experiment station before they could believe it was possible to plant and grow these trees they had only seen growing wild. After the herders saw they could plant and raise these highly valued trees for their own profit, they were eager to participate. Herder labor is readily available during the planting season (which is not always the case with farmers). Healthy planting stock was delivered in a timely fashion. The successful Lagbar project coordinator knew he could not inform the scattered herders when they should come to plant. Working with the herder families he arranged to plant on the day after the first rain. The scattered herders arrived at the appointed time and place as did the forester. In this case herder families were fed from the World Food Program on the day they planted trees but no other food or money incentives were used.

Reference Material

See Reports from the German Range Improvement Project, North-Ferlo, Senegal and the more recent Swiss "Land Management Near Wells" project in the Tchin Tabaraden district of Niger.

Also see the NAS Agroforestry report. Technical aspects of tree planting, seeding, and different ranges of conserva-

tion measures are covered in the "Soil Conservation Technical Sheets", University of Idaho (15).

Dune Stabilization

Brief Description

Successful dune stabilization efforts have been carried out in Senegal, Mauritania and Niger. Different techniques are used and less expensive ones are being developed continuously. Although stabilizing dunes might not, in itself, be considered agroforestry, Sahelian administrators and technicians point to a number of cases where moving dunes are encroaching upon valuable farm land. There is no use to invest in the development of an oasis or vegetable gardens if live dunes threaten to cover them in a few years. The agroforestry theme car, under such circumstances be evoked by simply including the threatening dunes in the general perimeter of the system in which residents live. The somewhat theoretical question, then, becomes whether the areas to be protected are agricultural in character or not. The pragmatic view of the Sahelians is that dunes should be stabilized wherever they threaten valuable pieces of land and are satisfied when funds earmarked for agroforestry activities can help.

Objectives

Stopping the movement of sand may be both complicated and expensive. In the 500 to 300 mm rainfall range, many dunes are relatively small, were previously stable, and until recent overuse were covered by natural vegetation. This type of dune can be re-vegetated in a matter of a few short years (e.g., CARE project in Yeglalane, Niger). Greater investments will be required for larger areas which have had no ground cover for an extended period, as is the case along the coast of Senegal. In areas of less rainfall, as in many locations of Mauritania where dunes threaten towns, villages and oases, halting or reducing the flow of sand is an immense undertaking.

Range of Application

Although efforts could be effective in most sand accumulations in the 100 to 500 mm range, donors will be interested only when some valued land or installation is threatened. Even when this is the case, financing for such projects is difficult to obtain. One constraint in the past has been the relatively high costs of these efforts. Up to around $2,000/ha have been spent by PVOs in different parts of the Sahel to fence, erect palisades, plant trees and protect the area. Recent developments in the Lutheran World Service

project in Nouakchott promises to offer a technique which will reduce these costs within the $500/ha range. There, areas of moving sand are stabilized by dense planting (1.5 in. x 1.5 in.) of Euphorbia cuttings with the areas protected from animals. Within these surfaces, natural vegetation, including trees and shrubs appear (unassisted) within the first two to three years.

Local Participation

As discussed in detail in the Soil Conservation Technical Sheets (15), local participation is essential in dune stabilization. Particiation is much more likely at sites involving a relatively small number of people with similar social and economic interests. Around towns and large villages it has proven to be difficult to develop the necessary unified community cooperative spirit. Contrary to the majority of other activities listed here, the purpose of tree planting is not to add value to the area planted, but to protect land at some distance. The dune area itself is usually of little value; residents and passing herders lose little when the dune is placed off limits. However, sometimes millet stalks or other materials required for the palisades have other valued traditional uses.

Dune stabilization is a project over which there has been much disagreement on incentives. In one area along the maritime dunes of Senegal, project officials found residents polite but disinterested in investing time in protecting interdunal areas in which they planted gardens. Yet, in another section of the project, residents eagerly planted trees. The difference was that, contrary to the first case, in the second there were easily accessible produce markets.

A problem for donors has been that in certain dune stabalization projects, residents have been paid cash for their millet stalks and/or were given food or cash for their participation. In neighboring areas residents have, then, refused to participate without similar compensation. Expense has discouraged several smaller PVOs from attempting to help communities stabilize dunes.

Dune stabilization frequently requires a great deal of labor, although much of the work can be done before the active farming season. Advanced planning is required if millet stalks are to be saved from the previous harvest season, as is active community support to protect the newly planted areas. Adequate supplies of carefully selected planting materials must be in excellent shape and delivered in a timely manner if they are to take hold in the adverse conditions generally present in these projects.

Reference Material

In addition to LWR and CARE project files and the standard texts on reforestation (13) and soil conservation in arid zones (15) and (6), detailed studies of past and on-going projects are extremely important.

Trees in Vegetable Gardens

Brief Description

Throughout the Sahel many small vegetable garden projects have assisted people in producing a wider variety of vegetables, often in places where gardening was not previously known or the area lacked adequate supplies of water. Trees can play an important part in these efforts in a variety of ways:

> Conservation aspects: Improvement of micro-climate by providing shade; reducing wind; leaf litter adding organic matter; and roots pumping nutrients.
>
> Production aspects: valuable food or fruit adding to the variety of items produced by such trees as date palm, Moringa oleifera, and Ziziphus mauritiaca.

In regard to tree food or fruit production, agroforestry efforts of this kind sometimes include both forestry and fruit tree raising (e.g. citrus, papayas, guavas) which have been part of horticultural efforts. Fruit producing species of local origin have generally not been raised in fruit tree

nurseries, although they may be as valued by the local people and may be better adapted. Ziziphus, known all over West Africa as well as in the mediterranean region, Annona senegalensis (a close relative to soursop) or Sclerocarya birrea are examples.

Objective

The objectives of this technique is to provide additional diversity of valuable gardening produce while inserting conservation and protection elements to the basic gardening operation (shade, organic matter, protection from wind, etc.)

This activity naturally blends into the one described below, "Live-fencing". As long as gardeners learn how to raise seedlings for either livefencing or food trees, they can learn to produce their own planting stock of fruit trees such as papayas. Quality citrus and mango fruit require more complicated grafting techniques and depends on availability of good grafting stock.

Range of Application

Trees can be added to any vegetable gardening effort between 100 and 800 mm of rainfall, but they are especially important in the drier areas where properly managed trees can also produce needed poles, branches for construction or some firewood.

Local Participation

Even in the most remote locations one finds trees in vegetable gardens. Moringa, for instance has been observed in small vegetable patches far from the path of any government or donor sponsored extension efforts. Obviously, many gardeners already know how to raise various trees from seed and to properly care for them in a nursery setting.

This activity only interests gardeners who have confidence in continued use of the same plot of land. Throughout the Sahel family gardens are the domain of women who may be insecure in their land-use rights. Commercial gardens more often belong to men. The identity of the gardeners must be established if special help in tenure rights or in availability of inputs are to be made to the right parties.

"Trees in vegetable gardens," is an activity for which considerable interest and demand already exists, and one which requires no major community organization, communal land, or change in labor patterns. Mini-nursuries can be established where there is communal or individual interest. Maintenance and protection requirements will usually not increase much by the addition of trees where gardens are fenced. Water is usually already available in garden cites. Providing some seed, a few basic tools, plastic pots, sprinkling cans and some advice on appropriate techniques can

have immediate results. Most of the projects of this type have included no outside incentives and in fact when desired trees are made available it has often been difficult for local nursery facilities to keep up with the demand.

Reference Material

Combination of tropical fruit tree manuals and project reports primarily of PVOs: Africare (Upper Volta), Save the Children (Upper Volta), CARE and Lutheran World Relief (Niger), Catholic Relief Services (Senegal), etc.

Acacia Albida

Brief Description

Much has been written in the last few years about the value and usefulness of A. albida in farm fields. Although scientific understanding of the complex relationships between the effects of this tree and the crops grown under and around it is by no means complete, local farmers generally welcome any assistance offered in introducing or re-introducing this tree in their fields.

Two distinctly different situations exist:

1. Areas where natural regeneration is destroyed either by grazing, cultivating, weeding or fires, seedlings do not have to be planted; accents can be placed on protecting natural regeneration by eliminating the causes that now kill the young trees.

2. Areas where not enough natural regeneration exists, farmers need to systematically plant A. albida and protect seedlings for three to five years against animals, fires and careless cultivation.

A series of publications and manuals on the various techniques is available.

Range of Application

Acacia albida is especially indicated on sandy "millet soils" extending from the Northern limit of cultivation to approx 750 mm rainfall. A. albida do grow in areas of higher rainfall where other farm-tree species (see below) may be more desirable or lucrative.

Local Participation

Different formulae have been tried involving inputs from local farmers. Land-use rights must be clear and assured before farmers will plant trees. In certain areas planting trees may indicate a permanent claim to land which owners or the Government may prohibit if the land is being farmed by tenants.

Generally it is relatively easy to get local people to plant A. albida in their own fields on a voluntary, non-paid basis. The problems occur afterwards when year-round protection efforts become necessary. The current agroforestry

strategy includes turning the harvested fields over to herders whose animals graze and fertalize the fields. There are often complicated traditional reciprocal relations with herding groups. Area-wide fencing causes farmers to lose the benefits of fertilization from animals grazing in the harvested fields. Fields must then be fertilized by carrying in manure or else the farmer may experience a drop in production. Farmers who remain at the farm site during the dry season to help protect the fields, may lose off-season employment elsewhere. Cattle owners, of course, lose a valued source of forage during the initial years of the project but stand to gain after mature trees produce edible pods.

Experience involving different approaches to assure maintenance of trees is mounting. One approach consists of simply paying farmers a bonus each of the first few years for trees that survived in reasonably good shape. In this case, the farmers themselves decide how to protect their own trees. In other instances large areas (of 100 ha or more) have been fenced and guarded by local villagers for three or more years. In yet other projects, each tree is protected with thorny branches, occasionally renewed by farmers. Another arrangement is for residents to hire people to watch the local animals and warn passing herders. This requires not only local but governmental support and legal backing.

Regardless of which approach has been chosen, none of the current projects claim total local non-paid involvement. This activity is an individual or family effort requiring no major social organization. Although the idea of re-introducing A. albida may be enthusiastically supported by the population, some outside "encouragement", either in some form of PL 480 commodities or outright payment especially for protection, has to-date been part of all successful donor programs. In a field site visited during the seminar, residents enthusiastically reported increased production due to the A albida tree project. However, the village chief told seminarists that even though results of the project are widely appreciated, because people were paid to plant and protect the first trees there would be no local interest in planting new areas if residents were only offered trees with no cash or food incentives. Incentives for this type of project need to be further investigated.

Reference Material

A number of excellent papers, publications and reports exist on the subject. The most important ones are cited in the bibliography others are referenced in the bibliographies of the cited text. The Wentling paper (16) contains references to many good sources.

Windbreaks

Brief Description

One of the problems farmers in the Sahel are facing is the adverse effects of winds on their land. As trees inside the farm fields and in the surrounding areas disappear, wind action becomes more severe. Inevitably valuable top soil is carried away, soil moisture evaporates faster and the lower moisture level, combined with other drying effects of the winds, further impair biologic activity in the soil. The net result is decreasing yields.

The concept of tree windbreaks is new to the average Sahelian farmer, although some small pilot efforts were begun over twenty years ago. Attempts in several countries have had mixed results. Substantial gains, however have been made in the Sine- Saloum area of Senegal and in the Maggia Valley of Niger. In the last location, 250 kms of double row windbreaks (mainly Neem and later Acacia scorpioides) have been established in seven years.

The technique is simple. Trees raised in a near-by nursery are outplanted in long straight lines oriented according to standard procedures. As in the case of many other tree plantations efforts, the biggest problem is their protection until the trunks are strong enough and crowns are out of reach from grazing animals. This has been accom-

plished in Niger by employing watchmen who also acted as local extension agents. In this case almost all animal owners were local farmers and watchmen were employed to explain the nature of the project to them and ask for their cooperation. The results have been quite satisfactory.

Technical information is available through different sources. (1) and (7) are two examples.

Range of Application

Windbreaks can be effective in several ecologic zones of the Sahel and are generally of most value in the 250 to 700 mm rainfall range. Although their main application pertains to dry land farm fields, windbreaks can be very beneficial in particular locations in open brush or around points of heavy animal concentration like large boreholes. This technique is also of value in connection with large scale irrigation schemes where existing tree cover had to be removed to permit the installation of ditches and canals and to level the land.

Local Participation

Although many farm communities, especially those near successful ongoing projects, have requested help in establishing windbreaks, this technique is not without important

social issues. One problem is to obtain the consent of those who hold surface use-rights to land which will be planted with trees when the systematic installation of the necessary long, straight tree rows must cross their field. Since most farmers farm several small and often irregular pieces of land, some will lose a large portion of certain fields or will have tree rows cross land dividing it into segments; others will lose no land. Costs are therefore unevenly distributed.

A second major problem is that in many instances ownership of the trees in windbreaks has not been clearly defined; who has use of dead branches or other economic benefits? In the case of A. scorpioides the pods have considerable value as natural tanning material but it may be unclear who has harvesting rights. If trees can occasionally be trimmed or pruned or when they are replaced by younger ones, who gets the wood or valuable construction poles?

Windbreak activity requires community organization over an entire area for successful installations, to plan for equitable distribution of costs and benefits, and to assure maintenance. It requires considerable local labor during planting season. It requires a strong institutional input with farmers getting information on this new technique and options for tree specie selection. It also demands a large quantity of planting stock.

Reference Material

A number of reports, manuals, etc. provide basic information. CARE, Inc. has a series of i ternal reports that provide some interesting cost and other economic data. In addition, a research study has analyzed the benefits of the CARE project. As mentioned before, this study demonstrates that protected farm fields yield over 15% higher than similar fields without windbreaks (1).

Live-Fences

Several indigenous and some exotic tree species can be trimmed and planted into hedges dense enough to discourage animals from passing.

Farmers in the Sahel, in face of everpresent domestic animals, need reliable and lasting fences around vegetable gardens, cassava fields, fruit tree sites (orchards) and compounds. Live-fencing of Euphorbia balsamifera have in the past been used to line stock-driveways in and out of villages and to protect cemeteries.

Options other than plants for fencing material are quite limited. Imported wire or wiremesh fabric is extremely expensive. A traditional practice in certain regions is to cut branches from thorny trees and assemble them in a continuous row around the area to be protected. This process is

time consuming, has to be repeated annually and requires an adequate supply of thorn tree branches. The demand for thorn branches in some locations is so high that the natural vegetation comes under severe stress. Other alternatives such as millet stalks, palm fronds or - more recently - junk metal and wire, all require a considerable labor investment and the use of material resources that could be well used for other purposes.

Live fences need protection for the first several years. Numerous species are suitable including Prosopis juliflora, A. scorpioides, ziziphus, and Parkinsonia acculeata. They can be planted in one or two rows at a tight spacing (50 cm to 1 m) and after one or two seasons trimmed with the cutoff branches used to plug the holes between stems. Other trees can be interplanted to make a combination hedge-windbreak (see "Trees in Vegetable Gardens"). In addition to performing it's protective role, hedges can produce some food, fruit, a few sticks of firewood or occasional poles.

Objectives

Live fences provide a barrier against free grazing, camels, horses, donkeys, cattle, sheep and/or goats. In addition, these fences also protect areas from unwelcome human trespassers. Secondary objectives may be selected to ad-

dress other local needs including windbreak functions, shade, food or fruit production, forage, occasional firewood, and branches for construction.

Range of Application

Living fences are useful for any specific areas which require protection. Different species are available for different ecozones and in many areas traditional knowledge of this technique exists. Current projects include raising certain species in plastic pots in small nurseries often by the gardeners themselves, and giving instruction on properly planting and maintaining the trees.

Local Participation

Women and men farmers, especially those working in vegetable gardens, already have a good feel for raising and planting trees. What is locally less well known and understood is how tree-rows can and should be trimmed to produce a tight, well functioning live-fence. Too often the plants are allowed to grow up into trees defeating the original purpose. The extension agents must understand and be able to help farmers master this technique. Adding trees around fields or gardens requires clear long term land-use assurances for those who plant. The major constraint in many areas is water during the nursery period.

Since live fencing is essentially an individual or family activity, communal organization and strong local leadership are not essential. Hedge rows can be a socially stressful activity, however, in any area where the exact borders of gardens are in dispute. Often fencing is introduced as part of an activity to improve gardens or introduce commercial gardening. If this is the case, it is important to be careful that the project is not designed in a way that the former gardeners are not displaced (women or tenants) for more advantaged groups.

Many project designs include "lending" the gardener wire fence inside which she (or he) is to plant the hedge. The idea is to remove the fence for other gardens when the hedge is of sufficient height. Designed in this manner, projects seem invariably to fail to motivate people to plant the needed trees and the imported fences remain in place. One successful CARE project in Niger, which involved helping residents build permanent wells for gardens, made the planting of the live fence a prerequisite for other inputs.

It is imperative that government agents, especially forest service personnel, understand the nature of these activities and advise and encourage local residents in their efforts. It some cases it has been necessary for forestry agents to make an exception in enforcing laws which forbid

the trimming or mutilating of trees of certain species. Only this flexibility will allow participants to properly trim and reinforce their hedges. Where agents had not been flexible, gardeners unable to trim and reinforce the planted rows reported that the hedges were failing to adequately protect gardens and that they feared they would have to abandon gardening in the near future.

Reference Material

Standard manual texts give a basic overview. Project records (reports, evaluations, etc.) from LWR, CARE, as well as US Peace Corps are useful.

Farm-Park Species

Brief Description

As already described under "Traditional Sahelian Agroforestry Systems," a number of indigenous tree species form the savannah park landscape across the Sahel where rainfall exceeds 400 to 500 mm. Species of prime importance are: Nere; Karite; Borassus; Baobab; and, Tamarind, although many others are also considered valuable by residents.

In many areas these savannah parks are slowly disappearing, mainly for lack of regrowth. The young trees succumb to increasing pressures from grazing animals, indiscriminant

cultivation, especially where mechanization or fires are used to clear fields.

As with Acacia albida, trees need protection to survive the crucial first five years until they have reached a certain height (and trunk strength) for their crowns to be out of reach of animals. Requirements of this technique are generally dependant on local needs and resources and are essentially the same as described under A. albida. Natural reproduction, where it exists, must be more systematically and effectively protected. Where it is lacking, farm trees must be introduced, or re-introduced. Here reliance should remain on local species, although some experimentation with new species should be tried in association with the traditional trees.

Where indigenous species are planted, genetic improvements should be introduced. While costly time consuming research is taking place, immediate improvement in the quality of seeds presently used could be made by more careful selection, correct extraction, and better storage. Creating seed banks to allow exchange of seeds and some preliminary provenance trials could yield immediate improvement in forestry projects.

Range of Application

Figure 1 serves as a general guideline, although rainfall is not the sole criteria. Two sources of information exist which may well provide better clues than an incomplete list of site requirements!

1. Different site conditions produce different vegetation "images". This can serve as indicators. See (10) for dominant species associated with the respective farm-trees.

2. Farmers living in the area not only have a good knowledge of which trees grow well on which sites (even micro-sites), but they can also provide valuable information of what other species of trees were present 30 to 60 years ago. This is another indicator of what could be tried, on a small experimental but not yet demonstration scale.

Local Participation

Local farmers must be given options and information to answer their questions determining species mix, spacing, method of protection and other pertinent in- and outputs. Their own expertise must be respected.

Mini village-level nurseries, such as ones introduced by the World Bank's forestry project in Niger, not only reduce transportation costs of seedlings but encourage widespread interest and participation. Planting and caring for the trees is the affair of individual farmers or their families. Peace Corps efforts in Upper Volta's Yatenga area, successfully offered support for farm park planting to groups of

families or to entire small villages. Species used were mainly Nere, Baobab, and some shade trees. Re-introduction of farm-trees can easily be coupled with soil conservation activities such as bench-terraces and windbreaks. The major difference in the socio-economics of these trees and those of the Acacia albida is that these trees shade crops and therefore may reduce production from crops planted around them. Additional information on local participation is found in the Soil Conservation Technical Sheets (15).

Reference Material

As with many other dispersed, individual agroforestry activities, field manual type information is scattered and most of it is found in unpublished reports, letters, project notes and other working documents. Several NAS publications (8) and (9) as well as Reforestation in Arid Lands (13), and a recent paper prepared by Associates in Rural Development (17) contain valuable information.

Village Woodlots

According to the discussions held during the seminar, Sahelians feel village woodlot efforts should be included in the list of AF techniques. This inclusion is supported by a Swiss Village Woodlot project in Upper Volta which, after an

initial period of two years, continued to use its infrastructure to initiate and support other communal activities such as planting farm-trees in farmers' fields.

Technical, management and administrative information on these woodlots, however, has been covered in numerous write-ups, reports, including (13), (15), and (5).

Many different legal-administrative arrangements exist for woodlots in the Sahel by design, by default, or by government fiat. The following categories should be separated from each other, because distribution of benefits is different in each case:

1. Individuals each own certain trees in the woodlots, in accordance with who planted them.

2. Individuals own percentages, or shares of the total, depending on how much work each individual or family had put into the planting effort.

3. 'Rural communities', organized according to national administrative laws "own" the trees; the proceeds in this case usually go to the officially established rural community treasury.

4. Land under the de facto jurisdiction of the local village chief is used; although self-help (free) labor may be provided by villagers, often the chief, or his successors will get the benefits. Sometimes a portion of the wood is given to families in the village, either in relationship to the original labor inputs or else by need.

5. Mini-plantations, executed by government services (possibly with outside funding support) may use "free" local labor organized by government agents, but proceeds are unlikely to go to those who participated in the work.

Under the circumstances it is understandable that local interest in these efforts varies from one site to the next. Unfortunately many social village woodlots were created, for expediency, without properly selecting the sites, the species and certainly without clearly spelling out who is to get what benefits, who controls and manages the stands and who owns this newly created resource. Not surprisingly, villagers show little interest or motivation to carry out the necessary protection and maintenance work (for free), if the wood is not guaranteed to be theirs.

Taungya on Public Land

Brief Description

The idea of raising trees together with agricultural crops on the same parcel of land has been practiced for many years in the tropics. In the Sahel, as elsewhere in Africa, foresters have long recognized the advantage of protecting and maintaining forest areas by allowing farmers to plant certain crops in the spaces between the freshly planted seedlings. The disadvantage of competition for water from crops in most cases has been outweighed by the elimination of competition from weeds and the otherwise expensive weeding and protection required.

Under this arrangement, crop raising is no longer possible after two to six years, depending on species and planting densities.

Experimental efforts have been underway in Senegal, Mali, Niger, among other countries to carry the concept one step further. If, for instance, part of a forest reserve or other public land unit is to be rehabilitated by reforestation, a more permanent relationship between farmer and forestry interest might result. If multipurpose species of interest to local farmers are selected and if spacing is such that farmers can farm around the trees for a number of years and then obtain valued secondary or tertiary products, farmer interest in tree planting and maintenance could be increased. After trees are eventually harvested farmers could again return to the same area with their crops.

Various arrangements with farmers, various species and different spacing are presently being tried on an experimental basis at different locations. One example are the "model site" efforts of the USAID funded FLUP project (Forest and Land Use Planning) in Niger. The accent is presently on farmers' choice of: Tamarind, Baobab, Nere and a wood-species little known outside its growing area: Prosopis africana. Although a completely satisfactory model for tree spacing, for assurances of benefits to participants or a method

of protection of the seedlings has not been developed, encouraging progress has been made in the last few years.

Objective

To establish a permanent rotation cycle which enables the growing of locally valued trees together with crops and/or controlled grazing to produce forest and agricultural products on a sustained basis.

Range of Application

The basic idea is applicable anywhere in the Sahel with rainfall above 400 mm and is particularly well suited where either government or communal forest areas need more intensive management.

Local Participation

Many national forest reserves that exist today were created by government mandate 30 to 50 years ago during the colonial period. Often, these reserves were established on land that "belonged" to farmers living in near-by villages. Local farmers, even econd and third generation afterwards still feel that these lands are rightfully theirs. Although forests are needed from a national perspective, many farmers' primary interest is to get their family land back so

they can farm it once again. Foresters view the same land as their mandated agency's responsibility to protect. Antagonistic feelings often reign high.

Foresters may be able to work with farmers, offering residents a chance to cultivate in forest areas (viz. their land) on some form of a rotational basis. If, subsequently, residents profit from tree products, that is, leaves, fruit, forage and some wood, feelings might improve and high protection costs be reduced. However, spacing of trees will have to be far enough apart so the farmers may continue farming until some other form of benefit becomes available.

Tanngya systems have ranged from ways to coerce local free labor and thereby reduce costs of government plantations to those formulae which give land-poor or landless persons a chance to have temporary or more permanent access to land or its produce. The real challenge is to design the activity so that protection of the trees means positive benefits for both the forestry agencies and local residents. If farmers see their access to limited land resources as ending when the trees grow, it is not surprising that unless there are other benefits animals "manage" to eat the young shoots or the trees are sabotaged more openly.

As in any activity which mixes crops and trees, the protection of trees after the crops are harvested may cause

loss of valued fertilizer, loss of animal fodder and added labor. Technical packages will be needed for broad spacing, for crops which do well in shade, or for associated economic benefits to farmers who invest added effort to see the trees survive.

Reference Material

Several of the CLUB/CILSS "bilan programmes" contain references on such efforts (3). Several research reports, notably from IITA, Nigeria contain useful information on trials. An initial economic model of such activities has been developed by K. Christophersen for USFS and AID (2).

Vegetation Strips

Brief Description

Originally proposed as a soil and water conservation measure (15), vegetation strips, installed along contour lines can reduce sheet erosion, help trap eroding top soil and protect lower fields from surface runoff. An additional benefit is the contribution of organic matter to farm soils between such strips. As a further step, these strips could gradually be moved, that is: while one strip is eliminated after several years of producing wood and other forest products, a second strip could be installed parallel to the

first. The result would be a gradual reconditioning of the soils over an entire slope or field as the process is systematically continued.

Independent from this concept is research and field trials of planting strips of rapid growth species of woody plants conducted by IITA (Nigeria) as well as similar research in Sierra Leone. Results of this "alley cropping method" indicate that strips of specific tree species (of the legume family), if properly trimmed and branches placed as green fertilizer onto adjacent crop strips, have a significant soil restoration and crop improvement effect.

Either approach, or a combination of soil improvement by leguminous or similar species placed along contour lines of slopes, seems promising. In addition, strips placed at right angles to prevailing winds could offer a combination windbreak/soil conditioner.

Prime candidates for such experiments are local species mixed with certain exotics such as: Sesbania grandifolia, gliricida, calliandra, desmodium, tephrosia, several species of albizzia and acacia to mention just a few. NAS publications include species trials of a much wider variety, some of which already have been planted at locations in the Sahel.

While these are new, interesting and perhaps valuable ideas for the future, it must be pointed out that "vegetation strips" experiments as mentioned here, have not yet been reported anywhere in the Sahel. Since the idea has already proven valuable under different climatic conditions, trials in the Sahel may be worthwhile, particularly if they are designed to reduce either wind or water erosion.

Shade Trees

A well established practice throughout the Sahel consists of raising relatively fast growing trees wherever shade is desired, in individual compounds, along roads, in market places, schoolyards, etc. Many trees planted during the annual treeplanting days or weeks serve this purpose. By far the most popular and useful species for shade has been the Neem (originally from Southeast Asia). Gmelina arborea is often chosen in areas with more rainfall and Prosopis juliflora does best in drier regions e.g. Mauritania and Central or Northern Chad. Since this tree planting activity as such does not fall under agroforestry, it is not treated any further here. However, village or mini-nurseries provide an ideal opportunity for local people to raise both their own shade trees and other trees used for various agroforestry activities.

Reforestation of Depleted Farmland

Attempts to use worn-out and abandoned farmland for such purposes as wood production is an activity, similar to shade tree plantations, which lies outside the realm of agroforestry. Once land has become so depleted that crops can no longer be grown profitably, it takes considerable time before the site can be restored enough for tree growing to be economical.

Land restoration through reforestation, however is possible and some encouraging small project sites exist where re-introducing vegetation according to sound ecologic principles can help bring land back into use. Not only does this type of resource restoration take time, but it is also relatively expensive. Also, uncertainty of ownership often discourages local residents from taking a more positive view toward such restoration efforts. The carrying or production capacity of a tract of land, regardless of how well stocked it may become with trees or forage grasses, remains zero to the local people, as long as the government forbids access.