

AGRICULTURE/FORESTRY OPPORTUNITIES

FOR THE

AGENCY FOR INTERNATIONAL DEVELOPMENT

Consultants' Report to the Agency for International Development

by

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(With an Appendix on research needs by Dr. Robert Chandler)

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PREFACE

This report is the result of 3 weeks of work in Washington, D.C. by the two authors, plus additional time for preparation. During the Washington phase, the authors interviewed 50 AID personnel regarding program and project aspects of agriculture/forestry linkages. We are grateful to these individuals for taking the time to meet with us, and to speak forthrightly about the prospects for--and problems of--an emerging Agency program that would link agricultural and forestry activities. We hope that we have not misrepresented the essence of those conversations.

The task was complicated somewhat by a divergence of opinion about the exact purposes of our review. We trust that this report is of sufficient scope to address the range of expectations, yet particular enough to provide a basis for immediate action.

Dr. Robert Chandler worked with us for a 10-day period to develop a specific research agenda and while he had no hand in this report, his views appear in Appendix I. We are pleased to have had him as a colleague for at least part of this endeavor.

DWB
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EXECUTIVE SUMMARY

1. Agriculture is the purposeful manipulation of the natural resource base for the attainment of food and related material needs on a sustained basis. Agroforestry involves the deliberate mixture or retention of trees or other woody perennials as part of the crop/animal production enterprises. However, the term "agroforestry" is often used to imply intercropping of trees and crops on the same field or piece of land. To us, this places undue focus on land as opposed to the farm family or pastoral unit. Hence we have used the term agriculture/forestry (A/F) to connote the broad range of activities under discussion in this report.
2. The key element that is missing in AID's emerging interest in agriculture/forestry integration is legitimation. This will only occur when A/F activities are accorded the necessary structure and incentives within the Agency that permit such activities to compete with traditional pursuits for funds, staff time, and senior administrator attention.
3. The Agency should establish a Task Force on Agriculture and Forestry consisting of senior-level administrators. This Task Force would legitimate and reinforce an Agency commitment to A/F.
4. The Task Force would create an Agriculture/Forestry Working Group consisting of current technical staff, contract personnel, and possibly several short-term consultants. The Working Group would be responsible for the development of specific plans to accomplish the recommendations contained in this report, as well as the development of an A/F Synthesis Project.
5. All recommendations in this report could be acted upon by July 1, 1986, with many of them representing feasible activities by October 1, 1985.
6. The proposed program in A/F would provide missions and host-country governments with technical assistance, research results, training opportunities, technology packages, network opportunities, organizational improvements, and institutional assistance. The program would also result in enhanced production of conventional agricultural commodities, opportunities to produce new commodities, improved management of agricultural and natural resources, and better policies regarding these resources.

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I. INTRODUCTION

The Agroforestry Sector Review Team was asked to consider existing programs within the Agency for International Development with the following objectives in mind: (1) identify opportunities within AID's projects and programs in which the Agency should be conducting agroforestry research and technology development activities; (2) examine the portfolios of S&T/FNR and S&T/AGR (as well as other AID projects and programs) and identify areas for collaborative research; (3) make a set of practical recommendations regarding how these opportunities and activities can be accomplished; and (4) develop an agenda for the implementation of these recommendations over a specific time horizon.

The Team starts with the assumption that the Agency recognizes the pertinence of efforts to link agriculture and forestry--indeed no other assumption is consistent with the four objectives given the Team. Our view is reinforced by a number of Agency and sector strategy papers declaring the importance--and desirability--of accomplishing an integration of agriculture and forestry. Hence, we did not take it as our task to convince the Agency of this. In the course of numerous interviews with AID personnel we discovered a difference of opinion regarding the robustness and universality of that assumption. But it is not for consultants to determine agency priorities.

Different individuals within the Agency will have their own views about the best ways in which to promote particular activities; an integration of agriculture and forestry is no different. Our interviews revealed a general perception of "drift" with respect to a firm commitment regarding agriculture and forestry interactions. For that reason we offer two

general categories of recommendations--some that address process, and others that address the more technical aspects of an agriculture and forestry linkage.

The Team was often urged to develop an Agency "strategy" for linking agriculture and forestry. We take as our task, therefore, precisely that. But it is important to understand that a strategy for any organization must, of necessity, consist of two dimensions. The first dimension of an organization's strategy is concerned with how it will structure and comport itself with respect to the external task at hand. This external task is the second dimension of a strategy. We believe that it would have been irresponsible--not to mention naive--merely to list a number of these external activities (projects/programs) without giving equal importance to the organizational matters. After all, it is not now the lack of good program and project ideas that stifles the Agency with respect to a linkage of agriculture and forestry; it is instead the absence of a total commitment to agriculture/forestry, and the lack of structure and incentives to accomplish those ideas. While the reader may quibble with the specifics of how we propose to overcome that current problem, we expect to find general support for the importance of the issue.

II. THE PROBLEM

On a global scale there is considerable concern over large-scale deforestation and the accompanying soil erosion and environmental degradation occurring in the LDC's. Indeed much of the present famine in Africa

may be linked to increasing population and environmental abuse as the pressure to produce more food continues to mount, and as fuelwood and other products are consumed in greater quantities. These are problems of enormous magnitude that will require innovative thought and action.

Over the past three decades the Agency for International Development has initiated many projects to address certain aspects of these problems. A major portion of the AID project portfolio has been devoted to increasing food production in the LDC's. In more recent years fuelwood projects have been implemented in response to the emerging energy crisis. A limited number of forestry projects have encouraged better management of the natural forests, plantings of shelter belts, reforestation, watershed management, range management, and flood control; the list of projects is long and implementation has met with varying degrees of success.

Out of this history there emerges a common theme by the proponents of different technologies to promote their favorite development instrument rather than keeping their minds on the broader goals of programs for development assistance. Foresters have become advocates for trees as the mechanism to solve development problems. Energy experts remind us that food must first be cooked and that fuelwood is scarce. Livestock advocates promote animals as an integral part of the farming system. Watershed specialists remind us that without protection the agricultural resource

base of many countries will be washed away. Agronomists promote intensive cultivation of food crops as the only way to feed a growing population.

These product-oriented debates have tended to dominate discussions about a long-term strategy for wise use of the agricultural resource base. We do not wish to imply that products such as fuelwood, or forage, or fruits, or cereals are irrelevant. But it is essential that these various products be viewed as ingredients in the general problem of improving the life of the rural poor, rather than as the goals or objectives of development assistance.

In this regard we are encouraged by the considerable interest by Agency administration in programs to combine agriculture and forestry. Such programs would recognize the logical interface between the two disciplines. The Team understands that the Agency in general, and the Bureau for Science and Technology in particular, have yet to develop a comprehensive view of development programs and projects in the area of agriculture and forestry (A/F). Indeed, this is one of the primary tasks the Team was asked to perform. In addressing that matter we start with a working definition of "agriculture", and then seek to place "forestry" in perspective.

Our working definition of "agriculture" considers it to be the purposeful manipulation of the natural resource base for the efficient attainment of food and related material needs on a sustained basis. This broad definition finds application in agrarian societies where farmers exploit a variety of niches in their ecosystem--from annual crops, to home gardens, to a few fruit trees, to perennial woody species for fodder, to

range forage, to fuelwood. Even with sedentary agriculturalists we find products and uses ranging over a considerable area.

With this perception, conventional notions in developed countries of the clear distinction between "agriculture" and "forestry" break down. In such economies agriculture is highly capitalized on private lands, and forestry occurs, for the most part, on public lands, on small private woodlots, or on large commercial holdings. Whereas the vast majority of wood harvested in the developed countries is destined for manufacturing purposes, in the developing world over 90 percent of wood is used for cooking food and for space heating. To view forestry and agriculture through Western eyes is, therefore, to misunderstand the essence of an agricultural society. When 80-90 percent of the population is engaged in agriculture, and virtually all of the harvested wood is destined for fires, the line between "agriculture" and "forestry" becomes blurred indeed.

The term "agroforestry" has come to reflect various aspects of the interface between agriculture and forestry. One compelling definition of agroforestry is that it is an intergrated system of land use:

...involving the deliberate mixture or retention of trees or other woody perennials as part of the crop/animal production enterprises. Thus it combines elements of agriculture,...with elements of forestry in sustainable production patterns on the same piece of land, either simultaneously or sequentially [Nair, p. 3].

While we find this definition to be useful, it--as seems to be the case with other definitions--seems to place emphasis on the use of annual crops (and livestock) along with woody perennials on the same unit of land either contemporaneously or sequentially. Left undefined is the nature of that "unit of land." Is it one hectare? A particular farm field?

A whole farm? A watershed? The region over which a pastoralist moves during the course of the year?

This biological concept of agroforestry, by being vague as to the scope of interest for a unit of land, will tend to cause confusion when it comes to program and project formulation. We submit that it is much preferred to shift the unit of analysis from land to people. That is, the concern in development programs is properly with people--investments in land are a means to an end, rather than an end in themselves. It is the farm family (or the pastoralist group) that is the appropriate focus of concern and analysis. With that as a starting point, we can then begin to conceive of development strategies that address the problems of people as they attempt to make a living; the relevant unit of land will be the logical result of an initial interest in people. That is, by specifying the families or groups that are of concern to us, the pertinent unit of land will be automatically determined.

One other clarification seems in order. While we here discuss the full gamut of agriculture/forestry interactions--from rice paddy up to the rather pristine natural forest--we recognize that the Agency will quite naturally find it easiest to work with host countries on those forestry activities that are appropriately integrated with conventional agricultural pursuits. This should not be taken to mean that slash and burn agricultural systems are excluded from what follows; indeed quite the opposite is true. But natural forests with little or no food production activity occurring therein will not normally be regarded as high on the Agency's list of priorities.

In conclusion, this report is about articulating an AID strategy in A/F. We find abundant evidence that host-country governments and AID missions understand the numerous problems to which A/F projects might represent possible solutions. Our discussions with regional bureau staff confirm this. What is missing, both within S&T and the regional bureaus, is a clear idea of how the Agency might work to bring that awareness to bear on the problem of program formulation, and of project design.

III. THE AGRICULTURE/FORESTRY INTERFACE

A. INTRODUCTION

Farmers in the LDC's, unlike their counterparts in the industrialized countries, utilize a full range of environmental resources in their agricultural pursuits. Of equal importance, the agricultural resource base in the developing world has the potential either to enhance or inhibit the productivity of the more intensively cropped portion of the system. Upland soil erosion not only interferes with hydroelectric generation, but it clogs irrigation ditches, alters the course of rivers, and silts up fields in the lowlands. All farmers, regardless of their location, have an interest in the ecological integrity of the watershed in which they are located.

Rural development will be fostered in the LDC's to the extent that improved land-use practices contribute to enhanced food and material products consistent with long-run ecological stability. This means searching for systems of land use and management that make the highest and best use of each part of the agricultural resource base. While economics can be one dimension of a concept of "highest and best" use, we are not restricting it to economics alone; we recognize that ecological and social values are often difficult to express in monetary terms and so our concept of "highest and best use" is multidimensional.

B. GOALS OF AN AGRICULTURE/FORESTRY PROGRAM

AID programs in A/F should have as their goal the development of activities and projects in consultation with missions and host governments that will do several things. First, such activities should help farmers--whether subsistence or linked to markets--to make more complete use of the agricultural resource base for the production of items of economic or personal value. Second, those A/F activities should contribute to the long-run enhancement of the agricultural resource base--reduction of erosion, and the increased production of natural vegetation that will stabilize degraded habitats. Third, such activities should have as their goal the strengthening of host-country capabilities to undertake management of their agricultural resource base for sustained productivity and diversity. A final goal is that A/F programs should strive to maintain biological diversity and genetic materials that will insure long-run ecological stability.

C. PURPOSES OF AN AGRICULTURE/FORESTRY PROGRAM

There are several purposes of an A/F program. First, missions and host governments require detailed knowledge of technological packages and opportunities. Some of these will pertain to the complementary production of conventional crops and woody species on the same piece of land (intercropping); to some this represents "agroforestry." Another kind of needed technical information pertains to proper management of farm woodlots and other forms of tree-plantings on farmland that is not devoted to culti-

vated crops. Yet a third technology package would address planting and management regimes for village/community lands.

A second purpose of A/F programs would be to provide training opportunities for AID and host-country individuals. Such training would expose participants to technological, institutional, and socioeconomic issues related to A/F. Training would also expose participants to promising program and project ideas.

A third purpose of A/F programs would be to promote both basic and applied research, ranging from biotechnology to demonstration plots in various ecological settings. Additionally, more must be known about farmer decision making, economic incentives, and institutional issues. This research should be conducted in conditions that approximate those found in the developing countries. The results of this research should be widely distributed to agencies involved in A/F.

A fourth purpose of A/F programs ought to be to identify a cadre of agriculture/forestry experts who are available for technical backstopping to missions and host governments. As development-assistance agencies become more involved in A/F there is an increasing cohort of individuals across the full range of relevant disciplines.

A fifth purpose of A/F programs ought to be the establishment of networks involving the above cadre of experts, AID personnel knowledgeable in A/F, researchers, and extension personnel. This network would facilitate the exchange of knowledge about A/F problems and opportunities.

A sixth purpose of A/F programs ought to be to work closely with organizations in the developing countries to improve the general level of management of the agricultural resource base. Many countries lack the

trained personnel--as well as the managerial history and experience--to deal with rehabilitation of seriously degraded lands, and the management of lands that are threatened but not yet seriously overused.

The seventh and final purpose of A/F programs ought to be to offer institutional alternatives for the establishment and maintenance of new plantings on non-private lands. Many countries have a tradition of open access to village or community lands and the problems of learning to manage these lands following release from a colonial past are often immense. There are models of management systems where open access resources have been turned into common property resources and managed wisely; the Swiss pastures and New England lobster fisheries come to mind. More could be learned about these institutional forms and their relevance to natural resources that are now open to all manner of overuse.

D. OUTPUTS OF AN AGRICULTURE/FORESTRY PROGRAM

The outputs of a successful program in A/F would consist of both products as well as policies. On the product side, rural people would continue to enjoy traditional commodities that have long been a part of their agricultural practices. In addition to these, however, an effective A/F program would make possible the sustained production of a variety of new and valuable commodities such as fuelwood, fruit, fodder and forage for livestock, and small lumber for domestic needs.

Another output of an A/F program would be improved protection against soil erosion--either in the form of windbreaks, or in the form of plants to hold soil against water erosion.

The two final outputs of an A/F program are perhaps less tangible, but certainly no less important. We have in mind associated efforts to strengthen those government agencies involved in the management of the full range of agricultural resources--water, land, rangelands, and natural forests. Part of this strengthening could improve the ability of donors to design and implement projects in concert with host-country counterparts.

Finally, a successful A/F program would also offer opportunities to improve the policies that affect agricultural resources. There is increasing recognition that economic development requires more than physical investments; real growth and structural change is the product of careful design of the incentives and sanctions that guide individual (and group) social and economic behavior.

IV. THE AGRICULTURAL ECONOMY AND FORESTRY POTENTIALS

Prior to the presentation in Part V of a detailed description of feasible A/F activities, it is necessary to review the nature of agriculture in the developing world to be reminded of how rural people use the agricultural resource base to make a living. With that understanding, it will be easier to formulate appropriate A/F activities. We will discuss three general classes of agriculture--intensive, mixed, and extensive--and will recognize several further distinctions within each of these three. In all we will consider seven distinct classes of agriculture, each with its own unique problems and opportunities for the realization of A/F programs.

The distinction between intensive and extensive agricultural activity is usually couched in terms of irrigated rice culture versus pastoralists. We will consider two variables to define the nature of agriculture in 38 low-income and middle-income countries as determined by the World Bank in its World Development Report 1984; the two variables are population density per square kilometer (1982), and cropped land per capita in hectares averaged over the period 1972-74. The purpose in such a graphical array is simply to illustrate the diverse nature of the ways in which humans rely upon their surroundings to make a living. The countries selected do not--in any way--represent priorities for the Agency. They are shown because they are among the poorer countries of the world, and because they represent countries in which AID has some programmatic interest. The 38 countries are arrayed in Figure 1.

Cropped
Land Per
Capita:
1972-74
(Hectares)

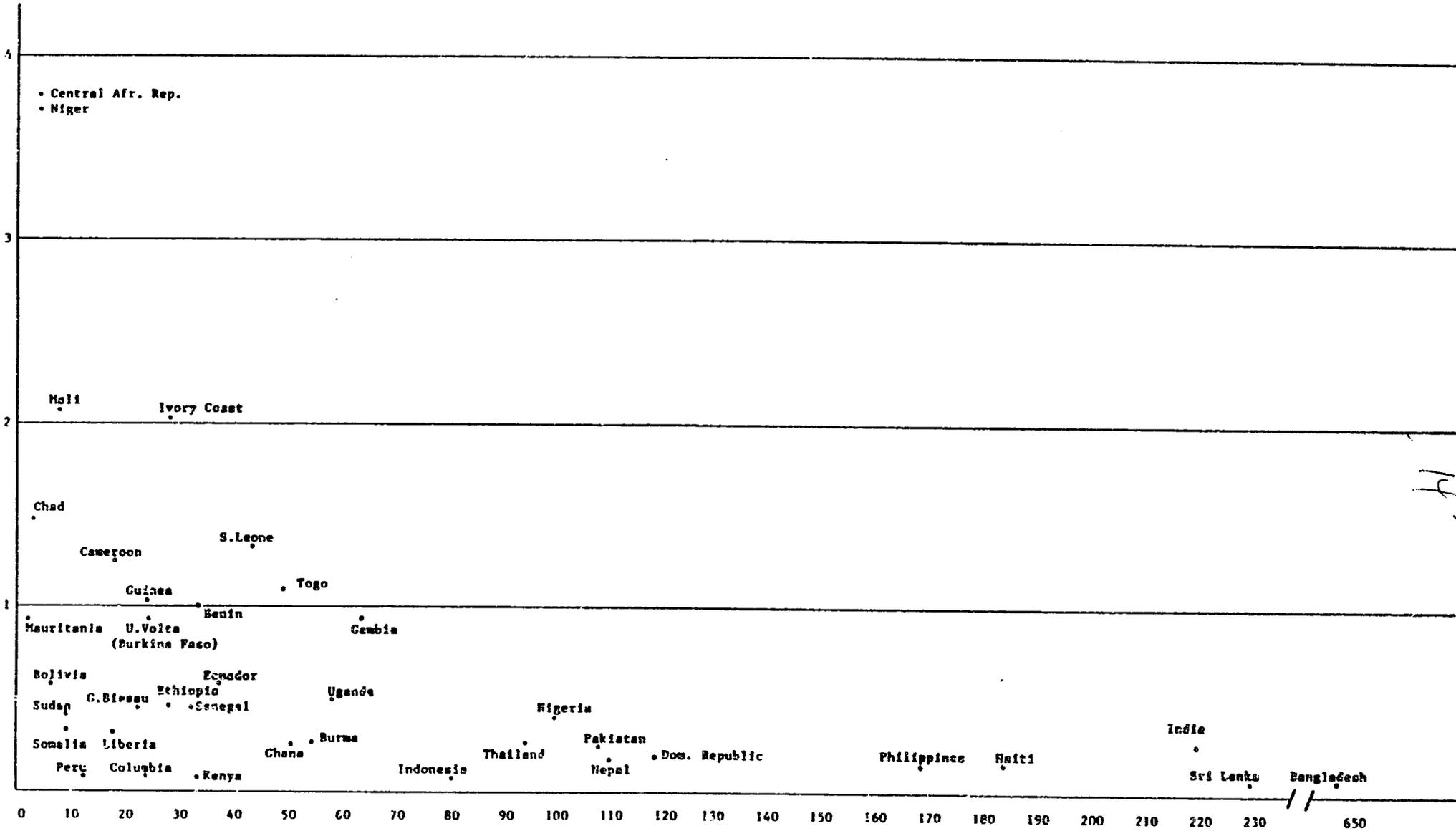


FIGURE 1

Population Density: 1982 (People/Km²)

We distinguish three rather distinct agricultural economies from Figure 1. First, at the extensive end we find eight countries with a population density of less than 10 persons per square kilometer; these are, as we would expect, largely livestock oriented economies. At the opposite extreme we find countries dominated by highly intensive agriculture--either irrigated or because of very high rainfall. Beyond 70 persons per square kilometer--somewhat less than the population density of Ohio--we encounter the intensive end of the spectrum. Between these two extremes are the mixed agricultural economies. Let us consider these three general classes.

A. THE EXTENSIVE MARGIN

There are eight countries of interest here with population densities of less than 10 persons per square kilometer; only two of them are found outside of the arid Sahel region of Africa. These two--Bolivia and the Central African Republic--are moderately humid. The agriculture of these countries is mixed in nature and they properly belong in with the mixed agriculture group; only their low population keeps them in the "extensive" group.

The countries that are clearly in this group comprise that belt of land south of the great North African desert--Niger, Mali, Chad, Mauritania, Sudan, and Somalia. In terms of cropped land per capita they range from a high of 3.6 hectares in Niger, to a low of 0.3 hectares in Somalia. Even Sudan, with one of the largest irrigation schemes in the world (the

Gezira-Rahad-Blue Nile), has only 0.4 hectares of cropped land per capita (1972-74).

Most of these countries grow sorghum and millet under rainfed conditions. Livestock are kept as a source of income for those who herd them, and as a source of wealth for those who own them. Milk is traded with sedentary agriculturalists to acquire millet--the staple of the diet in this region. Many western development "experts"--failing to understand the interdependencies between those who farm in this region and those who move with their livestock--propose that the pastoralists settle down. In fact, livestock keeping is the only possible agricultural use of much of this region and by doing so the sedentary farmers are able to acquire two critical products (milk and manure) that would otherwise be unavailable to them.

A successful program at the interface of agriculture and forestry in this region of the world must first recognize the complementary relationship between livestock and cropping. There is a temptation to say that livestock pose the major threat to the establishment of woody species. While this may be true, it would be an incorrect policy conclusion to suggest, therefore, that livestock raising must be discouraged. To reduce livestock in this region is to upset the relationship that exists between pastoralists and sedentary peoples; it would also remove the only possible use of millions of hectares.

Western range management specialists are often inclined to view this region with dismay. These individuals are, by training and culture, taught to believe that resources such as grass and shrubs are assets to be managed for optimum production. It is only natural that in a society with

the private ownership of land we would produce range managers who want the land to be of the highest quality; it is this concept of land ownership in our own culture that encourages such a premium on the assets that grow on the land.

Indeed it is the absence of private ownership of land that has been identified as an impediment to "development." Yet it is incorrect to assume that we can impose our institutional structure on these peoples. The pastoralists hold wealth not in land but in livestock. Agriculture and forestry programs will succeed to the extent that we understand the culture of these peoples, develop technologies that help them as they wish to be helped, and work with the public sector to perfect institutional arrangements that will arrest the most serious forms of environmental degradation.

In this region of extensive agriculture there are several serious problems for which forestry activities offer some promise. First is the serious depletion of wood for cooking and the manufacture of charcoal. This results in the burning of dung and crop residues, which deprives the soil of necessary organic matter. There could be no clearer evidence of the relationship between agriculture and forestry. Second, the disappearance of trees alters the microenvironment in which millet, sorghum and other food crops are grown. Finally, deforestation holds serious implications for the general macroenvironment and is considered to be a prime cause of increased aridity in certain parts of the world.

B. MIXED AGRICULTURAL SYSTEMS

As population density begins to increase we find agricultural systems that are a mixture of the pastoralist and the more intensive crop agriculture. For our interests the majority of these countries are found in the region just below the African Sahel; in Figure 1 these countries include one from South Asia (Burma), and three from South America (Ecuador, Peru and Colombia).

Here one finds humid or sub-humid climates and an agriculture that is both irrigated and rain-fed. Animals may or may not be a dominant part of the agriculture--if not the reason may often be more attributable to the presence of animal pests than to land scarcity (as will be seen at the intensive margin). Agriculture in this region is more sedentary than at the extensive margin, but there is still some pastoral behavior in a few places.

While the three Latin American countries are characterized by mountainous terrain, those in Africa are only moderately hilly. Soil erosion can be a problem in this type of agriculture, more often from rain than from wind.

The agriculture/forestry problems in this region are of several types. First, population growth is likely to have placed an increased burden on certain products such as fuelwood and small timber. As herds grow in number with the larger human population, forage and fodder have become increasingly scarce. Second, population growth has also resulted in a serious shortening of the fallow period in most slash and burn agricul-

tural systems. This brings about more destructive environmental practices. Finally, the extension of agriculture into former natural areas poses a threat to soil stability as well as to wildlife populations.

Agriculture/forestry programs in this setting would need to emphasize product availability, soil protection, and the integration of trees and woody perennials into the cropping cycle of sedentary farmers.

C. THE INTENSIVE MARGIN

At the intensive margin we will be interested in three general types of agriculture--all with unique A/F problems and possibilities.

The most obvious problems are found in the mountainous countries of Nepal and Haiti. Here, population pressure, and poor management and control of much land, combine to create serious degradation of the natural habitat; hillsides are washed away, streams and rivers are silted up, and the very existence of many inhabitants is problematical.

Agriculture/forestry programs in these mountainous environments require a two-pronged effort to: (1) reduce the rate of use of the natural vegetation; and (2) re-establish trees and other vegetation that have disappeared from over use. It is often possible to use private lands for the establishment of product-oriented forestry (fuelwood), thereby relieving pressure on the hillsides; this seems to be the approach taken in the Haiti reforestation efforts of AID. The Nepal Community Forestry Project is following a strategy of reducing livestock presence on the hill lands by encouraging stall feeding; individuals gather fodder for their livestock rather than allowing the animals to graze.

The second major agricultural region at the intensive margin actually contains two general types of agriculture--intensive agriculture in the flatlands, and shifting (or short-fallow) agriculture in the hills. The hill agriculture presents problems quite similar to those found in Nepal and Haiti. In addition, however, we find that this activity in the uplands poses a serious threat to the intensive agriculture of the flatlands. Hence while the soil erosion of Nepal and Haiti is exported directly to another country (or directly to the ocean), in these latter countries the upland soil erosion hampers intensive agriculture within the same country.

Here, A/F programs will need to be aimed at the uplands for their own sake, but also to preserve the highly productive agriculture below. This means that a premium is to be placed on soil-stabilizing species that are relatively fast growing. In certain settings it will be important that these species have some cash value on a sustained yield basis. In the lowlands A/F programs will need to emphasize product availability--especially fuelwood, fodder, forage, and small timber.

The final type of agriculture to be considered is that pure type at the extreme margin of intensity--the country that epitomizes that setting is Bangladesh. At approximately 650 persons per square kilometer Bangladesh is exceeded only by Central Java (with approximately 1,000 per square kilometer) in terms of population density for an agricultural economy. It hardly needs mentioning that land in this setting is extremely scarce; it is obvious that here crops and trees would often be competing for the same land. Yet even in the most intensively cropped areas there are ditch

banks, bunds, roadsides, and canal banks that will lend themselves to trees of various types.

At the intensive margin the major emphasis must be on a few products that are in shortest supply--and hence the most valuable. In Bangladesh this would be fuelwood, small poles, and fruit. In this type of agriculture animals are too inefficient to be kept for any purpose other than traction and so the animal keeping of the extensive agriculturalist is not found. Here, land is where wealth resides, not animals.

D. SUMMARY

We have discussed seven general types of agricultural economies, each with its own unique A/F problems and opportunities. At the intensive end of the spectrum, Nepal, the Philippines, and Bangladesh represent three distinct types of problems, and hence three distinct imperatives for A/F programs and projects. The mixed agricultural economies are best represented by the countries of north-central Africa (Liberia, Ivory Coast, Sierra Leone, Upper Volta, Benin, Togo, and Cameroon). Finally, at the extensive margin the Sahelian countries would seem to typify the A/F problem and possible solutions. We will now turn to a detailed discussion of program and project activities that will address problems in each of these settings.

V. ACTIVITIES IN AGRICULTURE/FORESTRY

We will draw a distinction here between those activities where leadership from the Bureau for Science and Technology is appropriate, and where leadership should logically come from the regional bureaus and country missions. While this distinction will not always be preserved, it seems to provide a convenient organizing rule for what is to follow.

A. SCIENCE AND TECHNOLOGY LEAD

The Bureau for Science and Technology should provide leadership and support to project activities in three general areas: (1) agriculture/forestry techniques; (2) host-country capabilities; and (3) general research needs. We will discuss each in turn.

AGRICULTURE/FORESTRY TECHNIQUES

SPECIES

SELECTION: For some time now there has been an interest in a large number of species that are suited to the integration with crops and livestock. The Bureau for Science and Technology should initiate a search that would have as its primary purpose the determination of a limited number of species of trees and other woody perennials that are highly suited to the various ecological conditions in AID countries. This does not mean an unrestrained search for exotics or "miracle" trees; we believe that prospects for successful programs are enhanced to the extent that indigenous species form the bulk of the genetic stock.

**CULTURAL
PRACTICES:**

The recognition of multi-purpose trees has fostered the popular convention that such trees can be planted and then provide all manner of product without attention to different cultural practices for each product. Some have been too quick to assume that the same cultural practices are appropriate for the production of fuelwood, fodder, small poles, and an understory of grass for forage. In fact, while there are some trees that can produce multiple products, it does not automatically follow that each individual tree must necessarily be expected to produce several products. S&T should take the lead in determining the optimal cultural practices for the efficient production of several products from a limited number of species. For instance, the same species might be planted at several different spacings, and be managed differently, depending upon whether the main product were to be poles, fuelwood, fodder, or one of these in conjunction with an understory of forage.

NURSERIES:

A successful program of integrating agriculture and forestry will require a network of nurseries and seed distribution facilities in various ecological regions of the world. S&T should take the lead in support of collecting superior seed and other plant materials, and in the establishment and operation of model nurseries.

DEMONSTRATION

PLOTS:

As with all new techniques, it will be important that farmers have an opportunity to observe various cultural practices showing the integration of agriculture and forestry. S&T should initiate a program to work with ICRAF and other entities for the purpose of designing and establishing such demonstrations in several regions of the world. These plots should demonstrate the proper methods for establishing tree plantings as well as the sustained management for alternative products.

SOCIOECONOMIC

CONCERNS:

The establishment and maintenance of trees and other woody perennials on private as well as non-private lands will require that extraordinary attention be given to the socioeconomic aspects of agricultural practices. Where security of tenure is in doubt then special

efforts will be required to design--in conjunction with local people--the institutional arrangements that will ensure the survival and wise management of the new community asset. Where projects on private lands are envisioned it will require that the Agency support efforts to demonstrate production and marketing opportunities to farmers. Hence, S&T should support a study of the socioeconomic aspects of A/F activities. This activity would have as its primary objective to synthesize what is known world-wide regarding the social and economic imperatives of successful A/F efforts. We must stress here that while biological aspects dictate which A/F techniques are possible, it is the socioeconomic aspects that determine success over the long run.

GOVERNMENT CAPABILITIES

All of the activities listed here will require close cooperation with country missions.

AGRICULTURE: The ministry of agriculture in many developing countries will not be well equipped to undertake innovative programs that link agriculture and forestry. Even in those instances where forestry programs are administered from within agriculture we should not expect quick progress. Conventional disciplinary and bureaucratic strictures are too durable to crumble quickly. The Agency will require great wisdom and patience in assisting ministries of agriculture in understanding the possibilities from an integrated approach to A/F activities. S&T should work with the regional bureaus to provide leadership in assisting ministries of agriculture to move toward a recognition of the contribution of A/F programs, and in structuring their organization and programming to allow the realization of this potential.

FORESTRY: At the time of independence many developing countries modeled their forestry departments after those found in the developed world. The countries in this latter setting view their forests in a far different light than we find in the developing countries. In the newly independent countries, forested areas were either denuded as a result of colonial exploitation, or comprised a source of products for the rural poor. With the establishment of forestry departments (or ministries) the emphasis was often on exclusion of the

rural inhabitant, and the establishment of a commercial forest operation from which a country might earn foreign exchange. The natural forest was transformed into something from which the vast majority of people were either evicted or excluded.

S&T should offer to assist the regional bureaus to work with forestry departments/ministries for the purpose of managing natural forests in the best interests of the rural population. This does not mean that the masses should have free rein in the forests; it does mean that forest management practices will have to be considered where a mix of export and subsistence objectives are simultaneously pursued.

EXTENSION

SERVICES: Just as with traditional agricultural practices, the adoption of programs in agriculture/forestry will require that special efforts be directed toward the establishment of extension programs to show individuals the essence of establishing and managing plantings. S&T should support activities that would have as their purpose a collaborative effort with the extension program in various countries to integrate A/F activities in with regular extension efforts.

UNIVERSITIES: As A/F activities become an accepted part of the economic life in the developing world it will be essential that training opportunities exist for future extension personnel, and that research be undertaken to provide answers to an array of technical and socioeconomic questions. S&T should support a link between U.S. universities and counterpart universities in certain countries, with the explicit purpose to improve instruction and research in A/F.

RESEARCH: In many countries the agricultural research enterprise is separated from the teaching activity--unlike the Land Grant system in the United States. S&T should provide assistance to the research agencies in the developing world so that they might become involved in research of pertinence to an emerging A/F program. If closer links with the universities in these countries are desirable then that opportunity might be explored. However, we do not suggest that the Land-Grant model be imposed (or even suggested) unless the host country is convinced of the need.

It will be impossible for many small countries to support such a research program and so the special role of the regional research centers is emphasized. With regional research activities underway, individual countries will be able to undertake adaptive trials and pilot projects under local conditions.

GENERAL RESEARCH NEEDS

THE CGIAR

CENTERS: The international agricultural research centers under sponsorship of the Consultative Group provide a valuable research opportunity to emerging programs in agriculture/forestry. S&T should assist several of the Centers to expand their research agenda to include A/F activities. The centers that come to mind are the International Institute for Tropical Agriculture (IITA), the International Livestock Center for Africa (ILCA), and the International Center for Research in the Semi-Arid Tropics (ICRISAT). Several of these Centers have begun research in farming systems and hence it is only logical that A/F be incorporated in the research mandate. In addition, means should be found whereby the various Centers can form closer linkages with the International Council for Research in Agroforestry (ICRAF).

ICRAF: The International Council for Research in Agroforestry, located in Nairobi, while not yet part of the Consultative Group, provides a unique opportunity to advance knowledge in various aspects of A/F activities. The research ideas contained in Appendix I assume that ICRAF would take a prominent role in this endeavor. It will be necessary to provide administrative support as an important part of all contracts with ICRAF, and we urge that S&T should work closely with the Council to define a relevant research program, and to provide mechanisms whereby the research results would be disseminated to all regions of the world.

AID should take the lead in the international community to develop mechanisms whereby ICRAF would receive core budgetary support over the long run. In the absence of this assurance of financial stability, the Council will be hampered in its research and outreach programs.

FARMING

SYSTEMS: There now exists a farming systems project within S&T that appears to be confined strictly to cropping systems. It is recommended that this project be modified/augmented to insure that livestock and woody perennials become a legitimate subject of inquiry in all future activities. Additionally, horticultural crops appear to have been excluded from much farming-systems work.

PRIVATE

SECTOR: A/F activities promise a number of opportunities for the Agency to pursue its current interest in promoting the private sector as an element in the development endeavor. Nurseries, fuelwood markets, and the commercial production of small poles and other forest products (lac, resins, etc.) are examples. S&T should provide leadership in the development of prototype enterprises for the production and marketing of certain scarce products deriving from A/F activities.

INSTITUTIONAL

ASPECTS: While many A/F activities will occur on lands that are held in fee simple (that is, "farm forestry"), it remains true that the most serious degradation problems often are found on lands over which control is problematic--vast reaches of the Sahel, forest/bush fallow systems in more humid regions, village lands in India. S&T should undertake research for the purpose of understanding the institutional opportunities for managing new assets established on such lands. We emphasize that the term "institutional" here refers not to its popular connotation (i.e. to organizations) but rather to the structure of rules, conventions, norms, and habits that define the rights, duties, privileges, and exposures of villagers with respect to valuable natural resources. Colonialism, then independence, and now the efforts at nation building imply that many local-level natural resource institutional arrangements have been destroyed, leaving in their wake a vacuum that seems to offer unlimited opportunities for resources to be over exploited. Western-trained analysts seem to assume automatically that the solution to over-use is to create private property over such resources. However, there is ample evidence that privatization is not sufficient guarantee against unwise use (the American "Dust Bowl", current problems of serious soil erosion and overgrazing on private lands) and so this research

endeavor should be directed toward the illumination of alternative institutional arrangements that are consistent with local cultural imperatives, yet protective of the long-run viability of the resource. The general problem of "land tenure" is pertinent here, but it goes beyond land tenure to include tenurial arrangements over trees and other vegetation.

BIOTECHNOLOGY: S&T should take the initiative in supporting research on various biotechnological aspects of A/F. Research on cell tissue culture and biological nitrogen fixation are of considerable importance over the long run. One prospect is that S&T might sponsor research on the benefits of mycorrhizas as it affects the establishment and growth of trees on nutrient-deficient lands.

A/F SYNTHESIS: S&T should initiate a project that would have as its main purpose the establishment of a capability within the Agency to respond to several critical needs as missions and governments identify a tentative interest in A/F activities. This project might well be modeled after the Water Management Synthesis II project. The project should have several components--training, technical support to missions, special studies, and technology transfer. Such a project would permit the training of AID and host-country personnel in A/F. It would also facilitate the location of specific expertise as a mission begins to formulate A/F activities. A third aspect would be the capability to assist missions and governments to conduct an early assessment of A/F problems and opportunities. Fourth, the project would be a clearinghouse for specific A/F techniques that are suitable for a variety of ecological and socioeconomic conditions. Finally, we envision this synthesis project as being the mechanism whereby most of the above-listed activities and initiatives might be conducted.

B. MISSION/REGIONAL BUREAU LEAD

A recognition of the way in which AID operates in terms of the Washington-mission dichotomy means that special attention will need to be given to activities that strive to bridge the normal problems in program and project conception, formulation, and design. Because agriculture and forestry interactions represent a new effort for the Agency we are optimistic that ways can be found to mobilize S&T, regional bureau, and mission interests and imperatives. It is at the mission level that the Agency will need the greatest imagination and foresight in formulating program and project ideas in A/F. As mission staffing levels remain constant--or even shrink--there is increased pressure to consolidate and focus development assistance efforts. The integration of agriculture and forestry activities will therefore be successful to the extent that AID can search for ways to integrate trees into ongoing agricultural projects, and to integrate farmers into projects that seem to be strictly "forestry" in character. While S&T can help in this regard, it is the mission staff and the regional bureau technical staff that will have the greatest impact in this regard.

The prospects for A/F can be considered as falling into four general types of program activities. Following Catterson [1984] we will briefly discuss: (1) farm forestry; (2) village forestry; (3) plantation forestry; and (4) natural forestry. The salient aspects of each will be considered as an aid to placing forestry activities in the context of conventional mission programs.

FARM FORESTRY

By farm forestry we mean any efforts to incorporate woody perennials into the agricultural practices on those lands either owned or controlled by farmers. This means that some lands may not be owned in fee-simple but may instead be held in usufruct. The essence of farm forestry is that a single family (or equivalent decision-making unit) undertakes agricultural practices independently of what others in the community may be doing. This does not mean that there is no interaction among these independent decision-making units--only that investment and management decisions are made independently. As will be seen below, it is this independence that distinguishes farm forestry from village forestry.

In farm forestry we are usually concerned with alternative land uses; alternative enterprises to be engaged in by the farm family. Land is the fixed asset under control of the family and the choice process is one of selecting alternative ways to earn income from that land--or to use the land in a way that yields products for direct consumption, or to yield other benefits such as soil protection or shade. While there may be collectively realized benefits from farm forestry--such as benefits from windbreaks or reduced soil erosion--it must be recognized that the major motivation for farm forestry will be potential benefits accruing directly to farmers and their families.

For this reason we should view farm forestry in much the same light that agricultural economists view farm management; the management principles are the same--only the range of possible enterprises is different. Critical variables become: (1) reliable supply of inputs; (2) relevant

extension programs; (3) secure expectations over yields; (4) simple techniques; (5) dependable and fair marketing opportunities; and (6) reasonable expectation of benefits exceeding costs.

It should not be assumed that farm forestry is some radical departure from what is currently happening in a number of countries. For instance, there are estimates that as much as 50 percent of the total fuelwood harvest in several South Asian and African countries originates on farms. The development problem is to assist those farmers to increase their production, and to find ways to encourage others to enter the market. To quote Catterson:

Farm forestry refers to sustainable forestry production activities, either through plantations or better management of existing resources by individual farmers and peasants on their land. Whether this be through an agroforestry technology approach combining crops and trees either in time or space, or through small woodlots or individual tree plantings, it calls for careful incorporation of tree components in the farming systems being employed. It aims at the opportunities inherent in a farmer's discretion about the utilization of his basic resources, land, labour and capital, in fulfillment of his own basic needs and economic opportunities [p. 9].

Catterson goes on to note that the essential element in the success of a farm forestry program will be the nature of the extension program that accompanies it. We share this view.

VILLAGE FORESTRY

Activities involving the planting and management of woody perennials on lands that are not under control of individuals (families) are classified as "village forestry." The nature of the control over land is

essential. In village forestry the establishment and management is collectively organized and sustained on lands that are collectively used and managed. For the most part village forestry projects will involve less than 10-15 hectares per unit, although a number of units may be considered as one project.

Village forestry should not necessarily be viewed as an alternative to farm forestry--rather both should be considered complements. This is especially true in settings where there are a number of rural landless, or where land control is skewed. Village forestry offers opportunities for products and resource protection that will benefit those with only limited (or no) land under their exclusive control.

In many settings village forestry will be conducted on lands of poor quality--too dry, too steep, or too rocky for cultivation. Many such lands will have been grazed for sometime, and they often will be overgrazed. It is for this reason that the opportunity cost--the foregone benefits--from devoting such lands to forestry will be very low, while the potential gain will be substantial.

Because such sites tend to be both degraded and harsh it will require great care to select appropriate genetic stock. And, once established, such plantings will require uncommon attention to ameliorate the tendency for abuse through unrestrained access. Some village forestry schemes are threatened from the very beginning by romanticized visions of "cooperation and shared-work" on the part of villagers. There should be no utopian myths that new assets will be nurtured by villagers often at the extreme margin of deprivation with regards to fuelwood and livestock feed. These

new village assets will require very great diligence, and prodigious enforcement to prevent their liquidation.

With this in mind we suggest that village plantations of modest dimensions may stand a better chance in two important respects. First, a small unit removes less land from traditional uses. And, although the land dedicated to village forestry may be badly degraded now, villagers will still worry if too much of it is taken out of use for a planting that may require 5-6 years before tangible products are realized. Second, management and enforcement are easier on a small site.

As with farm forestry, the availability of extension programs at the village level will be critical to success.

PLANTATION FORESTRY

Here we have in mind the large plantings of certain woody species for the explicit purpose of producing, in an efficient manner, and on a commercial scale, certain necessary products. In the development context the archetypical plantation would be for the purpose of producing wood for direct use or for the manufacture of charcoal. Such plantations could be in the private sector, or in the public sector. If the private sector is viable, and if private lands are available, then AID may be able to meet its "private sector emphasis" by assisting in such projects. It is also possible that public lands could be devoted to such plantations, but with the management residing in the private sector. Finally, where appropriate, parastatals may be the institutional form chosen.

Catterson points out that the advantages of such operations are to be found in the scale of the operation--and the economies that attend such

scale. Such plantations can be significant generators of employment, and under certain circumstances they can yield indirect benefits in the nature of windbreaks and soil stabilization. Moreover, if certain forest products are in short supply, plantation forests can relieve the otherwise severe pressure on natural forests. The major drawbacks are to be found in the high cost of establishment, and in the lack of disposable income in the hands of the rural poor to pay commercial prices for the product. Finally, the size of some undertakings means that it will be difficult to find plots of land available for such purposes.

It should also be noted that plantation forestry is possible on farm lands as a substitute for other agronomic crops.

NATURAL FORESTS

The natural forests of the developing world are, for the most part, major sources of a wide variety of products. Often bad management, and little control, mean that certain parts of those forests are seriously overexploited. It is also true that many of them are often at some remove from major population concentrations.

The natural forests have the obvious advantage of not requiring large sums of money for their establishment--as is the case with the forest plantations. However, natural forests have a history of use that makes it difficult to institute new management regimes. To again quote Catterson:

A gradual expansion of natural forest management as a fuelwood production strategy will be hard work requiring vision and determination to succeed. On the medium term it would appear to offer the most attractive and innovative option within the exclusive domain of the forestry sector to advance the cause of rural development in the fuelwood deficit areas of the Sahel region [p.12].

PROGRAM OPTIONS

Leadership from the missions and regional bureaus must come in the form of identifying indigenous agriculture/forestry techniques that seem successful, and in relating these systems to the problems, needs, and opportunities in the various host countries. We stress once again the proposition that indigenous systems offer the best hope for sustained success in agriculture/forestry programs. Unlike agronomy--where a very few species account for the vast majority of ultimate product--agriculture/forestry systems will involve literally thousands of permutations and combinations of species. While this does not mean that some effort in genetic engineering should be rejected, it does suggest that agroforestry must be regarded in a different light than agronomy.

In what follows we will offer, as illustrations, several ways in which A/F programs might be considered. This discussion will parallel the earlier treatment of agricultural systems at the extensive margin, mixed system, and those at the intensive margin. Additionally, it should be kept in mind that these programs will include farm forestry, and village forestry, with a lesser role for plantations and natural forests.

The Extensive Margin

We will focus the discussion of this agricultural system on the Sahel zone of Africa. There are three general models that warrant close scrutiny and understanding--the "agro-silviculture" model, the "silvo-pastoral" model, and the "agro-silvo-pastoral" model [Advisory Committee on the Sahel, 1983].

AGRO-SILVICULTURE: This system is basically trees and shrubs, and can include wheat, barley, sorghum, millet, olives, figs, grapes, maize, broadbeans, peas, cabbage, okra, cabbage, cucumber, beets, onion, and garlic. The woody perennials include date palm, citrus, mulberry, pomegranates, almond, cashews, neem (for shade) and acacia/prosopis (for live fences).

This system combines woody perennials with rainfed or irrigated crop production of a varied nature. The prototypes are said to exist along the Yatenga River in Burkina Faso (formerly Upper Volta).

SILVO-PASTORAL: This agricultural system is common in areas without cultivation, with two main types in existence. In the northern Sahel we find transhumant pastoralism, with trees and shrubs providing the main portion of livestock feed. In the southern Sahel, where it is less arid, we find a transition zone into cultivated crops. It is here that one finds some millet, cowpeas, and groundnuts.

AGRO-SILVO-PASTORAL: It is here that one finds all three types of agricultural activities--crops, livestock, and woody perennials. In Sudan, Chad, and Niger we find Acacia senegal and millet combinations. In Senegal, Burkina Faso and parts of Niger we find Acacia albida along with sorghum and millet. As indicated earlier these systems involve the exchange of milk by herders for grains produced by the sedentary farmers.

In all three types of agricultural systems at the extensive margin, the Agency should undertake programs and projects that will have as their purpose the enhancement of fuelwood production, and plantings that will offer stabilization to the environment from wind erosion. Because of the nature of land control and agricultural practices in the Sahel it seems reasonable to suppose that village forestry and farm forestry will be of equal significance. There are some natural forest areas that will require

improved management, and there may be instances in which forest plantations are appropriate. However, we urge that AID avoid becoming involved in large-scale projects that are expensive to organize, difficult to manage, and that will require extensive ancillary infrastructure for their success. Such projects also run the risk of being so large that they attract the attention of those already well situated; the advantage of small projects is that they are too minor to attract the elites and so the benefits are available for the poor rather than being appropriated by the well-placed.

Following the recommendations of the Advisory Committee on the Sahel, we suggest that agriculture/forestry programs will only be successful if they are designed to have broad citizen participation in both the establishment and operational phases:

Given current and probable future staffing levels, neither agricultural and livestock services nor their traditionally poorer colleagues in forestry departments can hope to muster enough manpower to work individually with rural dwellers to improve indigenous agroforestry techniques, let alone put those lessons into practice throughout the vast Sahelian area. Either rural people in the Sahel will teach as well as do agroforestry or it will not be done [Advisory Committee on the Sahel, 1983, p. 43].

The International Council for Research in Agroforestry is developing a method for diagnosing agroforestry problems, and for then designing appropriate projects. The Council staff will continue to offer guidance as missions attempt to understand such problems, and to implement programs and projects that address those problems.

We stress again, however, that outside "experts" and "high-tech" approaches to agriculture/forestry programs are to be avoided. It is local farmers who understand their own microenvironment and while the Sahel

region may appear to be one vast homogeneous ecosystem, local variations are extreme. There is a role for technical assistance, but missions must avoid the temptation to invite outsiders to design projects--in consultation with host-country bureaucrats--that have no input from the farmers who know the ecosystem. This too reinforces the earlier preference for small projects.

Mixed Agriculture

We will talk of two general types of mixed agricultural systems, one in the Andean region of Latin America (represented in Figure 1 by Peru, Ecuador, and Colombia), and the other in the humid belt across central Africa (from Liberia, Ivory Coast, and Sierra Leone east to Kenya). These two regions represent, for the most part, agricultural systems in which real "agroforestry" exists on a large scale on farms. It is in these countries that population density is such that sedentary agriculture dominates, and yet land is not so scarce that a good measure of it cannot be devoted to woody perennials.

LATIN
AMERICA: The most serious problem in much of Latin America is the degradation of hillsides arising from the practice of cultivated agriculture. In one sense, agriculture in this region is defying normal economic practices--largely because of institutional arrangements that allow large areas of fertile valley-bottom land to be devoted to pastures, while food crops for the displaced poor must be grown on steep hillsides. That is, extensive agriculture is practiced where intensive agriculture should be, and intensive agriculture is where the extensive production should be.

A development program focussed on agriculture and forestry problems in Latin America must start with this basic understanding of why different types of land are used as they are. As governments confront growing populations and stable food supplies, A/F efforts would seem to hold some promise--especially since certain types of projects offer the prospect of both food production and environmental stabilization. While cattle ranching may prevail in the valleys, there are large areas of fringe lands that would lend themselves to the planting of woody perennials that will provide food for the rural poor. Similarly, hill-stabilization efforts can be carried out with species that not only protect against erosion, but that also provide food and marketable commodities. The Latin America/Caribbean Bureau is well underway on a program concerned with "fragile lands." We encourage missions to incorporate A/F activities into these evolving efforts.

CENTRAL

AFRICA:

The agriculture/forestry problems in this region concentrate on fuelwood deficits, and on shifting-cultivation systems that are being forced into ever-shorter fallow periods. Along the northern edges of this region one encounters the agricultural systems common in the Sahel--acacia/prosopis, sorghum, millet, and livestock. As the climate becomes more humid, pests threaten some livestock and one moves into cropping systems where woody perennials appear, but there are fewer livestock.

The taungya system is considered to be an adaptive intermediate step between shifting cultivation and true agroforestry in this region [Nair]. The system involves the simultaneous practice of cropping and forest establishment. While wood production is considered to be the ultimate objective of the system, the intermediate objective is food production.

AID programs in this region must, as with the Sahel, start from the recognition that local farmers understand how different aspects of the local environment might best be utilized. The development problem is to identify marginal improvements in indigenous techniques, rather than attempting to locate exotic technologies for imposition into existing systems. In this region, where fuelwood is a serious problem, there may be instances where plantation forestry is feasible. However, it will most often be the case that farm forestry, and natural forest management, offer the greatest hope for success.

Intensive Agriculture

The agriculture/forestry problem in the regions of intensive agriculture can be divided into two general groups--problems in mountainous and hill regions, and problems in the plains where irrigated agriculture is prevalent. We will treat each in turn.

MOUNTAIN AGRICULTURE:

We will treat hill and mountain agriculture together here, and we will use Haiti and Nepal as the prototype agricultural systems in which agriculture/forestry problems are severe. The problems are well known, and require no elaboration here. A/F programs, to succeed, will require that efforts begin at the level of farm forestry. There is resource pressure on the forests of such countries because farmers are unable to realize the necessary products from their own farm lands. In Nepal it is not the large and well-to-do farmers who make much use of the public domain, it is the small farmers [Fox]. The small farmers are forced to use all of their farm lands for food production, leaving little land available for the production of fuelwood and livestock forage.

The Nepal Community Forestry Project has placed emphasis on stall feeding of livestock to keep grazing pressure under control on the hillsides. But any assistance in such agricultural settings will require two essential aspects: (1) efforts to augment the supply of needed products such as fuelwood and forage/fodder; and (2) efforts to alter the demand for such products. Supply-side programs will focus on investments and improved management of existing resources. Demand-side programs will focus on improved cook-stoves, and on fewer numbers of livestock--or on smaller animals that are more efficient feed converters.

PLAINS AGRICULTURE:

It is in the intensive areas of Indonesia, The Philippines, India, Sri Lanka, Pakistan, and Bangladesh that A/F activities have, perhaps, their greatest difficulty in being recognized as rational land-use alternatives. It is in these areas that the greatest investment has been made in agronomic infrastructure. It is here

that we find extensive irrigation systems, elaborate agricultural extension programs, and careful production and marketing strategies to ensure the respective countries that they might approach food self-sufficiency.

Yet it is also in these economies that we find extreme fuelwood shortages, a shortage of livestock feed, and a dearth of fruit trees. Development-assistance programs have fostered a monoculture of commercial agricultural practices that make it difficult to initiate programs to diversify land use. However, there are encouraging signs on the horizon. In Bangladesh, perhaps the epitome of land-scarce agriculture, the AID mission has identified an A/F project that would focus on farm-level production of fuelwood. The project will strengthen the capability of the Ministry of Agriculture to work with farmers in this endeavor. There are ample opportunities in such settings to promote the commercial production of fuelwood, to use field borders, ditchbanks, and roadsides for the production of livestock fodder, and to use home gardens for the production of fruits.

C. SUMMARY

AID missions and the regional bureaus will need to concentrate their efforts on at least four distinct activities. First, it is the technical staff in the missions and in Washington that can provide leadership in identifying successful and indigenous A/F systems in various regions. Second, these successful systems must be understood so that opportunities for technical improvements are well guided. It is also necessary that these improvements be understood and accepted by the local farmers. Third, the agency must understand how to replicate these successful systems on lands that are both suitable and available for A/F projects. Finally, it is through mission leadership that progress will be made in improving local and national government agencies and private voluntary organizat-

ions. A related opportunity is to work with such agencies to improve the institutional arrangements that govern resource use at the local level.

We stress again the critical role that research on agriculture and forestry technology and institutions will play in the development of effective linkages to create good A/F activities. The missions and the regional bureaus are essential partners with S&T in this important endeavor.

Finally, it would be a mistake to overlook that fact that few AID personnel have had much exposure to A/F programs and projects. Every effort should be expended by the missions and the regional bureaus to insure that staff-training opportunities in A/F are encouraged within AID. This could be accomplished with workshops, short-term visitations to ICRAF, or with specially prepared training materials.

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VI. ORGANIZATIONAL ISSUES IN AGRICULTURE/FORESTRY

While the bulk of this report has dealt with the technical aspects of an agriculture/forestry program, it must be emphasized that organizational issues within the Agency dominate any prospects for successful programming. It is this concern for organizational problems that constitutes the second dimension of an A/F strategy for AID mentioned in the Introduction.

It is also the case that organizational problems in the developing countries will bear significantly on the outcome of AID's A/F efforts. With respect to host-country issues first, forestry activities have traditionally been carried out by a separate ministry, or by a unit within the ministry of agriculture. Regardless of where it has been located, its actions have been in complete isolation of those agricultural entities concerned with field crops, horticulture, and livestock. Foresters have had the responsibility for managing the vast expanses of natural forests--and that management is almost always in the form of regulating entry and harvests; the effort has been largely regulatory in nature. The agriculturalists have been concerned with maximizing physical yields from monocultural systems, without much interest in the way that the different enterprises can be used to complement one another.

Within AID it is also obvious that organizational issues are paramount to the success of an Agency interest in agriculture/forestry. First, there are three distinct Agency Directorates with relevance for an agriculture/forestry effort--Food and Agriculture, Energy and Natural Resources, and Human Resources. Second, within the regional bureaus

forestry activities are part of energy and environmental programs rather than with agriculture. Not only does this impede logical alliances, but it tends to reinforce the perception that forestry is primarily concerned with large-scale plantations for the production of fuelwood. Finally, AID has very few trained foresters involved in forestry and agriculture activities.

There are several issues that must be addressed if agriculture-forestry efforts are to have any chance for success within the Agency. We urge that the Agency establish a Task Force on Agriculture/Forestry, composed of the Assistant Administrators or Deputy Assistant Administrators of the Regional Bureaus, PPC, and the Chair of the three relevant Sector Councils (Food and Agriculture, Energy and Natural Resources, Human Resources), to be co-chaired by the Deputy Senior Assistant Administrator for Science and Technology and the Assistant Administrator of one Regional Bureau (most likely Africa). This Task Force would be primarily responsible for assuring that agriculture/forestry activities receive priority attention at the highest levels of Agency administration. This high-level visibility and support is critical if there is to be the appropriate coordination between different management entities. In a word, this Task Force would provide the critical element that has heretofore been missing -- legitimacy.

To assist the Task Force, an Agriculture/Forestry Working Group should be established in S&T. This multidisciplinary team could be selected from among AID direct-hire staff, PASA/RSSA, IPA, or contract personnel as needed. One of the primary objectives of the Task Force and the Working Group would be to strengthen the relationship between the

Offices of Food and Agriculture, Energy and Natural Resources, and Human Resources. The areas of disciplinary expertise that will be required are as follows:

- o Tropical forester familiar with a wide range of woody plants, particularly those with potential for agroforestry.
- o Plantation forester familiar with tree-improvement and silvicultural techniques.
- o Agroforester familiar with intercropping and the integration of trees in farming systems.
- o Horticulturalist familiar with fruit and nut trees common to tropical areas.
- o Livestock-forage crop specialist with emphasis on woody forage plants and the management of livestock in agroforestry situations.
- o Field-crops specialist familiar with food grain and legume crops of the tropics.
- o Vegetable-crops specialist familiar with a variety of vegetable crops suitable for tropical agroforestry situations.
- o Soils specialists knowledgeable about tropical soils, agriculture, and agroforestry.
- o Agricultural or resource economist with farm management experience in the LDC's.
- o Anthropologist/sociologist with extensive experience in the tropics.

The above skills may be found in combination among some individuals, and it may also be possible to hire these disciplinary specialists for periods shorter than the life of the Working Group. Some of these skills may now exist among AID direct-hire staff.

The Task Force and the Working Group would: (1) undertake a synthesis of what is known about agriculture/forestry activities; (2) develop an Agency strategy in agriculture/forestry; (3) work closely with missions

and regional bureaus to identify the best places to initiate project activities; and (4) recommend backstopping staff needs by S&T and the regional bureaus. It would seem to make sense for the agriculture/forestry efforts to be concentrated in only one or two regions at the outset. Africa is an obvious choice. With the emerging efforts in India, Bangladesh, and Pakistan it may also be appropriate to include Asia. This does not mean that other regions should not proceed to develop agriculture/forestry projects; the fragile lands emphasis of the LAC Bureau seems particularly promising.

We close by reemphasizing the importance of the organizational problems within the Agency. There will be no progress in agriculture and forestry integration if there is not a strong commitment from the very highest levels of administration. Good administration means making difficult choices about a number of important things that might be done. We see every indication that the Agency considers agriculture/forestry programs and projects to be of utmost importance. But what matters is whether the senior administrators of AID believe that agriculture/forestry efforts can alter the environmental degradation now occurring in the developing countries--and can therefore contribute to the long-run ability of these countries to produce food. If so, talented technical personnel must be assigned to analyze, conceptualize, plan, implement, and evaluate these programs. In the absence of such a commitment, the Agency will accomplish little in stabilizing the resource base in developing countries.

VII. AN AGRICULTURE/FORESTRY STRATEGY

As indicated at the outset we consider an appropriate Agency strategy in agriculture and forestry to have two essential dimensions--an activity dimension, and an organizational one. We will address both in the context of the four objectives for this review.

A. OPPORTUNITIES FOR RESEARCH AND TECHNOLOGY DEVELOPMENT

We can summarize our findings by identifying three general activities in which research and technology development are appropriate for AID.

Technical Considerations

We have identified several interrelated activities that pertain to the technical aspects of agriculture/forestry. Central here are species selection research, research on cultural practices with different species grown for a variety of purposes, research on nurseries, and the establishment and monitoring of demonstration plots in various ecological and agricultural situations. Additionally, the Agency's interests in farming systems and in biotechnical research should be prominently mentioned.

In Appendix I. Robert Chandler has identified three specific activities that are consistent with the above plans. First is a research agenda that focuses on: (1) agroforestry in systems of shifting cultivation; (2) agroforestry systems in semi-arid areas where erosion is severe; and (3) agroforestry in the Sahel. Second is a training program that links Agency technicians to the process and results of that research agenda. And third is the establishment of an agroforestry network for the dissemina-

tion of research results. Such a network should logically be organized and administered by ICRAF.

Organizational Considerations

Agriculture/forestry efforts will be hampered unless the Agency devotes equal attention to programs and projects that deal with various agencies in the developing countries. Important in this regard are ministries of agriculture and forestry, agricultural and forestry research institutes, national extension services, and the universities. Research activities with, and technical support to, these agencies will be essential ingredients in the development of successful agriculture/forestry programs.

Institutional Considerations

Not enough is known of the cultural, economic, and social aspects of farmers regarding agriculture/forestry activities. The Agency should support research and prototype agroforestry projects to improve our understanding of these critical aspects.

B. AID'S PROJECT PORTFOLIO

The team did not have sufficient time to study in detail the Agency's entire project portfolio. However three projects appear to provide the appropriate scope and focus within which progress can occur.

F/FRED

The Forestry/Fuelwood Research and Development project appears to be

a very appropriate mechanism for integrating agriculture and forestry. In many countries the bulk of fuelwood is grown on farms and this project could be the locus of increased integration of agriculture and forestry.

Farming Systems

The Farming Systems project in S&T/AGR should be the most obvious integrating project possible. However, we were struck by the fact that it seems to be, almost exclusively, a cropping systems project to the exclusion of livestock, woody perennials, and horticultural crops. If AID is serious about integrating agriculture and forestry this project must be augmented by a serious commitment to agriculture/forestry interactions.

Agroforestry Research and Training Project

The stated goal of this project is to help improve natural resource management, and to increase forestry's contribution to on-farm production of food, fodder, energy, water, and shelter by supporting research and training in agroforestry. In concert with the previous two projects, this should give the agency a mechanism for improving the linkage between agriculture and forestry.

C. PRACTICAL RECOMMENDATIONS FOR ACHIEVING OBJECTIVES

The most important single step that the Agency might take to encourage an integration of agriculture and forestry is to legitimize that activity by creating an Agriculture/Forestry Task Force. The second step would be for this Task Force to establish a Working Group with the responsibility for the development of an Agriculture/Forestry Synthesis

Project. This project would have several components--training, technical support to missions, special research, and technology transfer. The Working Group would also be responsible for developing the scopes of work for the projects mentioned in parts A and B above.

The Task Force should also establish early contact with the CGIAR system--and with ICRAF--regarding the development of a research program on agriculture/forestry. It is obvious that the research activities being recommended throughout this report would be best conducted in conjunction with the various CGIAR Centers, and with ICRAF.

Finally, the Task Force and the Working Group should move quickly to develop an increased awareness of--and expertise in--agriculture/forestry interactions among all levels of AID personnel.

D. A TIME HORIZON

The Team is of the view that the Task Force and the Working Group could be established by March 1, 1985. Efforts to establish good working relations with several CGIAR Centers, and with ICRAF, could begin immediately. The Working Group could begin to develop the essence of the A/F Synthesis Project and should have it scoped out by July 1, 1985. The Working Group could also prepare briefing materials and other documents for distribution to selected missions by October 1, 1985. Follow-up contact with certain missions could occur beginning in November, 1985.

The research and technology development activities (part A above) can be initiated as soon as the staff of the Working Group is assembled. However, it must be recognized that the bulk of the activities implied there are of a long-run nature. For the remainder of the specific objectives,

the Team is of the view that many could be in place by the start of the 1986 fiscal year (October 1, 1985), and that the majority of them could be underway by July 1, 1986.

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APPENDIX I.
RESEARCH OPPORTUNITIES

Dr. Robert Chandler

Among the six priority areas that AID has selected for emphasis in its food and agriculture program is one entitled "increased production in less-favored natural resource areas." The suggestions and recommendations in this Appendix apply mostly, but not exclusively, to this priority area.

The less-favored regions of the world are highly variable ecologically. They include all areas where shifting cultivation is practiced, extensive semi-arid environments where irrigation is impossible and where inadequate and uncertain rainfall limits food, animal and wood production. Many of the semi-arid regions have the added disadvantage of steep slopes and uneven topography where soil and gully erosion are severe, where the populations of woody perennials* have been reduced greatly, resulting in scarce supplies of fuelwood. The severity of the problems in the disadvantaged areas increases continually because of the inexorable growth of both human and animal populations. It is estimated that approximately 500 million people in the world are attempting to eke out a living under harsh environmental conditions, where appropriate modern technology has not reached them or has not yet been developed.

*Because many other woody perennials--in addition to trees--have great potential in agroforestry systems, woody perennials is used to refer to both trees and shrubs.

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There is an urgent need to mount farming systems research programs that include crops, livestock, woody perennials--agroforestry systems that will protect watersheds, that integrate woody perennials, crop and animal production, and that, when properly applied, will enhance the economic and social well-being of rural populations.

The problems of the disadvantaged people in rural areas are so severe that there are no quick or easy solutions. Not only must appropriate research projects be designed to overcome the major constraints to productivity, but training programs in agroforestry have to be developed and widespread extension programs must be launched.

The ecological environments of less-favorable areas vary so greatly that a host of research projects will be required to devise solutions to the major problems causing extreme poverty in the disadvantaged areas. In spite of the complexity of the situation, an attempt is made below to outline a few research projects that are seriously needed to reverse the current downward trends in per capita production of food (plant and animal) and wood products, and to decrease rates of soil erosion and soil fertility depletion. Included will be suggestions as to how USAID can best support these research (and accompanied training) efforts with particular reference to Africa.

Before discussing the kinds of field research that are needed, it should be understood that the assumption is made that any system developed should be such that the products are marketable. The main purpose of all systems is to increase the income of rural people.

Research and Training Projects That Deserve Support from AID

The proposals that follow, to a large extent, are developed with the idea that support funds will be provided by AID to the International Council for Research in Agroforestry (ICRAF). This is done because ICRAF is the only

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agency in the world that is working exclusively with agroforestry. Furthermore, it has a professional staff of 16 people, most of whom have Ph.D. degrees in either the natural or social sciences.

AID has already invested one million dollars in ICRAF to build up the capacity of that institution to service its clientele (LDC inhabitants). The Council is now ready to play a more direct role in research. It is recommended that ICRAF be chosen as the agency to organize and administer an African network of research and training in agroforestry. Assuming that AID makes a sizeable grant to ICRAF, it is recommended that ICRAF develop the master plan for the network, and that it becomes intimately involved in hands-on research--helping the national research scientists to design, implement and guide projects that will produce the needed information to increase the productivity of disadvantaged rural populations in Africa.

1. Developing Systems of Permanent Agriculture to Replace Shifting Cultivation. It is estimated that about 250 million people in the world are practicing shifting cultivation as a means of subsistence farming. As populations increase, the time allowable for forest fallow decreases and in many areas crop yields are already decreasing because of depleted soil fertility. It is essential that systems of permanent agriculture be developed to save the forests from eventual destruction. In order to illustrate the kind of research project that could be developed, the assumption is made that a major, long-term project would be supported through the International Council for Research in Agroforestry (ICRAF), but with the work being done at the Central Agricultural Research Institute (CARI) in Liberia.

This institute is located in Suakoko in an area representative of the tropical humid forest zone of West Africa, particularly in the countries of Guinea, Sierra Leone, Liberia and the northwestern part of the Ivory Coast,

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where annual rainfall ranges from 1800 to 2800 mm. The soils are mostly derived from granitic materials, and are sandy, porous and acid. The topography is hilly and subject to severe soil erosion when the land is cleared of trees. Shifting cultivation is widely practiced and rainfed rice is by far the most important food crop. Forest trees are so abundant that there is no shortage of fuelwood. The presence of the tsetse fly makes it impractical for farmers to raise cattle. At present the only power for cultivation is man with his hand hoe. Consequently no farm family can cultivate more than one hectare, and usually it is less than that.

An agroforestry project in such an environment could include terracing the more gentle slopes near the bottom and tops of hills where such food crops as upland rice, maize, and vegetables would be grown year after year. The steeper slopes between the terraces would be protected from erosion by planting such woody perennial crops as cacao, coffee, coconut, and oil palm, as well as bananas, plantains and papaya. Forest trees would also remain on the slopes for use as fuel, poles, etc.

Trials would be conducted on the level terraces to find the most profitable ways of maintaining soil fertility without resorting to a bush fallow period. Such practices as bringing in leaf litter from adjoining forest stands should be tried, both as a mulch and incorporated as green manure.

In the West African humid forest zone, most families have control of 5 to 10 hectares for shifting cultivation; thus, there is an abundance of land from which to collect forest litter. This method would accomplish the restoration of soil fertility that occurs with the shifting cultivation technique. Obviously, there are many low-level technology experiments that can be conducted on the terraced areas, including alley cropping with leguminous woody

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perennials, such as species of Leucaena, Gliricidia and Sesbania. Furthermore, as has been successfully done elsewhere, instead of constructing level terraces with bunds to prevent soil erosion, areas could be cleared and contour hedgerows of leguminous woody perennials planted to catch the eroding soil and thus form "natural terraces."

Research work should not be confined to low-level technology. On the terraced areas, fertilizer trials should be conducted with not only the major elements of N, P, and K, but also with minor elements such as zinc, boron, and, when leguminous crops are grown, molybdenum. Furthermore, because draft animals are essentially non-existent in humid West Africa, mechanical means of land cultivation should be tried experimentally. Undoubtedly, land clearing and terrace construction will be done by hand, but after the stumps have been removed, or have rotted, small 6-8 horsepower walking, two-wheeled tractors could be used. It is fully realized that the infrastructure does not now exist for mechanical tillage in West Africa, but first the best methods for land preparation must be developed on experiment stations.

Obviously, many field and laboratory investigations will be conducted. Soil moisture regimes will be studied under different spacings. Soil organic matter and soil nutrient contents will have to be monitored in successive years after land clearing, and, naturally, crop yields will be measured. After systems of crop rotation and land use are well established, economic studies must be made to determine the profitability of the "permanent agriculture" system versus shifting cultivation.

The above sketch of a research project to study a permanent farming system to replace shifting cultivation applies only to humid forest zones well covered with trees. However, shifting cultivation occurs in the tropical savannas and variations in project design will have to be made to fit the

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drier environments where rainfall usually varies between 900 and 1200 mm. In such areas, the planting of additional woody perennials and closer examination of competition for soil moisture between food and woody perennial crops at different spacings will have to be made. Spacing, degree and frequency of pruning the leguminous woody perennials in alley cropping will be studied.

The development of the root systems of the woody perennials should be investigated, including the effect of their root systems on the food crops grown between the rows of woody perennials. Generally, much less upland rice will be grown, and the principal food crops will be maize, sorghum, cowpeas, and such root crops as cassava, yams and sweet potatoes.

A subject which is pertinent to all areas involving increasing the use of trees is that of land tenure policies. Farmers are much more likely to plant trees (as well as other woody perennials that would be part of a permanent agricultural system) if they know that they have permanent possession of their land. If they fear that the government may force them off the land, they certainly would not invest their meager resources in tree planting from which returns might be a decade or more ahead.

To support the humid forest zone project, it is suggested that AID make a grant to ICRAF which will permit that organization to place a regional agroforestry coordinator in Liberia who would stimulate, help plan and guide research projects in the tropical humid forest zones of West Africa, yet who would devote a large portion of his or her time to implementing a major research project in Liberia, by forming a team of scientists from among the group of professionals who are already stationed at Suakoko. Unfortunately, Liberia is now going through a severe economic crisis and, although it pays the salaries of its staff at CARI, operating funds are almost non-existent. Therefore, AID would have to provide all operating costs.

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There is a strong possibility that the Near East Foundation, with headquarters in New York, would be willing to provide funds for the salary and perquisites of the regional coordinator, if AID would furnish funds for operating the project (any discussion of financing research projects through ICRAF is predicated on the assumption that ICRAF's mandate will be revised to include greater participation in technology generation).

While discussing financial support for ICRAF's program, it should be pointed out that ICRAF finds it difficult to manage special projects without additional money for core budget to cover overhead expenses. It is recommended that AID either include an overhead item in its grant or find other ways of increasing the contributions to ICRAF's core budget. One suggestion is that AID determine whether the World Bank would be willing to make a sizeable (say \$200,000) grant to ICRAF for core budget support, to provide the overhead costs of the AID-supported research projects.

An important source of cooperation and assistance in conducting agroforestry research in Africa is the three international agricultural research centers that either are located on that continent or have major research programs there. The International Institute of Tropical Agriculture (IITA) in Nigeria is already conducting research in agroforestry. The International Livestock Center for Africa (ILCA) in Ethiopia could readily study woody perennials and forage crops as a part of farming systems involving livestock. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), although with headquarters in India, has a major operation in Niger. It would appear that it could include in its African research program studies of farming systems combining food crops, woody perennials and livestock.

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In order to include these institutions in a network (discussion at the end of this section) of agroforestry research in Africa, the suggestion is offered that representatives of AID/Washington who have an integral knowledge of agroforestry, visit the three International Centers to determine their interest in cooperating in such a network.

2. Developing Agroforestry Systems in Semi-Arid Areas Where the Topography is Hilly and Where Both Sheet and Gully Soil Erosion are Severe.

An example of this ecological situation is in the Machakos District of Kenya, which receives about 700 mm of rain annually in a bi-modal pattern. Too few woody perennials remain and this, along with severe overgrazing, has caused excessive soil erosion. During the British colonial period much of the steeper terrain was terraced. As an anti-colonial gesture, many terraces were destroyed after independence, and productivity has decreased. Furthermore, the numbers of unconfined goats and cattle are larger than the remaining vegetation can support.

The research needs of this environment include studies of hedgerow contour planting, re-establishment of terraces accompanied by spacing trials of alley cropping with leguminous woody perennial species, with and without fertilizer being applied to the food crop. Studies are urgently needed on the degree of competition between leguminous woody perennials and food crops for space, soil, moisture and nutrients. In addition, information is lacking on the yields of woody perennials used for fuelwood and forage when planted as hedgerows, living fences and in alley cropping (yield measurements should be made on such primary products as forage or mulch, with by-products such as firewood measured as a secondary product of the farming system).

ICRAF scientists have attempted to extrapolate some results of this type obtained in the humid areas of Asia to the semi-arid regions of Africa with

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unsatisfactory results. Farming systems research should be conducted to identify the most satisfactory means of protecting newly planted woody perennials from livestock. Living fences, and confined feeding of goats and cattle are possibilities that have proved successful elsewhere, when adequate supplies of forage are available in a cut-and-carry system.

Watershed protection, water harvesting, and gully erosion control are essential elements in restoring the hilly, semi-arid environment that is so badly degraded in much of East Africa. ICRAF, having its headquarters in Nairobi, could help design and conduct research in this area if adequate financial support is provided. Much of this work could be done by research fellows assigned to ICRAF working under the direction of the senior scientists of ICRAF.

3. Agroforestry Research in the Sahel. This belt of sub-Saharan Africa stretches from the Atlantic coast of Northern Senegal and Southern Mauritania eastward to Somalia's coast on the Indian Ocean. Annual rainfall ranges from less than 300 to about 600 mm, falling mostly from mid-July to mid-October, but with about half of the precipitation occurring in August.

The use of woody perennials in the arid Sahelian environment is quite distinct from that in areas of greater rainfall. There are few groves of trees, yet scattered single trees are a part of the natural vegetation. In the northern portion of the Sahel where annual precipitation is often no more than 300 mm, most of the perennial grasses have disappeared, and by the end of the dry season woody perennials are about the only source of food for livestock. The annual grasses reseed themselves when the rains come in July.

The northern portion of the Sahel traditionally has been populated by nomadic herdsmen, who drive their cattle southward after the rainy season has ended and the livestock have consumed most of the grassy vegetation. Rainfall

increases from North to South, so better grazing conditions are available in the Southern Sahel. There is a modern trend, however, toward a more sedentary population, particularly because of the many deep wells that have been drilled to tap fossil water sources. Sometimes as many as 20,000 cattle are maintained around a single well with the result that all vegetation has disappeared for a distance of several kilometers from the well.

Space in this report does not permit discussing all of the many research projects that should be initiated in the Sahel. However, a listing of some of the more important ones follows:

- a. Means of improving the survival rates of newly established seedlings of such valuable and well-adapted tree species as Acacia senegal (the source of gum arabic) and Acacia albida (important because it drops its leaves at the start of the rainy season, thus allowing food crops to be grown under its canopy without competition for light and water). It has been reported that reforestation efforts in the drier parts of the Sahel have resulted in only about 20 percent survival during the first year.
- b. Protection of areas from livestock and people so as to study the natural return of woody perennials and grasses (at least a 10-year study is needed).
- c. Determine the optimum number of trees per hectare of land as a guide to re-establishment of the tree population (under current conditions grazing animals obtain nearly half their food from woody perennials during the latter part of the dry season). More woody perennials are needed not only for forage but to increase fuelwood supplies. A World Bank report states that fuelwood consumption in the Sahel exceeds current growth rates by factors of 5 to 10.

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- d. Slight land depressions are scattered over the Sahel where water accumulates during the rainy season and lasts for varying periods into the dry season. Although herdsmen water their animals from these sources, they are otherwise under-utilized. Studies should be made for growing crops and woody perennials around these areas, using inexpensive irrigation methods tapping the groundwater sources that exist.
- e. The economic feasibility of growing trees under irrigated conditions along the Senegal River in Senegal, Mauritania and Mali should be studied. After two dams now under construction are completed, over 400,000 hectares can be irrigated in the Senegal River basin. Furthermore, the economics of growing grasses and leguminous forage crops under irrigation should be studied.
- f. Although about 120 species of woody perennials are found growing naturally in the Sahel, promising multipurpose exotic species should be tried experimentally.
- g. The impact of windbreaks on the growth and survival of food crops should be explored.
- h. It appears that little research has been conducted in the Sahel on the introduction and testing of exotic species of grasses or of woody perennials. It is possible that yet untested species from the arid zones of Asia or Latin American might contribute to livestock feeding in the Sahel, and in other semi-arid parts of Africa.

To accelerate research work in the Sahel, it is suggested that USAID provide sufficient funds to ICRAF to enable it to station a regional coordinator in the area who could stimulate and assist in planning and carrying out research along the lines mentioned above. This person could transfer the

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results back to ICRAF, and could also keep in touch with several other international agencies that are supporting research and development work in the Sahel, such as the Institute for World Forestry (Hamburg, Germany) the Club du Sahel, CILSS, IDRC, the World Bank and others.

4. Research or Training Projects that Support or Develop Technology for the Three Major Projects Outlined Above. Agriculturalists, foresters and agroforesters have written much recently about technology development and training required to make significant progress in designing farming systems involving associations of crops, woody perennials and livestock. Some of the more apparent projects are presented below:

- a. Multipurpose woody perennials improvement, seed collection, storage and distribution. ICRAF is establishing a data base for woody perennials with its computer facilities. This is an excellent move, but it is necessary to collect seed from superior trees and shrubs, to maintain its purity, to store it properly and to multiply and distribute it. This is obviously a network activity participated in by private and national agencies. IDRC of Canada has shown an interest in providing support for such an effort.

Although work should proceed immediately in developing seed sources of superior strains of woody perennials, a long-term program that should be undertaken is that of tree improvement (tree breeding). There is evidence to support the idea that similar increases in productivity of trees and shrubs can be brought about through plant breeding, as has already been achieved in breeding agricultural crops.

- b. There is considerable evidence to indicate that mycorrhizae may play a significant role in the early establishment of newly planted trees,

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especially by increasing the uptake of phosphorus and perhaps other essential mineral elements. This area of research needs investigation. It would seem to be an ideal project for a U.S. university with an international program to undertake. Obviously, the field trials in tree establishment must take place where the problems lie.

- c. Although agroforestry is an old art, it is a new area for scientific investigation. The training of personnel, including scientists, teachers, field workers, and even administrators, is needed. For some scientists and administrators it is simply a matter of acquainting them with the potentials of the agroforestry approach to problem solving.

There are two important tasks to be performed in agroforestry education and training. One is to develop curricula for agroforestry in both post-high school vocational schools and in degree-granting institutions of higher education, especially in the third world countries. The other is to develop training manuals and courses for young scientists in the countries where agroforestry is, or can be, important. These courses should be designed so as to train the trainers; that is, to prepare people to return to their own countries and conduct training courses there.

With respect to the first task, in a report on a mid-term assessment of AID-supported projects at ICRAF, it is recommended that funds be made available to ICRAF to organize a task force of educators to design appropriate agroforestry curricula.

Regarding the second task, it is recommended that support be continued for ICRAF to conduct training courses in Kenya and at least one course a year in other countries. However, future courses should be designed to develop

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expertise in attacking major agroforestry problems that confront the farmers, rather than to simply enlarge the trainee's exposure to agroforestry.

A part of the earlier recommendation was that ICRAF prepare a training manual in agroforestry. Since that time, April 1984, it has been discovered that OIDC/USDA in cooperation with Duke University and the Organization for Tropical Studies, Inc. (but with funding by AID), is now engaged in developing instructional materials in Spanish for use in Latin America. CATIE in Costa Rica is a key institution in developing this course.

Since Mrs. Esther Zurberti of ICRAF is Spanish speaking and is in charge of ICRAF's training program, the suggestion is offered that she work closely with the people at CATIE and utilize whatever materials are appropriate for the ICRAF agroforestry training course. Furthermore, of course, she undoubtedly can contribute valuably to the preparation of the training manual for Latin America.

An Agroforestry Network for Research and Training

Although suggestions are made in this report as to how individual projects might be organized and supported, there is a need to develop an African network for research and training. Such a network should be organized and guided by ICRAF. An early activity would be to hold a workshop to determine the interest and needs of sub-Saharan Africa where the development of agroforestry systems is especially urgent. Research projects should be initiated with as much participation by national scientists as possible. Research conferences should be held at least every two years to report progress and to plan studies for the future. ICRAF's staff should visit cooperating countries frequently to provide encouragement and guidance to ongoing projects.

As mentioned earlier, the seed collection, testing and distribution activities should be an integral part of the network. The training program must become a network activity also. As ICRAF trains the trainers, it is essential that agroforestry training courses be conducted in other African countries. It is only in this way that a cadre of professionals in agroforestry systems of land management can be developed.

Because IITA is already conducting research projects in agroforestry and because it has excellent facilities for feeding and housing trainees, the possibility of that institute conducting an occasional course in agroforestry should be explored.

In any discussion of networks, it should be mentioned that research in agroforestry could well be integrated, in part, into ongoing AID programs or projects such as those in fuelwood, farming systems and on-farm forestry. Wherever trees, crops and animals are part of a system, there is an opportunity to gain additional knowledge as to how agroforestry can contribute to increased productivity and to the protection of fragile environments that have been overexploited by man.

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APPENDIX II.

INDIVIDUALS INTERVIEWED BY THE TEAM
(all with AID unless noted otherwise)

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