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SUSTAINABLE AGRICULTURE

Comments of the

RESEARCH ADVISORY COMMITTEE

at its January 14-15, 1988 Meeting

Office of Research and University Relations
Bureau for Science and Technology

January 15, 1987

Introduction

This report was prepared in two stages. It began as a summary of the discussion by a panel of the Board on Science and Technology for International Development (BOSTID), National Research Council (NRC). The Panel was convened on December 14, 1987 at the request of the Office of Research and University Relations, Bureau for Science and Technology, Agency for International Development (AID), to prepare a discussion document for the January 14-15, 1988 meeting of the AID Research Advisory Committee (RAC). The report was revised to reflect the RAC discussion and now may be considered an advisory statement from the RAC to AID on the subject of sustainability in agricultural systems and economic development.

Discussions from which the report was prepared centered around a draft document submitted by the AID Office of Agriculture, Bureau for Science and Technology entitled "Sustainable Agriculture." That draft document presented AID's current strategy and outlined a set of issues which AID asked the RAC to address.

Characteristics of Sustainable Agriculture

Between 1950 and the mid 1980s, world population doubled. During those years, however, food production grew at a rate greater than overall population increases, averaging about 3% per year until 1975 and greater than 2% per year since that date. Not only was world famine on a catastrophic scale avoided, but there have been notable per capita food production and consumption increases such that for many food commodities, low prices and surpluses are a problem for producers. Yet hunger still exists in many regions of the world, even in those countries where there are agricultural surpluses.

Nutritional deficiencies are more widespread than famine, plaguing a much larger percentage of the population in less

developed countries than in more industrialized countries. Deficiencies retard development of the young, increase susceptibility to diseases, and adversely impair health and quality of life. For those reasons, one major challenge for the 1990's is to foster greater productive capacity and access to affordable food supplies in those countries that continue to face recurrent shortages. Another challenge is to encourage better food distribution systems.

The maintenance and enhancement of agricultural productivity is now understood to be intimately linked to effective management and sustaining of the biological and ecological potential within a given agricultural ecosystem--the agroecosystem. Concerns for sustainability are not new for the Agency for International Development nor for other groups involved in agricultural development. The issues are, however, profound and far reaching because sustained agriculture is often incompatible with practices that have come to be widely accepted and practiced throughout the world. Examples include overgrazing of rangelands, deforestation in mountain and tropical environments, and poor management practices of irrigated lands.

A truly sustainable farming system has the following characteristics:

- It should maintain the long-run biological and ecological integrity of natural resources (soils, water, plants, animals etc.) without which agricultural production cannot be increased, and possibly not sustained. Continuing attention to the effective long-run control of animal diseases and crop pests is a key component of the biological sustainability of a farming system, as are methods to maintain soil fertility.

- It should be viewed as an integral--and viable--part of a country's economic development strategy or process and should take into account cultural and socio-economic traditions. A system cannot be considered sustainable if farmers are unwilling or unable to adopt it.

- It should provide ample economic returns to farmers, and farm-related industries to support essential investments in annual farm production activities, such as: tillage, planting and ongoing resource conservation practices (maintaining terraces and ditches); regeneration of crops, forests, and orchards; replacement and improvement of soil fertility and livestock; development and transfer of improved technologies; and maintenance of annual income sufficient to support families are all dependent on farming as the principal source of income.

- It should contribute to food security and to the health and vitality of the rural cultures involved in the multiple aspects of food production.

The concept of sustainable agriculture involves both spatial and temporal dimensions, and the unifying concept for the complex of related farm system management components is the agroecosystem. Agroecosystems involve inter-relationships among the individual farm, its immediate agricultural locality, and the larger landscape or region in which it resides, including the social, economic, and political conditions of the nation. Concerns for sustainability must take into consideration the effects of these relationships within the system.

One of the critical features of sustainable agriculture, however, is its time frame--the period over which agricultural systems continue to be productive of goods and services. That time frame ideally should be measured in hundreds, rather than

tens, of years. In some regions, the extent of resource degradation associated with certain high-input "modern" farming systems is growing. In some instances, other systems typically described as "traditional" systems, are known to have been in continuous operation for 1,000 years or more. It is equally true that many modern productive agricultural systems are not only sustainable; they have in fact created the soil fertility and the resource base that sustains them. Some of the world's most productive soils were once considered infertile and non-productive. And the historical record is replete with civilizations that destroyed their resource base with traditional agricultural practices. Ultimately, agriculture should be a system composed of natural and human resource use patterns organized so as to allow sustainable production over the long term.

Based on the foregoing comments, the RAC recommends that AID not use terms such as "low-input" or "organic" or "regenerative" agriculture as equivalent to "sustainable" agriculture. This point was forcefully and vigorously endorsed in the discussion by RAC members. The term "low-input" agriculture is accurate and useful only with reference to certain inputs in certain regions and within specific management systems. Most "low-input" systems require a high labor input and are often characterized by low-output.

Sustainable agricultural systems may be less reliant on energy-intensive inputs purchased off the farm (fertilizers, pesticides, fuel, machinery) and relatively more reliant on labor and management practices to conserve soil, available water, and genetic resources, and maximize the efficiency of biological cycles and processes. Accordingly, the RAC recommends AID use the concept "sustainable agriculture" as its basic operational term and one that is the most appropriate for reviewing and modifying AID's ongoing food and farming system research and technology transfer activities.

While agricultural sustainability must be a concern worldwide the current status and trends in approaches to the sustainability of agricultural production systems vary greatly across the globe. Sustainable agriculture concerns and issues need to be defined and approached on a regional, and ecosystem basis. They depend on interactions of:

- National economic status and level of development, agricultural policy, and demographic trends

- Current effectiveness in the management of land and water resources

- Economic capability of farmers to generate sufficient income to support agricultural development

- Practical availability of cost-effective technologies and production inputs suited to a given region's soil, climate, and technology base.

Agricultural sustainability also must be assessed in relation to the crops and types of farming enterprises (modern, traditional or some combination thereof) which are practiced and for which there is a demand within a given region. Economic and market forces often tend to push farmers toward land use patterns and management practices which appear to be profitable in the short run. But such practices often set the stage for changes in agro-ecosystems and the resource base which ultimately may combine to thwart the biological integrity of particular farming systems.

Sustainable Agriculture: The Research Dimension

In considering possible research directions, meaningful criteria to judge sustainability must be articulated, and a process designed to review AID's research activities in light of these

concepts. AID's agricultural policy statement should encourage research programs that contribute to farming systems that are ecologically, biologically, and socio-economically sustainable.

The RAC strongly believes that sustainable agriculture should not be considered as a separate program category within AID. Again, this point was strongly endorsed by RAC members in the discussion of the report. Rather, sustainability criteria and concepts should be woven into the design and administration of all agricultural programs and projects.

Suggestions and discussions have come from both within AID and elsewhere to shift AID's agricultural research emphasis to "fragile" and/or marginal environments such as areas with highly variable rainfall or steeply sloping areas and poor soils. It should be noted that "fragile" and "marginal" are not identical concepts. All soils if not properly cared for are fragile as are other resources. Some soils such as those on steep slopes are more vulnerable and therefore properly deemed fragile. However, there are many economically marginal where the terrain or soil structure are similar to those of high productivity areas but where there may be a deficiency in rainfall or soil nutrients. Many of the world's most productive soils were once in this category and were made productive and sustainable by amending the soils or with irrigation.

Many studies, including some by the National Academy of Sciences have indicated that there are uncultivated "infertile" lands that might be utilized in the future if more tolerant varieties of crops can be developed or effective means can be found to reduce soil toxicity.

Considerations of equity require two major problems be addressed simultaneously. If the growth of food production falls below that of population growth, then the cost of subsistence or

food security will rise hurting the poor urban and rural buyers of food stuffs. Thus research on sustainability for the currently richer, more productive farmlands must continue at some level. However, the world's poorest farmers tend to be on marginal (almost by definition) lands and many are on lands that are marginal and fragile. They are there because they need to eat. If their farms fail then they are likely to try to convert other lands from current sustainable use (such as rain forests) into farms that end up being marginal and fragile and not sustainable. If this cycle is to be broken, research and action must also be taken to help increase productivity and create sustainability on these marginal lands. In the RAC discussion, many seemed to favor some shift of resources to research on marginal lands.

- Effective development of richer (more productive) farm lands in favorable climatic zones is helpful--indeed essential--to reduce population pressure on the more fragile environments. The RAC does see a need, however, for additional research to develop alternative agricultural strategies for the development of fragile environments particularly in countries with limited, highly productive farming regions in areas with favorable climates. As population pressures increase, marginal lands can and will have to be more adequately utilized on a long-term basis, especially as the relative rate of deterioration may be higher in more productive systems than in marginal lands.

- World and regional food needs will continue to grow with population growth. The experience of individual panel members indicates that fertile soils with favorable climates offer the most promise for increasing production as new technologies are developed and become affordable. Unfortunately, production practices in some of the most favorable agroecosystems are not based on principles of sustainability.

Globally, food production is growing faster than population. In many countries and regions, primarily in Africa and the Middle east, population is growing faster than food production. In many areas of these regions, the preponderant majority are working on marginal lands. Global food abundance will have little impact upon them except to keep down the price on what little they may sell or in terms of food aid in a period of crisis. Consequently, research and extension must continue for those on these marginal lands if the people and the lands are to survive.

In the development of research projects to foster sustainability, it is essential to enunciate criteria by which a farming system or future technology will be evaluated.

Criteria to assess impacts of research activities and agricultural technologies on sustainability could include:

1. Impacts on soil erosion and deterioration, including such aspects as soil loss, organic composition of soil, water stress, and salinization.

2. Impacts on the genetic characteristics of pest populations within an agroecosystem. Relevant research might examine how technology and management could affect the nature, scope, and ease of control of plant and animal diseases, and virulence of pests, and adaptability of plants and animals to local conditions and resources.

3. Impacts on and relevance of management skills and know--how. There is a real need at the farm level for requisite management and related skills and incentives to make cost-effective use of technologies or practices related to sustainability and to avoid misuse or misapplication of such practices or technologies in ways that could cause short- or longer-run problems.

4. Likelihood an agricultural practice or technology will prove useful in the production of a commodity or crop that will remain part of a country's overall agricultural and food system.

Criteria complimentary to contemporary cost-benefit analysis, and other methods that discount future costs or benefits are needed to assess research activities leading to long-run changes in management practices, systems, skills, and technology. Possibly, sustainability could be considered a required necessary cost of all agricultural projects. In particular, long-term multidisciplinary research activities on fragile lands and stressed ecosystems should be designed and undertaken to help determine what sort of remedial and management priorities could prove to be cost-effective in restoring or sustaining agricultural production. Such research should include consideration of the institutions and policies in selected developing countries affecting access to and use of land resources, including public range and forestlands. The time horizon for continuity of this research needs to be of the order of several decades.

In light of the pressing need for resource management and enhancement activities, AID should undertake sustainability systems research that currently is difficult to justify in light of the criteria and methods AID must use in the calculation of economic returns of aid, and the quantification of benefits stemming from AID programs. To implement research results, however, USAID needs to strengthen its abilities to plan research based on a broad view of agroecosystems. At present, compartmentalization of technical specialties constrains this kind of overview in AID. Current projects, such as Environment and Natural Resources Planning and Management, for example, could be strengthened and expanded to assist in sustainable agriculture design, planning and analysis.

Sustainable Agriculture: Institutional Questions

The question was raised whether United States institutions had the capacity to provide assistance overseas on agricultural sustainability issues. For U.S. expertise to be constructively tapped in fostering sustainable agriculture in developing countries, resources and encouragement must be made available to U.S. institutions to help generate the necessary examination of the biological, ecological, technological and socioeconomic dimensions of sustainability. A high degree of multidisciplinary skill and management, backed by time overseas and resources, are likely to be essential.

There is also a vital need for means to measure, and therefore quantify, the degradation of the agricultural environment. The economic benefit of sustainability has meaning in comparison to other agricultural practices that are degrading the region's long term ability to produce an agricultural output. Generalizations about current practices, particularly those labeled "modern", being not sustainable require definable evidence in order to warrant remediation through practices that are sustainable but may be otherwise more costly or less productive. Both macro and micro measurement studies are needed.

In the U.S., interest and research activity on sustainability of agricultural systems is growing. (See the report "The Role of Alternative Farming Practices in Modern Production Agriculture" [working title] from the Board on Agriculture, NRC, forthcoming summer 1988.) One example is that some form of conservation tillage is now practiced on a substantial part of U.S. cropland. It should be noted that much of what is called alternative agriculture in the United States produces a lower yield higher cost output that commands a higher price from affluent consumers who are willingly to pay a premium for "organic" or "natural" foods. Paying a higher price for foods for which there is no nutritional

or other scientifically measurable difference except origin may be a luxury that few other countries are able or wish to afford. In the research area, integrated pest management and rotational cropping systems are gaining in importance.

Moreover, there is considerable experience that can be analyzed and applied regarding the soils and farming practices in other countries. The Panel noted that the 1890 agricultural schools are known to be one important reservoir of those kinds of skills. Clearly there are both domestic and international aspects involved. The Panel recommends that:

- Traditional domestic resources and research funding arrangements be utilized in helping to redirect U.S. agricultural research programs to a greater emphasis on sustainable agricultural systems.

- AID be asked to help support studies of international agricultural systems that have been sustained over very long periods of time. (Nile delta and valley, Indus River plain, Pueblo region of Mexico are possible examples.) Since some like the Indus Valley are experiencing problems such as salinization and water logging, we can learn both the good and bad about traditional agriculture. Such studies could help to elucidate the design of current and new research toward sustainable systems. In addition, AID could continue to give attention to the adaptation of research results from modern agricultural systems to the more traditional agricultural systems.

- AID consider convening workshops in the U.S. and elsewhere to promote sharing of information on sustainable agricultural systems. Clearly, opportunities to interact with people from abroad who have different traditions will

enrich the programs in the United States. They, in turn, will benefit from U.S. agricultural experience.

- AID should assess the present institutional capacity and constraints of developing countries to foster sustainable agricultural research and production. This review should focus on systems and models for farming system research and technology transfer, using when appropriate a case study approach. AID should also support demonstration farms designed to study and evaluate sustainable agricultural systems in developing countries.

Sustainable Agriculture: Discussion of AID's Priority Issues

In its request for a review of issues on agricultural production sustainability, AID included a set of specific questions for RAC to address. These questions and responses to them are listed in this section of the report.

A. Sustainability of Food Production and Rural Incomes

1. Level of Inputs: (a) Are low-input technology approaches more likely to lead to sustainable agricultural systems that are both economically and environmentally sound than modest-to-high input approaches? (b) To what extent are the decisions location specific?

(a) Low input vs modest-to-high input. This issue was discussed in the first section of this report (Characteristics of sustainable agriculture). It is very important to differentiate the concept of "sustainability" from that of "low-input agriculture". Sustainability does not necessarily depend on a reduction of inputs, but on changes in approach and inputs; management inputs are vital. Technology becomes central to the concept in a way that it is not now for sus-

tainable agriculture. To maintain levels of food production adequate to feed a growing world population, the concept of sustaining farm systems under sound biological, ecological, and socioeconomic conditions must evolve and accommodate higher yields and in many cases higher levels of inputs, i.e., increasing levels of sustainable productivity. The guiding principle is how to optimize the production gained from purchased and natural resources. The focus should be on the performance and sustainability of a farming system, not the absolute level of any given input within the system.

The mix of inputs might change, but it is not likely to be in the direction of less inputs. More likely, there could be less chemical and more biological inputs in some sustainable systems, biological inputs based on sophisticated research but in practice accessible to large numbers of farmers.

(b) The level of inputs consistent with sustainability are very location specific.

2. Quality of the Production Environment. (a) Should primary development activities be limited to areas with favorable environments for agricultural production? (b) If agriculture on marginal lands or in fragile environments can be made sustainable, what type of development assistance should be offered and with what conditions? (c) What limitations should be placed on agricultural use of fragile environments and how can restrictions be effective?

This issue was addressed on pages 6-8.

B. Sustainability of Natural Resources

1. Forestry-agriculture interaction. What sound alternatives to shifting cultivation practices are possible that would lead to sustainable production and maintenance of the environment?

Attention should be given to the roles of trees in agriculture as related to crop rotations, nutrient cycling, soil and water conservation, fuel, lumber, and foliage as feed for livestock. (See, for example, BOSTID report Agroforestry in the West African Sahel. NAS Press, 1983.) Local knowledge, practices and varieties need to be incorporated wherever possible.

Production and management for more permanent vegetation has an essential role in the maintenance and building of soil. New techniques of intercropping using multiple purpose trees should be developed as a research priority.

2. Soil and water conservation and utilization. How can sustainable agriculture activities be integrated with the management and utilization of natural resources such as soil and water?

Soil and water management and utilization of natural resources including land, water, and vegetation should be considered as the fundamental basis of agricultural systems, and not as areas for separate program activities. Ecologically based criteria should be used in programs and the concept of the agroecosystem should be used in evaluation.

Part of the problem is in the idea of "natural resources". Resources are not natural, they are created by technology. The term "resource" is strictly anthropocentric and should be. Early humans had ideas and skills that allowed them to make stone tools, so certain stones became resources. When humans learned to plant rather than merely harvest, agricultural land was created. And

throughout history, as virtually everyone in the RAC discussion agreed, new technologies have allowed us to cultivate previously unproductive land.

Without question there is damage being done to some lands around the world and there should be concern for sustainability. But there should be more emphasis on the science and technology that sustain and enhance productivity.

3. Cultivation practices. Under what circumstances is sustainability of production limited by high (or low) intensity cultivation?

Cultivation practices should be tailored to ecological and cultural niches. Caution should be observed in the introduction of cropping into areas with difficult topography, inferior soils, too little rainfall or other related constraints. Often such areas should not be cropped and should be left in range/pasture land for livestock production, or for tree growing and natural vegetation for conservation and watershed protection.

Development or incorporation of existing strategies of intercropping should be adopted to provide arrays of cropping patterns to hedge against pest outbreaks often experienced in large-area, single-crop situations, and to provide alternate habitat for beneficial insects. Research into mechanisms of intercropping as a method to optimize food resources and to minimize pest outbreaks should be encouraged.

C. Environment and Biological Diversity

1. Present situation. What environmental changes and loss of biological diversity are occurring that affect sustainability of agriculture production?

A principal concern is the extent to which agricultural management practices and systems have led to the development of secondary pest outbreaks or resistant populations for the outbreak of pests that can survive in an agroecosystem despite pesticide treatments. These environmental changes have greatly affected the sustainability of agricultural production systems. The genetic traits and susceptibility of insect populations to conventional control methods are major environmental characteristics which in turn are related to biological diversity and sustainability. Frequent use of broad spectrum pesticides, under some conditions, can undermine sustainability by disturbing balance among pest species in an agroecosystem, and creating an ecological vacuum in which one or a few species of pests can thrive out of control.

Another key concern is the "loss" of locally adapted genetic stock as it is displaced by higher yielding or hybrid varieties. The issue of sustainability is central to the ongoing debate on the adequacy of the system of storing genetic materials for future use. AID has been a major supporter of these research and storage centers.

2. Improvements. What improvements are needed?

- In addressing environmental changes and loss of biological diversity greater attention should be given to opportunities offered by biotechnological tools and techniques. Biotechnology, for example, can be highly effective and relatively inexpensive in producing diagnostic materials for plant and animal diseases and other purposes. The development of tissue culture to multiply superior varieties of crops and trees for environmental protection or restoration applications should be stressed because of speed and cost effectiveness.

- Integrated Nutrient Management is as vital for agriculture as nutrition programs are for child survival.

- Integrated Organism Management concepts and strategies should be fostered to ensure that ecological principles of organism control as applied to agricultural production systems eradicate pests while preserving benign or beneficial organisms.

- Weather information and knowledge of crop and pest/-beneficial biology is essential for development of prediction systems to optimize application of pest management strategies, including pesticide use where needed. Weather information systems available on-line to crop and pest forecasters are an essential resource which will foster more accurate crop production and pest event prediction.

- Research is needed on dispersal of organisms, both beneficial and harmful and in both cultivated and non-cultivated habitats, as well as support for monitoring systems. It is essential that this research lead to methods of quantifying the monitoring systems. That, in turn will help to plan less chemically intensive strategies, where appropriate, to sustain agricultural production.

D. Other Issues

1. Policy Decisions. What LDC policy decisions, in priority order, are vital to developing sustainable agriculture while maintaining or enhancing the environment and maintaining biological diversity?

- Policies to encourage economic viability in agricultural production.

- Existence of credit systems to support agriculture. Technical assistance and extension are necessary for farmers to benefit from research on sustainability.

- Policies to encourage ecosystem maintenance which are coherent with the stated policy for profitability in agricultural production.

- Encouragement and support for a land tenure system appropriate to the country and its ecosystems.

2. Research. What are the knowledge gaps in information needed to consider each of the above questions? What research should AID undertake to provide new knowledge on the subject? Research questions related to the policy decision outlined above include:

- What are circumstances under which labor will be substituted for machines, pesticides, and other chemicals (growth stimulants)?

- Are the conditions in which labor will be substituted for other inputs achievable, and if so, are they sustainable?

- At what level of integrated inputs is an agricultural production system most profitable? (Understandably, this is highly dependent upon the local conditions.)

- What alternative management strategies can be followed to achieve profitability in agricultural production? Economic viability or profitability must be measured by both individual and societal frames of reference.

Research topics and priorities that are specific to individual countries need to be developed and should be focused on the impacts and consequences of particular agricultural technologies, practices, or policies. The research agenda should include both macro- and micro-economic sustainability.

ANNEX A

Panel Members, Participants and Observers

NRC Meeting on Sustainable Agriculture

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