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DESFIL
Development Strategies for Fragile Lands

THE INTERFACE OF TECHNOLOGY WITH INCENTIVES AND POLICY FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT IN SUB-SAHARAN AFRICA

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ACRONYMS

AF	Agroforestry
ANRO	Agriculture and Natural Resources Office
API	Assessment of Program Impact
CBA	Cost-Benefit Analysis
CFA	Communaute Financiere Africaine
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CR	Communaute Rurale
DESFIL	Development Strategies for Fragile Lands Project
FAO	Food and Agriculture Organization
GIS	Geographic Information System
IARC	International Agricultural Research Center
ICRAF	International Center for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IITA	International Institute for Tropical Agriculture
IMF	International Monetary Fund
KAP	Knowledge, Attitudes and Practices Survey
LOP	Life of Project
LUMP	Land-Use Management Practice
M&E	Monitoring and Evaluation
NGO	Nongovernmental Organization
NPA	Non-Project Assistance
NRM	Natural Resources Management
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer
OTA	Office of Technology Assessment
PAM	Policy Analysis Matrix
POL/CDIE	Political/Center for Development Information and Evaluation
PRA	Participatory Rural Appraisal
PVO	Private Voluntary Organization
SFE	Soil Fertility Enhancement
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
USAID	U.S. Agency for International Development

I. INTRODUCTION

African agriculture faces a major challenge in the next few decades. It will need to double food production to keep pace with a growing population and provide an adequate source of household income to purchase additional food (Mellor et al., 1987). Although traditional, extensive, shifting agriculture will remain important in a few regions, the vast majority of the African farmers—women and men—will have to move toward a more intensified, permanent agriculture where more internal and external inputs (including information and management) are more efficiently used (Rodale, 1985). Technology has always played an important role in this process throughout the world. Therefore, technological innovation to enhance low-resource agricultural systems will be a major factor in determining Africa's ability to meet the challenges ahead.

Improved management of the natural resource base depends essentially on promoting land use systems that retain a permanent vegetative cover over the land surface (Lal, 1987). This protects the soil from wind and water erosion, increases soil fertility, improves the soil organic matter content, and maximizes water penetration. Crops, grasses, or trees grown under such systems inevitably benefit—as do the resource users of the land who find productivity and profits once again on the increase.

This point is critical because, ultimately, how a country's land is managed and used depends upon the perceptions and actions of its many thousands of individual farmers—women and men, pastoralists, foresters, and other land users (Harrison, 1987). These people have the ability to bring about fundamental changes in land use. The challenge is to create the conditions that will provide this motivation.

A new approach is needed—one that will ensure the large-scale participation of rural people in conservation of the natural resource base because of the benefits it will bring (Spencer, 1986). The assumption that there is a "technological solution" is no longer valid in and of itself. Policy implications and other incentives needed to change resource users' behavior to sustainable management of the natural resources base must be understood. Governments will still need to take the overall responsibility for conservation, but their main role will be to promote the participation of rural people in finding and applying solutions. Farmers and herders, not planners, are the people who finally decide what will and will not be done on agricultural lands. They make rational decisions according to their own circumstances. What they decide is influenced by physical factors, such as soil and climate, the technical advice and assistance available to them, the socioeconomic features of their community, and their own personal situations.

A central thesis of most development efforts is that technology to combat land degradation in Sub-Saharan Africa (SSA) is readily available and that what is needed is to transfer this technology to the farmers (Wittwer, 1988). This belief in the adequacy of the present scientific and technical knowledge is debatable, but continues to be reflected in the focus on technology transfer found in many discussions on intensifying Africa's agricultural production systems.

Despite this belief, it is widely recognized that attempts at improvement have failed to make a broad impact (Anderson and Thampapillai, 1990). Most natural resources management (NRM) interventions have focused upon the physical environment and upon measures to solve technical problems. They tend to overlook the fact that development is about people, their immediate welfare, and the well-being of their descendants. It is the way in which people of the current generation utilize natural resources that determines the physical potential to support future generations.

There is a sufficient range of technically proven and economically attractive natural resources interventions to halt the decline of rural production systems in SSA. Better technological packages can and should be developed, but technology is not the limiting factor. The greater development challenge is to understand and establish the enabling conditions necessary to bring about widespread adoption of appropriate and sustainable NRM strategies and practices.

The poor performance of most NRM projects in SSA is evidence that an entirely different approach to NRM is needed. If resource users are to play a key role in NRM, conditions should be created that enable them to use sustainable NRM practices with little or no external support. This will be possible only if techniques have the following characteristics: simple, low-cost, low-maintenance, and efficient; for example, short-term yield increases and/or stabilized yields. A recent policy document of the International Fund for Agricultural Development (IFAD) on NRM in SSA (Critchley et al., 1992) has identified and analyzed a range of issues for designing NRM and planning strategies. The document states, "The first step in the design process of a new NRM program or project should be the identification of indigenous farming systems, and the next step should be to determine whether and how these traditional conservation techniques can be used as starting points or building blocks for a modified, more sustainable systems approach to NRM, and how their efficiency can be improved" (Critchely et al., 1992: 43).

Many studies have found that successful efforts have tapped local initiative, and that social, economic, political, legal and policy factors, as well as the correct technology options, were vital parts of a framework needed to provide the incentives for farmers to intensify and more sustainably manage their production systems (SPAAR, 1987). There is a growing realization that the sum of technology-driven projects carried out without restructuring this framework to include socioeconomic factors will not add up to sustainable development.

This paper discusses certain factors or conditions that are conducive to sustainable agricultural development in SSA, issues to consider when promoting sustainable agriculture and NRM, certain incentives that could lead to improved resource user participation in the sustainable management of natural resources of fragile lands in Africa, and a technological and socioeconomic framework that could lead to the design of appropriate strategies for African resource users to sustainably manage their natural resource base through improved agricultural systems.

II. ENABLING CONDITIONS

The importance of having rural resource users and their communities involved in planning and design of interventions is critical to intensifying African agricultural production systems (Conway et al., 1987). Lack of community involvement in many of the past development efforts have led project planners to focus on such topics as agroforestry techniques, water retention, or the economics of village woodlots and other types of plantations. When consulted through participatory rural appraisals, farmers and herders often focus directly on income, credit, prices, and stable markets—the preconditions for successful investment for transforming production systems (Conway et al., 1987). Almost universally, they saw the technology problem as one that could be solved (at least at their community level) with appropriate help from the outside, **once certain conditions were in place.**

Some areas where actions, if taken, could create conditions necessary to enable resource users to practice sustainable NRM in SSA include:

- Investments to rehabilitate the natural resource base
- Local participation and the use of indigenous knowledge
- Decentralized management
- Indigenous institutional development
- Land tenure security
- The role of women
- Extension services for technical assistance.

A. Investments for Regenerative Agriculture

Land rehabilitation must be seen not only as a way of conserving natural resources, but above all as a way of improving production and generating sources of incomes so that users of that land will be encouraged to invest in its improvement. In short, if it is not in the interest of those who must make it happen, it won't happen. This basic principle has eluded many project planners and implementors over the past two decades, contributing heavily to some of the more spectacular natural resource project failures in SSA.

New NRM strategies require a move from extensive to more intensive land use (Francis et al., 1986). This in turn implies making investments that will not necessarily have an immediate payoff. Some (such as contour dikes) will yield short-term benefits that will continue for two or three years. Others (such as *Acacia albida*) will provide sustained benefits, but may not have an impact until several years after the investment is made. Also implicit in the strategy of more intensified land management is the *diversification* of land use to reduce risk and stabilize yields and income flows (Jayne et al., 1989). Grain, fuel, fodder, construction supplies, and marketable products (poles, fruits, vegetables, grasses, and so forth) are among the outputs of a more diversified farming system.

B. Local Participation and the Use of Indigenous Knowledge

The question of participant incentives affects the level of participation, the rate of adoption both within and beyond a given project, and the sustainability of new approaches to NRM when projects (and/or support) come to an end. Development planners and policy makers are beginning to recognize the need to understand existing knowledge systems and decision-making processes as they focus their attention on the role that resource users can play in planning and implementing NRM interventions (Warren, 1991). These systems influence current farming practices and responses of the resource users to agricultural and natural resource policy initiatives and technological innovations.

Ecological rehabilitation involves systematic management of renewable natural resources at the local level (Berkes, 1989). Three axioms are raised here: 1) that resource management is necessarily a localized process, 2) that better techniques exist but are not always known by the populations, and 3) that greater empowerment of local organizations is a prelude to better NRM.

Some of the basic priorities for a regional NRM strategy are: 1) adoption of appropriate strategies improve NRM across the region; 2) elimination of immediate, nontechnical obstacles to widespread adoption, for example, lack of skills transfer and local empowerment; and 3) further research to complement, but not replace, traditional management systems where known practices exist which reduce risk.

C. Decentralized Management

Sustainable NRM in SSA calls for an understanding of the incentives that determine strategies and practices resource users adopt at the community level (ARD, 1992). The incentives that determine what decisions are made are shaped by a complex relationship of technical, socioeconomic, and political factors as well as by the attributes of the resource; the attributes of the resource users and communities; and the rules affecting access, use, and control of resources. Once these factors affecting resource user behavior are understood, improved technologies and/or institutional reforms may be identified. Appropriate incentives would allow resource users to modify their strategies and adopt more sustainable NRM practices.

Three key issues integrate and synthesize an analysis of conditions conducive to decentralized community-based NRM in three countries in SSA (ARD, 1992): 1) preserve and promote indigenous social capital that can greatly enhance the ability of local communities to sustainably manage their natural resources; 2) establish the legal status of community-based organizations to make and apply rules, mobilize resources, constitute new special purpose jurisdictions, and resolve disputes according to local rules; and 3) decentralize public authority to allow local resource user groups to govern and manage their natural resources.

Decentralization is both a matter of defining local rights and increasing them. By implication, defining local rights also requires redefinition of the role of the state. It will be

necessary to establish a framework in which the state role is more oriented toward establishing the "infrastructure" within which local development could take place: resource inventories, training, extension, credit systems, pricing policies, and, of course, a framework for local management rights. Herein lies the new role for community organizations: rural development policies must seek to increase the incomes of rural inhabitants and help a nongovernmental sector to take shape (Spencer, 1986). The success of this "nongovernmental sector"—individuals, households, local communities, rural organizations—will determine the course of NRM in SSA. The success of the public sector (government and donor) is judged in terms of its ability to serve as a catalyst.

D. Indigenous Institutional Development

Despite the rapid growth in urban centers, the greater percentage of the population in most African countries reside in numerous small towns and villages. Many African governments have tried a variety of mechanisms to ensure more equitable distribution of national development efforts to the rural sector. A growing number of development planners are recognizing the fact that it is cost-effective to work with and through indigenous rural organizations and institutions, providing opportunities for them to strengthen their capacity for self-reliant development for sustainable NRM (Warren, 1992).

Until recently, many national and international development agencies have tended to overlook the historical and contemporary role of indigenous organizations and associations in community-level efforts to identify and prioritize their problems and seek solutions to them (Warren, 1991). It is now apparent that indigenous knowledge and decision-making are operationalized through indigenous organizations such as traditional councils, gender groups, and social and religious groups. It is essential to include these indigenous organizations in the planning, design, and implementation of community-based NRM interventions in order to assure sustainable agricultural development.

E. Land Tenure Security

The underlying premise for the land tenure argument is contained in point A, capitalize the land. The land is degrading rapidly, with productivity declines occurring in step. Land scarcity and demographic pressures make it impossible to offset these declines by continuing to bring unexploited land into production; the usual trend is that fragile lands are being cultivated (Lawry, 1989). Traditional methods of extensive land use are therefore no longer sustainable, and rehabilitation measures must, in order to be successful, assure that users of productive lands will be encouraged to invest in its improvement.

Land tenure and agrarian structure, defined broadly as the nature and distribution or rights and access to land and other resources, have an important influence on technology adoption (Roth et al., 1992). Where land tenure is insecure, there are few incentives for resource users to invest in regenerative or sustainable agricultural management practices.

Women's resource allocation rights are an often neglected part of the land tenure equation (Kumar, 1987). Men and women bear different work burdens and respond to

different incentives. For example, women's work could be sharply reduced by greater community production of fuelwood, because they do the brunt of the collection. Men, on the other hand, with decision-making authority on allocation of land resources, may not be as motivated to invest in firewood production. Such resource allocation problems would not necessarily be resolved through greater security of land tenure, unless the concept of greater security was broadened to include both sexes, rather than just the distinction between the "household" and the "community".

F. The Role of Women

The historic role of women in rural areas has been altered by desertification and rural exodus (Kumar, 1987). As a result, women today are performing different tasks, and, in particular, they play an essential part in ecological rehabilitation and local-level NRM.

However, their formal status within society is still incongruous with this new level of responsibility they are assuming. Increasingly, women are asking for sufficient land so that they can meet their food and monetary requirements; they are seeking access to farm machinery and, therefore, credit facilities; and they wish to take part in the decisions that affect the life of the community.

In SSA, a number of issues need to be addressed to include women in sustainable agricultural development. What are the opportunities and constraints for women resource users to participate fully in development planning and implementation of sustainable NRM interventions? What is the existing indigenous knowledge influencing womens' NRM strategies and practices at the household and community levels and what is the potential to use this knowledge for developing sustainable NRM interventions? What are the economic survival strategies of women as household and community members and what are the potentials of these sustainable NRM interventions to improve their economic bases.

Training of male extension agents to target women resource users is needed in those areas of activity where women are involved. Extension work is too often aimed exclusively at the men (Spring, 1985). In addition, aid should be made available in order to lighten women's day-to-day workload and to diversify productive and other activities enabling them to find new sources of income.

G. Extension Services for Technical Assistance

Local experience, or indigenous knowledge, is particularly useful in technology development (Moock, 1986). Valuable lessons can be learned from successes as well as from failures of past agricultural research and extension programs and projects. Extension services should play major roles in agricultural education and development schemes. They offer direct technical assistance to the resource users on a day-to-day basis, and they could provide research scientists with invaluable information on resource users problems and needs. If experience sharing is organized and encouraged, development efforts progress faster and reach wider audiences. A genuine communication policy should be adopted by developing countries in order to achieve these aims. Such a policy addressing the needs of the local

resource users and their communities would accord rural problems the priority they deserve to achieve sustainable NRM. One of the most effective tools for the transfer of technology, such as sustainable NRM interventions, has been through the use of participatory methodologies that include research, extension, and local resource user groups to identify the problems (and their underlying causes) and acceptable solutions to the sustainable management of fragile lands.

To consolidate efforts to improve agricultural and environmental rehabilitation techniques, close attention should be paid to the development of managerial and leadership skills required for the management autonomy of local communities (Moris, 1985). Experience sharing is needed here also, but suitable training of extension personnel in NRM is an even more pressing requirement.

III. PRODUCTION SYSTEMS, INCENTIVES, AND POLICY

There is an alarming conflict between increasing environmental degradation in SSA and the pressing need to increase food production and reverse stagnation in agriculture (World Bank, 1986). There is also a concern that the introduction of high-input systems may further degrade the environment in SSA (Andrews, 1987). Low-input systems are traditionally lauded for being "kinder" to the environment—low tillage, for example, maintains soil integrity, such as soil structure and texture. This controversy focuses on the static, direct effects of low- and high-input production systems on the environment. Recently, however, proponents of systems to intensify production have stressed that land use is inefficient and performance is poor with low-input systems (Carr, 1989). The poverty that arises therefrom, combined with increasing food needs (as a result of rising population), leads farmers to crop marginal lands of lower quality, which is easily degraded.

This section discusses three important issues that face agricultural researchers and policy makers in promoting sustainable agricultural and NRM systems in SSA: 1) appropriate production systems, 2) incentives for farmers to invest in sustainable agriculture and NRM, and 3) the effects of policy on these incentives. This discussion will focus on the Sahel of West Africa where there are several agroecological zones distinguished mainly by the rainfall isohyet in which they are located: sahelian (most northernly zone), sudano-guinean, and guinean savannah.

A. Appropriate Production Systems

- Have socioeconomic studies of traditional production systems been conducted to assist in the understanding needed for recommended interventions?
- What production systems should researchers be proposing to farmers for evaluation?
- Where and when should high-input versus low-input systems be promoted?
- What are the environmental consequences?
- How do the answers to these questions differ between high- and low-potential areas?

In the Sahel, higher-input systems perform better than low-input systems mainly in high-potential zones in the Guinean belt. In these zones, intensification of production would reduce pressure to crop marginal lands (Lal, 1987). Higher incomes would produce growth linkages and provide more cash for investments in soil conservation. In the low-potential areas to the north of the Guinean belt, by contrast, fertilizer, new varieties, and deep tillage have not produced more promising results than traditional methods because of a variety of soil and moisture problems. Clearly, intensification is not automatically desirable or sustainable.

Low-input, high-productivity systems are often touted as a panacea, and they are especially attractive in West Africa because of the difficulties experienced in accomplishing a "green revolution" in that region (FAO, 1984). Modified traditional systems (which include techniques such as green manuring and bunding) promise output increases with a low level of reliance on imported inputs and infrastructure (although extension costs can be substantial). Given foreign exchange constraints and underdeveloped infrastructure, this is quite an advantage. But research on the development of "nontraditional" (high-input) systems is still in an early stage. Great hopes reside in their potential, but it is important to note that the extension and support costs (for delivery, storage, and so forth) of these techniques could be prohibitively expensive in countries, such as those in the Sahel, with scarce fiscal resources, small and/or underdeveloped extension services, and poor roads and other facilities.

It is very important to distinguish between types of zones in recommending production systems and designing sustainability measures (Charreau, 1974). Low-potential zones are areas of high degradation combined with high population density (for example, the Central Plateau in Burkina Faso). Sociopolitical factors and diseases and pests in higher-potential zones constrain permanent migration out of the low-potential zones. Erosion, porosity, acidity, and low organic matter content typify their soils.

There are also areas where current performance is low, but the relative potential for increases in productivity and intensification is high (Lal, 1987). These areas are mainly south of the Sudanian savannah areas, in the Guinean savannah belt (for example, the southwest of Burkina). Population densities are often lower than those in the low-potential zones.

In the two different types of regions, there will be different environmental problems and challenges, as well as different agricultural strategies. This translates to different research approaches. In the low-potential zones, low-input or modified traditional systems appear to be the most sustainable and affordable (Gow, 1989).

In the higher-potential zones, such as those in the Guinean savannah belt, intensification appears possible and desirable, provided measures of "sustainability" (mainly soil conservation investments, such as incorporation of organic matter into the soil, bunding and terracing to prevent erosion) are given high priority (Lal, 1987). These will also augment productivity. Until the necessary infrastructure is in place for intensification, modified traditional systems are a useful intermediate step.

B. Incentives

- Will farmers want to invest in the productivity and sustainability innovations proposed to them by agricultural researchers?
- How should these innovations be designed to maximize the probability of adoption?

The innovations that are necessary either to sustain high-input systems in the Guinean savannah belt or to sustain modified traditional systems in the Sahelian and/or Sudanian savannah zones require investments by rural households and their communities (FAO, 1987). The main investments would be in "water-harvesting" structures; these might include rock or soil bunds, grass hedges, bushrows, terraces, tied ridges, and so on. These require substantial expenditures of cash and labor at the household and community levels.

Expenditures on fertilizers and traction animals and equipment compete for the same pool of cash and labor as do investments in bunding. Researchers and governments want farmers to invest in both kinds of inputs without necessarily taking into account that the household does not have enough resources to pay for both, nor a reliable credit market to loan it the money to do so (Sanders, 1988).

Moreover, in a degrading and unstable environment such as the Sahel, perhaps the household's first priority should be to diversify away from farming. Households may want to maximize present earnings in cropping and invest the surplus into livestock and off-farm enterprises. Instead of reinvesting off-farm earnings in cropping or water-harvesting structures, households may use them to diversify further (Norman et al., 1981).

These possibilities are often neglected by crop researchers, governments, and environmentalists, who assume that the rural household in a region at environmental risk is first and foremost a farming household. This implies that innovations that can improve the farm resource base are automatically attractive to households.

It is precisely in areas at the greatest risk that this assumption is least tenable. For example, recent work by Reardon (1992), which supports earlier research results of Delgado (1989) and Matlon (1987), shows that cropping constitutes from a quarter to a half of income in rural Burkinabè households from the Guinean and Sahelian zones. Overall income—from cropping and noncropping sectors combined—is a much more important determinant of household food security than is cropping income alone. A substantial portion of these households' food comes from purchases. This runs counter to the conventional image of Sahelian households as self-sufficient, subsistence farmers. Households diversify income because of extreme fluctuations in returns to cropping (due to output and price fluctuations from erratic rainfall and weak market prices). Households are sensitive to the net payoff and when they receive it from investments in the various sectors, including cropping, livestock, and off-farm activities. In this context, investments in water harvesting and soil conservation structures compete with investments in activities that may have higher short-run payoffs, more stable long-term payoffs, and the potential to serve as repositories of savings and hence insurance (such as livestock).

Hence, researchers need to take into account the opportunity costs across sectors and the capital constraints facing rural households when they design sustainability investment schemes. They have to be relatively cheap and emphasize short-term payoffs.

C. Effects of Policy

- What are the effects of policy on the patterns of farmers' investments in sustainable agricultural practices?

Sustainability proponents often put special emphasis on direct investments in resource conservation by Sahelian governments, due to problems of externalities, capital constraints, and short planning horizons at the household and village levels (Blaikie, 1989). The investment of scarce fiscal and foreign exchange resources involves difficult choices.

Governments can influence household investment patterns and incentives through policies that affect: 1) net returns and transaction costs (directly via price policy and indirectly through food aid and infrastructure), 2) the stability of the investment climate (even at the rural level) and hence the farmer's planning horizon, and 3) financing of research and hence the stock of appropriate and available innovations from which the farmer can choose (Blaikie, 1989).

It is important to guard against simply assuming that higher crop prices will lead automatically to either farmers' investment in sustainability or higher rural welfare in degraded zones. Higher prices have occurred without an investment boom taking place

(Brklacich et al., 1991). Disincentives to investments in the cropping sector include both the extreme variability of prices and capital market constraints. During the last decade, food prices relative to cash crop prices have tended upward. In individual years, crop prices have been extremely high. There have been official farmgate price increases in a number of countries. Despite all this, the riskiness of investment in cropping productivity and sustainability has not changed much because of tremendous interannual swings in prices as the result of fluctuating output. Sahelian governments do not have the fiscal capability to smooth out these fluctuations through market interventions. Moreover, even when producer prices are high for millet and sorghum from degraded zones, merchants and even governments make available cheap maize and sorghum from zones relatively unaffected by drought, according to research by Reardon (1992), Delgado (1989), and Matlon (1987). Hence, the degraded zones are not closed economies in which incentives can be controlled and enforced.

Therefore, in summary, ways that policies actually influence markets, intersectoral opportunity costs, and hence the environmental choices of rural Sahelian households are complex. Exchange rates, marketing regulations, and interest rates all play a role (Blackwell et al., 1991).

Overvaluation of the CFA franc reduces the attractiveness of Sahelian cattle exports to the coastal countries, relative to cheap imports of meat from the European Union or Argentina (Rep. du Mali, 1987). Given that livestock husbandry is probably one area where the low-potential zones of the Sahel have comparative advantage, these policies may promote distortions in the local economy and act as disincentives to developing appropriate crop-livestock linkages. Bottlenecks and controls resulting from marketing regulations may create thinner markets and greater price fluctuations, which render investment in agriculture less appealing. High real interest rates due to underdeveloped capital markets may encourage households to shorten their investment planning horizons and will probably discourage sustainability investments.

National and international research organizations need to conduct both technical and policy research on how governments can most effectively—and cheaply—encourage sustainability investments at household and community levels (Anderson and Thampapillai, 1990). Research should help determine where governments should provide indirect supporting investments (for infrastructure) and what they should be. Research emphasis also needs to be placed on tracing the effects of sectoral and macro policies, such as exchange rates, food prices, and price and availability of credit on investment incentives both in cropping in general and in water-harvesting structures in particular.

IV. INCENTIVES FOR FARMER PARTICIPATION

A. Incentive Needs

The need for incentives to encourage farmers to adopt improved NRM practices has been well documented (Reij et al., 1986). The simple reasons are that many farmers have

little or no resources to invest in such work. Furthermore, many of the soil and water conservation benefits accrue in the future and to others.

Incentives are of many kinds; some are direct and others are indirect (FAO, 1980). Among direct incentives, the popular one is giving cash subsidies in accordance with work performance or as partial wages. Food and other items are also used as incentives. There are pros and cons for using cash as subsidies. Cash is easy to handle but it can be misused by farmers. On the other hand, giving commodities would increase management problems such as transportation and storage and also involve farmers' preference.

Indirect incentives, except technical assistance, are less used in developing countries. Some, like tax exemption, deduction, and security in land tenure, and so forth may require exhaustive discussions and lengthy years of planning with land and tax authorities. Such proposals often need legislative support. Others, like farm credits and marketing service, can be very effective if the project takes an interdisciplinary approach. Sometimes, disincentives can also be effective for promoting conservation work. Governments can set a firm policy that farmers who continuously misuse slopeland or practice destructive type of cultivation cannot receive crop subsidies, farm credits, or other related assistance.

Effective use of incentives requires a detailed knowledge of the farming systems as well as a thorough understanding of the farmer (Hudson, 1983). A good incentive will promote the farmer's goals, will encourage eventual self-reliance on the part of the farmer and the community, and will fit into both short-term and long-range plans. A special consideration in conservation work is to provide incentives for proper maintenance.

Incentives should also be given to government staff who work in the field (Sanders, 1988). The working conditions in rural areas especially in uplands are mostly rough and inconvenient. Without proper incentives such as adequate per diem, priorities for promotion, and opportunities for advanced training, projects will have difficulty in attracting and maintaining competent and dedicated personnel.

B. Farmer Participation

Farmer participation is the key to the success of any NRM program or project. The problem is how do we induce farmers to participate?

Soil and water conservation work requires heavy investment of labor, time and cash (Stocking, 1985). Farmers may need to sacrifice part of the cropping land for conservation purposes or to change the landscape completely. In many instances, the land may initially suffer low production. After establishing conservation structures, maintenance work will still be needed for many years to come. Yet, the benefits cannot be easily seen or will take some time to show. Unlike applying fertilizers or insecticides, soil conservation usually alters the existing farming systems and many traditional cultural practices. Any farmer would consider twice before he or she accepts such drastic change and risk.

There are generally two schools of thought on inducing farmers' participation. One school advocates that a well-designed and executed education and extension campaign would suffice to convince most farmers to join such a program (Sheng and Meiman, 1987). They don't think that incentives, especially direct subsidies, are necessary because most developing countries have severe financial constraints and farmers may develop a subsidy-dependent mentality for every government-generated program. The other school of thought realizes that it is not fair for small farmers to share the total cost of conservation when their meager income could be reduced in the first few years and the benefit may occur to the next generation or to others downstream (Sheng and Meiman, 1987). Incentives, either direct or indirect, should be given to those farmers who participate in the program. This is deemed as a cost-sharing program or a system to exercise equitable income distribution.

These views are not mutually exclusive. To induce farmers to participate willingly in a program requires good extension. Unless farmers understand well that improved NRM practices will do them good in the long run, they may not maintain the practices even after they did the work. On the other hand, to convince a majority of the farmers to join a program only by means of education may need a good many years. Many farmers simply have no resources or time to start the work unless some tangible incentives are given. Experience shows that in addition to education and extension, giving proper incentives, in cash or in kind (including food), has promoted farmers' participation and speeded the protection of the land.

One of the most important incentives is technical advice and follow-up, which should be offered to all farmers who join a program or project (Sheng, 1986). Such technical service would include drawing up NRM plans for their farms, contour surveying, supervision and assistance for construction and maintenance of conservation structures, crop management, and so forth. Small farmers of one or two hectares should be given subsidy or material incentives in addition to free technical service.

V. THE DESFIL TAXONOMY: A TECHNOLOGICAL AND SOCIOECONOMIC FRAMEWORK FOR SUSTAINABLE AGRICULTURAL DEVELOPMENT

A. The Need for a Technological Framework

The technological framework with the most promise for promoting food security in Africa calls for an evolution of existing agricultural production systems. More rapid improvements are possible in high-potential areas, but these areas are in a minority and changes there will not address the needs of the majority of farmers and herders who have few resources. Thus, few areas can expect rapid and widespread technological change like that which occurred in Asia. African soils are generally poorer, water and labor are often less available, human and institutional resources are less well-developed, and major research efforts are needed on a number of important food crops.

To be successful given the great diversity present in African farming systems, an equally diverse array of technologies adapted to local social, economic, and environmental conditions is needed. Although Africa will benefit from global agricultural research, African

problems will require a greater emphasis on African-specific solutions. DESFIL proposes three efforts that could contribute to this process:

- Increasing African research capacity through human and institutional development;
- Improving links among researchers, extension agents, farmers, and herders; and
- Giving greater emphasis to on-farm adaptive research following a participatory approach involving local farmers—women and men—in the identification and analyses of constraints (and their related causes) to technological adoption that would lead to sustainable agricultural production systems.

Technologies developed to support low-resource agriculture should reflect the high premium this approach places on risk aversion and the need to maintain flexibility in the face of uncertainty and limited access to resources. Farmers throughout the world are justifiably conservative when failure of technology could mean bankruptcy or even starvation. Therefore, many practices of low-resource agriculture ensure at least some production in bad periods, even at the expense of higher yields under more favorable conditions. To date, most agricultural research has emphasized maximum production even though other concerns face poor farmers and herders. For example, intercropping, a practice in which crops are grown together in an intermixed fashion, helps to reduce risk of one crop's failure. Yet, only 20 percent of International Agricultural Research Center (IARC) funding involves intercropping, although some 80 percent of African food is grown as intercrops (OTA, 1988). Only an estimated 10 percent of USAID's research and extension efforts in agriculture involve intercropping (Francis, 1987).

Technological flexibility is also needed because agricultural conditions will continue to change, and at different rates, throughout Africa. Development of technology needs to build in the flexibility to react to anticipated and unanticipated events. Rapidly growing populations, migration of young men to urban areas, and growing numbers of female-headed households all have implications for the development and dissemination of technology.

Currently, most resource-poor farmers and herders rely primarily on resources internal to the farm or their immediate environment. These include sunlight, rain, nutrients from plant and animal wastes, and local labor. Eventually, additional external resources (purchased fertilizer, machinery, and so forth) will be available but this shift to increased use of external resources is likely to be slow and gradual in most areas of Africa. Consequently, technologies that rely on local resources, labor, and institutions should be emphasized over the near term. Much development assistance has bypassed the majority of African farmers and herders because it emphasized external resource use instead. Thorough economic analysis is needed to determine the feasibility of all technological interventions, but especially to make sound choices between using external and internal resources.

Farmers and herders' knowledge is among the internal resources available for developing useful, acceptable, and affordable technology. Their participation in identifying problems and solutions would enhance the effectiveness of technical assistance. Existing

agricultural practices should be the starting point of a process combining the best of traditional and improved technologies. This requires, for example, that farmers and herders be active participants of research teams, that their nonformal experiments be incorporated into research plans, and that units of measure be meaningful to them.

B. The Need for a Socioeconomic Framework

The first steps are to identify and remove those factors responsible for detrimental land use. Degradation results primarily from incorrect land use and bad land management—from the land being used in a manner incompatible with its capacity. Farmers and other land users rarely deliberately degrade the land from which they have to make a living and feed their families. Incorrect use and bad management of the land are usually the result of ignorance or, more likely, social, economic, and political pressures.

The first step is therefore to analyze why undesirable land uses are being practiced. There may be many answers—population pressures may be high, agricultural pricing policies inappropriate, inputs unavailable, or land tenure systems may be forcing farmers to over-exploit the land. Without an analysis of the underlying causes of land degradation much time, effort, and money will be spent in dealing with the symptoms rather than the causes of the problem. The analysis may lead to the conclusion that the problem cannot be overcome until some major constraint affecting land users is dealt with. This may mean providing outlets for alternative crops, providing some needed technical assistance for the more effective use of internal household and communal resources, or adjusting the land tenure system—subjects rarely considered by conservation programs of the past.

Farmers and other resource users have to deal with a succession of problems while they strive to earn reasonable income, feed and cloth their families, pay off their debts, and educate their children. They have neither the time nor the inclination to adopt new and risky practices to tackle processes of land degradation that, on their time scale, are so slow as to be barely discernible. New NRM programs must recognize this fact and develop practices that provide short-term incentives and tangible benefits to the resource users. In practice this means stabilizing yield (not necessarily maximizing or even increasing yield), reducing risks, or providing other direct benefits such as making farm work easier or more profitable.

C. The DESFIL Taxonomy

Reliable data on land resources—including soils, climate, vegetation, topography—and an inventory of land use practices—both traditional and improved, and their biophysical and socioeconomic aspects—are needed if ecologically sound and socially acceptable land use practices, incentives, and policies are to be developed. Some of these data are more widely available than is generally realized. However, the data is usually fragmented, of different scale and reliability, and stored in different ministries, libraries, and universities. Even where information is already readily available, particularly about soils and climate, other aspects may call for surveys and inventories to be made to gain a holistic appreciation of the problems facing resource users of fragile lands in SSA.

The first major task is to find out what data are available and where they are located. The second is to gather existing data together, arrange them in a usable form, assess their utility, and decide what additional data still needs to be gathered. Even countries which have already carried out a land resources data survey are likely to find out that more data of one kind or another are needed.

The DESFIL taxonomy will consist of an encyclopedia of data collected relative to technologies, incentives, and policies that have led to land degradation and those which could establish conditions necessary for sustainable NRM of fragile lands. The data will be organized according to agroecological zones, including arid and semi-arid lands, tropical humid lowlands, and steep slopes.

As data is collected and organized, information gaps will be identified. Case studies will be designed to collect the necessary field-level data using a participatory rural appraisal (PRA) approach to actively involve the resource users in identifying their problems, the underlying causes, and solutions that are appropriate according to their biophysical and socioeconomic environment.

During the course of developing the encyclopedia of worldwide experiences in NRM, a manual that will provide a framework for conducting a similar country-specific inventory will be developed. These tools will assist policy makers, development agencies, and field-level NRM practitioners to develop recommendations for NRM strategies for fragile lands that address particular problems in any country with similar agroecological and socioeconomic conditions.

D. The Database on the Impact/Diffusion of Sustainable Agricultural Practices

Under the DFA, the Africa Bureau is responsible for achieving and reporting on broad-based people-level impacts, yet these impacts from NRM interventions are long-term in nature. Therefore, analysis using the NRM Analytical Framework has led to the development of certain intermediate indicators to monitor and evaluate the impacts of these interventions over time. It has been found that the greatest amount of uncertainty was between Level II (changes in conditions) and Level III (adoption of practices) where most of USAID's investments are made. Some questions to be answered are:

- Did program assumptions include all the necessary and sufficient conditions?
- How does one determine if targeted enabling conditions have, in fact, been established?
- How does one determine that the enabling conditions contributed to the widespread adoption (for example, were they the only contributors) of sustainable agricultural practices?
- When widespread adoption has not been achieved, were conditions overlooked that hindered adoption?

- Are changes in policy resulting in changes of farmers' perceptions (for example, land use rights)?

To answer these and other NRM-related questions, the DESFIL project, through financial and technical support from the USAID Africa Bureau's ARTS/FARA Division, is developing an electronic database to provide an opportunity for consistent observation and systematic analysis of sustainable agricultural practices in NRM programs. The database will be structured using the NRM Analytical Framework.

The DESFIL approach to developing the database stresses the need for sociological, socioeconomic, and environmental studies before, during, and after implementation of sustainable agriculture and NRM programs. More is required, however, than descriptive overviews of local social customs and settings if they are to be useful for promoting improved community-level management of natural resources. To be useful, studies should focus on those aspects of peoples' lives that are most concerned with how they organize access to and use productive resources, including natural resources. Studies should focus on particular NRM/production issues as a point of departure, but the focus should not be narrowly technical in nature.

For social analysis to be effective, it must carefully listen to what resource users—women and men—say about what they do (for example, accounts of "how our way of land tenure works," or about "how we go about managing our fields"), and it must also look at what, in practice, they do, and why. Finally, social analysis must look at changes in how farmers go about using and managing productive resources.

Social analysis must draw from several sources to be effective:

- The indigenous knowledge and natural resources management practices of local populations;

- A research strategy based on a review of existing research material and development project reports and careful field-level observations during a limited time frame; and

- Local feedback to the analysis, by submitting the results of the study to the local population for their comment and discussion.

Social analysis should be an interdisciplinary undertaking in which individuals or teams having training in relevant areas are integrated and participate with managers and planners and with local populations in defining, studying, analyzing problems and underlying causes, assessing the results, and devising potentially appropriate interventions.

E. What Will the Database Do for USAID Bureaus and Missions?

The database will assist USAID to understand under what conditions natural resources users will adopt and use sustainable agricultural practices. What is it that resource users can

and will do? What is it that the resource users could or would do if it were not for certain constraints? What are those constraints? And finally, what, under a certain set of conditions, can USAID do to help alleviate those constraints.

USAID, under the DFA, is held accountable to report on broad-based people-level impacts. The database will be compiled on what lessons have been learned to date, and continually updated as more information is gathered on conditions that affect user behavior in their pursuit of a better livelihood. The importance of understanding what affects user behavior does not stop at program design. Much more is learned during implementation, which emphasizes the importance of the need for intermediate indicators for monitoring and evaluating program impacts. Program assumptions should be continually tested. It is not a mistake to find out that certain assumptions were not correct. Understanding resource user behavior should be a program output.

Other uses of the database could be to:

- Show what kind of indicators are needed and where they have to be applied to measure changes in an efficient and timely manner;
- Provide insight into the validity of the various linkages that are assumed;
- Serve as a basis for a reporting system;
- Assist as a planning tool that helps think through the NRM-related issues that are connected to foreign assistance activities. It links, on the basis of field-tested experiences, the different levels of events and elements that are inexorably tied to each other through a series of cause and effect linkages; and
- Correlate key relationships between enabling conditions that have led to "successful interventions" and develop inferences for programmatic options.

VI. CONCLUSION

NRM programs and projects are difficult to sell because results from them often require a long time to materialize, benefits are widely dispersed and not easy to identify, and individual resource users must invest heavily. Thus, the NRM of fragile lands is an uphill battle against pressures from individuals and nations looking for quick and direct returns on their investments. However, if NRM interventions are planned and implemented properly, it is possible to encounter less problems and achieve both short-term and long-term benefits. An effective interdisciplinary approach is needed for any NRM project. Team work should be stressed with the participating resource users involved throughout the process. NRM projects must be looked at as complicated systems, requiring an interdisciplinary approach that combines biophysical and socioeconomic elements. A process or learning approach must be used that involves the farmers or land users in each step. In such a participatory approach, the resource users and all other stakeholders learn from each other.

VII. Literature Cited

Anderson, J. R., and J. Thampapillai, J. 1990. *Soil conservation in developing countries: Project and policy intervention.* PRS No. 8, World Bank, Wash. D.C. pp. 45.

Andrews, D. J. 1987. *Intercropping in low-resource agriculture in Africa.* Contractor report prepared for the Office of Technology Assessment. Springfield, VA: National Technical Information Service.

Associates in Rural Development, Inc. 1992. *Decentralization and local autonomy: Conditions for achieving natural resource management.* Decentralization and Finance and management Project, A.I.D., Wash. D.C.

Berkes, F. 1989. *Common property resources: Ecology and community-based sustainable development.* London: Bellhaven Press.

Blackwell, J., R. Goodwillie, and R. Webb. 1991. *Environment and development in Africa: Selected case studies.* Economic Development Institute of the World Bank Policy Case Series, Analytical Case Studies, No. 6. Wash. D.C.: The World Bank.

Blaikie, P. 1989. *Explanation and policy in land degradation and rehabilitation for developing countries.* Land Degradation and Rehabilitation 1:23-27.

Brklacich, M., C. R. Bryant, and B. Smit. 1991. *Review and appraisal of the concept of sustainable production systems.* Environmental Management 15:1-14.

Carr, S. 1989. *Technology for small-scale farmers in Sub-Saharan Africa: Experience with food crop production in five major ecological zones.* World Bank Technical Paper Mo. 109. Wash. D.C.

Charreau, C. 1974. *Soils of tropical dry and dry/wet climatic areas of West Africa and their use and management.* Lecture Series, Cornell Univ., Ithaca, N.Y.

Conway, G. R., J. A. McCracken, and J. N. Pretty. 1987. *Training notes for agroecosystem analysis and rapid rural appraisal.* International Institute for Environment and Development. U. K.

Critchely, W., C. Reij, and S. D. Turner. 1992. *Soil and water conservation in Sub-Saharan Africa: towards sustainable production by the rural poor.* Rome: IFAD.

Delgado, C. 1989. *The changing concept of mixed farming in savannah West Africa: A conceptual framework applied to Burkina Faso.* Quarterly Journal of International Agriculture 28:3-4.

FAO. 1980. *Report on the study tour on incentives for community involvement in forestry and conservation programmes.* Rome.

FAO. 1984. *Improving production systems as an alternative to shifting cultivation.* FAO Soils Bulletin No. 53. Rome, Italy: FAO of the United Nations.

FAO. 1987. *Improving productivity of dryland areas.* Committee on Agriculture, Ninth Session. Rome, Italy.

Francis, C., R. Harwood, and J. Paar. 1986. *The potential for regenerative agriculture in the developing world.* American Journal for Alternative Agriculture 1 (2):65-75.

Francis, C. 1987. "*Challenges of intercropping: Policy Issues.*" Contractor report prepared for the Office of Technology Assessment, Arlington, VA: NTIS.

Gow, D. 1989. *Development of fragile lands: An integrated approach reconsidered.* In: J.O. Browder, (ed.), Fragile lands of Latin America: Strategies for sustainable development. Boulder: Westview Press.

Harrison, P. 1987. *The Greening of Africa; Breaking through the battle for land and food.* An International Institute for Environment and Development-Earthscan Study. Toronto: Paladin Grafton Books.

Hudson, N. W. 1983. *Soil conservation strategies in the Third World.* Journal of Soil and Water Conservation 38 (6):446-450.

Jayne, T. S., J. C. Day, and H. E. Dregue. 1989. *Technology and agricultural productivity in the Sahel.* USDA Agricultural Economic Report. No. 612. pp. 27.

Kumar, S. K. 1987. *Women's role and agricultural technology.* In: Mellor, Delgado, and Blackie (eds), Accelerating Food Production in Sub-Saharan Africa. Baltimore, MD: The John Hopkins Univ. Press. pp. 135-147.

Lal, R. 1987. *Managing the soils of Sub-Saharan Africa.* Science 236:1069-1076.

Lawry, S. 1989. *Tenure policy and natural resource management in Sahelian West Africa.* LTC Paper No. 130. Madison: Land Tenure Center, Univ. of Wisconsin-Madison.

Matlon, P. 1987. *Potential and practice in food production technology development in the West African semi-arid tropics.* In: Mellor, Delgado, and Blackie (eds.), Accelerating food production in Sub-Saharan Africa. Baltimore, MD: The John Hopkins Univ. Press.

Mellor, J., C. Delgado, and M. Blackie, (eds.). 1987. *Accelerating food production in Sub-Saharan Africa.* Baltimore, MD: The John Hopkins Univ. Press.

Moock, J. L. (ed.). 1986. *Understanding Africa's rural households and farming systems.* Boulder, CO.: Westview Press.

Moris, J. 1985. *Indigenous versus introduced solutions to food stress.* IFPRI/FAO/AID workshop on seasonal causes of household food insecurity, policy implications, and research needs.

Norman, D. W., M. D. Newman, and I. Ouedraogo. 1981. *Farm and village production systems of the semi-arid tropics of West Africa: An interpretive review of research.* ICRISAT Research Bulletin No. 4. Pantancheru, India.

Office of Technology Assessment. 1988. *Enhancing agriculture in Africa: A role for U.S. development assistance.* OTA-F-356. Washington D.C.: U.S. Government Printing Office.

Reardon, T. 1992. *Cereals demand in the Sahel and potential impacts of regional cereals protection.* World Development 19-5.

Reij, C., S. D. Turner, and T. Kuhlman. 1986. *Soil and water conservation in Sub-Saharan Africa: Issues and options.* Rome: IFAD.

Republique du Mali. 1987. *Memento: Integration agriculture/elevage.* Ministere de l'Agriculture/Compagnie Malienne pour le developpement des Textiles, Bamako.

Rodale, R. 1985. *Internal resources and external inputs—the two sources of all production needs.* Workshop on regenerative farming systems. Rodale Institute presentation to USAID. Washington, D.C.

Roth, M., K. Wiebe, and S. Lawry. 1992. *Land tenure and agrarian structure: Implications for technology adoption.* Land Tenure Center Research Paper. Madison: Land Tenure Center, University of Wisconsin.

Sanders, D. W. 1988. *Environmental degradation and socioeconomic impacts: Past, present and future approaches to soil conservation.* Paper presented at the 5th International Soil Conservation Conference, Bangkok, Thailand.

Sanders, D. W. 1988. *Soil and water conservation on steep lands: A summary of workshop discussions.* In: Conservation Farming on Steep Lands. Soil and Water Conservation Society and World Association of Soil and Water Conservation. Ankeny, Iowa.

Sheng, T. C. 1986. *Watershed management planning: Practical approaches.* In: FAO Conservation Guide No. 14. Rome.

Sheng, T. C., and J. R. Meiman. 1987. *Basic considerations in planning and implementing soil conservation projects.* Paper presented to WASWC/SCSA Workshop on "Soil and Water Conservation on Steep Lands." San Juan, Puerto Rico.

SPAAR. 1987. *Guidelines for strengthening National Agricultural Research Systems in Sub-Saharan Africa*. Special Program for African Agricultural Research (SPAAR). The World Bank, Wash. D.C.

Spencer, D. 1986. *Agricultural research: Lessons of the past, strategies for the future* In: Berg and Whitaker (eds.), Strategies for African development. Los Angeles, CA: Univ. of Calif. Press. pp. 215-241.

Spring, A. 1985. *Using male research and extension personnel to target women farmers*. Paper presented at the Kansas State Univ. FSR Symposium, Manhattan, KS, Oct. 14, 1985.

Stocking, M. M. 1985. *Development projects for the small farmers: Lessons from Eastern and Central Africa in adapting conservation*. In: El-Swaify et al., (eds.), Soil Erosion and Conservation. SCSA. Ankeny, Iowa. pp. 747-758.

Warren, D. M. 1991. *"Using indigenous knowledge in Agricultural Development."* World Bank Discussion Paper No. 127. Wash. D.C.: World Bank.

Warren, D. M. 1992. *Strengthening indigenous Nigerian organizations and associations for rural development: The case of Ara community*. Nigerian Institute of Social and Economic Research, Occasional Paper No. 1, Ibadan, Nigeria.

Wittwer, S. 1988. *Issues of concern in land use for developing countries*. In: Sustaining land productivity in developing countries. USDA and A.I.D. pp. 25-34.

World Bank. 1986. *Poverty and Hunger: Issues and options for food security in developing countries*. Wash. D.C.: The World Bank.