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Report of a conference on

Agricultural Research for Development:

Potentials and Challenges in Asia

Edited by Barry Nestel

German Foundation for
International Development

International Federation of Agricultural
Research Systems for Development

International Service for
National Agricultural Research

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Food and Agricultural Development Centre (ZEL) of the German Foundation for International Development (DSE).

The conference was jointly organized by:

International Federation of Agricultural Research Systems for Development (IFARD), Asian Region

International Service for National Agricultural Research (ISNAR)

The host institution for the conference was:

Agency for Agricultural Research and Development, Ministry of Agriculture, Government of Indonesia

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JAKARTA, INDONESIA

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FOREWORD

In October, 1979, at the invitation of the German Foundation for International Development (DSE), the Rockefeller Foundation, the German Agency for Technical Cooperation (GTZ), and the Division of Agriculture and World Development of the Federal Ministry of Economic Cooperation of the Federal Republic of Germany, an international conference entitled "Agricultural Production: Research and Development Strategies for the 1980s" was held in Bonn. Experienced leading scientists from a wide variety of disciplines who were concerned with the food production needs of developing countries attended. The conference was unusual in that it brought those involved in agricultural research and development together with policy-makers from government agencies and donor institutions.

The objective of the conference was to contribute to the meeting of the world food needs by providing the governments of developing countries and the managements of assistance agencies with advice and recommendations relevant to the optimization of investment in tropical agricultural research and development.

State-of-knowledge reports were prepared on soil, water, energy, and biological resources, the natural resource base that sustains agriculture. These four reports served as a basis for discussion among working groups organized respectively around the same four themes. At the end of the conference, an editorial committee prepared a final report drawn from the initial state-of-knowledge papers and the final recommendations of the four working groups. This final report contained a large number of recommendations for future action.

At Bonn socioeconomic influences on research and development were deliberately omitted from consideration. The expectation was that this topic would be treated in a series of area meetings, at which the general Bonn findings would be related to specific country situations. In keeping with this plan, ISNAR (International Service for National Agricultural Research) – in cooperation with the Asian chapter of IFARD (International Federation of Agricultural Research Systems for Development) – organized a conference to explore further, in the regional context, a selected number of the issues raised at Bonn.

Also sponsored by the Government of West Germany through the German Foundation for International Development (See Annex 1 for a description of DSE activities) and the Ministry of Economic Cooperation, this conference took place in Jakarta, Indonesia, from October 24 to 29, 1982 with the Government of the Republic of Indonesia as conference host.

The Bonn gathering had generated a large number of recommendations. The organizers of the Asian regional follow-up conference selected specific recommendations from Bonn for detailed consideration that were related to problems and issues in the current agricultural research context of Asia.

On the evening of October 24, the conference in Jakarta opened with a formal dinner at which Dr. M. S. Swaminathan (President of IFARD), Dr. W. K. Gamble (Director General of ISNAR), and H.E. Dr. H. J. Hallier (Ambassador to Indonesia of the Federal Republic of Germany) welcomed participants. The Minister of Agriculture of the Republic of Indonesia, H.E. Prof. Ir. Soedarsono Hadisapoetro, was the evening keynote speaker. After his address, the minister inaugurated the conference in traditional Indonesian style by striking a ceremonial gong.

The first formal session of the conference, Monday morning, October 25, was chaired by Dr. Ch. M. Anwar Khan from Pakistan who was assisted by Dr. C. R. Panabokke of Sri Lanka as rapporteur. The session dealt with the topic of "Cooperation Between National Research Systems and the International Research Support Community." The main paper of this session was presented by Drs. J. C. Madamba from SEARCA and M. S. Swaminathan of IRRI. Dr. W. K. Gamble of ISNAR read a second paper, "Improving the Global System of Support for National Agricultural Research in Developing Countries."

The Monday afternoon session was chaired by Dr. W. Fernando of Sri Lanka, with Dr. R. D. Reyes of the Philippines acting as rapporteur. Dr. S. M. Miranda of ICRISAT, spoke on the topic "Land and Water Resource Inventories in Relation to Farming Systems Research." General discussion followed, after which the international board of trustees of IFARD convened. In the evening, a business meeting of the Asian Chapter of IFARD took place.

On Tuesday, October 26, the morning session was chaired by Dr. K. B. Rajbhandary from Nepal, with Mr. A. E. Charles of Papua New Guinea serving as rapporteur. There were two papers at this session: "Appropriate Methods for Closing the Technology Gap," by Mr. Sadikin S. W. of Indonesia; the second, relating to a proposed IRRI conference on "The Role of Women in Rice Farming," presented by Dr. M. S. Swaminathan.

The fourth and final plenary session of the conference began after lunch on October 26. The subject examined was "Sustained Agroforestry." Dr. F. S. Pollisco from the Philippines presided over the meeting, assisted by Dr. Vichai Nopamornbodi of Thailand as rapporteur. The principal speaker was Dr. B. Lundgren from the International Center for Research on Agroforestry (ICRAF) in Nairobi.

On Wednesday, October 27, the conference divided into four working groups, each of which was led by the relevant chairman of a previous plenary session. These groups further explored ideas which had arisen during the discussions following presentation of papers to the conference as a whole. Each group prepared summary and recommendations for presentation at the final session of the conference.

On the afternoon of October 27, the conference participants paid a field visit to Karawang, an area to the east of Jakarta where the transfer of new high-yielding rice technology has been successful, leading to outstanding yield increases in recent years. The group was entertained by the Karawang community. Visitors had an opportunity to conduct a stimulating and animated dialogue with two dozen farmers from the local (farm development) INSUS program and with field extension personnel, extension specialists, and district-level agricultural leadership. Travel then continued to the new research station at Sukamandi where the group spent the night.

On Thursday, October 28, the participants toured the new facilities of the Institute for Food Crop Research at Sukamandi, drove to Ciawi to visit the Research Institute for Animal Production, and finally called in at the Central Research Institute for Food Crops at Bogor.

The primary objective of the field trip was to offer participants an opportunity to observe at first hand various research facilities established by the Indonesian research and development system at different stages of its evolution. The Indonesian Agency for Agricultural Research and Development (AARD) inherited facilities from a number of other agencies and has had to fit these into its overall national research system.

Dr. Sadikin explained that during the course of integration, AARD had to face difficult decisions relating to investment in research infrastructure in terms of optimizing the use of financial resources available, not only in terms of capital outlays, but also with respect to maintenance costs. Conference participants visited research facilities of various levels of complexity and investment, many of which had been established with external assistance. They had fruitful discussions about relating investment and maintenance costs in such facilities to national research programs and priorities and to research output. After a useful and productive wind-up discussion on this topic at the end of the day, Dr. and Mrs. Sadikin were hosts at an informal dinner for the group.

The final session of the conference was held in Jakarta on Friday, October 29, under the chairmanship of Dr. J. C. Madamba. Each session chairman, or his rapporteur, presented the summary and conclusions from his working group meetings. These presentations were followed by the closing ceremony. Dr. B. T. Mook spoke briefly for ISNAR, Dr. J. C. Madamba for IFARD, Dr. H. de Haas for the German Government, and Dr. R. H. Yarrow from Fiji on behalf of the conference participants collectively. In the absence of Prof. B. J. Habibie, the Minister of State for Research and Technology, his concluding remarks were presented for him by the deputy minister, Prof. Dr Sukaji.

In this volume of proceedings plenary papers are reproduced in their entirety. In a final chapter appear summaries of the discussions which followed presentation of each paper, and conclusions which arose from working group efforts. This final chapter is based on notes provided by session chairmen and rapporteurs.

ISNAR and IFARD are especially grateful to the Government of West Germany for the generous financial support which made the Jakarta conference possible. They would also like to express appreciation to the Government of the Republic of Indonesia for providing such a warm welcome and excellent facilities. Particular thanks are due to Dr. Ibraham Manwan and Mrs. I. Paransih and to their colleagues in the Centre for Agricultural Research Planning who bore the brunt of the local workload.

ACRONYMS

AACU: Asian Association of Agricultural Colleges and Universities

AAASA: Association for the Advancement of Agricultural Sciences in Africa

AARD: Agency for Agricultural Research and Development (Indonesia)

ADAB: Australian Development Assistance Bureau

ADB: Asian Development Bank

AFAA: Association of the Faculties of Agriculture in Africa

ALCA: Latin American Association of Agricultural Sciences

ALEAS: Latin American Association of Higher Schools of Agriculture

AOAD: Arab Organization for Agricultural Development

APCC: Asian and Pacific Coconut Community

APGRC: African Plant Genetic Resources Committee

ARC: Agricultural Research Center

ASEAN: Association of South East Asian Nations

AVRDC: Asian Vegetable Research and Development Center

BIMAS: The Indonesian Integrated Crops Development Program (initially for rice)

CARDI: Caribbean Agricultural Research and Development Institute

CATIE: Center for Research and Training in Tropical Agronomy (Costa Rica)

CAZRI: Central Arid Zone Research Institute (India)

CFI: Commonwealth Forestry Institute

CGIAR: Consultative Group on International Agricultural Research

CIMMYT: International Center for the Improvement of Maize and Wheat

COFAF: Committee on Food Agriculture and Forestry (of ASEAN)

CTFT: Centre Technique Forestier Tropical (France)

DSE: German Foundation for International Development

EMBRAPA: The National Agricultural Research Organization of Brazil

FAO: Food and Agriculture Organisation

GDP: Gross Domestic Product

GTZ: German Agency for Technical Cooperation

IAs: International Associations

IAAE: International Association of Agricultural Economists

IACO: Inter-African Coffee Organization

IARCs: International Agricultural Research Centers

IBPGR: International Bureau for Plant Genetic Resources

IBRD: International Bank for Reconstruction and Development (World Bank)

ICAR: Indian Council for Agricultural Research

ICARDA: International Center for Agricultural Research on the Dry Areas

ICIDIAT: Inter-American Center for the Integrated Development of Soil and Water

ICIPE: International Center for Insect Physiology and Ecology

ICRAF: International Council for Research on Agro-Forestry

ICRISAT: International Crop Research Institute for the Semi-Arid Tropics

IDRC: International Development Research Centre (Canada)

IEMVT: Institut d'Elevage et de Medecine Veterinaire des Pays (France)

IFAD: International Fund for Agricultural Development

IFARD: International Federation of Agricultural Research Systems for Development

IFPRI: International Food Policy Research Institute

IITA: International Institute for Tropical Agriculture

ILCA: International Livestock Center for Africa

INIPA: National Institute for Agricultural Research and Development (Peru)

INSUS: Special Intensification Program (Indonesia)

IPB: The Agricultural University at Bogor, Indonesia

IRAT: Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (France)

IRRI: International Rice Research Institute

JICA: Japanese International Cooperation Agency

NARC: National Agricultural Research Center

NARS: National Agricultural Research System

NES: Nucleus Estates Smallholders Schemes (Indonesia)

OIRSA: Regional International Organization for Plant and Animal Health (Central America)

PCCMCA: Central American Cooperative Programs for Food Crop Improvement

PELITA: 5-Year Development Plan (Indonesia)

PRECODEPA: Regional Cooperative Potato Program (Central America)

RSG: Research Support Group

SABRO: South Asia Breeders Organization

SEAMEO: South East Asian Ministers of Education Organisation

SEARCA: Southeast Asian Regional Center for Graduate Study and Research in Agriculture

UASRC: Union of Arab Scientific Research Councils

UNESCO: United Nations Educational and Scientific Organisation

UNDP: United Nations Development Programme

UNICA: Association of Caribbean Universities and Research Institutes

USAID: United States Agency for International Development

VISCA: Viscayas State College of Agriculture (Philippines)

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WELCOME ADDRESS

H.E. Dr. Hans Joachim Hallier

Ambassador of the Federal Republic of Germany to Indonesia

It is indeed a great honor and pleasure to accept your kind invitation to this opening ceremony of the International Conference on "Agricultural Research for Development - Potentials and Challenges in Asia."

Some of you may ask why the Ambassador of the Federal Republic of Germany to Indonesia should take the opportunity to address this distinguished gathering. This conference, which will be opened tonight, is a joint effort of various international agencies working in the field of agricultural research. it is a follow-up to a conference on "Agricultural Production, Research and Development Strategies for the 1980's" which was held in Bonn in 1979 and was sponsored by my government.

This conference here in Jakarta results from a fruitful cooperative partnership between well-known international institutions, namely: the Indonesian Agency for Agricultural Research and Development (AARD), the International Service for National Agricultural Research (ISNAR), and the International Federation of Agricultural Research Systems for Development (IFARD); as well as the German Foundation for International Development (DSE), the German Agency for Technical Cooperation (GTZ), and the Federal Ministry for Economic Cooperation (BMZ) of the Federal Republic of Germany, which – in the framework of technical cooperation between developing countries and Germany – contributed essential funds to make this important conference possible.

The Government of the Federal Republic of Germany pays particular attention to agricultural policy in developing countries, especially to research on new strategies to work out new and more effective ways to meet the ever-increasing tasks in this field.

The agriculture sector constitutes the most strategic component of the economy in developing countries in Asia. It plays an important role in contributing significantly to the countries' Gross National Products and gives employment to a high percentage of the total labor force in Asian countries. In the future, as well as in the past, agriculture will continue to be a cornerstone of economic development and will remain an important pillar of growth and stability. Substantial parts of the region's resources for economic development are likely to be derived from agriculture.

The governments of Asian countries give high priority to agricultural programs aimed at increasing production, especially of food crops. Research plays an essential role in helping these governments to achieve their high development goals.

Major efforts are especially required to increase food production in various developing countries. Research work on agricultural development will make contributions to find better and more productive ways to achieve these goals. Exchanges of experiences and views, know-how transfer, will help to introduce new and innovative approaches.

I consider that it was a happy choice to bring this international conference to Indonesia, because Indonesia can demonstrate in such an impressive way what can be achieved in the agricultural sector. Enormous efforts have been undertaken by the Indonesian government to bring about self-sufficiency in food production.

In the not-too-distant past, Indonesia was one of the world's largest rice-importing countries, but it has now become self-sufficient in rice production due to an impressive growth rate of production. In the near future Indonesia will most probably be in a position to build up food stocks for the emergency needs not only of itself but also of other ASEAN-countries as well.

This conference on agricultural research, in which highranking delegates and experts from countries all over Asia are taking part, provides an excellent opportunity to discuss and work out new strategies to increase agricultural productivity, to stimulate more and new impulses for research work on agriculture, and to underline the important role agricultural research plays in developing countries.

I am pleased that my government, through the aforementioned German agencies, has the opportunity to cooperate with you in this field.May I express my best wishes for a successful conference.

KEYNOTE ADDRESS

H.E. Prof. Ir. Soedarsono Hadisapoetro

Minister of Agriculture of the Republic of Indonesia

It gives me great pleasure to welcome you all to this conference on "Selected Issues in Agricultural Research" held in the metropolitan city of Jakarta. We feel honored that Indonesia was selected as the venue for the conference, particularly because agricultural research in Indonesia has gained its right momentum where it plays an active and important role in supporting the national development undertaking.

It is, indeed, my privilege to have the opportunity to open the conference officially, and I will follow its proceeding with special interest. I have a personal commitment to the conference because for many years during my earlier career I was involved in agricultural research activities.

The topics listed in the agenda for your deliberation seem appropriately selected since they are issues of major concern to our agricultural and rural development efforts. The role of science and technology in supporting and providing guidance for development, particularly in the agricultural sector, has, undoubtedly, been recognized. In Indonesia the Agency for Agricultural Research and Development has played an important part in carrying out the task of promoting the application of science and technology to small farming in order to increase both productivity and production.

The results of agricultural research activities in this country have been encouraging. In the last 13 years the production of rice has nearly doubled, from 11.7 million tons (milled rice equivalent) in 1970 to 22.3 million tons in 1982. This success was attributable to the following factors:

1. the use of improved rice varieties resistant to brown plant hopper;
2. the implementation of INSUS (special intensification programs) which provide farmers with a complete package of inputs and special guidance;
3. the increase of investment in the development of irrigation systems;
4. the adaptability of farmers to the application of new technologies, and to the possibility of planting three crops of rice per year;
5. the improved agricultural research system that provided new improved varieties and improved cropping systems, and thereby improved farmers' incomes;
6. widespread extension and training activities.

As far as rice production is concerned, we have already achieved our Third Five-Year Development Plan target. In fact, we are two years ahead of schedule. We hope in the next five-year plan to be able to achieve self-sustaining agricultural growth.

The increase in rice production has allowed the per capita calorie intake level of the Indonesian people to rise above the required minimum level; it has provided a national food reserve capable of ensuring an adequate supply of rice throughout the year at a stable price. At present we are also making every effort to promote the production and improvement of other food crops, including estate and industrial crops. We hope that through such endeavors we will be able to achieve the goals of the national Five-Year Development Plan in terms of food production.

Agriculture will remain a priority sector in our forthcoming five-year plan which is scheduled to begin April 1, 1984. This plan will put emphasis on raising farmers' incomes and rural employment opportunities; on increasing food production to achieve self-sufficiency with foods of adequate nutritional quality; on expanding exports of agricultural products and reducing imports; on supporting the development of primary industries; and on making appropriate use of natural resources while managing the environment soundly.

The plan is certainly challenging and will require proper management. Its implementation will need to be supported by well-planned research activities which are relevant to the developments being carried out. In this connection I am pleased to note that this conference will examine several major issues of research which concern us, namely soil, water, energy, and biological resources. These four topics were recommended at the Bonn conference of October 1979, and I hope they will be discussed extensively and in great depth here, so that this conference will be able to formulate recommendations of immediate practical use. It is also important for this conference to examine the technologies being developed at international agricultural research centers and to discuss how these technologies can be transferred to national research institutions.

Our national agricultural research has made significant progress. The quantity and the quality of the work carried out by our research centers has been greatly improved. I might even venture to say that our research work has reached an international standard. We have already determined the research system which is most advantageous for our conditions and the type of research which must be conducted in order to solve the problems confronting us. With our improved capability we are not only sustaining our national research activities but also expanding our joint efforts with international agencies in order to resolve problems of developing countries at large.

International agricultural research centers (IARCs) should strive for closer links with national research systems if they aim to maintain their role as founders of advanced technologies for agricultural development. The IARCs should not compete with the national systems, but should complement them; every effort should be made to establish an effective and collaborative research network. I think ISNAR and IFARD can play an important role in promoting a harmonious relationship between national and international research systems.

Ladies and gentlemen, as you may have noted, we are now experiencing a long dry season in Indonesia. Some productive areas of the country are facing a serious lack of water for their crops. However, thanks to our agricultural researchers, who have developed the early maturing and drought-resistant crop varieties which farmers are now using, we are hopeful that this drought will only have a limited harmful effect on our crop production in 1982.

Before concluding, may I wish you success in your deliberations and express the hope that you will have an enjoyable stay in our country.

With this final remark, I hereby declare the conference on "Selected Issues in Agricultural Research" officially open.

COOPERATION BETWEEN NATIONAL RESEARCH SYSTEMS AND THE INTERNATIONAL RESEARCH SUPPORT COMMUNITY

Joseph C. Madamba
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Introduction

Research continues to transform the image of agriculture in a number of Third World countries. The degree of development varies among these countries, but the signs are clear: these nations have come to realize that research offers the best solution to the food problems that have been besetting mankind in recent times.

A global picture of the research sector shows encouraging changes in the developing world. In 1980, according to a review of Third World agricultural research systems sponsored by the International Service for National Agricultural Research (ISNAR) and the International Food Policy Research Institute (IFPRI) (Oram and Bindlish, 1981), expenditure in 76 developing countries had reached US$890 million per annum and the number of scientists engaged in relevant pursuits almost 36,000. Compared to previous IFPRI estimates for 1975, in five years national expenditure on agricultural research had risen by 71% and number of scientists by 38%.

The Oram and Bindlish analysis for 47 comparable countries in 1971, 1975, and 1980 indicates that considerably more resources are now being poured into national agricultural research systems (NARS) than was true a decade or even a quinquennium ago. In relation to agricultural Gross Domestic Product (GDP), the average expenditure on research for 51 countries has risen from 0.3% in 1975 to 0.56% in 1980. The 1980 figure is slightly above the United Nations World Food Conference suggested 1985 target of 0.5% (World Food Conference, 1974). In terms of numbers of scientists, the 1980 figure is also higher than that of the 29,100 researchers proposed by the World Bank in its Sector Policy Paper on Agricultural Research as a target for all Third World countries in 1984 (World Bank, 1981).

At present about 25 developing countries have NARS which are adequately financed and staffed and capable of accommodating national and regional needs. A similar number of countries are at an intermediate stage, with adequate staff for research on key commodities, but lacking a critical mass for all purposes.

These developments are encouraging, particularly when one realizes that, as the World Bank has stressed, the effectiveness of research programs during the eighties will determine how well the 3.2 billion people who live in developing countries will be fed in the coming years. To meet their yearly agricultural production goal of a growth rate between 3% and 4%, most developing countries will need to step up their investment in agricultural research substantially, from an average of 0.3% of the agricultural Gross Domestic Product in 1975 to a target level of at least 1.0%.

National Agricultural Research Systems

In more ways than one the gradual agricultural modernization of developing countries can be significantly attributed to the development and strengthening of their national agricultural research systems. The emergence of these research systems has been brought about by the realization of a given country's leadership, at most times enlightened by members of the agricultural research community themselves, that research should be welded into a viable instrument to move agriculture forward.

In the case of Asia, for instance, a number of countries in the region began setting up their NARS in the 1960s and 1970s. At present the NARS of these countries are at different stages of development. While some have remained weak, their progress hampered by the problems confronting them, other research mechanisms reflective of the Asian setting might now be used as suitable models for fledgling NARS to adopt.

Study of the NARS in Asia indicates that India, South Korea, the Philippines, and Indonesia have developed viable mechanisms for implementing national agricultural research and development programs. It is probably only in India, the Philippines, and South Korea, however, that research program planning has moved beyond its specific institutional setting and encompasses a national perspective of gearing research to tackling national problems in agricultural development. Recently, Indonesia and Bangladesh have taken steps to inject an overall national perspective into their research program planning. In other Asian countries, research program planning still remains essentially geared to a specific institution's perspective.

The structure of a NARS may be rather complex. Venezian (1982) states that the typical organizational framework for agricultural research in developing countries may include several kinds of institutions, although in small and/or less-developed countries, only major institutions are likely to be present:

1. The central national agricultural research institute. This is composed of several regional and/or local centers and experimental stations. It is usually the largest, best-staffed, and best-funded research institution. Its programs have an applied, problem-solving orientation, are of a long-term nature, and are apt to cover a broad spectrum of subjects and tasks. These programs usually include some basic research.

2. Decentralized and/or specialized public research institutes. These are similar to a national agricultural research institute in organization, but deal either with more restricted geographical areas, or with specific crops or problems. They may, or may not, be formally linked to the central national organization.

3. Universities, colleges, and schools of agriculture. The degree to which these institutions actually engage in research varies greatly among and within countries. In many instances their research function is significant. Usually, however, universities conduct research on a project basis, which means shorter-term, more specific but less coordinated studies; the tendency is away from applied and towards theoretical research. Links with national institutes are frequently weak, relations often competitive.

4. Farmers' organizations. In many countries there exist experimental stations or research institutions which are supported by farmers' organizations. These are typically smaller and more narrowly focused and applied in their research than the national or decentralized institutes. Ties with other parts of the research establishment are informal and weak.

5. Industry-supported institutes. Large business or industrial concerns, often foreign, may occasionally run agricultural research institutes devoted to crops or problems that are of commercial interest to them. The results of this research do not necessarily become public. Their effect on domestic agriculture and overall national research is generally fairly limited.

6. Private sector research institutes. Though these are not common, several developing countries have agricultural research institutes which are supported by private groups and foundations or are run for profit by individuals. Such institutes usually constitute a minor component of the national research system, but they can be important within restricted geographical areas or for speciality crops.

These various components illustrate the potentially extensive nature of an NARS. Each constituent element is likely to have its own structure and priorities. Marshalling the full capabilities of them all to fit into the national research perspective may well be a Herculean task.

Many additional problems and constraints impede the rapid development of agricultural research systems in developing countries. These problems may differ widely, but most derive from a few interrelated factors, including shortages of funds, manpower, facilities, programs, and strategies.

The inadequacy of financial resources remains among the major obstacles to agricultural development in developing nations. In most of these countries, conflicting demands are made on their limited financial resources. In practical terms this usually means that agricultural research is given a low priority for fund allocation. The situation is aggravated by the fact that most agricultural research activities involve a long-term investment without any immediate visible returns.

A review of past levels of financial support for NARS does not, indeed, make encouraging reading. One analysis of the period from 1959 to 1974 (Boyce and Evenson, 1975), for example, shows that low-income Third World countries as a whole spent too little money on research compared to extension during the period under review. Higher-income developing countries spent more on research, both in absolute terms measured by comparative criteria (value of agricultural product, expenditure per scientific man-year, the proportion of research in agriculture-related sciences), and relative to extension expenditure. Thus higher-income countries were better able to proceed with original research; poorer countries were dependent on borrowing new technology from elsewhere, either attempting to transfer it to farmers directly through extension services or, at best, trying first to modify it to suit their needs and local environment through adaptive research.

Oram and Bindlish (1981) pointed out that both country reports and replies to FAO and other questionnaires suggest that an average of 15% of annual agricultural research expenditure is used for capital investment; the remaining 85% supports recurrent operating expenditures and salaries. The bulk of such spending in many developing countries seems to go for salaries. Inflation and an increasing number of scientists returning from advanced training abroad have eroded operating budgets still further. In several countries, after salaries have been paid, little is left over for research operations.

In the case of low-income countries, it is understandable that physical facilities are limited. While a number of countries in Asia — e.g., India, the Philippines, Malaysia, Indonesia, and South Korea — have, in recent years, been able to attract substantial overseas funds for building up their research infrastructure and have also invested considerable sums for this purpose from their own resources, other countries have not been as successful.

Another problem confronting many developing countries is the scarcity of competent research scientists. In most of the NARS of those nations, a lack of research manpower, as well as an imbalance in expertise coverage, is evident. In some instances, while building up a local pool of trained manpower, countries rely in part on foreign scientists. Despite significant gains in indigenous expertise during the last decade, however, massive training and retraining needs still must be met.

The magnitude of the problem is revealed in "Investment and Input Requirements for Accelerating Food Production in Low-Income Countries by 1990" (Oram et al., 1979), a study which surveys future training needs for research and extension services in 36 developing countries. The authors conclude that, allowing for normal turnover, about 4,200 research scientists, 8,450 technicians, and 24,000 senior and field-level extension workers will have to be trained by 1990 to serve the needs of the countries concerned.

Admittedly, it takes time to build up a manpower-generating capacity, basically because it takes time to train those who can provide leadership for research institutions. The situation becomes disturbing when highly qualified manpower, owing to frustration with the prevailing research environment, emigrates to more advanced countries in search of proverbial greener pastures. This brain drain phenomenon has become one of the manpower-associated problems nagging developing nations in recent years (Ardila et al., 1981).

Another problem that should be looked into more seriously is the quality of research that is actually being carried out. How well is it organized and managed? Sevred and Oram (1974) have drawn attention to the apparently excessive dispersion of resources to regional stations and substations poorly endowed with scientific staff. In the early 1970s, for instance, about 50% of all research stations in most developing countries appeared to have had fewer than five trained researchers. Compounding this unfortunate state of affairs was the dearth of qualified technicians to back them up. Moreover, deficiencies in seed production and muluplication services were noted as weaknesses, both constraining output and the availability to farmers of improved genetic materials and diverting scientists' time from their primary task of research.

The lack of enlightened rapport between the research community and government policy-makers has also remained a problem. Too often government decision-makers, with the exception perhaps of those in agriculture ministries and a few specialized agencies, lack appreciation of the true potential of agricultural and resources research.

The communication gap between government leaders and the research community often leads to a misallocation of the resources provided for research, either in terms of national priorities or because of sharp fluctuations in the amount of resources made available. This instability has an adverse effect on the morale of researchers. To overcome it there is a need for a regular dialogue between government and the research sector in order to enlighten the former on the need for long-term program stability and consistency in research funding. These two factors are both critical to the development of a research career structure. Career structure is often considered to be of more importance to research staff productivity and stability than salary level itself.

It is also desirable for the research system to participate in national agricultural and rural development planning. A study of NARS in developing countries, particularly in Asia, shows that with few exceptions (India, the Philippines, Malaysia, South Korea), in their respective national agricultural and rural development planning exercises, policy-makers have not made exhaustive use of their national research systems.

The research sector must be effectively tapped in order to inject relevance and realism into national plans. Research activities must not only be marked with local or national relevance and orientation, they must also be specific, realistic, and above all, quantifiable. And it is precisely here that the expertise of those engaged in agricultural research systems can be utilized meaningfully.

Fragmentation of responsibility among several ministries remains common, as noted by Oram and Bindlish (1981). This is evident in the fact that many countries still have to work out appropriate machinery for research coordination (including that of donor aid to research); that excessive dispersion of resources in an attempt to meet all local needs continues to be widespread; and that the congruence of the allocation of resources to priority fields of research displays considerable room for improvement.

The effectiveness of research coordination depends to a considerable extent on how well organized and how stable the national agricultural research system is. In most Asian countries the coexistence of a number of agricultural research institutes and of a weak research coordinating mechanism complicates the tasks of coordination and national research planning. This often results in the overlapping of research programs and a duplication of effort.

A mere coordination mechanism for research, however, is not enough. Any body entrusted with operationalizing a national agricultural research program should be clothed with the powers necessary to ensure the cohesive orchestration of that program.

Notwithstanding the formidable problems besetting the NARS of developing countries, there is reason to be optimistic about their further development. At the national level more and more developing countries are realizing that it pays to invest in agricultural research. They have seen the successes achieved by other countries — developed as well as developing — in improving their agricultural economies through increased research investment. Credit must also go to those members of the research sector who have taken upon themselves the task of enlightening national leaders about the value of channeling more resources into research.

International Agricultural Research Centers

One of the most encouraging developments in world agriculture during the past two decades has been the establishment of international agricultural research centers (IARCs). The advent of the IARCs has added a new dimension to the global food production campaign, for these centers work with national commodity programs and scientists throughout the world.

The first IARC to be established was the Philippine-based International Rice Research Institute (IRRI). In 1966, the Mexico-based Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) was expanded into an international institution. CIMMYT actually evolved out of a collaborative program launched in 1943 by the Mexican government and the Rockefeller Foundation. Breakthroughs in rice research by IRRI and in wheat by CIMMYT triggered what has come to be popularly called the green revolution in cereals.

Other IARCs came into being in the 1970s. The operations of these international centers became more systematic following the establishment of the Consultative Group on International Agricultural Research (CGIAR) in 1971. CGIAR is an informal association of governments, international and regional organizations, and private foundations dedicated to supporting a system of agricultural research centers and programs around the world.

CGIAR is sponsored by the Food and Agriculture Organisation (FAO) of the United Nations, the World Bank (IBRD), and the United Nations Development Programme (UNDP). It comprises some 45 countries, international and regional organizations, and private foundations. Today CGIAR supports 13 international agricultural research centers, funds for which are provided by 35 contributing members.

The purpose of CGIAR is to bring the resources of modern biological and socioeconomic research to bear on accelerating the long-neglected possibilities of agricultural progress in the tropics and sub-tropics, those zones where nearly all low income countries lie. The research and training programs undertaken by the IARCs and sponsored by CGIAR seek to arm developing countries with superior varieties of essential crops and improved farming systems for the production of food plants and animals.

International Associations

Another significant development in world agriculture during the past decade has been the establishment of international associations (IAs) whose objectives include the promotion of agricultural research. The IAs have had different origins, purposes, structures, and methods of funding.

There are about 50 such international associations operating in different regions of the world today. Some are worldwide in scope, others regional. Prominent examples of IAs of global reach are the International Federation of Agricultural Research Systems for Development (IFARD) and the International Association of Agricultural Economists (IAAE).

Among the IAs operating in Asia and the Pacific region are the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), the Asian Vegetable Research and Development Center (AVRDC), the Asian Association of Agricultural Colleges and Universities (AAACU), the ASEAN Committee on Food, Agriculture and Forestry (COFAF), the Asian and Pacific Coconut Community (APCC), and the South Asia Breeders Organization (SABRO).

The IAs in Latin America include the Inter-American Association of Agricultural Sciences (ALCA), the Latin American Association of Higher Schools of Agriculture (ALEAS), the Caribbean Agricultural Research and Development Institute (CARDI), the Center for Tropical Agricultural Research and Training (CATIE), the Inter-American Center for the Integrated Development of Soil and Water (ICIDIAT), the Regional International Organization for Plant and Animal Health (OIRSA), the Central American Cooperative Program for Food Crop Improvement (PCCMCA), the Regional Cooperative Potato Program (PRECODEPA) and the Association of Caribbean Universities and Research Institutes (UNICA).

There are numerous IAs as well in Africa and the Middle East: the Association for the Advancement of Agricultural Sciences in Africa (AAASA), the Association of Faculties of Agriculture in Africa (AFAA), the Arab Organization for Agricultural Development (AOAD), the African Plant Genetic Resources Committee (APGRC), the Inter-African Coffee Organization (IACO), the International Center for Insect Physiology and Ecology (ICIPE), and the Union of Arab Scientific Research Councils (UASRC).

Venezian (1982) states that, in general, IAs are set up to achieve one or more of the following activities:

1. training;
2. research;
3. technical assistance;
4. diffusion of information;
5. exchange of knowledge, professional discussion;
6. coordination, planning, central administrative services;
7. promotion and/or protection.

Since IAs were first established, they have, to varying degrees, contributed to the development of agriculture in nations within their sphere of operations, particularly in those countries where they are based.

A typical case is AVRDC, established in 1971 in Taiwan to work initially on six crops of importance to Asia: sweet potato, white potato, tomato, mungbean, soybean, and Chinese cabbage. In tomato research and development work, AVRDC's accomplishments have been dramatic. The tomato-processing industry in its host nation has become a multi-million dollar enterprise, an extraordinary rags-to-riches story considering that in 1968 only 18 ha of farmland in Taiwan were planted in tomatoes for processing. By 1980 about 6,000 ha were under this cash crop. The rapid expansion of the industry owes a great deal to the responsiveness of Taiwan's business sector to the output of research on the tomato subsequent to the establishment of AVRDC in that country.

SEARCA's programs in research, education and training, technology dissemination and use, institutional development, and technical assistance have also given no small boost to agricultural and rural development in SEAMEO member states as well as in other Asian countries and elsewhere.

The SEARCA graduate study program has already turned out 120 Ph.D. and 200 M.S. graduates from Indonesia, Malaysia, Thailand, the Philippines, Singapore, Vietnam, Kampuchea, and Laos. Over 5,000 nationals from countries in Asia and elsewhere have benefited from its specialist, short-term training program. SEARCA's research programs and projects have likewise assisted countries in the SEAMEO region.

The significant role that IAs can play in bringing about agricultural and rural development was recognized at a recent meeting of research administrators and scientists (ISNAR/IADS, 1982). The overall conclusion of this meeting was that international associations can make a significant impact on national agricultural research. The participants also acknowledged that in addition to performing their direct roles, IAs can play an important part in attracting funds and other support for national agricultural research systems from international and bilateral sources. They can also educate government officials and the public at large about the value of agricultural research.

Relationships Between NARS and Other Research and Development Institutions

Most of the NARS, IARCs, IAs, and other organizations and institutions we have been discussing emerged during the past 20 years, particularly during 1965 to 1974, now known as The Decade of Awakening in relation to the world food-poverty-population problem. The past two decades have witnessed an upsurge in serious studies of the problem, in the formation of strategies, and in the mobilization of resources and scientific talent towards achieving a solution.

During this same period the world has also entered a new era of agricultural development, an epoch of concerted, campaign-style, rapid-pace agricultural and rural development. This is "an era wherein agricultural scientists and specialists are being asked to join — even to lead — in the concerned national efforts to accelerate rates of increases in agricultural productivity and in incomes of vast numbers of small farmers in the poorer countries. The added challenge of this task is that this feat must be accomplished, not in the 50- to 75-year time frame required for similar progress in North America and Europe, but rather between now and the year 2000 when the food crisis becomes acute in view of the rapid increase in population, particularly in the Third World countries" (Wortman and Cummings, 1978).

More than ever before agricultural research centers as well as development and support organizations and institutions are expected to play an active role in this task. Fortunately, many of these organizations, whose interests are often mutual, have developed working relationships among themselves in order to be of even greater service to developing countries. In some cases IARCs, as well as development institutions and organizations based in other parts of the world, have either initiated outreach programs in specific regions themselves, or else joined with their regional counterparts, as well as with IAs and national agencies, in order to help speed the development process.

Considered in their totality, the resources being invested to strengthen the NARS by the IARCs, IAs, regional institutions, bilateral assistance organizations, foundations based in developed countries, and major development financing institutions appear to be massive. Yet there has been overlapping and duplication, as well as instances of unproductive competition among such institutions and organizations. Therefore an urgent need exists to trace the strands of their interrelationships, to identify gaps and problems, and to find solutions for these difficulties.

Relationships among NARS

Much still remains to be done to bring about the kind of close working relationship among NARS that is so badly needed, particularly among those situated in the same region and encountering similar problems. At present, communication among researchers in neighboring countries is frequently poor, which leads to unnecessary repetition of work. The situation has been aptly described by Qasem (1982): "a researcher is likely to know more about research in a European rather than in a neighboring country."

This state of affairs can perhaps be explained by the fact that the research and development programs of most developing countries operate more or less independently of each other. Consequently, inefficient use of resources takes place. Such waste might well be kept to a minimum or even avoided altogether if an effective regional mechanism involving the sharing of experiences and available resources can be put into sustained operation in such a way that what are now separate country programs eventually evolve into a mutually reinforcing regional development network.

The challenge is not being ignored, fortunately. In recent years more and more NARS in developing countries have been joining forces in cooperative efforts, forming links either through their own initiative or through that of international agricultural research centers, international associations, or development and assistance organizations and institutions.

Relationships between NARS and IARCs

Experiences during the past two decades have illustrated how developing countries have benefited from the activities of the IARCs. The remarkable strides made by these international centers can be attributed to a host of factors. IARCs are well endowed with funds, well-trained and experienced scientists, adequate facilities, and viable programs. By concentrating their efforts on research, they have demonstrated how well-coordinated scientific investigation can accelerate agricultural development. They have catalyzed major discoveries in the field of agriculture and opened new horizons in food production, thus motivating millions of farmers to modify their traditional farming practices.

Notwithstanding these successes, there remains the need to improve and expand relationships between IARCs and NARS of developing countries. Time and again this need has been expressed at scientific meetings, among them the workshop on "The Present and Future Roles of the CGIAR System in Assisting National Research Programs" held at SEARCA on March 16 and 17, 1981 (SEARCA, 1981).

The participants of this workshop, research administrators from the Asian region, raised several points for consideration by the CGIAR system.

1. IARCs should better understand the problems faced by the NARS. Improved understanding could well be accomplished through better communication systems. A corollary to this is the need to set up a national agricultural development agency as the contact institution which would communicate with various international and other research centers to make an integrated and viable national program possible.
2. IARCs should explore the possibility of passing on some of their programs to national research systems to be undertaken under bilateral or other types of assistance. There should be a sorting out of mature technology ready for extension to NARS. IARCs should be ready to identify what the NARS could adopt. NARS in turn should make clear what their capabilities realistically enable them to attempt.
3. IARCs should form task forces for periodic review of research programs in national centers designed to determine requirements for support.
4. IARCs should work closely with national research centers in identifying ways to increase productivity and overcome poverty, and in helping the NARS to initiate action towards these ends.
5. IARCs should consider assigning some senior staff to host countries on a full-time basis in order for them to be able to participate in national agricultural research and development activities. National scientists might also spend sabbatical leave at international centers.
6. IARCs should assist in developing the technical manpower profile of national research systems. Training must be oriented towards preparing young scientists to work in their own countries using up-to-date knowledge on available technology.
7. IARCs should consider conducting an in-depth study of returns-on-investment in selected national research systems and in the IARC research network.

Relationships between NARS and IAs

Since international associations as a rule originate and are based in developing countries, they usually fill needs not as readily met by international organizations. The indispensability of IAs has become so well established that, as Venezian (1982) has emphasized, should appropriate IAs not exist in a region, or should they be inactive, a well-considered development strategy would promote their formation, and nurture their growth prior to tapping their potential for strengthening the NARS. "In fact," Venezian adds, "this initiative often corresponds to the practices of large international organizations, which view IAs as the appropriate institutions to provide continuity, or maintain certain activities beyond the time when the international organization must move on to something else. This pattern has been characteristic of the activities of some foundations as well as USAID, whose country programs have had more limited time spans than those of inter-governmental organizations."

Indeed, current and past experiences have demonstrated many areas and activities related to NARS where IAs have an effective contribution to make. The Bellagio conference of 1981 (ISNAR/IADS, 1982) identified the following general constraints under which national programs operate, and to which IAs might respond helpfully:

1. Short supply of qualified manpower, both scientific and managerial. IAs might be able to take the lead in organizing training. Any association that wanted to do so, however, would have to find answers to several difficult questions, including: what fields, both scientific and managerial, need most attention; who should be trained; how should such training be carried out.

2. Incomplete access to good information on which to base research. National programs often find it difficult to discover what relevant work is going on outside the country. International associations could disseminate such information. Again, several questions would have to be answered first: what types of international information does a national program need most; in what form will such information be most useful; how should a national program organize its own information program to generate material for international networks.

3. Inadequate intercountry coordination in research programs. IAs may be able to facilitate the exchange of persons and materials (e.g., germplasm) with the objective of minimizing duplication of research efforts. They may even be able to develop research plans which can be implemented by individual member countries. In Southeast Asia fresh attempts are being made to strengthen the operating mechanism of the ASEAN Agricultural Research Coordinating Board. Likewise, regional meetings of NARS leaders organized by IFARD and ISNAR have been trying to lay the foundation for an effective dialogue among NARS aimed at overcoming the coordination problem.

4. Insufficient advocacy of research system interests. Both national governments and international agencies must acquire more understanding about the constraints under which agricultural research is carried out. An institutional voice is needed to articulate problems and to lobby for their solution. Both IFARD and ISNAR might have roles to play in this connection.

5. Weak. .s in public/private sector research linkages. It has been noted that, particularly in the northern hemisphere, an increasing amount of agricultural research is being done in the private sector. Countries in the southern hemisphere can take advantage of this turn of events by utilizing the IAs to act as their intermediaries.

Relationship between NARS and Donor Countries and Agencies

For some time now donor countries and assistance organizations have been major sources of funds for the national agricultural research systems of developing nations. This support has, in no small measure, been instrumental in helping to strengthen the NARS.

Boyce and Evenson (1975), in their analysis of national and international agricultural research and extension programs, reported that the level of aid (in 1971 prices) to developing countries for these activities was about $55 million in 1959, rising to $80 or $100 million by 1965, but dipping to $60 or $70 million in 1971. Of this latter sum, they estimated that United States, British, and French aid for research, totaled about $40 million.

Oram (1978) noted that expenditure on national research systems rose during the 1970s. His analysis indicated that donor funding (in constant 1975 dollars) to national research institutions averaged about $364 million a year during the period 1976 to 1980, rising steadily each year, in real terms, to about $460 million by 1979, after which there were signs of a leveling-off. Total disbursement for research over the quinquennium, therefore, exceeded $2 billion, once we add the cumulative 1976-80 funding of nearly $400 million for the CGIAR institutions. Donor contributions to national programs alone in 1976 appear to have been about four times the estimate for 1971 by Boyce and Evenson; by 1980 overall external support for agricultural research in the Third World, including international and regional institutions, was probably in real terms more than six times greater than what it was in 1971 -- approximately $540 million in 1980 compared to $80 million in 1971.

Oram and Bindlish (1981) state that the 1980 aid total is in itself higher than IFPRI's estimate of total national research expenditures by 65 developing countries in 1975. This aid figure, moreover, does not include assistance from OPEC, Saudi Arabia or Arab funds, nor any Eastern Bloc country.

The increase in real terms in research funding seems to follow from the recognition by an increasing number of donors that improved agricultural technology is instrumental in achieving faster economic growth, improved nutrition, greater employment, and more equitable income distribution. Such awareness has been reflected in three developments:

1. a substantial increase in priority to the funding of national agricultural research by some large traditional donors;
2. awakened interest in supporting agricultural research by newer donors;
3. increasing contributions from certain international and regional funding organizations, in particular the development banks (which entered the picture significantly in the early 1970s), and from more recently established funds, such as the International Fund for Agricultural Development (IFAD).

Despite substantial research support gains since 1970, Oram and Bindlish (1981) note a disturbing reversal in the contributions of a number of donors since 1978 or 1979. Among 12 donors for whom they had annual data for 1976-80, 8 showed a decreased level of funding in 1980 compared to 1979; 4 were already lower in 1979 than in 1978. There has also been such a marked leveling-off in financial support for CGIAR institutions in the last three years that it practically amounts to a no-growth situation in real terms.

In the case of support to national systems, Oram and Bindlish (1981) reason that the apparently lower level of funding may simply reflect the coincidental, simultaneous termination of a number of large loans or grants. Looking at the overall situation, however, it seems more likely that the decline is a result of changing political and economic circumstances in some major donor countries. Another possibility, one which Oram and Bindlish hope is not true but which they feel cannot be ignored, is "some loss of confidence in investment in research as a means of accelerating agricultural growth because of expectations of major benefits which have not yet been fulfilled."

Overview

Significant developments during the past two decades reinforce our optimism that agricultural research is approaching better times. Among these developments the foremost deserve recapitulation: the establishment of NARS in developing countries; the growth of IARCs as well as of IAs; and the increasing activity of donor countries, as well as of assistance and development organizations and institutions, in supporting agricultural research.

Nevertheless, the early histories of national agricultural research systems suggest that much more remains to be done in the years ahead. As matters now stand, a host of problems, both internal and external, some indeed closely interrelated, continue to undermine the stability of national research systems.

There is an urgent need, for instance, to strengthen the NARS so that they can prove responsive to the challenges of the 1980s and succeeding decades. The fact that developing countries have practically doubled the resources allocated to agricultural research in the second half of the 1970s by combining their own efforts with those of various donors is encouraging, but should not generate false illusions. Even to approach parity with the agricultural research situation in scientifically advanced countries would require multiplying overall 1980 expenditures by two and one-half and the number of scientists by more than three. For many poorer countries these multiples would have to be still greater. Even among the better-equipped developing countries, gaps in staff, management deficiencies, and weaknesses in support services reduce the effectiveness and impact of agricultural research. Moreover, the realization that external support for agricultural research in developing countries appears to be leveling-off or even declining is an especially grave one when we recall the precarious food situation in many of these lands.

Horizontally, the NARS have yet to strike up smooth working relationships among themselves in order to complement each other's strengths. Vertically, the NARS should exert themselves more to improve collaborative efforts with the IARCs and IAs, as well as with donor institutions and development institutions and organizations.

At higher bureaucratic levels, there is a need for better coordination of donor activities within developing countries, and, possibly, for a radical rethinking among donors of how best to achieve an appropriate critical mass of resources at the national level. In the interests of maximizing available development assistance for building up research and development capability in developing countries, it would seem eminently reasonable for such institutions and organizations to pool together their resources in mutual support of their common objectives. Such development support could then effectively be channeled into program networks responsive to the national priorities of given developing countries. Such program networks could very well cover specific commodity programs or specialty areas.

Summing up, we have attempted to present a broad context in which to view the evolution and development of NARS, IARCs, and IAs, as well as the contributions of donor countries and agencies to the continued development of agricultural research in developing countries. Seen in such perspective, the need to bring about more productive working relationships among these sectors is a glaring one.

Notwithstanding encouraging strides achieved in agricultural research during the past two decades, many developing countries have yet to establish a viable national research system which dovetails into their specific, pressing needs. This situation places these countries far behind others in the Third World which have already developed research systems and are thus in a better position to achieve national agricultural and rural development objectives. One should realize, however, that a national research system is not a cure-all for problems that have been impeding agricultural and rural development in poorer countries. The greater challenge lies ahead: how to make the components of such a research system serve as a viable instrument for national development.

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IMPROVING THE GLOBAL SYSTEM OF SUPPORT FOR NATIONAL AGRICULTURAL RESEARCH IN DEVELOPING COUNTRIES

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Introduction

The need for a global effort to reduce hunger and insecurity was clearly recognized by the architects of the post-World-War-II set of international institutions. Their concern lead to the creation of FAO (the Food and Agriculture Organisation), which at present has 152 member nations. During the early years of FAO, far fewer countries existed in the world and there were only a small number of agricultural assistance organizations. An explosion in the number of nation-states during the decolonization era of the 1950s and 1960s, however, created demands for additional assistance. As a result, a welter of multilateral, regional, bilateral, and autonomous institutions and programs arose to help out in the agricultural sector.

Notable among new multilateral initiatives were international agricultural research centers. Since 1972, the work of these centers has been coordinated and supported by the Consultative Group on International Agricultural Research (CGIAR). For the large number of bilateral agencies which assist agricultural research and development, however, no comparable organ to provide coordinating support at the national level is generally available. In fact these bilateral, and many multilateral, initiatives are so heavily project-oriented that, in part as a consequence of the mode of support used, the viability and productivity of the institutions which they seek to help are in no sense assured.

This paper, therefore, is concerned with possible reforms in modes of support for national agricultural research systems in their search for more viable products. The reforms proposed seek to exploit lessons learned from the CGIAR experience and to match these lessons with the needs of developing countries and of donors. While this paper primarily addresses problems of funding, it recognizes that a system of support is but one of many important factors that influence the performance of a research institution. The discussion that follows is predicated on three convictions:

1. effective agricultural research systems are critical to bringing about improvements in the well-being of people in most developing countries;
2. the accomplishments of agricultural researchers and institutions are materially affected by the system of finance and support which provides their backing;
3. given changes that have taken place in developing countries and within the donor community, reforms in traditional support systems may well be overdue.

Shortcomings of the Present System of Support

Over the past 30 years the number of people active in the agricultural development assistance field has increased rapidly. This growth has been uncoordinated, with expansion taking place most rapidly at the bilateral level. Assistance has been subject to the ups and downs of political fortune and to the often sudden vagaries of the trade cycle in donor country economies. Among the poorer countries priorities have too often been determined by the availability of development assistance rather than by domestic needs or comparative advantage. These developments have spawned a situation in which an aggressive scramble for scarce assistance resources among and between aid agencies and their recipients is more typical than cooperation or mutual achievement.

Actual investment in agricultural development and in agricultural research in particular have but recently shown significant growth. For a group of 51 developing countries, it has been estimated that resources invested in national agricultural research have risen from 0.3% of their collective agricultural GDP in 1975 to 0.56% in 1980. These figures translate, for a large number of prominent developing countries, into an annual growth rate exceeding 10% in expenditure and/or the number of scientists employed in agricultural research (Oram and Bindlish, 1981).

This rise in the level of investment in agricultural research is important. It comes, at least in part, in recognition of the critical function that effective research can perform. Policy-makers are reaching for the high rates of return that have been generated by successful agricultural research programs. Such expenditures embody the belief that development of agricultural research capacity in poor countries may be one of the most effective ways for them to meet their basic needs.

In principle increased attention to agricultural research is a shift in the right direction. The outcome of this shift depends, however, upon the effectiveness with which increased resources going into national agricultural research are used. Performance is closely related to the mode and continuity of support provided to a country, from both external and internal sources. Without reform in the support system there is reason to believe that returns on additional investments in the development of improved agricultural technology will fall short of expectations.

Ruttan (1982) has identified four basic organizational models of agricultural research:

1. the USA land-grant, research-extension-education model;
2. the research institute model;
3. the department or ministry of agriculture model;
4. the agricultural research council model.

While significant differences exist among these organizational models, for all the principal source of funding is government — national, state, or provincial. Private-sector funding of agricultural research is nominal in most developing countries, though a levy is sometimes collected to support research on particular export commodities (e.g., coffee, rubber).

In developing countries most research institutions augment the funds available from their governments with grants, loans, and technical assistance. Each aid agency (multilateral, regional, bilateral, or private) that provides such assistance has its own priorities, capabilities, and mode of operation. These may or may not mesh well with the needs, priorities, procedures, and absorptive capacities of recipient countries. Donor countries may use foreign aid as an instrument of national foreign policy and diplomacy, an area in which goals are not necessarily compatible with those of development assistance itself. During the 1970s, for example, while there was a decline in USAID resources allocated to countries where technical and institutional needs were most severe, increased allocations were made to countries considered politically sensitive. In recent years over 80% of the Economic Support Fund has been disbursed to three countries — Israel, Egypt, and Jordan.

Clearly, much latitude exists for both disagreement and improvement. Experience over several decades of development assistance, however, backed by studies of what has been done and how in support of agricultural research, suggests some major shortcomings in our present system of providing assistance, policy-making and implementation.

Over-Reliance on the Project Approach

Most major development assistance agencies rely primarily on the project approach, which appeals to them as flexible, and as convenient for:

Assuring donor identity. This may be crucial to the assistance agency in its continuing efforts at home to obtain resources for ongoing work. The project as a discrete unit can be described in presentations to Congress, for example, or to governing councils, boards of trustees, or citizens at large.

Administration and management. The project provides a handy unit for purposes of resource allocation, accounting, implementation, and evaluation

Leverage. This may be important to the achievement of donor diplomatic or political goals at home, as a means of enforcing "tied" sales, and in requiring certain performance standards in order to extend a grant or provide continuing technical assistance.

Participation. Because a project has an identity, this, especially in bilateral arrangements, increases opportunities for a personal donor-recipient relationship. A project usually involves more than a cold, mechanical financial transaction. Where technical assistance is involved, both the giver and receiver may benefit. First-hand involvement in and familiarity with international agriculture, as acquired through projects, by donor country professionals, can, for example, constitute a distinct gain in human capital development for the donor nation.

Despite these desirable attributes, the project approach as it generally functions has serious drawbacks. Through it, assistance agencies may exert undue influence on the content of national programs. Donors, bilateral as well as multilateral, may dominate programs through their own perceptions of priorities, through efforts to maintain a commitment schedule (e.g., push ahead with facilities even though they cannot be domestically staffed), or through a self-interested desire to market "tied" inputs (to sustain political support from suppliers, universities, or consulting firms at home). Indeed, selectivity in program support and donor bias may result in the funding of projects that are inconsistent with national priorities or national program development. Such projects, as a result, are often unproductive because the associated investments required for overall program effectiveness are lacking (Gamble, 1982).

Of even greater concern is the awareness, won from long experience, that in itself project support has rarely contributed effectively to the development of viable national agricultural research institutions. To speak positively for a moment, in a number of countries the project approach has assisted the rapid development of professional capacity and facilities. Unfortunately, such rapid development has all too often been followed by the erosion or collapse of overall program capacity once external project support starts to decline (Ardila et al., 1980). In fact, one may speculate that alternating cycles of development and erosion are inherent in the project approach as it now generally is applied.

External Orientation of the Incentive System

External project assistance often provides an alternative to the winning of internal political and financial support for a program or institution. National program directors frequently find that the generation of external support requires less intensive entrepreneurial effort than cultivation of in-country backing. The kind of domestic support for a project commonly required by donors (e.g., matching funds, provision of counterpart funding) can often be conjured up through creative manipulation of budget categories or imaginative accounting rather than by doing any real incremental spending. Such "paper" financing is particularly prevalent when donor representatives are themselves under pressure from the assistance agency management to "move" resources. Plans drawn up frequently over-extend existing domestic investment capacity (e.g., recurrent costs).

As a consequence of the various forces just mentioned, most existing project systems have built-in incentives for national program leadership to direct their entrepreneurial efforts towards the donor community rather than towards the domestic political system. The external rather than internal orientation of the incentive system therefore does little to promote activity towards developing, building, and sustaining a domestic constituency (e.g., commodity groups among producers within the country). Over-dependence on foreign support and the associated absence of any politically or economically powerful indigenous constituency contribute significantly to cycles of development and erosion in national agricultural research and extension organizations. Any reforms in support systems should, to be sure, attempt to reverse the perverse orientation of incentives that now characterizes existing modes of research operation.

Inadequate Effort to Build Institutional Support

Another reason why the fortunes of national research ebb as well as flow is that no means of generating understanding and political support are built into operations from the onset. While assumed to be important, the development of institutional viability is seldom made an explicit goal of a project — or of the program of which the project is a part. Actions within the country itself designed to help assure continuity are frequently given low priority, if undertaken at all. Experience suggests, however, that the long-term viability of agricultural research systems depends on the emergence of organized producer interest groups who are willing and able to exert influence on the legislative and executive budgetary processes. This is because the support of agricultural research forthcoming from finance and planning ministries, given the pressures under which these ministries must operate, is not dependable. Their support is likely to fluctuate with perceptions of the severity of temporary food crises and foreign exchange demands.

To assure reasonable domestic levels of fiscal support on a regular basis, national research program leaders and program beneficiaries have to commit themselves to a sustained political development effort. From the inception of any research endeavor, such an effort needs to be planned for and made an integral part of program activities. This means establishing contacts with farmers, exporters, consumers, and decision-makers on a scale and with an intensity unusual for developing countries.

Excessive Diffusion of Resources

The project system lends itself to launching a fragmented set of initiatives. This is especially true when individual projects are independently negotiated with different donors. The temptation is to initiate a multiplicity of small, short-term activities without concern for whether they are adequately linked to one another. Many of these separate projects or sub-projects may not fit into, or in any tangible sense support, a coherent national strategy or program. If so, diffusion of domestic as well as external resources inevitably occurs.

In the absence of adequate, unrestricted core budget support and carried to an extreme, narrowly defined and closely restricted project funding, while helpful for accounting and for some monitoring purposes, can ultimately strangle an overall program. Diffusion of support among many short-term projects can also generate excessive administrative costs. Relative to support that remains for productive research, an unduly large proportion of limited available resources is spent bureaucratically, in project formulation, negotiations, and monitoring.

"Stop and Go" Funding

Abrupt adjustments in resource flows, often a consequence of some revision in a donor's political views or even of the individual preferences of changing donor representatives, also contribute to the erratic alternating periods of plenty and want which characterize the life of national research institutions. This destabilizing force is exacerbated by the inconstancy of domestic support.

Most institutions, to a greater or lesser degree, face funding discontinuities. In newly developing countries with fragile institutions, such financial disruption can be fatal. If vital scientists and administrators are lost (to international organizations or other countries) during a prolonged "lean" period, years may elapse before replacements can be found, or trained.

Inadequacies in Communication among Donors

In several countries information exchange among donors about their programs and intentions is limited. This may be the result of policy either on the part of the donors or of national leadership in the developing countries concerned. Poor communication, however, also may occur simply because no appropriate mechanism exists for assembling and exchanging reliable information of this type. Whatever the reason, instances do occur where donors, perhaps unknowingly, actively compete for what they consider to be attractive individual projects. What is cause for concern here is that for want of more adequate information, projects of one type flourish while other aspects of the overall program, equally critical, languish or die.

Collectively, shortcomings of the above types impede effective use of available resources. If it were possible to reduce or to eliminate the undesirable effects of these constraints, the support provided could have a far more constructive impact on development.

The Needs of National Programs

A great deal of the foregoing discussion has concentrated on donors and patterns of their cooperation with national programs. The problem for development that national needs may not always coincide with donor priorities has been stated explicitly in some places and alluded to in others. Not everything about the project approach should be condemned. What is absolutely necessary, however, is a well-articulated program developed by the national institution responsible for the work, a program which clearly sets forth overall goals and then established procedures so that aid projects will be compatible with them. National institutions should be able to formulate their needs and make clear what assistance will be required to meet these needs. This is already happening in some countries, but more need to follow.

How then might existing support systems be reorganized in order to mitigate or even to eliminate the harmful effects of the present shortcomings which we have identified?

Approaches to Reform

To improve support systems there are at least four possible approaches:

1. modified project support mode;
2. multilateral mode;
3. formula funding;
4. country-level research support group.

These approaches are not mutually exclusive; they all contain common elements.

Modified Project Support Mode

If we are realistic, the project, because of its many attributes, appears likely to remain the major development support vehicle. Because of the rising cost of launching and sustaining development initiatives that make any appreciable difference, however, governments, private voluntary organizations, foundations, and other assistance agencies now increasingly seek partners. Instead of "competing" among themselves, they are often interested in becoming "partners in program support," even in the absence of any formally organized consortium or consultative group. With guidance from national officials in those countries where priorities have been systematically established, individual donors can be encouraged to help underwrite components (projects) within a coherent program. Such support can be structured to include contributions toward essential core or unrestricted budget categories as well.

The shortcomings of the "self-contained" project approach have become increasingly well understood. Modifications are being made. The World Bank now offers project loans within the framework of a program development plan. At the U.S. Agency for International Development, internal discussion is focusing on the use of "common theme" regional approaches to the transfer of technology and the development of institutional capacity. Such developments are to be encouraged and their pace accelerated. What the research support group approach, to be discussed presently, can do that the project mechanism alone cannot is to assure multiple donor participation with the host country in the developing and funding of the overall program of an institution.

Multilateral Mode

This approach would channel all support through multilateral organizations. In theory this appears to be an uncomplicated, straightforward way to improve support systems. Assistance on a program rather than a project basis could be provided, assistance suited to the circumstances of individual countries.

The problem here is that donors appear reluctant to adopt this mode as a means of allocating and administering their bilateral assistance. They are not prepared to consign their bilateral funds to a common pot which will be managed by a third party. The reasons for their unwillingness are many, but they boil down to the donors' insistence (quite understandable) that, as the sources of funding, they retain a direct voice in determining where and how their gifts are used.

On the other hand several bilateral donors are apparently predisposed to join in partnership with multilateral organizations in support of a program, if appropriate arrangements can be made. According to its advocates the fourth approach to the reform of support systems mentioned earlier, the one which involves a research support group, can be designed to preserve "donor sovereignty" while encouraging joint participation.

Formula Funding

Envisioned here is a move on the part of the donor community toward program funding. In order to induce national program directors to redirect their entrepreneurial efforts towards building domestic political and economic support, a formula needs to be developed which would tie the size of donor contributions to the growth of domestic program support. As domestic support increased, donor contributions would also rise. The formula would adjust the ratio of external to domestic support to take into account differences in fiscal capacity. Donors might agree, for example, to provide as much as 40% of the national agricultural research budget in a country with low fiscal capacity, while the externally provided share might drop to 10% in a country with high fiscal capability.

How could such a system evolve from the multiplicity of existing bilateral and multilateral assistance programs? One possibility would be for the donor community to place its resources in support of a national agricultural research system into a common fund. The formula method of allocation as agreed upon by the countries involved would then apply. The common fund, in turn, would be administered by an existing international agency such as the World Bank, the United Nations Development Programme, or the Food and Agriculture Organisation.

There are decided advantages to this approach. Support would go to an integrated program, not be parceled out project by project. The level of support to the program would be determined by taking into account national fiscal capacity, the importance and potential of the agricultural sector, and the level of domestic resources actually provided. The matching of funds would be "real" and subject to careful audit. Formula funding would thus be conducive to building national support for agricultural research because of the modified incentive structure.

If, however, donor resources were contributed to a common fund for third party administration, donor interest and commitment might rapidly fade. The discretionary latitude of foreign affairs ministries in donor countries would be somewhat compromised. Legislatures and administrators in donor countries might view formula funding as an "open checkbook" approach with their retaining only limited control over program level or content. Resistance to formula support through a common fund might also be expected from special interest groups: assistance agency staff members, consulting firms, and universities who would foresee less need for their services; developed country exporters of goods and services whose sale of "tied" items might be threatened; multilateral agency staff members who might anticipate a decreasingly important role for their institution if theirs were not the "coordinating" organization; and the leaders of projects in developing countries who have a proprietary interest in maintaining present modes of funding.

For a reform to be adopted it must achieve general acceptance at the outset. The formula funding concept embodying a common fund cannot claim such approval. Resistance to becoming a contributor to a common fund administered by another agency is too widespread.

Country-level Research Support Group

This approach is indebted to the experience which has been accumulated with the CGIAR model. To form and operate a country-level research support group (RSG) will require close working relations between the host country and aid agencies, and improved collaboration among donors. In order to function an RSG needs to have at its disposal a relatively long-term program for the development and operation of the national agricultural research system. To draft and keep this program up to date, the national research system may require external assistance, but in general the program should be the product of indigenous experts in agricultural science and development. To help shelter the program from shifting political breezes, emphasis should be placed on long-term agricultural research needs and goals, and on the incremental steps required for implementation.

It is expected that long-term program development and the setting of priorities would be undertaken together with members of the RSG. Once an acceptable program has been framed, donor members of the RSG, it is hoped, would collectively agree to help provide the host country with the components essential to the execution of the program as a whole. The host country, in turn, would assume responsibility for moving its national research program along the agreed-upon development path.

Initial commitments might be for three to five years, subject to annual review and course corrections suggested by analysis and feedback from actual experience.

Use of an institution such as an RSG can potentially help a developing country in a variety of ways:

1. to avoid many of the pitfalls of the project mode, while retaining several of its positive attributes. Donor identity could be retained by relating grants to components of the agreed-upon overall program. These could then even be called projects if, for administrative purposes, this was considered desirable. Donor-recipient negotiations, most of which would take place at group level, would become meaningful, for the RSG, like CGIAR, would be likely to involve bilateral grants developed in the framework provided by a forum of multiple donors and the host country. The impersonal process of contributing to a common fund is not envisioned. This does not, however, preclude "incentive funding" of a formula type. At the same time the danger will be held to a minimum that any single donor dominate the priority-setting process or that essential program components be slighted.

2. to build a national constituency by concentrating right from the start on this essential ingredient for viability. The donors, for example, might agree to increase their contributions by some fraction of the rise that occurs in the real support provided by the nation involved. Alternatively other matching provisions might be agreed upon to provide incentives for nurturing and cultivating national constituencies.

3. to provide reasonable continuity in support. Commitments would be fairly long term, subject to review and extension well in advance of termination dates. This would diminish the risk of program fragmentation frequently associated with narrowly defined project funding.

4. to reduce the administrative and management workload of the host country through the planning and review processes which the RSG would follow.

5. to place donors in a position of genuinely complementing and supplementing one another and the national program instead of their wastefully competing for "good investment opportunities."

6. to tighten its own priority-setting, performance evaluation, and program modification process by systematically meeting RSG requirements, drawing whenever necessary upon the professional expertise of RSG members.Fundamentally, success in the use of the RSG approach would require all parties involved to be open to learning by doing. Such a support mode is often discussed, but little used, a fact which suggests perhaps that its implementation is no simple matter.

Implementation

The preceding assessment of approaches for reforming support systems indicates that the research support group merits our recommendation. It must be recognized that the RSG procedure is not one that can or should be applied to all countries. Many countries have alternate systems already at work. Elsewhere, however, if there is interest and need, host countries may wish to test the idea in cooperation with donors. No precise pattern for such a funding arrangement exists. Before implementing any such system, however, it would seem that members of the incipient RSG would have to reach agreement on structure, governance, function, and related matters.

Membership

The host country, probably through its national research institution and the appropriate ministry or ministries, would delegate members for the RSG. Each external donor, multilateral or bilateral, prepared to provide a specified minimal level of support would also designate members, presumably professionals familiar with the host country.

Organization

The RSG's chairperson should be named by the host country. In some countries a rotation of the executive position among group members might be preferred. The RSG's secretary would also, in all probability, be provided by the host country. In the initial stages external technical assistance to the secretariat might be provided by one of the donor members or by an organization such as ISNAR. Leadership responsibility for the management and operation of the group would be vested in the host country.

Functions

1. The RSG would participate in discussions through which a program of development for the agricultural research system is formulated. Such a program, perhaps encompassing the first five years of the RSG's existence, would specify a workplan, priority activities, elements to be expanded or reduced, and a proposed budget. The program budget would be developed within the framework of the country's needs and expected resource availability. The RSG would not develop the document itself but might provide technical assistance as well as guidelines for internal review (i.e., means for determining the local relevance and importance of the problems being addressed and of the research methodologies being used; procedures to establish links with the country's extension and educational institutions).

2. The RSG would work out, within the limits of available resources, how to provide the external support required collectively to sustain components judged essential to the program as a whole. If the procedures evolved by CGIAR were followed, individual donors would make grants in support of identifiable components of the agreed-upon programs (including allocations to core activities of the system). These would be bilateral, and negotiated in the multilateral forum of the RSG. Such grants would be subject to rules governing both the grantor and the grantee. Every reasonable effort would be made to simplify the terms of the grants, however, as well as to provide relatively long-term and harmonious time frames, to standardize review and evaluation procedures, and to meet matching requirements.

3. The RSG would develop provisions for integrating existing project or program grants and loans into ongoing budgets. This process would be virtually automatic if the initial donor members of the RSG represent institutions already active in the country.

4. The RSG would formulate operating guidelines for itself, principles to help establish procedures, attitudes, and style of operation. These might include: adoption of

relatively informal or consensus modes of decision-making; building in of incentives for developing increased support for and commitment to agricultural research within the country (e.g., provisions in fund matching arrangements for external assistance to rise as real domestic support increases); encouragement of interdisciplinary approaches to problem diagnosis and solution; institution of on-farm research, possibly as a joint effort with extension services; and systematic feedback from representatives of producer groups in the evaluation process.

5. The RSG would establish a meeting schedule and agenda. Initially it might be desirable for the RSG to meet twice per year. The first of the two meetings could well be devoted to an assessment of the program's performance, a review of plans, and discussion of needs for the coming year. Major policy issues would be addressed in this forum. The second meeting would then concern the budgetary process itself — the matching of program requirements with available resources. The productivity of these meetings will be determined, in no small measure, by the adequacy and quality of the materials assembled or prepared in advance by the secretariat.

Budget

While the members of the RSG would underwrite the costs of the participation of their representatives, the secretariat, the program-budget group, and possibly the chairperson will require budgetary support. One of the tests of the RSG concept may be the capacity and willingness of the host country to meet the essential running costs of the new organization. As a gesture at the start, donors might decide to provide technical assistance and/or financial help to the secretariat for the first three to five years. Without a substantial national financial input and commitment, however, the new RSG might come to be viewed as a foreign implant rather than an indigenous organization created to serve local needs.

Next Steps

Before meaningful discussions concerning the establishment of an RSG can be undertaken between a potentially interested developing country and donors, some individual, group, or institution must accept responsibility for elaborating the ideas discussed here, for helping design and implement trials — if an experimental effort is to be made, and for analyzing the results. Then national leaders will have to decide if they wish to pursue the RSG approach further. Should they wish to embark on a field-testing venture, they must:

1. identify countries and donors interested in exploring and implementing the ideas sketched in this draft paper;
2. seek ways to assemble information on and simultaneously assess worldwide experience with consortia, consultative groups, or similar institutional arrangements for mobilizing support for the development and operation of research systems;
3. revise the content of this draft paper in light of comments and suggestions received and insights obtained from research on prior initiatives of this nature;
4. determine ways to help one or more of the countries and associated donors that desire to do so develop and operate a RSG or similar system; these efforts would include the formulation of testable hypotheses and goals for evaluation purposes.
5. establish a means to monitor whatever trial efforts are undertaken, subsequently analyzing performance, and reporting the results.

Conclusions

While interest in national agricultural research institutions is increasing, together with available levels of funding, serious shortcomings in their systems of support have become apparent. These have arisen in part from an over-reliance on the project approach and the perverse twist which it gives to research entrepreneurship. Incentives are stacked in favor of cultivating external agencies rather than building up national support. Leadership is preoccupied with courting foreign aid, so that no effective constituency (producer groups, exporters, consumers, suppliers) emerges inside the country. As a result, the viability and long-term productivity of the national research establishment is threatened because it enjoys inadequate political and grassroots support. Often then, the effectiveness with which resources are used falls far short of the expectations of both donors and developing countries themselves.

While the system of support is but one factor influencing research productivity, its improvement can contribute to huge gains in performance. All available information indicates reform is overdue. Otherwise, the transfer of resources to national research may even prove counterproductive.

Identification of the shortcomings of current research systems of support facilitates the choice of a preferable approach. A mode that places principal responsibility for planning and implementation squarely on the shoulders of the host country, at the same time providing incentives to build local constituencies, holds exciting promise. The innovative system of support developed by CGIAR contains many elements worth trial and adaptation. Reforms might proceed along other lines as well. In general, however, evidence encourages the belief that the most promising and comprehensive approach to reform involves creation of country-level consultative groups composed of host country and donor members.

This draft paper calls these proposed institutions research support groups (RSGs). It suggests that national leaders consider establishing RSGs in those developing countries where both the national leadership and donors are prepared to experiment with the concept.

Acknowledgments

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LAND RESOURCE INVENTORIES IN RELATION TO FARMING SYSTEMS RESEARCH

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Introduction

A problem in agricultural development which all developing nations face is how to obtain estimates of the food-producing potentials of different soils under increasingly intensive cultivation. Two things are needed for proper evaluation of a nation's soil. One is a soil classification system that serves as a guide for making and interpreting a soil inventory; the other is the soil inventory itself. Many national institutions are developing adequate capabilities to identify and classify soils, but in most cases they are not yet able to translate this information into practical prescriptions for farming systems that will increase food production. For a classification to be effective it must accommodate all soils in the world, since agrotechnology transfer requires the use of a comprehensive system that can accommodate soils on an international scale. The classification system must also have sufficient depth to enable soil responses to management and manipulation to be predictable.

Farming Systems Research and the Agricultural Environment

In farming systems research, as in other types of research, the agrotechnology transfer process involves the continuum of technology generation, verification, packaging, dissemination and use. This in effect means conducting research in soils on a number of locations, such as research centers, verification station sites, and farmers' fields. This methodology derives from increasing recognition of the fact that most experimental results are location-specific, season-specific, genotype-specific, and management-specific. Their extrapolation to other sites, seasons, cultivars, and management methods requires an understanding of the whole complex crop system. Most agronomic experiments contribute little to such understanding because of the lack of balanced site (soil) crop-weather-management data. Specifically with soils, it has been pointed out that an enormous number of field experiments involving fertilizers have been conducted over the years throughout the world. It is sad to note that findings have usually applied only to the exact crop or environment in which the experiment was done, therefore providing little guidance about how the crop would respond at another site or in another season. Results have rarely, if ever, been compared with any existing theory about how the crop in question might have behaved had it been exposed to slightly different soil or weather conditions.

It is ordinarily accepted that the production base of any farming system is plant growth, which is influenced by environment and management. Environmental conditions are taken as factors that influence plant growth but are not subject to modification by management. Zandstra (1977) considers plant growth and crop yield (Y) to be the result of two multidimensional vectors, the environment (E) and management (M), so that Y = f(E, M).

He regards the environment to consist of such land- and climate-related variables as available rainfall and irrigation, textural profile of the soil, phreatic level, soil toxicities, the topographic positions of the field, use or nonuse of bunding, day length, solar radiation, and temperature, and of the availability of such resources as power, labor, and cash. Management includes the types and arrangement of crops in time and space (the cropping pattern). It covers choice of variety, and methods of crop establishment, fertilization, pest management (weeds, insects, and diseases), and harvest (component technology) for all crops in the pattern. The economic performance of the system depends on the economic environment: the cost of inputs and prices for produce.

Strictly speaking, farming systems research addresses itself to each of the farm's enterprises, and to the interrelationships among them and between the farm and its environment. The research uses information about the farm's various production and consumption systems to identify ways to increase the efficiency with which the farm uses its resources (Zandstra et al., 1981).

Target and Research Area Selection

Effective selection of target and research areas is one of the critical activities in the farming systems research process. Selection begins with high-level government decision-makers deciding on one or more target areas as special foci of attention. The designation of specific research areas then begins and continues until improved technologies are diffused throughout the target area step by step.

The process of selecting areas proceeds roughly as follows (Shaner et al., 1982):

1. the decision-makers select the target area or areas;
2. the research team divides the target area into su' reas according to characteristics most important fi he farming systems research effort;
3. the team selects the research area within the target area;
4. the team selects farms and farmers within the research area for conducting on-farm research;
5. when research results are promising, the team and the extension services select multiple locations within the target area for verification of new technologies on a broader scale;
6. if the results of the multi-locational tests are satisfactory, the team and governmental agencies select areas for pilot production programs to evaluate the new technologies on a more intensive scale;
7. after resolving any problem arising from the pilot production programs, the extension service and other relevant agencies implement the new technologies according to suitable sub-areas within the target area;

8. finally, these government agencies may extrapolate relevant technologies to similar areas outside the target area.

The team uses a broad range of data for target area and sub-area selection which includes information on the environment. In its work in Southeast Asia, IRRI developed an approach which classifies the physical resources of an area according to its climate, topography, and soils. On Asia Cropping Systems Network sites, land types have been identified on a basis of the most important determinants — those which most strongly influence the performance of cropping patterns in an area. To date, the soil's physical profile texture, clay type, and hydrological variables (seepage and percolation, and the field water-environment potential) have been most useful in the identification of land units in wetland production complexes (Morris et al., 1979). In dryland production complexes, slope and soil chemical factor (pH, organic matter, or cropping history fertility) have been found to be more important (McIntosh and Effendi, 1979).

The following steps and issues relate to classifying land types for cropping systems research (Zandstra et al., 1981).

1. First, separate the land type into dryland and wetland.

2. Then differentiate between irrigated and rainfed land. Rainfall will normally not vary sufficiently from place to place within a site to necessitate stratifying the areas on the basis of rainfall. Irrigation, however, can greatly vary. With respect to irrigation, the source and the duration of irrigation can be important.

3. The next most important quality for identifying land type is landscape or geomorphology. Although this does not intrinsically influence crop production, it is associated with many determinants, such as soil depth, depth to water table, water-enrichment potential, slope, soil texture, and fertility.

4. In wetland areas the lowest and highest position of the water table can have great relevance to the types of cropping pattern suited for that land type. An area with a shallow water table (less than 1 m) during the dry season may have a vastly different production potential from one with a deeper water table (greater than 2 m). In areas subject to flooding the water table will be above ground level for part of the year, and the duration of flooding will become an important determinant.

5. Because of its effect on soil-water relationships, soil texture is the next most important determinant of the cropping system. Substantial differences in clay content may justify the recognition of a different land type and the development of a different technology for it.

6. Soil fertility and soil chemical conditions are two factors that can often be corrected by management.

7. Major socioeconomic differences occurring within sites can influence cropping patterns and need to be identified.

Plant-Soil Interpretations

Plant production depends on the kind of soil climate, what man does to the soil, and his skill in doing it. The plant relationship is based on those soil properties that affect root ramification which, in turn, are dependent upon the supply of soil moisture and plant nutrients. Manipulation of these soil properties is a part of management input (Bartelli, 1978 & 1979).

A plant production function involves proper crop selection, proper timing of management inputs, and a clear understanding of plant-soil-water relationships. It has been established that the following measurable properties influence plant-soil relations: effective depth or the root ramification zone, particle size distribution, organic matter content, salt content, cation exchange capacity, base saturation, clay mineralogy, permeability, saturated and unsaturated conductivity, soil wetness, depth to perched or apparent water table, available water-holding capacity, and shape and degree of slope.

The land qualities important to crop growth can be summarized as moisture availability, oxygen availability in the root zone, nutrient availability, and the absence or presence of toxicities. With respect to management, resistance to erosion, trafficability, length of dry periods for land preparation and harvesting, and resistance to compaction are all qualities which play major roles (FAO, 1976).

Rational Land Use and Land Classification

The technique which makes it possible to determine the most suitable use for any area is "land classification." There are many different systems of classification, each of which consists of categorizing the land according to some special property. One kind of classification is made according to suitability for a particular crop or cropping system: very suitable, fairly suitable, and not suitable. Suitability for a particular form of land use is often the basis of a classification system, for example, suitability for a particular farming system.

Like other kinds of land classification, the frequently used land capability classification practiced by the United States Department of Agriculture has a particular purpose. This purpose is to record all relevant data which might affect a decision about the combination of agricultural use and conservation measures which allow the most intensive agricultural use of land while keeping down the risk of erosion. All factors and characteristics which influence the risk of erosion must be considered. This is done by first collecting all the relevant facts in a soil survey, and then assembling them in a convenient order known as a standard soil code. The standard soil code consists of a series of letters and figures, each of which denotes the value of a particular characteristic. A typical code used in the Philippines looks something like this (Hudson, 1971):

$$\frac{2\ \mathrm{III}}{\mathrm{a}\quad 1}$$

and the physical features described are in these positions:

$$\frac{\text{Depth - Texture - Permeability}}{\text{Slope - Erosion}}$$

The effective depth is the depth of soil that can provide a medium for root development, retain available water, and supply available nutrients.

Texture refers to the mechanical composition of the top layer of soil. In undisturbed soils this is the topsoil, or the A horizon, and in arable land it is the soil in the plow zone. This will have a depth of from 150 to 250 mm, the lower limit often recognizable by a change in color.

Soil permeability is defined as the ability of the soil to transmit air and water. Quantitatively, permeability is the rate of flow through a cross-section of saturated soil per unit time under a specified hydraulic gradient.

Considerable variations are found in slope. In the Philippines the steepest slope which is classified as arable is 25%.

All soil survey coding systems include some assessment of how much erosion damage has occurred in the past.

Appendix 1 provides the description and range of values used in this classification.

The attribution of a piece of land to one of eight capability classes is determined by considering several of the soil characteristics which have been assessed in the survey and recorded in the standard soil code. Each capability class has specified limits for each factor. For a soil to be rated as belonging to a particular capability class, the specification for every factor must be met. The first four classes are suitable for cultivation, the remaining are unsuitable (Appendix 2).

One quantitative system of land capability classification in wide use is the U.S. Bureau of Reclamation Irrigation Suitability Classification (Maletic and Hutchings, 1967). This system is used for the specific purpose of determining the extent to which land is suitable for irrigation. The definition of suitability includes the expectation that there will be profitable production on a permanent basis under irrigation. Thus the land must have a favorable "payment capacity," which is defined as the residual funds available to pay the cost of irrigation water after all other costs have been met by the farmer. This is expressed as an equation where Y = payment capacity; X_1 = productivity rating (%); X_2 = land development cost ($) and X_3 = farm drainage cost ($). Budget analyses are used to derive the constants a, b, c, and d in the equation.

$$Y = -a + bX_1 - cX_2 - dX_3$$

Land classes are developed which represent specified ranges in the economic evaluation. Six classes of land discussed in Appendix 3 are used: four are arable lands, two non-arable. The arable land is land which, in adequate size units, and if properly provided with essential improvements such as leveling, drainage, and irrigation, would have enough of a sustained production capacity to meet all production expenses and pay the costs of irrigation.

The Benchmark Soil Concept and Agrotechnology Transfer

The benchmark soil concept is related to the idea of transferring technology by analogy. A benchmark soil is one occupying a key interpretation position in the soil classification framework and/or covering a large area. It is considered to be a representative reference site from which research results, or best farmer practices, can be transferred or extrapolated to other soils with similar properties.

On the basis of the benchmark soil concept a project has been set up which has as its stated purpose the testing of an innovative methodology for use in developing countries to help them obtain adequate agrotechnology for increased food production and better nutrition (Swindale, 1977). The concept being tested poses a fundamental question: can agrotechnology be transferred from one region to another on the basis of Soil Taxonomy at the family level? The project aims to correlate food crop yields on a network of benchmark tropical soils and to determine scientifically whether agroproductive technology is transferable among tropical countries. To attain these objectives transfer (soil fertility), variety, and soil management experiments are being carried out on carefully selected benchmark soils in the same soil families in a number of tropical countries, among them Indonesia and the Philippines in the ASEAN region. The implied assumption is that soils which belong to the same phase of a soil family are considered sufficiently similar to sustain the transfer of agrotechnology from one region to another. To account for the effect of weather, such climatic variables are monitored as temperature, rainfall, relative humidity, solar radiation, wind speed, wind direction, and soil temperature. Procedures include the use of irrigation to supply the desired amount of soil moisture to make this a controlled variable.

The USDA (1975) soil classification system entitled "Soil Taxonomy" is a multicategoric comprehensive system that groups soils with similar physical and chemical properties which affect their behavior and use (Appendices 4 and 5 provide brief descriptions of the multicategory system). In the USDA classification system, properties useful in interpreting soil surveys for agricultural and non-agricultural use are provided in the soil family category. To meet most of the needs for practical implementations, soils are grouped so that the responses of comparable phases of all soils in one family are nearly alike. Thus the family occupies the critical position in Soil Taxonomy between the heterogeneity of the subgroup and the homogeneity of the series (Johnson, 1978).

Families are defined by a number of properties:

1. particle size distribution in the horizons of major biologic activity below plow depth (the "family control section");
2. mineralogy of the same horizons that are considered in naming particle-size classes;
3. soil temperature regime.

Other characteristics, such as soil depth penetrable by roots, soil slope classes, soil consistency classes, classes of coatings on sand, classes of cracking, content of polysulfide, etc., are applied if they are important in a particular subgroup. Soil family properties are particularly significant to the movement and retention of water and to aeration, and so affect the use of soils for growing plants. Thus soils that occur in widely separated parts of the world and are classified into the same soil families should have nearly the same management requirements and similar potentials for crop production.

An excellent example to illustrate this point is presented by Uehara (1978) on the Black soils of the Red-and-Black complex found in ICRISAT's experimental station area. In terms of management, these Black soils are more clearly related to the Black soils of the same family that occur in other regions of the world than to the Red soils that occur adjacent to them. Uehara comments:

> The deep Black soil (Vertisol) at ICRISAT has the family name "fine, clayey, montmorillonitic isohyperthermic, typic Pellustert." Its Red counterpart (Alfisol) has been classified as member of the "clayey - skeletal, mixed, isohyperthermic Udic Rhodustalfs." Two important features indicated in the names of these soils are the soil moisture regime designated by the letters "Ust" in Ustin, Ustert, and Ustalf, and the temperature marked by the term isohyperthermic. It is no accident that one of ICRISAT's main research foci is directed towards optimizing water management in crop production. The

pronounced dry spell, which stands as a major food-production constraint, is indicated at a very high Suborder category in the classification scheme by the prefix Ust, which is taken from the latin word combust (to burn).

There are soils at ICRISAT, however, that remain wet for long periods during the year. These are soils found in the low areas. They are members of the "fine loamy, mixed, isohyperthermic family of fluventic Haplaquepts." Their wetness is indicated by the letters Aqu in Aquepts.

The results of ICRISAT land and water management work, therefore, have wide application not only in the Indian subcontinent but also in the semi-arid regions of the tropics that have comparable soils. ICRISAT's ecological niche is clearly defined in the Soil Taxonomy by the Ustic moisture regime. Extensive areas in the tropics do have Ustic moisture regimes and therefore can benefit from the practical management systems developed at ICRISAT.

The Ustic ecological niche however is still too broad to permit practical transfer of technology. There are, for example, soils in Brazil that are classified as Acrustox. Unlike the high base soils at ICRISAT, the Acrustox are weathered to the extreme (Acr means extreme). In Acrustox, fertility problems are as limiting as the water constraints. Even the soil water management system would need to be modified to suit the conditions of Acrustox. A high clay Acrustox and a high clay Pellustert would have very different water holding and water transmitting properties. These differences among soils become increasingly clear as one moves down the taxonomic ladder.

The soil water relations, or for that matter many agronomically important soil properties of Acrustox and Pellusterts are implicitly specified in the family category by texture and mineralogy. In general, water transmitting capacity decreases as clay content increases, but for equal clay contents, the water permeability of Acrustox is markedly higher than that of Pellusterts.

As it is for most important soil parameters, soil permeability must be interpreted from texture, mineralogy and other diagnostic criteria used to classify a soil at the higher categories. Particle size distribution and mineralogy are the principal causes of the physical and chemical characteristics of a soil. The effects such as soil erosion, water holding capacity, phosphorus fixation, soil compactability, nutrient retention capacity, phosphorus and a host of other accessory characteristics must be inferred from the causative and diagnostic features. The ability to extract as many useful accessory characteristics as possible from a classification system grows with experience.

If a soil classification system is to serve as a basis for agrotechnology transfer the system must stratify climate, as well as other crop production parameters. In Soil Taxonomy, cloud cover and rainfall are related to the soil moisture regime that appears in the Suborder category; soil temperature, which is related to air temperature, appears in the Family category ... The soil temperatures are stratified into warm (hyperthermic), moderately warm (thermic), cool (mesic) and cold (frigid) for temperate climates and isohyperthermic, isothermic, isomesic and isofrigrid for the tropics...

The Need for a Soil Inventory

Soil inventories of various intensities in different scales are obviously needed for use at all levels of planning, development, and utilization. Swindale (1977) lists several scales for soil maps: 1 million and 1:250,000 for national and regional planning, 1:20,000 with phases of soil series for rainfed farming; and 1:5,000 with phases of soil series for irrigated farming. Murthy et al. (1977) recommends a minimal scale of 1:15,000 for detailed soil mapping, with phases of series as mapping units, and 1:50,000 for reconnaissance mapping with association of series which helps in correlation and interpretation for planning and development at the micro and macro levels, respectively.

For an appraisal of the productivity of an area, it is necessary to have a fair knowledge of the kinds and distribution of its soils along with their physical and chemical properties. Uniformity in scales, mapping units, composition, and intensity of observations has to be strictly maintained since it is necessary for soil correlation. From such data, soil classification interpretation can be developed to suit requirements (ICAR, 1982).

Material in a soil inventory is usually supported by chapters on physiography, climate, vegetation and land use, soils in relation to factors of soil formation, micromorphology, use of survey information, and soil maps for land-use planning. Such a report as a whole supplies necessary background for understanding the soils of a given area.

Implications of a Comprehensive Soil Inventory System to Farming Systems Research and Planning

Should the encouraging results now being obtained in the Benchmark Soils Project become more definite in support of the project's basic hypotheses, countries will need to reassess field research in activities such as in farming systems, which is noted for its high site-specificity. Continuing favorable results would have the following implications:

1. a lot of research information will suddenly become available for immediate use or adoption;
2. cost of site-specific trials will be greatly reduced;
3. the transfer of information on soil management practices, crops and cropping systems, water management practices, erosion control measures, suitability to new crops, economics of crop production, use and problems of irrigation, and other components of farming systems will be enhanced.

It will also be possible to conclude that because of the built-in system introduced in selecting research sites and stations based on the soil family level, a network of benchmark soils for various important soil families would help in streamlining research in agriculture, particularly farming system research.

The basic structure for achieving desired research efficiency already exists, according to Beinroth et al. (1980):

> ... in the form of a network of national and international Agricultural Research Centers (NARC's and

IARCs). These two types of centers play somewhat different roles. The IARCs conduct research that is more amenable to horizontal technology transfer. For some years now, the IARCs have been developing transferable germplasm and farm' systems for the major agro-ecological zone. It is almost certain that their efforts have lessened the severity of food shortages in the resource poor regions of the world.

Research by the NARCs has a narrower horizontal scope and is heavily oriented towards vertical technology transfer that is rendering scientifically sound technology appropriate for assimilation in local farming systems.

Greater research efficiency in the research centers can be achieved by refining procedures to match and tailor agrotechnology for specific agro-environments and socio-economic situations.

These procedures, if based on sound taxonomic principles are the means to organize knowledge so that the behaviour and performance of the object being classified and studied may be transferred to other locations where similar conditions exist.

International coordination is needed to ensure that:

1. a common soil classification system is used by all participating countries;
2. a uniform procedure for making and interpreting soil surveys, based on a common soil classification system, is employed;
3. standard procedures for matching crop requirements to land characteristics are developed and used;
4. international soil correlation and quality control standards are maintained in soil surveys and land evaluations.

As a general strategy in testing the transferability of new farming systems technology, soils in the same family can be identified on a farmer's fields and used for testing and further refinement of technology. Other closely related soils can then be chosen to form a network throughout the country and other regions, so that the transfer methodology can be applied to accelerate the diffusion of new technology to farmers (Swindale & Miranda, 1981).

To take advantage of these promising implications, Asian countries will have to accelerate their land inventories with the goal in mind of drafting maps using the soil family level in the Soil Taxonomy as the basic mapping unit. With the increasing availability of high-speed computers, data banks that store soil information defining soil families would represent a big step towards a better understanding of the agricultural environment. Such data banks could also provide incentives for the more purposive collection of common sets of minimum data on soil, weather, crops, and farming systems so that experimental results obtained either on-station or on-farm can be useful not only locally but also in explaining results from other locations.

Key Issues for Conference Discussion

1. Is the USDA Soil Taxonomy, which is only one of many soil inventory systems in the world, comprehensive and effective enough to accommodate soils on an international scale and to enable soil responses to management and manipulation to be predicted?

2. Is the target and research area selection method for farming system research described in this paper acceptable? Is there scope for land inventories to be used in facilitating, and possibly even improving, the process of research area selection?

3. Based on the experience of participants in the Asian Cropping Systems Network, how helpful has classifying land types been for cropping systems research?

4. Is some form of land capability classification being used in rationalizing land use in connection with the conduct of farming systems research?

5. How sound is the "benchmark soils" concept in transferring technology in farming systems? Does the soil family in the Soil Taxonomy incorporate the land qualities considered important in issues 1, 2, 3, and 4 above, in assessing the food producing potentials of different soils under increasingly intensive cultivation?

6. How valid is the basic structure for achieving research efficiency described by Beinroth et al. (1980) in terms of NARS and IARCs?

Code symbols in the Philippines in land capability classification

For Effective Soil Depth

Symbol	Description	Range
1	Very deep	More than 150 cm
2	Deep	90 to 150 cm
3	Moderately deep	50 to 90 cm
4	Shallow	25 to 50 cm
5	Very shallow	Less than 25 cm

For Texture of Top Layer of Soil

Symbol	Texture	Description
L	Loamy fine sand, loamy sand, coarse sand, fine sandy loam, sandy loam	Coarse
M	Silt loam, loam, very fine sandy loam, silty clay loam, clay loam, sandy clay loam	Medium
H	Clay, silty clay, sandy clay	Fine
V	Fine clay	Very fine

For Soil Permeability

Symbol	Rate of flow (inch/hr at 1/2 inch head)	Description
1	Less than 0.5 to 0.2	Very slow to slow
2	0.20 to 2.50	Moderately slow to moderate
3	2.50 to 10.00	Moderately rapid to rapid
4	Over 10.00	Very rapid

Symbol	Slope %
a	1 to 3%
b	3 to 8%
c	8 to 15%
d	15 to 25%
e	25 to 40%
f	40 to 60%
g	Over 60%

Extent of Erosion Damage

Symbol	Description
0	No apparent erosion
1	Less than 25% topsoil lost. Some rills may be present.
2	25% to 75% topsoil lost. Small gullies may be present.
3	More than 75% topsoil lost. Shallow gullies or a few big ones may be present.
4	All topsoil lost. Land truncated by gullies.
5	Soil profile destroyed.
6	Catstep – small terraces like steps on slopes of overgrazed hills.
7	Gullies more than 30 meters apart.
8	Gullies less than 30 meters apart.

Appendix 2

Land Classes in the USDA Land Capability Classification (Stallings, 1957)

Class I soils have no, or only slight, permanent limitations or risks of damage. They are very good. They can be cultivated safely with ordinary good farming methods. The soils are deep, productive, easily worked, and nearly level. They are not subject to overflow damage. However, they are subject to fertility and puddle erosion.

Class II consists of soils subject to moderate limitations in use. They are subject to moderate risks of damage. They are good soils. They can be cultivated with easily applied practices.

Class III soils are subject to severe limitations in use for cropland. They are subject to severe risks or damage. They are moderately good soils. They can be used regularly for crops, provided they are planted to good rotations and given the proper treatment. Soils in this class have moderately steep slopes, are subject to more severe erosion, and are inherently low in fertility.

Class IV is composed of soils that have very severe permanent limitations or hazards if used for cropland. The soils are fairly good. They may be cultivated occasionally if handled with great care. For the most part, they should be kept in permanent hay or sod.

Class V soils should be kept in permanent vegetation. They should be used for pasture or forestry. They have few or no permanent limitations and no more than slight hazards. Cultivation is not feasible, however, because of wetness, stoniness, or other limitations. The land is nearly level. It is subject to only slight erosion by wind or water if properly managed. Grazing should be regulated to keep it from destroying the plant cover.

Class VI soils should be used for grazing and forestry, and may have moderate hazards when in this use. They are subject to moderate permanent limitations, and are unsuited for cultivation. They are steep, or shallow. Grazing should not be permitted to destroy the plant cover.

Class VII soils are subject to severe permanent limitations or hazards when used for grazing or forestry. They are steep, eroded, rough, shallow, droughty, or swampy. They are fair to poor for grazing or forestry, and must be handled with care.

Class VIII soils are rough even for woodland or grazing. They should be used for wildlife, recreation, or watershed use.

Appendix 3

Land Classes in the U.S. Bureau of Reclamation — Irrigation Suitability Classification (Bureau of Reclamation, 1953).

Classes 1 to 3 represent lands with progressively less capacity to repay project costs. Thus, Class 1 lands are highly suitable for irrigation farming while Class 3 lands are suitable for irrigation farming, but are approaching marginality because of deficiencies in soil, topographic, and drainage characteristics.

Class 4 is a limited arable or special use class. Lands are included in this class only after special economic and engineering studies have shown them to be arable. They may include lands suitable for high value crops such as fruits and truck crops, where high production costs can be justified on the basis of high returns.

Class 5 is a special study class. Lands in it are non-arable under existing conditions but have sufficient potential that they are segregated for special study prior to the completion of classification on a project. The designation of lands as Class 5 is tentative and must be changed to arable or Class 6 by the end of a project. They may be placed in Class 5 because of specific agronomic deficiencies which require additional observation. A second cause for placing land in Class 5 is when the deficiency is known and understood, but the lands are not allowed into an arable class until the deficiency is corrected.

Class 6 lands are non-arable and non-irrigable. They are generally steep, rough, broken, or badly eroded lands, or lands with special subsoil problems such as shallowness to bedrock or pans, or excessively coarse- or fine-textured soils.

Appendix 4

Soil Taxonomy (USDA, 1975), A Multicategory System

The definitions of the higher categories are more abstract than those of the lower categories (family and series), yet the features used to satisfy the definitions of all categories are soil properties.

The order category consists of 10 classes of soils whose features differ according to the degree and kind of dominant sets of soil-forming processes that have existed. Within the order classes, suborders are distinguished by soil properties that reflect the major control of current processes, climate, parent material, and biological activity and examples of such control. Within each suborder, great groups are defined by soil properties that provide additional influence on current processes not identified in the higher categories.

Great groups are divided into subgroups whose properties represent departures from a central concept of the great groups. These departures are usually a result of the intergradation of processes but some are extragrades, with properties not related to other genetic pedons. Within each subgroup, the family classes contain soils having similar physical and chemical properties that affect their responses to management and manipulation for use. The soil in families can be further classed into series whose restricted ranges of properties provide further homogeneity of morphology and composition.

Examples of Relationships among Category Subdivisions in Soil Taxonomy

Category name	Basis for differentiation	Examples of class name	Main feature of the class
Order	Dominant soil process that developed soil	Ultisol	Clay accumulation; depletion of bases.
Suborder	Major control of current processes	Udult	Soil moist most of the time; humid (udic) climate.
Great group	Additional control of current process	Tropedult	Fairly constant soil temperature all year; tropical environment.
Subgroup	Blending of processes (intergrades or extragrades)	Aquic tropudult	Temporary wetness in rooting zone.
Family	Internal features that influence soil-water-air relations	Fine loamy mixed iso-thermic aquic tropu-dult	Texture and miner-alogy a control section, and soil temperature.
Series	Nature of materials that affect homogeneity of composition and morphology	Cerrada	Soil forming in weathering diabase

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OVERCOMING TECHNOLOGY GAPS

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Introduction

During the past three decades there have been many dramatic developments in agricultural technology. When referring to the challenge of overcoming technology gaps, I mean those gaps which separate the laboratory from the farm, and agricultural research centers at various levels, including the national and the international, from each other. The technology package to which we should aspire in order to overcome these gaps will have to be economically sound, socially acceptable, and environmentally appropriate.

International Agricultural Research

At the regional and international conferences, symposia, and seminars held among agricultural development professionals which I attended in the late 1950s and early 1960s, representatives from developing countries were usually the most vocal in stating the importance of science and technology for development. They were the most active in formulating recommendations to governments, international organizations, and agencies for strengthening the capabilities of developing countries to conduct their own agricultural research.

In the 1960s, however, it was not developing countries themselves but rather industrialized countries who responded to the proclaimed need to step up investment and to strengthen the global capacity for agricultural research. A number of industrialized countries were in a position to do so because of their colonial experience prior to World War II, the adequacy of their financial resources, and their supply on hand of trained and reasonably well-paid research staff. France, for example, established a group of research institutions which dealt with tropical agriculture:

1. IRAT (Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières) for rice and food crops;
2. IRFA (Institut de Recherches sur les Fruit et Agrumes) for tropical fruit;
3. IRHO (Institut de Recherches pour les Huiles et Oléagineux) for oil palm, coconut and other oil crops in the tropics;
4. IRCT (Institut de Recherches du Cotton et des Textiles Exotiques) for cotton;
5. IRCA (Institut de Recherches sur les Caoutchouc) for natural rubber;
6. IFCC (Institut Français de Café, de Cacao et autres plantes stimulantes) for coffee, cacao, tea and cola crops;
7. IEMVT (Institut d'Elevage et de Médicine Vétérinaire des Pays Tropicaux) for tropical animal health and production.

In addition to these institutes there are a number of other agricultural research centers (ARCs) in developed countries which specialize in tropical agriculture such as the Royal Tropical Institute in Holland and the Tropical Products Institute in Great Britain. Also, a number of European universities are well organized to provide advanced studies and training in the field of tropical agriculture. Many American universities have shown increased interest in international agricultural research, and Japan established a tropical agricultural research center in 1968. Since one-third of the Australian continent has soils and environmental conditions quite similar to those of most of the developing countries, it is not surprising that Australia has developed special capabilities in animal husbandry and rainfed agriculture in varied soils and environmental conditions suitable to the agricultural development efforts of the developing countries.

In the late 1960s there was a new thrust in international agricultural research when the IARC (international agricultural research center) concept came into being. There are now 13 IARCs, 11 of which are located in tropical or sub-tropical parts of developing countries. Their situation enables them to generate a "body of knowledge" about tropical agriculture from within a tropical environment. Some of the IARCs have already established a prestigious reputation. They have had a substantial impact on the food production of the world in general, and of the developing countries in particular.

The IARCs now provide a significant source of "improved technology" for world agriculture. They also act as an important source of advice and consultation to national agricultural research systems (NARS) and centers (NARCs). It was not surprising that during the 1960s and the 1970s the centers of excellence for solving problems of agricultural development in the developing countries were primarily the NARCs and the IARCs.

National Agricultural Research Systems

In the 1970s world agricultural production greatly increased because of greater research expenditures in developing countries. National agricultural research systems in developing countries, which had been the weakest link in the global research effort, began to organize themselves better and to develop their own identities.

The thrust in industrialized countries in the 1960s to bolster their own agricultural research capacities and the subsequent establishment of a network of international agricultural research centers financed by the Consultative Group on International Agricultural Research (CGIAR) triggered the emergence and revival of national agricultural research systems in developing countries. This development may have influenced the international donor community to give a higher priority to providing assistance in the field of agricultural research.

Some of the national agricultural research systems in Asia which already had an adequate scientific manpower base started to strengthen their research organization and management, to improve their research programs, and to establish effective working ties with both international research centers and national research systems in developed countries. Some of the less advanced national research systems had first of all to develop their research skills and to establish the infrastructure essential for their research before they could start streamlining their research programs and intensifying collaboration with foreign and international research institutions.

In Indonesia the 1973 State Guidelines for National Development decreed by the People's Consultative Assembly called for the strengthening of national capabilities in science and technology to support and provide orientation for national development. The government responded by establishing 14 agencies for research and development by presidential decree, most of them under the authority of existing ministries. One of these agencies, the largest in terms of manpower, budget, and work program, was the Agency for Agricultural Research and Development (AARD). AARD is one of the nine top echelon units within the Ministry of Agriculture. Its executive, the director general, reports directly to the minister.

In 1975 AARD embarked on a program to absorb and integrate all previously existing research institutes within the Ministry of Agriculture. There was a gradual merging of research personnel and program planning to affect greater efficiency in the production of new technology. By 1976 AARD administrators were directly managing their own budget, personnel, physical facilities, and research programs.

External Support

Let me cite an example with which I am very familiar. The level of international and bilateral support to the Indonesian agricultural research system has been and continues to be encouraging. World Bank and USAID support dates back to the first year of AARD's existence. The World Bank gave a loan in 1975 to supplement the government's budget to finance the upgrading of scientific staff, and to build or renovate the physical facilities of four research institutes: one on rice and another on vegetables in Java, and one on rubber and another on estate crops in Sumatra. A more substantial loan was added in 1980 to strengthen AARD's scientific manpower base further and to improve research facilities for food, industrial crops, fisheries, and forestry.

In 1976 USAID provided loan and grant funds to supplement the budget for the establishment of the Sukarami Research Institute for Food Crops in West Sumatra, and its network of experimental farms and research stations on Sumatra. In 1981 USAID gave loan and grant aid to help AARD in establishing and strengthening the research infrastructure in Kalimantan, Sulawesi, and the eastern part of Indonesia.

The Australian government through the Australian Development Assistance Bureau (ADAB) made generous grant funds available to establish the Animal Husbandry Research Institute at Ciawi, West Java; to strengthen Indonesian research capabilities in animal husbandry, animal health, and forage crops; and to devise ways to make more efficient use of fertilizers. Japan, through the Japanese International Cooperation Agency (JICA), continued its support of research on rice and mariculture.

Yet, despite increased research expenditures in developing countries, as illustrated by the Indonesian example, it is sobering to note that developing countries themselves still only spend about one-third as much of their gross domestic product on agricultural research as developed countries do. In terms of research expenditure related to agriculture per capita, disparities between developed and developing countries are even more striking (World Bank, 1981).

The International Federation of Agricultural Research Systems for Development (IFARD) and the International Service for National Agricultural Research (ISNAR) — the organizers of this present conference — were created in the 1970s to help strengthen the NARS and overcome the technology gap between the IARCs and the ARCs of industrial countries on the one hand, and the NARS of developing countries on the other. I suggest that what IFARD and ISNAR can do to bridge this technology gap should be taken up as a topic for our discussion today.

Technology Transfer from ARCs and IARCs to NARS

Experience during the last two decades indicates that the low research capacity of developing countries has limited the effectiveness of technology transfer from centers of excellence to the developing world. This in turn has reduced the dividends from well-intended IARC investments. Devel ing countries lag behind in acquiring highly technical expertise in agricultural research. More alarming is the growing disparity between the financial incentives for research between the national systems of developing countries and the IARCs.

To provide a basis for subsequent discussion, I would like to refer to an experience of cooperation and technical assistance which we have had with IRRI (International Rice Research Institute). It has been a successful experience from which we can all learn a great deal.

IRRI's involvement with the Indonesian rice research program dates back to 1967 when the high-yielding varieties IR5 and IR8 were introduced into the country. A formal cooperative research and technical assistance contractual arrangement between the Ministry of Agriculture and IRRI, with financial support from USAID, was signed in 1972. Initially to last for five years, it was extended for a second five years in 1977 and reached an end in June 1982.

The following achievements can be noted (Sadikin and Cowan, 1982):

1. the working relationship established between IRRI and CRIFC (Central Research Institute for Food Crops) of AARD made it possible for the Indonesian research system and its scientists to follow how IRRI planned, carried out, reviewed, and evaluated the results of its research program;
2. through its liaison scientist and resident scientists (in Indonesia) IRRI had continuous and prompt feedback on Indonesian rice production challenges and needs;
3. through this cooperative arrangement, 21 Indonesian scientists received Ph.D. degrees, 30 received M.Sc. degrees, and a total of 332 participants received short-term training in new technologies abroad (primarily at IRRI) in some 38 different training programs;
4. the area planted in IRRI and Indonesian high-yielding varieties increased from 168,000 ha in 1968 to 1.3 million ha in 1973, and then to over 5.5 million ha in 1981;
5. the rate of growth in rice production was 4.6% per year during 1970 to 1981, and 6.1% for 1975 to 1981.

In January 1981, one and one-half years before the cooperative arrangement terminated, AARD and IRRI agreed to maintain a continuing working relationship through a collaborative research program. Certain research program areas such as rice-based cropping and farming systems, water management, and upland rice may well be more productive if carried out through collaborative research with Asian NARS. Research activities could then be assigned according to who has the comparative advantage to do the research best. For upland rice research, for example, AARD has experimental stations located in wet and dry climates as well as at high and low elevations. IRRI still does not have land for expanding its research to meet the upland rice production challenge. AARD can provide sufficient land for research on water management (irrigation) in an important irrigation common area. Its research institutes have developed expertise in corn, sorghum, grain legumes, tuber crops, vegetables, fish, and poultry — all important components in a rice-based cropping and farming system.

Indonesian scientists and administrators view this opportunity for expanded and intensified collaborative research with high expectations. We will also use our experience of cooperation with IRRI to establish new and similar working relations with other IARCs and ARCs in industrial countries.

We look to IFARD and ISNAR for inspiration, counsel, and support in these anticipated activities.

In my view the IARCs and ARCs can help promote the transfer of technology to the NARS in the following ways:

1. by setting a high priority for training in the work programs and budgets of the IARCs and ARCs in order to facilitate an increase in the technical capability of the national organizations;
2. by sending invitations to the leadership and staff of NARS to participate actively in the planning and implementation of IARC programs, as well as in their review and evaluation;
3. by including collaborative research with NARS in the core programs and budgets of IARCs and ARCs;
4. by giving service and assistance to NARS in the collection, botanical and agronomic characterization, conservation, and distribution of germplasm;
5. by rendering assistance to NARS in information and bibliographic services;
6. by arranging regular consultation among leaders of NARS, IARCs, and ARCs.

We must deal forthrightly with criticisms frequently directed toward agricultural research if research is to remain an essential, ongoing dimension of agriculture as an industry. We should remember Ruttan's comment about the IARCs:

> If the international institutes develop a capacity to link the national systems into a carefully articulated international system, they will assure their own continued viability. If they become viewed as being competitive with national research systems, they could fade away into mediocrity.The effectiveness of the international system depends on the development of strong national systems (Ruttan, 1982).

Channeling Technology Transfer: Laboratory to the Farm

It is important for us to remember the "links in the chain" necessary to develop technology and to transfer it into an effective use pattern. This chain is only as strong as its weakest link!

There are several steps:

1. generation of research;
2. technology evolution;
3. technology transfer;
4. audience — farmers, community leaders/managers of agriculture firms, policy-makers, and universities/agricultural schools.

It is important for us to have an organizational structure, physical facilities, personnel, and a government commitment before we can have an agricultural research program. From our research we are able to develop packages of technology for our farmers which will permit them to produce greater quantities of high-quality food and other agricultural commodities more efficiently. This, in turn, will increase their family incomes. Those of us administratively responsible for the generation of research and technology cannot permit the process to stop at this point! If the knowledge which our scientists gain from their research is not put into a form which can be utilized by the farmer then we have not succeeded. I think we will all agree that we have made some substantial progress. There does still remain a "technology gap," however, and it is for this reason that we are addressing ourselves to this topic today.

There is frequently a tendency among many of our professionals to think that farmers are our only audience. They are indeed our prime audience. We must never forget that fact. Yet, there are others, too, who play an extremely important role in minimizing and reducing the technology gap.

Once we have technology it must be channelled effectively, efficiently, and promptly to the farmers in a form which they can comprehend. Each nation's system for transferring research results to its farmers may, by necessity, be different. The ultimate goal is always the same. Optimism prevails among scientists and policy-makers that there will continue to be a good response by Asian farmers to "new technology packages," such as the introduction of high-yielding varieties with the associated use of fertilizers and agricultural chemicals, and the appropriate application of water and relevant farm-management practices. The transfer or introduction of technology must be supported by incentives to make its application profitable for the farmer. I would like now to review four channels to illustrate some basic concepts which can aid in expediting technology transfer and reducing the technology gap.

Extension

The first channel is extension, a time-honored educational approach, well known to all of you. The Indonesian extension staff have employed some methodologies which have proven very effective and fruitful. One of the most widely recognized and accepted sequences has been technology generation, verification through on-farm demonstration, extension assistance, and application by the farmers. In rice production an integrated scheme known as the BIMAS program was developed. This consisted of a package of inputs, among which were extension, credit, good seed, fertilizers, and insecticides. The "technology package," which included land preparation, good seeds, fertilizer, and the appropriate and timely application of plant protection and crop management practices, was first tried by students of IPB (Bogor Agricultural University) on a 50-ha verification-and-demonstration plot on farmers' fields. The yield increases obtained encouraged these farmers to experiment further, eager to exploit the new techniques fully. Using the experience of the IPB students, the provincial agricultural services, through their extension arm, launched a large-scale introduction of this technology package, directed first to well-irrigated areas with adequate infrastructure and, a point of exceeding importance, to good farmers who were known innovators. It was a capable, effective, and low-risk campaign. Inputs were made available at the farm gate, and on time; irrigation water and plant protection were assured; marketable surplus flowed to buyers; and farmers organized themselves to tackle day-to-day problems cooperatively.

The campaign soon demonstrated remarkable yield increases well above the national average yield plateau. The government supported the BIMAS program with research, training, extension, rural credit, inputs, and later with a floor-price policy. There were BIMAS management boards established at national, provincial, and district levels. The program had a large enough capacity to involve millions of farm families all over the country. Key farmers became a part of the educational team. The introduction of new high-yielding varieties of rice like IR5 and IR8, together with the BIMAS program in 1967 and 1968, brought about improved rice crops and encouraged the spread of the BIMAS program.

A severe drought in 1972 seriously affected the program. The explosive brown hopper outbreak in 1975 to 1977, as well as sporadic, localized droughts have also set back the Indonesian rice production program. Fortunately, the introduction of new varieties through the BIMAS package included rice resistant to biotype-1 and biotype-2 of the brown hopper. With the aid of a simple system for monitoring pest biotypes and an integrated pest control system, farmers managed to overcome the brown plant hopper infestation. Over the years the BIMAS program has undergone continual change. Improvements have resulted from reviews, reorganization, and adjustments. Every effort has been made to help BIMAS farmers establish village unit cooperatives to facilitate the purchase of inputs and the sale of their produce.

The latest organizational development within the BIMAS program is called INSUS. INSUS, a special intensified production program, involves a group approach to extension, relying heavily on the active participation of farmers in decision-making about inputs to be purchased, fertilizer application rates and times, plant protection schedules, and water management. There is a guaranteed price for the rice produced. The BIMAS and especially the INSUS programs are excellent demonstrations of how an attractive and profitable technology package can be adapted and adjusted by farmers themselves to suit their own needs. This is an illustration of the "laboratory to farm" channeling of a new package of technology which has been successful. There was no technology gap! The smooth transfer of new ideas and/or materials is confirmed when we observe that substantial increases have taken place in the use of high-yielding varieties fertilizer consumption, average rice yields, and total rice production during the last two decades.

Based on Indonesia's positive experience with rice, the BIMAS and INSUS approaches are now being adapted to production programs for other commodities, including corn, grain legumes, vegetables, and poultry.

Direct Approach

A second channel for technology transfer is the direct one which leads from the NARS (national agricultural research system) to agricultural firms (government or private) or to progressive farmers who have the capability to verify and adapt technology to their local needs. The introduction of new varieties or clones should of course be cleared first through the National Seed Board or equivalent organizations. Successes of such operations are catalytic to the widespread adoption by farmers of new varieties, clones, and accompanying technologies. Examples of direct technology transfer in Indonesia include the introduction of new clones and their complementary technologies in the cases of: rubber, tea, coffee, oil palm, potatoes, lowland tomatoes, hybrid cabbages, running water systems in fish production, and development of shrimp hatcheries.

The expansion of the research infrastructure and the establishment of additional research institutes and experimental farms in varied agroclimatic regions and environments in Sumatra, Kalimantan, Sulawesi, and the eastern parts of Indonesia has stimulated, strengthened, and expedited this approach to disseminating research results.

The NES (nucleus estates smallholders) projects for both new and replanted estate and industrial crops also serve as a good vehicle for the channeling of new technology to the user.

The NES model can have a multiplier effect by illustrating to neighboring farmers the wisdom of adopting a better technology. This approach has merit for many situations with food crops, fish, and animal production programs as well.

Decision-Makers

A third channel can be to and through policy- and decision-makers at both the national and the provincial level. Decision-makers should be thoroughly conversant with the nature and particularly the concept of the technology being evolved, and with possible new technologies about to be made available for implementation. It must be recognized that these persons play a very important role in influencing change. Therefore the results of research must be translated into a form that will be comprehensible to them but that in no way distorts the authenticity and accuracy of the results. Such translation can only be done by professionals. Otherwise a technology gap will remain.

Research results must be supplied to national and provincial agricultural leadership on a continuous basis to aid them in policy formulation and in making adjustments to planning and programming. These findings should provide substance and objectivity to the packaging of planned agricultural development policies and anticipated programs. Policy- and decision-makers must be kept informed of research findings which are to be disseminated so that researchers may solicit their understanding and the full support of their authority, influence, and counsel. At the same time research workers must make it their business to appreciate the challenges and constraints which policy-makers face.

This is an important dimension of overcoming the technology gap. Wherever possible the impact or the anticipated impact of innovations must be taken into account when presenting research results and/or research programs to decision-makers. Bankers must have some such measure before they will seriously consider advancing credit, a shortage of which is sometimes the limiting factor in effectively introducing a new package of technology.

Universities and Agricultural Schools

A fourth channel for technology transfer involves universities and agricultural schools. In most countries these institutions are responsible to the ministry of education, and may be somewhat isolated from the research agency of the ministry of agriculture. Universities and agricultural schools have responsibility for training future scientists and development professionals. If they are to do this job well, they must be aware of what the research system is doing. Therefore there must be a close liaison. It is a two-way street.

The traditional procedure for scientists is to record the results, interpretations, and philosophies of their research in scientific papers which are published in scientific journals, or the proceedings of symposia or workshops. This is an important mechanism for communication among scientists. Published results must be made available promptly to our university colleagues so that wherever appropriate such new knowledge may become "part and parcel" of the training of future scientists and agricultural leaders.

If teaching is to be well founded, of necessity it must have a research program to support it. Graduate students will, of course, carry out thesis research. This research will most likely be of a fundamental nature. The staff of the NARS should be aware of theses work which is being done, because it could provide useful information in support of much of their own technological research.

All too frequently researchers overlook the importance of good communication techniques. We know these skills are essential but often fail to devote sufficient attention to their development. If we are to minimize the technology gap, we must have an efficient technology transfer system. This requires professionals who understand the business of communication, particularly to agricultural audiences. The role of such professionals may be every bit as important as that of scientists. Once a scientist has obtained information from his research, and analyzed and interpreted it, it may be necessary to translate his findings further into accessible forms.

Decision-makers need information in a form which gives them an economic measure of its potential value. Extension workers need facts presented in such a way that they can be readily used in educational programs with farmers. The general public is likely to prefer information in the kind of digestible form characteristic of journalists or reporters from television or radio. In every instance, however, universities and agricultural schools are responsible for training "communicators" to convey what has to be conveyed appropriately.

Priority Topics for Asian NARS

In order to encourage discussion during this session, I would like to suggest that agricultural research in Asia can be classified into four different groups depending on crop or topic. For the first group there are three areas where we in Asia have been pre-eminent in research: rice, rubber, and cropping/farming systems research. I believe that any major advances in these crops and systems in the foreseeable future will be made at research stations in Asia.

The second group includes typically Asian commodities where, as things stand at present, major research advances are not likely in Asia. Now would seem an opportune occasion to suggest that there is a need for Asian NARS to improve their research capacity in these commodities which number among them coconut, cassava, oil palm, tropical fruits, lowland vegetables, water buffalo, and ducks. I would like to invite ISNAR and IFARD to participate in a review of our existing research capabilities for these commodities. This review would identify the strengths and weaknesses of our NARS relevant to these commodities and then suggest how we in Asia might improve our research institutes. As the first step in this review, I want to propose that Indonesia host conferences on coconuts, tropical fruits, cassava, and ducks in 1983 and 1984. These conferences would help plan strategies for the development of an Asian research capability in these commodities.

The third group includes topics or areas which are not typically Asian and for which I feel, although it is important to do so, we have not yet developed adequate expertise . This group includes fresh- and brackish-water aquaculture, tropical soils, forests in the humid tropics, and small ruminants. Here, clearly, it is up to the Asian NARS to improve our research capacity. I can only pose the question, what should we do about these topics?

The final group covers research on the social and economic systems of Asian farmers in the environment in which they must make day-to-day decisions on how to maximize their incomes. Do we have the capacity in each of our own countries to improve the quality of this research? ISNAR and IFARD might be able to recommend how to improve our research in the fields of economics and sociology.

Criticisms of Agricultural Research

As the final part of my paper, I would like to direct attention to five common criticisms of our research efforts. We must respond to these criticisms if we are to maintain viable agricultural research systems.

1. Agricultural research is expensive and not all Asian countries can afford it. It would be valuable if ISNAR and IFARD could prepare a convincing analysis to prove that the returns from agricultural research are excellent in developing countries. This would facilitate our annual research funding discussions.

2. Agricultural researchers are not practical enough to solve farm-level problems. The difficulty is not that research is insufficiently practical, but rather that there are too many important problems for study. Our limited resources force us to select only a few high-priority problems for investigation. We must be sure that those problems are the ones of greatest relevance to our countries' national planning.

3. Research is a long-term investment and developing countries need rapid returns from existing knowledge. We require case studies to prove that agricultural research is not just a long-term investment, but can also yield quick dividends from specific activities.

4. Research is only for policy-makers, not for farmers. This criticism is that we respond only to national problems at the request of policy-makers, paying too little

attention to farmers and officials at the regional level. The problem is one of limited facilities, funds, and personnel. Our resources do not permit us to respond to all problems in all localities. We are forced to be selective in our choice of problems at the farm level. Here again the matter of setting priorities is important.

5. The link between farmers and researchers is weak. Organizational linkages are different in each country. Some NARS do not have a mandate to give extension assistance to farmers. Yet, the essential thing is for research results to reach farmers rapidly. Thus the research/extension link becomes of paramount importance.

These are only five examples of criticisms about our agricultural research. There may be others in your own countries which we should also discuss today.

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WOMEN IN RICE FARMING

International Rice Research Institute (IRRI)[1]

Introduction

Women's work generates a substantial portion of household cash income in rural Asia, particularly in the poorest households (Agarwal, 1981). Rural women work long hours in both domestic and agricultural production because they frequently have primary responsibility for both household subsistence needs and child welfare. Improving rural welfare is inseparable from improving the earning opportunities of rural women. Any technology that can increase rural women's productivity, allowing them to work less and earn more, will be particularly beneficial to the welfare of rural households.

Women play a major role in rice cultivation, post-harvest processing, and marketing. Although their tasks vary in different cultures, women often supply most of the labor for transplanting, weeding, harvesting, manual threshing, and drying. They are also involved in making decisions about the adoption of technology, the purchase of inputs, and the management of hired labor. Their participation in some Asian countries is increasing as men migrate to urban areas (ESCAP, 1981).

There is a need to understand whether in the past women benefited from the introduction of new rice technologies; how women could benefit from emerging and potential technologies; and how technology transfer programs can reach and involve women. IRRI proposes to hold a conference in 1983 to bring together researchers from various Asian countries to explore these issues. Conference participants would include both social scientists doing research on the welfare of rural women and agricultural scientists, extension workers, and policy-makers who are concerned with the development and transfer of technology. The conference will be divided between a review of the past and discussion of the future. Several questions will be addressed:

1. What is the state of technology development for women-specific occupations so that productivity and income can be improved and drudgery minimized?
2. What is the impact of new technology on women's employment -- does the new technology lead to displacement of labor or diversification of labor use?
3. How can technology transfer programs ensure that improved technologies become available to women?
4. What is the role of women in developing and operating technology generation and delivery systems?
5. Can technologies be devised which can help to diversify income opportunities for women?

Technology Development in Relation to Women-Specific Occupations

In order to address this subject, it is first necessary to answer certain basic questions for each country. What tasks do women perform in rice cultivation? What role do women play in farm household decision-making? What technologies are currently used in rice cultivation? After a clear understanding of the present situation has been gained, new technologies for rice cultivation should be reviewed to identify how women might benefit from them.

Two factors determine whether poor rural women derive any profit from a new technology. First, the new technology must increase the productivity of women's labor in order to increase their earning potential. Will the technology produce more output with less time? If so, will the technology increase women's earning opportunities or displace them from their current tasks? Increases in both labor productivity and labor demand occur only when other factors are not substituted for labor. In other words, increased output must be generated through gains in labor productivity, holding the productivity of other factors constant. Second, in order for this increased productivity to be realized, social institutions and technology transfer programs must allow women access to the new technology. Does the new technology require access to resources or knowledge that women will not have?

It is important to distinguish between women in small farm households and women in landless rural households. The access to resources, earning opportunities, and ability to gain from new technology of women in these two categories will differ greatly. Issues concerning labor use and productivity will most affect the landless women who seek wage employment. Issues of access to new technology will especially concern women in small farm households who are involved in farm management.

Many of the new rice technologies now emerging can have an impact on women's role in rice cultivation. Increased sophistication in farm household decision-making will be needed, for example, for integrated pest management and weed control. Women's role in these activities needs to be better understood so that technology transfer programs can reach them. Another example is the increased intensification of land use through planting of upland crops after rice. These crops could increase women's income directly and also indirectly through providing inputs to traditional livestock production. The use of direct seeding and herbicides to replace transplanting and weeding, other facets of emerging technology, may reduce demand for women's labor. An understanding of alternate opportunities available to the women likely to be displaced is needed.

Here it should be pointed out that technology which is still "new" in one Asian country may already be in widespread use in another. The technologies that are "emerging" will vary for different countries and for different environments within countries. In the following discussion of labor utilization and technology transfer programs, the questions outlined can serve to evaluate either the impact of new technologies or past experience after technology adoption.

The Impact of New Technology on Women's Employment

New rice technology, introduced in the mid-1960s, consisting of improved seeds, fertilizer, and management practices, has increased the production of rice in many areas of Asia. Numerous studies under the "conse-

[1] This paper was prepared by a committee at IRRI and presented at the conference by Dr. M.S. Swaminathan, Director General.

quences" work of the economics department at IRRI have documented the increased labor demand following the introduction of modern rice varieties (Barker and Cordova, 1978; Herdt, 1980). This increased demand can be attributed to the ability of the new rice technology to increase labor productivity through generating more output without requiring an equivalent increase in labor input. Labor demand rose in order to take advantage of the potential for profitable production increments.

Some analyses of the impact of this technology have confused the effects of rising population pressure with those of the introduction of new technology. More labor is now used in rice production, but this increased labor absorption may not have offset the growth of population and consequent decline in real wages. Furthermore, the effects of mechanization have also been misunderstood. Mechanization may displace labor from one task but increase total labor use by allowing double-cropping.

The new rice technology apparently has the capacity to increase earning opportunities for rural women in rice-producing areas. The introduction of straight-row transplanting, higher-yielding varieties, and double-cropping increase the demand for labor in women's tasks, benefiting women who rely on wage income. The additional output also increases the income of women in small farm households (Agarwal, 1981).

. Very few studies have focused on the impact of new technology on women, including the effect of a change in one activity on the total demand for women's labor. A farming systems approach is needed to understand how women's total earning opportunities are affected by changes in rice cultivation. Specifically, we need to know:

1. How has the contribution of women's hired and family labor to rice cultivation changed?
2. Have the tasks specific to women changed with new technology?
3. Do women in small farm households now have more or less time for other production activities? Do these women have access to the increased income from rice cultivation? Are children in the household able to do less work and go to school more regularly, thereby reducing the rate of school drop-outs?
4. Do women in landless households now have more or fewer opportunities for wage labor in rice cultivation? If these women have fewer opportunities in rice farming, what are their other sources of income? Are they able to replace lost income from rice farming without increasing the number of hours they work?
5. What is the effect of changes in women's labor participation on family welfare in both types of households?

The Benefit of Technology Transfer Programs to Women

A technology with the potential to increase women's earning opportunities may not benefit women if institutions do not allow access to this technology. Institutions that determine women's access to resources include sex segregation of rural labor markets, the traditional intra-household division of income, and technology transfer programs introduced by national governments. Thus both traditional cultural norms and institutions introduced in the process of modernization affect women's access to technology.

The ways in which institutions can limit women's access to technology are well documented. Credit and extension programs do not always attempt to reach women nor do they invariably recognize women's role in agriculture (Boserup, 1970; Staudt, 1978). These oversights can lead to a situation in which only men have access to new production techniques so that in time male dominance becomes established in tasks that were previously performed by women (Cain, 1980). Thus an apparent increase in demand for "women's" tasks may not actually result in additional opportunities for women's labor. Furthermore, even when women do more work, the resulting extra income may not accrue to them and their children (Jones, 1982).

In order to design technology transfer programs to meet women's needs we need to answer the following questions:

1. What is women's current role in farm household decisions about cultivation and management of resources?
2. What types of expanded extension and management activities will new technologies require?
3. What investments are needed to take advantage of new technologies?
4. What access do women in farm households have to credit and production inputs?
5. How successful are current programs in making information available to women? Where they are not successful, what are the barriers to reaching women?

The Role of Women in Technology Generation and Delivery Systems

Greater involvement of women in technology generation and transfer is likely to ensure that women's interests are represented and that programs to reach them will be successful. Such involvement can take several forms. Rural women's organizations which extend credit and training already exist in many countries. Experience has shown that when a technology transfer program works through existing rural women's organizations it succeeds best in meeting women's economic needs (Dixon, 1980). Similarly, women extension workers are more likely than men to reach women in farm households. Yet, extension workers in most countries are men, with the exception of the Philippines and Thailand, where one-quarter to one-half of extension workers are women (Germaine, 1980). It may be of interest to compare the effectiveness of Philippine and Thai programs in reaching women with related achievements in other Asian countries. In some countries women's involvement is hindered by their lack of education. Where a large proportion of rural women are illiterate, technology transfer will not be effective without an educational component to teach literacy and economic skills. Finally, women are involved in agricultural research and policy-making to varying degrees in different Asian countries.

In order to begin to understand the role women play in technology generation and delivery, it would be useful to answer the following questions:

1. What proportion of agricultural extension workers, scientists, and policy-makers are women?
2. How much access do women have to training and education at all levels? What percentage of rural women are literate? What percentage of university students in the agricultural sciences are women?

3. What is the current role of rural women's organizations in improving women's economic opportunities? How can these organizations be involved in technology transfer?

Possible New Technologies to Diversify Women's Earning Opportunities

If new technologies displace women from rice cultivation, it may be possible to diversify their earning opportunities at other tasks. Some examples of possible alternative activities are fish culture, utilization of rice by-products, and raising livestock. Identification of these possibilities will be easier after a full understanding has been gained of the role of women in rice cultivation and of the extent to which new technology is likely to lie within their reach.

An Action Proposal

In order to review and to discuss the questions and issues raised in this paper, in September 1983 IRRI plans to bring together about 50 scientists from various countries for a conference. The group will consist of roughly the same number of physical and social scientists. National research programs in each country will be invited to contribute a paper on women's current role in rice cultivation and the present state of technology development. These papers will provide the basis for a review of past experience. FAO will also prepare an overview paper on the issues. Reports on specific research looking at the impact of new technology on the welfare of rural women will also be presented during the first session.

The second session of the conference will be devoted to a discussion of emerging technologies. Physical scientists from both national programs and IRRI will report on potential new technologies for rice-based farming systems. Technologies will be reviewed by environment, i.e., rainfed lowland, rainfed upland, and irrigated, deep water, and flooded conditions, because this approach will provide an opportunity to view changes within the framework of the entire farming system. After each presentation, the likely impact on women and the implications for technology programs will be discussed.

In the third session the role of women in technology generation and transfer programs will be examined. Potential benefits from increasing women's involvement and public policies to encourage women's participation will be discussed.

On the final day the discussion leader of each previous session will present conclusions and recommendations. The conference may provide the basis for a network of collaborative studies on rural women, in addition to arranging the publication of a volume of papers. It is hoped that guidelines can be drafted for future technical research priorities and for public policy with respect to technology transfer. An increased understanding of women's role in rice production may help to identify areas of study which appear promising for finding ways to enhance women's productivity. Similarly, such understanding may help to design policies that facilitate women's access to technology.

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AGROFORESTRY

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The Agroforestry Approach — Potentials and Constraints

Definition and Scope

"Agroforestry" has arrived and become firmly established as a term and concept in international development and rural science terminology in a surprisingly short time. It was not until the later 1960s and early 1970s that the word started to appear, occurring then mainly in forestry circles as a wider, collective name for all the various forms of taungya afforestation systems long in practice in many tropical countries (King, 1968). General textbooks on tropical agriculture and farming systems from the 1970s do not even mention the word (e.g., Ruthenberg, 1980; Manshard, 1974). The final "breakthrough" of the concept can probably be dated to the report of Bene et al. (1977).

Since 1977 at least a dozen international meetings specifically about agroforestry have been held; major UN conferences held during the last five years invariably mention the value of agroforestry in their resolutions and recommendations (e.g., the FAO World Forestry Congress, 1978, and UN Desertification Conference, 1977; the UN Conference on New and Renewable Energy Sources, 1981; and the UNEP Session of a Special Character, 1982); all principal donor agencies, both bilateral and multilateral, have recently taken up agroforestry in their lending and spending programs; international and national institutions, journals, and consultants, specializing in agroforestry are mushrooming all over the world.

There are probably many interrelated reasons for this explosive increase in interest. No doubt the built-in dynamics of "fashion" have stimulated the process, but there is much more to it than that. Agroforestry is the first concrete concept that builds on a synthesis of much of the practical experience and scientific knowledge acquired over the past decades in tropical agriculture, forestry, ecology, soil science, and rural socioeconomics. Our increased understanding of tropical environments, both social and ecological, and our frequent disappointments and failures when trying to implement modern land-use technologies in ecologically sensitive and socioeconomically complex situations have led to a realization that alternative approaches to land development must be given higher priority.

What then is agroforestry? There is certainly no general consensus. Many definitions have been proposed, good and bad, broad and narrow. Many, unfortunately, make subjective and presumptuous claims that agroforestry, by definition, is a superior and without doubt a more successful approach to land development than others. It would, however, serve no purpose here to list a large number of definitions (see Agroforestry Systems, 1982). The following definition has the advantage of being objective:

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

This definition outlines the broad boundaries of agroforestry and the typical characteristics of such systems:

1. agroforestry normally involves two or more species of plants (or plants and animals), at least one of which is a woody perennial;
2. an agroforestry system always has two or more outputs;
3. the cycle of an agroforestry system is always more than one year;
4. even the most simple agroforestry system is more complex, ecologically (structurally and functionally) and economically, than a monocropping system.

It is apparent that this definition of agroforestry encompasses many well-known land-use systems long practiced in the tropics. Traditional shifting cultivation and bush fallow systems, for example, are included: woody fallows are clearly a deliberate and important part of the system, interacting both ecologically and economically with the crops grown in the cultivation phases. Systems with natural fallows can, of course, be classified as "primitive" agroforestry since no deliberate choice and planting of woody species takes place.

Furthermore, all forms of taungya afforestation systems are included, as well as systems in which tree crops such as rubber, oil palm, and coconut are underplanted with other crops or pastures.

Naturally, more typical agroforestry systems, such as the home gardens of many wet tropical regions, or the deliberate use of fodder trees and shrubs in the dry tropics, are part of the concept.

The definition and all that it includes brings out the very important point that agroforestry is only a new word, not a new practice. Its novelty lies in the realization that so many different land-use systems and practices, some of which have traditionally fallen into the field of horticulture, some into agriculture, some into forestry, and a considerable number of which have not attracted any systematic attention at all, have a common denominator in approach worth exploring and developing in a more systematic and scientific way.

The word agroforestry is admittedly rather unfortunate in that it linguistically evokes the notion of its being a subdivision of forestry (Stewart, 1981) rather than an integrated form of land use in a much wider sense. The word is now so firmly entrenched, however, that there is no point in wasting energy or effort on trying to find a better one.

Potential of Agroforestry

The aim and rationale of agroforestry systems and technologies is to optimize positive interactions between components (trees/shrubs and crops/animals) and between these components and the physical environment in order to obtain higher total, more diversified, and/or more sustainable production from available resources than is possible with other forms of land use under prevailing ecological and socioeconomic conditions.

The attractiveness of an agroforestry approach to land development lies in the potential role of trees/shrubs to alleviate some of the major physical and economical constraints facing farmers and pastoralists in many parts of the tropical world.

The most apparent ecological potential exists in areas where soil fertility is low and depends mainly on soil organic matter, where erosion potential is high, and where the incidence of surface soil desiccation is high. On such marginal lands the deliberate use of woody perennials may, if properly integrated in the land-use systems, enhance both land productivity and sustainability. The fewer capital and technology inputs available to farmers, the more motivated they will be, theoretically, to use trees and shrubs to enhance organic matter production, to maintain soil fertility, to reduce erosion and to create a more even micro-climate.

The value of agroforestry is, however, by no means restricted to marginal lands. Some of the most successful small farmers' systems in the tropics are in fact found on high potential, fertile soils, where intensive agroforestry systems have for many years proven their ability to support dense and growing populations economically.

Further potential for agroforestry, equally applicable on marginal and rich land, exists in socioeconomic situations where land tenure and/or lack of rural infrastructure (communications, markets) and cash make it vital for people to produce most of their basic needs (food, fodder, fuel, shelter, etc.), from a limited land area, in favorable instances their own.

In general terms, therefore, the idea and approach of agroforestry seem sound. Erosive rains, organic-matter-dependent soil fertility, an increasing fuelwood scarcity, and a lack of cash and infrastructure among the vast majority of tropical land-users are some of the most relevant ecological and socioeconomic arguments for tree integration into farming and pastoral areas (Bene et al., 1977; Eckholm, 1979; FAO, 1981c; World Bank/FAO, 1981). Indirect arguments in favor of the agroforestry approach to land use are the all-too-frequently-observed productivity declines and land problems that almost invariably follow indiscriminate removal of permanent vegetation cover (be it forest, woodland, or planted trees). Agronomists are also realizing increasingly that the only feasible, long-term approach to development for some crucial tropical areas, the Amazon rainforest, for example, is a tree-based land-use system, either horticultural crops, forestry, or agroforestry (Alvim, 1979; Hecht, 1982).

The systematic and scientific development of agroforestry appears to hold especially great promise in the practically unexplored field of genetic improvement of multipurpose tree/shrub species. In agriculture, horticulture, and forestry, systematic and determined efforts to improve desirable characteristics in crops through selection and breeding have achieved remarkable results. The green revolution, a major part of which has been the development of improved varieties of rice, maize, and wheat, is the most widely known example. No less spectacular results have been obtained in forestry and horticulture. Palmberg (1981), for example, reports on *Eucalyptus camaldulensis*: "The results (of trials) showed that the potential gain in productivity which can be achieved simply by selection of the best-adapted provenances for prevailing environmental condition, could amount to several hundred percent." Likewise, the average yield of rubber has increased 17-fold in a century as a result of breeding and improved management (Nair, 1981).

There is no scientific reason why selection and breeding to improve features desirable in agroforestry, such as fodder, food and fuel quantity and quality, rooting characteristics and phenology favorable to interplanting with annual crops, nitrogen-fixation, pest resistance, and drought resistance cannot result in equivalent success. Indeed, rewards from the very few efforts towards systematic improvement that have already been made prove the point. As a result of the "sorting out" of provenances, subspecies, and varieties of *Leucaena leucocephala*, for example, a situation exists today where it is possible to obtain seed meeting particular requirements, e.g., growth habits. Even more exciting is the apparently highly successful work being conducted at CIAT to "breed out" the two major disadvantages of *Leucaena*, its high-mimosine content and its intolerance of acid soils (Hutton, 1981).

Potential gains from systematic improvement of agroforestry species have been strongly emphasized by the World Bank which has declared its special interest in supporting such work (World Bank, 1981a). A thorough discussion of the potential and problems of genetic improvement of tree species, for agroforestry among other purposes appears in Burley (1979).

At present it would appear that an almost unlimited scope exists in agroforestry for the innovative and imaginative development of technology packages. The alley-cropping work at IITA is a good example of how unconventional thinking has resulted in an agroforestry solution to the problem of declining soil fertility and crop production. Introduction of shade-tolerant forage grasses and legumes under pine plantations has in places increased land productivity substantially, e.g., in the Jari project in the Brazilian Amazon (Briscoe, 1981). The possibility of addressing particular land productivity problems, e.g., soil erosion, organic matter and fertility, drought, seasonal fodder shortages, and fuel and building pole needs, by combining trees and shrubs with desired characteristics in suitable spatial or temporal arrangements with annual crops and/or animals, poses new challenges to research and development organizations.

Some Problems and Constraints

Before agroforestry systems and technologies can and will achieve any significant impact on the alleviation of tropical land productivity problems, many constraints must be overcome. Several authors have recently discussed the difficulties which agroforestry faces. This paper, although arranged in a slightly different way, is based on papers by Adeyoju (1981), Andriesse (1978), Arnold (1982), Budowski (1981), Burley (1980), Catterson (1981), and Openshaw and Moris (1979).

Among the most obvious general constraints to a significant contribution by agroforestry towards increasing the productivity of tropical lands is the very magnitude of the problem itself. We are talking about hundreds of millions of farmers and landless people spread over vast expanses of tropical lands. Physical as well as socioeconomic limitations to rational land use are innumerable. Rapid population growth, unsafe land tenure, erosion, droughts, floods, declining soil fertility, lack of infrastructure, political instability, and illiteracy are characteristic of regions where agroforestry approaches to land use have a potential role to play. It is self-evident that agroforestry development can never be seen in isolation from general social and physical development problems.

The development of agroforestry systems and techniques requires, at many levels and stages, the kind of integrated and multidisciplinary approach for which existing institutions, both national and international, are rarely equipped. Education at technical and professional levels almost always takes place along traditional disciplinary lines, i.e., forestry, agriculture, animal husbandry, etc. In a similar way research institutions ordinarily work on strictly discipline-oriented problems. Even where systems research programs are being undertaken, these are often, and understandably, strongly biased towards the basic discipline of the institute where the program is housed.

At government and administrative levels, rigid boundaries more often than not separate departments dealing with different aspects of land use. Today such division is being accentuated by increasing competition for scarce development resources. In many, probably most, tropical developing countries, forestry and agriculture are under different ministries. The latter is likely to be the more prestigious and powerful ministry with respect to land management, while the former usually carries responsibility for agroforestry (i.e., in the few countries where any formal agroforestry program exists).

Land legislation and its supervision often reflect administrative divisions: distinct laws govern forest as opposed to agricultural land. Some countries even have laws making all trees, including planted ones, government property. It goes without saying that such laws effectively undermine attempts to convince farmers to plant trees.

Although most international agencies, e.g., UN bodies, development banks, and bilateral aid agencies, pay lip service to agroforestry and to an integrated approach to land development, nonetheless traditional disciplinary boundaries still impede the effectiveness of their work, too. As in the case of national institutions, agroforestry is often considered as a branch of forestry, or even of environmental conservation, which means that resources for its promotion and development are allocated via forest divisions or departments. As a consequence, unfortunately, international research and development funds for agroforestry are, in relative terms, scarce.

Without our in any way underrating the importance of the determined efforts made by the World Bank, FAO and other international bodies in the field of agroforestry, it is still doubtful whether they will have any major impact, unless there is a radical rethinking within these organizations of the nature and potential role of agroforestry. Some examples in support of this contention:

1. agroforestry is strongly promoted by the World Bank, but mainly in its "Forest Sector Policy Paper" (World Bank, 1978);
2. agroforestry development support is incorporated into the "Forestry for Rural Communities " program of the FAO Forest Department;
3. agroforestry has been identified as a priority research field in tropical forestry in a joint World Bank/FAO (1981) report prepared for the International Union of Forestry Research Organizations (IUFRO) conference in Kyoto, Japan, in 1981;
4. when the same paper was presented to the "Sixth Session of the FAO Committee on Forestry" in May 1982, the following introductory words were used when summarizing the section on agroforestry: "To achieve the integration of social with production and protection objectives, integrated forest management needs to involve a holistic approach to the use of forest land and forest resources" (FAO, 1982);
5. similarly, when the International Council for Research in Agroforestry (ICRAF) was created in 1978, it was the result of an IDRC-sponsored study to identify the major priority area in tropical forestry research (Bene et al., 1977);
6. ICRAF was not admitted to the Consultative Group on International Agricultural Research (CGIAR) on the grounds that forestry was not in the mandate of the CG institutes.
7. two of the most important recent reports on how to tackle problems of agricultural production in developing countries, reports which will have far-reaching implications for the international communities' funding priorities, "Agriculture: Towards 2000" (FAO, 1981c) and "Accelerated Development in Sub-Saharan Africa - An Agenda for Action" (World Bank, 1981b), do not mention agroforestry at all, nor an equivalent approach to land use under any other name.

Such evidence illustrates a fundamental institutional constraint with respect to agroforestry, one which, in a crude summary might read:"Agroforestry is institutionally considered a sub-division of forestry. Forestry institutions deal with forestry and forest land. The major potential of agroforestry lies in the integration of trees into agricultural and pastoral lands. The development of these lands is the mandate of agricultural institutions. Agricultural institutions are not mandated to deal with agroforestry."

Another impediment to the progress of agroforestry is the difficulty inherent in technology transfer. Extension may be relatively easy in well-established and moderately prosperous agricultural areas where the physical and administrative infrastructure is well developed, but it is far more difficult in those vast expanses of lands where the agroforestry approach to land use is most acutely needed. Here the unavailability of extension services competent to teach integrated land development is a serious shortcoming indeed: even where roads and funds are adequate to enable extension workers to reach target farmers, extension workers, just as their "mother" ministeries, are all too likely to be oriented to single or separate disciplines.

Farmers, moreover, will have to be convinced about the benefits of new technologies. It may not be very difficult to introduce new and better species, or, in areas where trees are already part of the traditional land management system, to make farmers adopt marginal improvements in management practices. It is considerably more of a challenge where managed trees and shrubs are novelties. The period between planting a tree and achieving appreciable benefits from it involves risks that farmers with limited resources may not be prepared to take. Similarly, it may be next to impossible to convince land-users to make long-term investments where land tenure is uncertain. Social and cultural attitudes may be obstacles to adopting sound agroforestry practices locally. It is certainly worthwhile for development and extension personnel to analyze such attitudes closely, for they may very well be in good part rational. People's negative position towards trees in tse-tse-fly-infested areas is a point in case.

Finally, there are many down-to-earth management constraints to be overcome before functioning agroforestry systems can be implemented. Raising, establishing, protecting, and managing trees require skills and sustained effort new to many farmers. Water availability for nurseries, protection of young plants against domestic animals, increased time needed in managing more than one production component, minimizing negative interactions between trees and crops, all these tasks are likely to require additional resources, both labor and capital, which may be beyond the means of poor farmers. Credit and aid schemes will have to ensure the possibility of wide participation in the establishment phase of agroforestry systems.

Some Examples of Agroforestry Practices

As with many new sciences in search of an identity, agroforestry has had its fair share of classification efforts (Combe & Budowski, 1979; King, 1979; Torres, 1979; Grainger, 1980; Vergara, 1981). It would take too long here to make a detailed review of all proposed classification systems. Certain criteria for differentiation of agroforestry systems, however, commonly recur:

1. physical structure — in particular the spatial arrangement of woody components in relation to crops (e.g., if trees are planted at regular intervals, in alleys, in patches, or in a haphazard way), and type of vertical stratification (e.g., if it is a two-story or multi-story system);
2. temporal arrangement — whether crops/animals and trees are permanently mixed or rotated (fallow system), and the periodicity of tree rotation;
3. relative importance and role of components — whether the system is agrosilvicultural (i.e., aiming to establish tree plantations), silvopastoral (trees/shrubs supporting animal production), agrosilvopastoral (crops, trees, and animals in mixture), or whether trees serve only a protective/supportive role for crop production;
4. production aims/outputs from system — whether food, wood, fodder, or any other single product dominates, or whether it is a multiple-output system;
5. social and economic features — whether the venture is large scale or small scale, commercial, subsistence, or intermediate.

There are innumerable examples of traditional agroforestry systems and practices in the tropics, some highly successful, others succumbing to the pressure of expanding human and domestic animal populations. Global reviews of such practices can be found, for example, in Combe and Budowski (1979) and Nair (1982). Several regional and country accounts have also been compiled in recent years (e.g., Budowski, 1979 for Central and South America; von Maydell, 1979 for the Sahel in Africa; Atmosoedaryo and Wijayakusumah, 1979 for Southeast Asia; and FAO, 1981a for India and Sri Lanka).

It is probably safe to say that the most diverse range of successful, traditional agroforestry practices exists in the two regions of Southeast and South Asia. It is also in these regions that the most active research and development efforts are being made today to improve agroforestry practices further. Similarly, institutional, disciplinary constraints on agroforestry are probably less severe here than in other regions or at the international level. It is certainly no coincidence that agroforestry has been included as an issue in agricultural research at the present regional meeting.

In India two traditional systems of great importance are the small-holder coconut plantations underplanted with food crops, spices, and pastures in the humid South-West Coastal region (Nair, 1979; Nair and Varghese, 1980), and the agrosilvopastoral systems of the Rajasthan Desert based on the remarkable tree *Prosopis cineraria* (khejri) (CAZRI, 1981; Mann and Saxena, 1980). Various forms of tree or home gardens here on Java occupy about 20% of the arable land and represent one of the most successful, multiple-output traditional tropical land-use systems based on a combination of perennial trees and crops. It is important to note that these tree gardens as a rule form part of a whole farm system which also comprises fields of annual crops (Wiersum, 1982; Bompard et al., 1980).

The integration of multipurpose trees such as *Leucaena leucocephala* (ipil-ipil) and *Albizia falcata* into small farmers' land for commercial and protective purposes is a common and rapidly expanding practice in the Philippines (Generalao, 1982; Pollisco, 1979; Veracion, 1980).

In Malaysia systematic developments are being undertaken to introduce livestock into small-holder rubber plantations (Wan Embong, 1979; Wan Embong and Abraham, 1976), and in Sri Lanka projects are being implemented to develop the traditional mixed Kandy forest gardens.

These examples illustrate how rich the Indian sub-continent and the Southeast Asian region are in agroforestry experience, much of which is transferable to other tropical regions.

Agroforestry Research Today

There are probably few fields in which there is such a high potential for substantial pay-offs on investments in research as in agroforestry. Systematic research for generating suitable new technologies incorporating woody multipurpose perennials in agricultural land-use systems is barely in its infancy.

If we keep in mind the broad definition of agroforestry cited earlier, then certainly agroforestry research has been, and continues to be, conducted at several disciplinary- and commodity-oriented research institutes throughout the tropics. Examples include research to refine pasture establishment and underplanting in tree crops (especially rubber and coconut); research on shading coffee, tea, and cocoa; studies of traditional shifting cultivation; research on suitable taungya practices; fuelwood tree species trials; and work on browse species in dry regions.

Although much of this work is of direct relevance and interest to the systematic development of agroforestry systems, it is also clear that most of it is being done with strongly discipline- or commodity-biased aims: to maximize productivity of rubber estates, increase yields of coffee, minimize costs of timber plantation establishment, and find the fastest-growing fuelwood or the most high-yielding or nutritious browse species. All such objectives are appropriate to the mandates of the institutions carrying out the research.

There is, however, little ongoing research towards developing technologies and systems which, through the optimum use of multipurpose trees and shrubs, address the multiple problems faced by small- and medium-sized subsistence (or mixed subsistence/cash) farmers or pastoralists in the tropics. This is where the great challenge and potential of agroforestry technology-generating research lies and where scope exists for almost unlimited innovative and imaginative thinking and work. Finding and improving the best locally adapted (ecologically and socially) species for meeting farmers' combined fuelwood and dry season fodder needs, finding the spatial arrangement and management of this species which minimizes its competition with annual crops and maximi. s its positive soil- and microclimate-enhancing potentials, finding a woody species that combines cash production (e.g., fruits, nuts, fuel) with excellent features as a soil terrace stabilizer these are the kinds of discoveries to which agroforestry research aspires.

Why is more not being done in this field? The main reason would seem to be the institutional constraint referred to earlier. As a result of the rigid disciplinary lines along which most land-development research is being conducted, there simply are no institutions with the mandate or the multi-disciplinary resources required to attempt integrated investigations in an entirely unbiased, problem-oriented way.

Among the approximately 600 forest research organizations and more than 1000 agricultural research institutes and agencies involved in tropical and sub-tropical land-use research identified in a recent study by the World Bank/FAO (1981), less than 90 are currently conductii g research on agroforestry or have the capacity to do so.

In spite of this fact, a fair amount of research is under way concerning agroforestry technology components and systems. The latter, however, tends to be of a descriptive, qualitative nature, and the former, though often aiming at generating new technologies, does so for the most part in an ad hoc, piecemeal way without a clear prior analysis of the specific local land-use problems which the new technology is supposed to solve. These reservations aside, much of this research is of considerable potential value It simply remains debatable whether the studies which have been begun are the most relevant to their respective situation.

Some international institutions, i.e., those either based in developed countries or supported more or less entirely by funds from developed countries and working on problems common to more than one country, are doing agroforestry research, or working on information and training in support of such research:

1. ICRAF in Nairobi is the only institution conceived expressly to perform agroforestry research on a global basis;
2. the international tree crop institutes (U.K., U.S.A., and Australia) are primarily occupied with data compilation relevant to multipurpose trees;
3. the Nitrogen-fixing Tree Association (Hawaii, U.S.A.) is studying the assessment and development of leguminous trees;
4. the National Academy of Sciences (U.S.A.) collects information about fuelwood and legume tree species;
5. the Commonwealth Forestry Institute (U.K.) is involved with information, research, and training;
6. the East-West Center (Hawaii, U.S A.) includes agroforestry in its program of publications, meetings, and training;
7. the United Nations University is arranging workshops on agroforestry;
8. some components of UNESCO's research program include agroforestry;
9. some agroforestry projects are initiatives of universities in developed countries, e.g., the University of Arizona's Office of Arid Lands Studies (U.S.A.), Wageningen Agricultural University (the Netherlands), the Universities of Hamburg and Freiburg (Federal Republic of Germany), and the University of Montpellier (France);
10. some CGIAR centers are engaged in technology-generating research of an agroforestry nature, e.g., IITA on alley cropping (*Leucaena*-maize), CIAT on *Leucaena* (acid soil-tolerance and mimosine content), and ILCA on browse trees and shrubs; an increasing awareness of the role of trees in the farming systems of their mandate areas has also become noticeable at IRRI, ICRISAT, and ICARDA, but it has not yet led to specific research activities;
11. FAO's Panel of Experts on Forest Gene Resources works in conjunction with IBPGR on data collection and assessment of information about arboreal species for the improvement of rural living, particularly in arid/semiarid areas.

In addition valuable information of direct and indirect relevance to agroforestry is stored and, in many cases, systematically updated in former colonial agriculture and forestry institutions, such as the Tropical Products Institu · (U.K.), various commonwealth institutes and bureaus (U.K. and Australia), The Royal Tropical Institute (the Netherlands), and CTFT, IRAT, and IEMVT of France (for tropical forestry, agriculture, and animal husbandry, respectively). Although this cumulative list may seem impressive, it is not likely that in budgetary terms the total volume of work in progress directly related to agroforestry exceeds US$10 million per year.

At regional and national levels an increasing number of institutes are adding agroforestry-related research to their programs. Some of the more long-standing and interesting research efforts have originated, not surprisingly, in the South and Southeast Asian regions.

In India several of the Indian Council for Agricultural Research institutes are involved in refining technologies and systems of direct relevance to agroforestry, particularly the:

1. Grassland and Fodder Research Institute (IGFRI) in Jhansi multipurpose (fodder) trees;
2. Central Arid Zone Research Institute (CAZRI) in Jodhpur *Prosopis cineraria* and other dry-land multipurpose species;
3. Central Plantation Crops Research Institute (CPCRI) in Kasaragod multi-story, mixed cropping;
4. Central Soil and Water Conservation Research and Training Institute in Dehra Dun: the use of multipurpose trees for conservation.

Other Indian institutions partially involved in agroforestry include:

1. the Forest Research Institute and Colleges at Dehra Dun taungya and other tree establishment methods and fuelwood;
2. the Indian Institute for Management in Allahabad social aspects of village and rural use of trees;
3. the Xavier Institute in Bihar sociological and institutional aspects of agroforestry;

4. several agricultural universities at scattered locations throughout India.

As in India, a number of institutes elsewhere in Southeast Asia are actively engaged in research on various aspects of agroforesty or on related technologies:

1. in Indonesia — the Organization for Tropical Biology (BIOTROP), the Forest and Forest Products Research Institutes of the Agency for Agricultural Research and Development in Bogor, the Institute of Ecology in Bandung, the Forestry Faculty of the Gadjah Maja University in Yogjakarta, and Perum Perhutani in Jakarta;
2. in the Philippines — the Forest Research Institute, College, Laguna, the Paper Industries Corporation (PICOP), the University of Los Baños, and the Visayas State College of Agriculture at Leyte;
3. in Malaysia — the Malaysia Agricultural Research and Development Institute, the Rubber Research Institute, the Forest Research Institute at Kepong, the Palm Oil Research Institute of Malaysia, and the University of Malaysia at Kuala Lumpur;
4. in Thailand — the University of Chiang Mai and Kasetsart University;
5. in Papua New Guinea — the University of Papua New Guinea at Lae.

This list, which is incomplete, suggests the variety of institutions engaged in some form of research on agroforestry-related subjects. In Southeast Asia, SEARCA has recently taken the initiative to create a Regional Agroforestry Research and Education Network in which many of the institutions mentioned above will, it is to be hoped, take part. A series of research projects are planned in which ICRAF will share in the project formulation phase.

ICRAF's Role and Program

The International Council for Research in Agroforestry (ICRAF) was set up in 1977 at the Royal Tropical Institute in Amsterdam. It moved to its present headquarters in Nairobi, Kenya in 1978. ICRAF's mandate is to stimulate, initiate, and support research for the development of sustainable and productive land-use systems (in the developing world) based on the integration of woody perennials with crops and/or animals.

The council, governed by an international board of trustees, is entirely independent from all supra-national bodies, and receives its operational funds principally from various bilateral donor agencies and private foundations.

ICRAF spent some initial years searching for an identity and a strategy to fulfill its mandate. This was no easy task in a new and exciting field, one full of temptations in the form of a practically unlimited number of challenging and interesting problems and activities. ICRAF set to work, moreover, in an atmosphere charged with enormous international expectations; but it was endowed with extremely modest funds. At its 1981 and 1982 meetings ICRAF's Board of Trustees finally agreed upon a comprehensive work plan for the coming four-year period. This plan had three foci.

1. The development within ICRAF of an interdisciplinary capacity and appropriate methodologies to assess constraints in land-use systems and to identify agroforestry solutions to overcome these constraints. In order to achieve this end, after systematically identifying the expertise and knowledge required in the field of agroforestry, ICRAF recruited a multidisciplinary core team of scientists and land-use experts. The team consists of an agronomist, a horticulturist, a forester, an animal husbandry expert, a social anthropologist, a farm economist, a bio-climatologist and a physical land evaluation expert/soil scientist. Both in Kenya and elsewhere through collaboration with international, regional, and national institutions, the team is now working on the development of a diagnostic and design methodology.

2. The systematic collection and evaluation of existing knowledge about agroforestry technologies, and the development of methods for the appropriate study of such information.

3. The establishment of an efficient program for disseminating information about agroforestry methods and technologies to scientists, development planners, and institutions in developing countries.

These objectives are to be achieved through seven mutually supportive programs within which all ICRAF projects and activities will be carried out:

1. management and administration — this component deals with program planning and coordination, fund raising, public relations, and general administration;
2. information services — ICRAF will offer an information request service and assemble documentation files on agroforestry, particularly on various agroforestry systems and on multipurpose trees. It will have a library for in-house and external use and produce publications on agroforestry. An IDRC information specialist, a documentarian, a library assistant, and a publications officer make up the library staff, with disciplinary inputs provided by other staff where necessary;
3. training and education — ICRAF will mount training courses in agroforestry research and development methods and in material development. Fellowships and on-the-job training will be available. This program, supported by USAID and the Ford Foundation and led by a recently recruited training officer, is expected to get under way in 1983;
4. agroforestry systems research and evaluation — the development of interdisciplinary methods to study and develop agroforestry systems, e.g., the diagnostic and design (D&D) methodology, economic evaluation of agroforestry systems, and methods of assessing systemic sustainability. This program will also be responsible for a global inventory and evaluation of existing agroforestry systems;
5. agroforestry technology research and evaluation — ICRAF will review the potential role of agroforestry technologies for enhancing food, fuel, and fodder production, soil conservation, and socioeconomic well-being; and develop methods to study and evaluate agroforestry technologies, particularly those which involve multipurpose trees;
6. field station — a small (40 ha) field station, 70 km outside Nairobi, is being developed as a support for other ICRAF programs. It will include agroforestry demonstration plots for training and public relations. It will also be a site for field research in connection with methodology development;
7. collaborative and special projects — the creation of an international network of agroforestry research and development projects in developing countries will facilitate the dissemination and testing of the council's interdisciplinary diagnostic and design methodology.

Projects are under way with institutions in Peru (INIPA, CIAT, North Carolina State University), Philippines (SEARCA, VISCA), Costa Rica (CATIE), and Kenya (National Dryland Farming Research Station at Katumani). Preliminary contacts have been made with ICARDA in Syria, IITA in Nigeria, CAZRI (ICAR) in India, and EMBRAPA in Brazil.

It must be stressed that ICRAF is not set up as an institute to generate locally adapted agroforestry technologies or whole systems through field research. This can only be done by local institutions with the facilities required to carry out long-term field research. Nor is ICRAF able to fund the work of other institutions. It is a council, housed in a mid-city office building in Nairobi, with a modest annual budget and a senior scientific and administrative staff of 15. It is, however, the only institution established expressly to work with agroforestry research issues on a global scale. It is one of the few organizations in the world with the professional competence to deal with practically all aspects of land development: physical, biological, social, and economic. The fact that ICRAF's scientists retain and cultivate working relations with outside colleges and institutes has led to a situation where the council's network of contacts not only crosses international and language barriers, but also transcends disciplinary and institutional boundaries. This situation, in combination with the council's own institutional independence, makes it possible for ICRAF not only to collaborate with any type of institution, but also to initiate cooperation between scientists and institutes in both developing and developed countries.

How to Identify Relevant Agroforestry Research — ICRAF's Diagnostic and Design Approach

Research towards development of locally adapted agroforestry technologies and systems attempts to address the real problems of farmers and other land-users. In so doing it invariably encounters difficulties at many different levels:

1. how to identify relevant research topics;
2. how to ensure a sufficiently multi-disciplinary input;
3. how to cope, in field research and trials, with the complexity (interactive components) and periodization (rotation of trees/shrubs) inevitably involved in agroforestry technology validation research;
4. how to develop, evaluate, and rate, in quantitative terms, the germplasm of multipurpose trees/shrubs.

The second question has been partially answered in the previous text. The third has been discussed in several papers by Huxley (1979, 1981a, 1981b, 1981c, 1982a, and 1982b). The fourth is the subject of an ongoing joint project between ICRAF and the Commonwealth Forestry Institute (CFI), financed by the U.S. National Academy of Sciences. This project will draw up guidelines for an international network of national research projects aimed at developing fast-growing nitrogen-fixing trees. The problem of genetic development of multipurpose trees and of agroforestry combinates of trees and herbaceous crops has also been discussed by both Burley (1979) and Pickersgill (1981) and will be the subject of an ICRAF/IBPGR/CFI workshop in mid-1983.

The remaining question, the first one, how to identify relevant research topics, will be considered here. If agroforestry is to live up to the world's expectations with regard to its problem-solving capabilities, it will have to significantly improve its ability to choose research topics and embark on development efforts which accord with the actual needs and potentials of tropical land-use systems. ICRAF's research strategy places a major emphasis on the development of a diagnostic and design methodology to guide agroforestry research and development (R&D) toward relevant and practical solutions to location-specific land-management problems. A sketch of the principal features of this evolving methodology appears below together with an explanation of their internal logic and rationale.

Why Diagnosis is Necessary

Our ultimate aim is to develop land-management systems and technologies with specific capabilities to solve land-use problems in areas where agroforestry is deemed to have a role. When confronted with an ailing land-use system, agroforestry planners and practitioners must identify and prescribe relevant problem-solving treatments. The nature of their task is analogous in many respects to that of a doctor who confronts a diseased human organism.

It is a cardinal rule in the medical profession that diagnosis should precede treatment. In practice there are exceptions to this rule, of course, but it would be unthinkable for doctors ever simply to ignore the diagnostic process altogether, and prescribe treatment without due regard for the specific nature of the patient's illness. We would hardly tolerate a haphazard, hit-or-miss approach to treatment from professions dealing with human pathologies. How strange then that we have come to accept such an approach when it comes to treating pathologies arising from man's use of the earth. Is this not in fact what happens in many cases when a traditional agricultural or forestry research station develops a new technology and recommends it for dissemination? In how many instances is the treatment preceded by an adequate diagnosis of the actual and perceived problems which confront the majority of land-users in the recommendation domain? The answer of many researchers, that they "already know what the problems are" without having to bother with the complications of a formal diagnostic procedure, is analogous to a doctor's making either the patently absurd assumption that all patients are the same, or his claiming arrogantly that a well-trained practitioner is able to treat patients without recourse to an examination.

No wonder the cure rate for land-use problems is so low! Technologies developed for conditions which prevail on research stations, high access farms (Rolling, 1980), and forest management units are often abysmally inappropriate when extended to the majority of land-users in an agroecological zone. The problem is not that the biophysical parameters of the zone have not been taken into account. To the contrary, these are usually well understood. What goes wrong is that single discipline-oriented researchers too often fail to perceive that the "patient" in the final analysis is the existing land-use system, which has its own internal organization and its own unique set of operational constraints and potentials.

The problem with an ad hoc approach to technology generation is that researchers are rarely capable of taking the full set of relevant design criteria into consideration. It was never a very effective strategy to design technology on the basis of only a partial set of design criteria and then to treat the failure of farmers to adopt the resulting technology as an extension problem. It will almost always be more useful to place the onus of responsibility for unsuccessful transfer of relevant technology squarely on technology development professionals, recognizing that the problem is, in the first instance, a design problem. There is simply no substitute for good design. To achieve this objective will usually require coordinated inputs from an interdisciplinary team of professionals, as well as from the intended users of the eventual technology product.

A problem-oriented diagnostic approach to agroforestry design is felt to be the most direct and logical route to effective and transferable agroforestry technologies and land-management systems. In developing its diagnostic and design methodology, ICRAF recognizes that a quick turnaround on diagnostic and design activities is absolutely necessary in order to have a timely influence on the project planning cycle. It is not envisaged that a long drawn-out survey process will be either necessary or useful. Rather, the council's aim is to develop a practical, effective, and quickly realizable D&D protocol which can prove its utility in a wide range of environments around the world.

The Logic of Agroforestry Diagnosis and Design

The logic of any methodology must be compatible with its aims, and the aims of ICRAF's D&D methodology are eminently practical. In the final analysis the success of the methodology will be judged not by the number or by the elegance of resultant agroforestry technologies, but by the impact of the methodology on the total landscape, i.e., how effective it has been in the transformation of human landscapes into more productive and sustainable land-use systems. A successful D&D methodology must somehow guide potential users to agroforestry technologies which embody three essential attributes: productivity, sustainability, and adoptability.

The first two criteria are virtually axiomatic. Agroforestry has been almost universally defined as an approach which seeks to improve the productivity and sustainability of land-use systems. Plenty of technologies are capable of increasing productivity, but are they also sustainable? Likewise, there are numerous technologies for resource conservation, but are they productive? Agroforestry has demonstrated significant potential for achieving both objectives simultaneously. This combination of goals is not, of course, an automatic feature of every conceivable agroforestry system, but it is indeed part of good agroforestry design, where measurable production and conservation benefits are, or ought to be, two sides of the same coin.

With regard to the adoptability of new agroforestry programs, it is perhaps not superfluous to point out that any technology, no matter how efficient or elegant in its problem-solving capabilities, will have little impact unless it is acceptable to a significant percentage of its intended users.

Nutritionists refer to an analogous fact of life when they note that the nutritional value of any food that is not eaten is zero, regardless of its chemical composition. The practical point for agroforestry diagnosis and design is that many factors other than gross technological irrelevance may limit the adoptability of an otherwise promising technology. These factors must somehow be identified, and dealt with by the D&D process.

Most possible adoption constraints have to do with the level of available resources and management skills in a given system, or with the incompatability of candidate technology with either existing practices and/or cultural norms and values associated with the general technological tradition of the area. It may be difficult, or even impossible, to diagnose all of the potential adoption constraints before undertaking farm trials of candidate technologies. The D&D process can, however, be guided initially by a certain psychological corollary to basic problem-solving technique: it is not the solution of problems per se which is of greatest interest to potential technology-adopters, but the solution of perceived problems. The core of ICRAF strategy is the common-sense assumption that the ability to solve a problem begins with the ability to define it. Such an orientation advances us half way towards our goal, inasmuch as technologies capable of solving local problems are more likely to be adopted than those which are not. The most common error of the R&D/extension process is the local introduction of technologies which solve problems which exist somewhere else, e.g., on a research station or in some other land-use system.

For an adoption-oriented, impact-maximizing strategy which focuses R&D attention on the solution of perceived problems in existing land-use systems two practical implications stand out. The first pertains to the diagnostic phase, a time when it is absolutely essential to involve the land-user in the R&D process, for only he or she can shed light on perceived problems. This realization explains the importance in ICRAF's D&D methodology which is placed on analyzing perceived management problems and strategies at the household or unit management level. The second implication pertains to the design phase. It arises from the fact that not all problems which constrain the productivity and sustainability of a household land-management system are necessarily perceived by the manager. This is particularly likely to be true with sustainability problems. Even when such a problem is perceived, its solution may not rank high in the farmer's priorities so that technologies designed to solve the problem fail to awake user interest. Many people may regard this as an extension education problem, but it can clearly also be considered a problem of technology design.

Where research scientists and land managers may not share similar perceptions of land-use problems, in certain instances the multifunctional nature of many potential agroforestry technologies may come to the rescue. The challenge for the technology designer is to find an attractive way to link an unwanted conservation function, for example, to some desirable production function of a well-chosen multipurpose technology. One might then obtain sustainability benefits as a by-product of a farmer's decision to adopt the proposed technology for its production incentives, i.e., for the help it gives him in solving some high-priority household supply problem.

By way of illustration, in our D&D work in Kenya we have encountered farmers with little or no present interest in erosion control, a severe problem in dry hill areas. These farmers, nevertheless, appear very interested in planting hedgerows of fast-growing leguminous trees to satisfy their household fuelwood needs. By planting dense hedgerows of coppicing fuelwood trees on the contour with row spacings selected for effective erosion control, we can achieve two ends with a single, appealing design. Such design tactics lend themselves well to the incorporation of flexibility for future functional expansion. Other farmers in Kenya, for example, have been identified as having a definite, present interest in erosion control, but no immediate, perceived problem with fuelwood supply. Where trend analysis indicates a future fuelwood prob- such farmers can be induced to plant dense hedgerows with fuelwood potential in order to hold down the soil. Presently the farmers can begin to manage the hedgerows for fuelwood once the anticipated crunch does come.

Productivity and sustainability, then, are the criteria we apply in analyzing existing land-use systems in order to diagnose constraints which limit the performance of the system. Productivity, sustainability, and adoptability are the criteria we use to identify corresponding agroforestry potentials and to evaluate candidate technologies and land-use system designs. In our analyses it is necessary to distinguish between two distinct levels or orders of constraints and potentials: those pertaining to the performance of output sub-systems in existing land-use systems, and those pertaining to the appropriateness of candidate agroforestry technologies.

Thus two orders of evaluation, each dealing with constraints and potentials of a different type, are required for thorough research. These two orders of evaluation are embedded in the following sequence of analytic activities which progresses from diagnosis to design:

1. characterize essential features of structure and function in the existing land-use system and identify output sub-systems;
2. evaluate the performance of the sub-systems (identify problems);
3. determine what constraints limit the performance of the sub-systems;
4. identify general potentials for performance-improving (constraint-removing) interventions of an agroforestry nature (candidate technologies);
5. determine constraints which may impair the appropriateness of candidate agroforestry technologies (components and practices);
6. identify remaining potentials for specific agroforestry technologies (existing or to be developed).

With the foregoing as a general conceptual background, let us look a little deeper now into the logic of agroforestry diagnosis and design and consider what is necessary at each of the above-listed steps if we are to do the job well.

Identification of Output Sub-systems.

We have said that we shall give priority to the household land-management unit, or its functional equivalent, as the primary decision-making unit and reference system for our analysis of land-use patterns and problems. This is because the household is ordinarily the primary decision-making unit with respect to specific land-use practices. Of all the possible ways to define sub-systems, we have opted for a definition in terms of output sub-systems because: a) this is the least restrictive of the modeling possibilities; b) it is the most compatible with various useful techniques of input-output analysis; and c) it is the most consistent with the way land-users actually manage their land, i.e., to produce desired outputs. A major output sub-system, then, may be defined as the set of all activities, resources, and other land-use factors which are involved in the generation of an output intended to satisfy one of the basic production objectives of the household.

In deciding specifically what output categories to consider as basic, it is important, if we are to develop a practical methodology, to satisfy two general requirements: a) the need for general applicability, and b) the need for adequate representation of the idiosyncracies of local land-use systems. To satisfy both these requirements and to facilitate ready linkage with standard categories of agroforestry technologies, we have found it fruitful to follow what we call "a basic needs approach." There are six output categories which we consider basic to the economic well-being of households everywhere: food, energy, shelter, raw materials for home industry, cash, and community integration.

Items 1,2, and 5 are self-explanatory. Item 3 is intended to include all forms of shelter (housing for people and livestock, shade, windbreaks, etc.) and enclosures (fences, kraals, boundary markers, etc.). Item 4 is a catch-all category meant to accommodate all raw materials for household or village manufacture of everything from clothes and kitchen implements to medicinal preparations, i.e., all locally manufactured consumer items, whether for home consumption or sale. Item 6 is another broad category including all forms of "social" production and consumption, e.g., feasting, gift-giving, bridewealth, patronage, taxes, education, etc.

Underlying this sub-system approach are the assumptions that a) the basic needs in the list are universal; b) local systems may display great variety with respect to the forms in which these needs are ideally satisfied (food and fuels preferences, shelter types, etc.), but essentially the same themes are valid everywhere; and c) local and regional land-use systems, whatever else they may do, are organized to produce goods aimed at satisfying these basic needs. The way in which various land-use systems fulfill this function, of course, will differ. In commercialized land-use systems, cash crop production for income to purchase basic commodities will be the predominant household strategy. In subsistence-oriented economies, the household land-use system will be organized to meet needs more directly.

The use of basic needs terminology should not be understood to imply any restriction whatsoever on level of economic development. The needs we have distinguished may be basic in type, but they admit many levels of satisfaction. We are interested in laying a foundation for the development process, not in constructing a ceiling.

Problem Identification

Once basic needs sub-systems have been identified, we may procede directly to problem identification. The objective of this step, to particularize problems which exist vis-à-vis the productivity and substainability of the basic land-use systems, is first approached through intensive interviews with representative farmers to ascertain what difficulties they experience in supplying their basic consumption needs. The following example, from Kathama, Machakos District, Kenya, illustrates the application of the methodology to a semi-arid-zone mixed farming system in the midlands of East Africa.

Problems identified in household basic-needs supply sub-systems:

1. food sub-system — seasonal shortages of staple foods are normal, deficits must be made up by purchases; drought-related crop failure requiring famine relief occurs, on an average, once every five years; low milk and meat production results from dry-season feed shortage for livestock;
2. energy sub-system — there is an insufficient production of fuelwood from farmers' own lands; they must purchase fuelwood for household and cottage industry use. A lack of large trees for firing bricks also exists;
3. shelter sub-system — the lack of construction quality timber and poles means that farmers must purchase expensive supplies. There is a shortage of large trees for firing bricks, and an inadequate supply of fencing and shade trees. Wind dessication of crops is potentially a problem;
4. raw materials sub-system — farmers must purchase expensive fuelwood supplies for butchery and brick-making enterprises;
5. cash sub-system — low net household income can be attributed, in part, to the cash outflow for staple foods, fuelwood, and construction wood (see above); the earning and saving potentials of livestock enterprises are limited by the dry-season feed gap.
6. community integration — there are difficulties in meeting expectations for cash contributions to numerous harambee self-help projects, as well as educational expenses.

Identification of problem-ridden sub-systems prior to a detailed analysis of the land-use system as a whole is an economical measure. Thereafter diagnostic attention can focus on sub-systems which appear to be in especial trouble.

Analysis of Land-Use Constraints

Once vulnerable sub-systems have been recognized and the general nature of household supply problems has been ascertained, the stage is set for an analysis of the land-use system designed to trace the etiology of supply problems. To continue with the Kathama example:

Antecedent causal factors:

Crop land:

1. low fertility and declining yields;
2. lack of manure;
3. oxen too weak for dry-season plowing and planting as recommended for efficient use of limited soil moisture;
4. soil erosion and water loss from poor infiltration and heavy runoff of rain water;
5. waterlogging on low spots;
6. labor bottleneck at plowing and weeding times;
7. pigeon pea pests.

Grazing land:

1. small grazing area;
2. insufficient dry-season feed production.
3. overgrazing and soil erosion.

The first step of this analysis involves intensive discussions with farmers to probe their perception of the causes of these problems, while the interviewer conducts a visual inspection of their farms. Additional objective measures are being developed to supplement the interview and observation data in order to arrive at a more quantitative appreciation of land-use problems. The output of this step is twofold: a spot diagnosis, and sufficient information for drafting a structural model of problem etiology. Indeed, a causal network diagramming technique has been found useful in analyzing the interrelationships among land-use problems and in identifying the critical constraints which limit the productivity and/or sustainability of the system.

Identification of Potentials for Problem-Solving Agroforestry Interventions

The resulting model or models of problem etiology then serve as the basis for identifying points in the system where potentials exist for interventions designed to remove, reduce, or avoid specific constraints. The procedure for this analysis is, in principle, quite straightforward: the analyst simply studies the causal diagram(s) and, for each node in the causal network, asks himself the question, "Is there anything trees could do to solve or mitigate this problem?" Ideally, this exercise should be conducted as an interdisciplinary brainstorming session with the intention of opening up thinking about possible land-use alternatives.

While the primary aim is to emerge from the exercise with a set of design specifications for hypothetical problem-solving technologies of an agroforestry nature, non-agroforestry alternatives should also be considered. Where these are incontestibly superior to an agroforestry alternative, they should be recommended. If, after careful consideration, there appear to be no promising agroforestry approaches, then the agroforestry exercise should be terminated and the problem referred to appropriate non-agroforestry specialists. Agroforestry does not have a solution to offer for every land-use problem, and there is simply too much real agroforestry work to be done in the world to waste time trying to force agroforestry technologies into land-use systems where they have no clear and significant role to play.

At present the state of our knowledge about agroforestry technology is so limited, however, and we have little hard information, that it is perhaps better to err on the side of optimism regarding the potential of hypothetically appropriate agroforestry land-use systems. Such optimism should seem justified in order to stimulate further national development and R&D of hypothetical agroforestry technologies. One desirable output from such R&D would be the data necessary to evaluate, objectively and quantitatively, the comparative performance of agroforestry and non-agroforestry land-use alternatives.

Minimally, when the agroforestry diagnosis and design team has completed this step of the analytical process, it should have a clear picture in mind of what general kinds of agroforestry technologies, by addressing specific end-use or service potentials in the system, might have a role to play in solving land-management problems. In Kathama, to return again to our previous example, the following specific problem-solving agroforestry alternatives were identified:

1. alley cropping/mulch farming with leguminous and other suitable trees to control erosion, increase rain water infiltration, reduce runoff, conserve soil moisture, improve soil fertility and structure, reduce the traction requirements for tillage (or the tillage requirement in general by minimum tillage management), diminish the labor requirement for weeding, and possibly provide some measure of pest control through the use of insect-repelling mulch species;

2. multi-purpose fodder trees in grazing areas to reduce or eliminate the dry-season feed gap, and as hedgerows, in and around crops with concommitant erosion control and windbreak benefits and fuelwood and mulch coproduction possibilities; the improved feed situation should allow dry-season plowing and planting;
3. hedgerows and living fences of high-yielding fuelwood species and fruit-producing thorn bushes for better livestock control; appropriate plantings can also function as protection against famine in bad years and as a source of supplementary livestock feed in average years;
4. multi-story fruit tree plantings with undersown grass/legume pasture;
5. cut-and-carry fodder trees for increased pen-feeding of livestock to improve dry-season nutrition and increase the amount of collectable manure.

Identification of Constraints on Potential Agroforestry Interventions

The next step is to evaluate which of the generally appropriate and functionally relevant agroforestry technologies recently identified remain specifically promising in the context of a detailed analysis of site constraints. The order of analytical procedures is here again intended to be economical, for the gathering of detailed data on site and land-management characteristics can now be limited to whatever is necessary to evaluate concrete technological hypotheses.

Before making a final screening of candidate technologies (components and practices), we must ascertain what constraints might interfere with their adaptability to site conditions and/or their adoptability in the context of local farming practices. First we reject those components which are rendered inappropriate by climatic, edaphic, and/or biotic constraints. In Kathama, for example, the biotic constraint of high termite populations in the semi-arid zone of Kenya excludes from consideration any mulch species which provides a good habitat for these pests. We are left, then, with those potential mulch species which have at least the hypothetical ability to repel or discourage termite infestation (e.g., *Adzadirachata indica, Adhatoda vasica, Derris indica*). This is a good illustration of notional agroforestry technology with an unknown potential which could prove rather high. This fact alone would appear to justify its further research and development.

After a screening of components on grounds of natural adapability, the rejection process shifts to the identification of practices which are unlikely to be adopted by farmers because the practices conflict, for one or more reasons with the local farming system, e.g., unfeasible resource requirements, labor bottlenecks, management incompatabilities, etc. To refer again to Kathama, here the establishment techniques initially used to plant out the first round of alley-cropping farm trials were found to be incompatible with the local practice of plow weeding which buried the young mulch tree seedlings under a heavy layer of soil. It may, however, be possible to modify local farming practices somewhat to accommodate the new technology (e.g., local farmers seem to have no objections to a change in their time-honored plow-weeding practice). Otherwise it may prove necessary to search for an acceptable agroforestry alternative.

Finally, having eliminated various suggested components and practices along the way, we arrive at a set of feasible agroforestry alternatives which must be compared with each other, with existing land management practices, and with non-agroforestry alternatives to determine which, if any, of them offer promising potential for incorporation into site-specific, problem-solving agroforestry designs.

Follow-ups and Conclusion

The "rapid appraisal" diagnostic and design procedures outlined above are merely the beginning of the technology R&D cycle. For project development appraisal should be followed, depending on the state-of-readiness of the technology in question, by immediate on-farm trials of the more promising agroforestry technologies (existing off-the-shelf solutions, so to speak, from the current inventory of agroforestry technology), and/or by on-station R&D to develop notional or candidate technologies for later incorporation into on-farm trials. These activities entail their own methodological needs. In the fullness of time, ICRAF intends to collect, develop, and disseminate information and methodologies relevant to the full range of biophysical and socioeconomic research questions involved in the development of agroforestry's potential to provide solutions to global land-use problems.

In conclusion, what has been described in a brief and sketchy form above is the core logic of an evolving diagnostic and design methodology which, in its totality, is intended to serve as a reliable tool for arriving at effective agroforestry solutions to local land-use problems the world over. Successful completion of this decidedly ambitious undertaking will be possible only with the full and active participation of the international community of agroforestry research workers. ICRAF eagerly solicits comments on and contributions to the methodology outlined in this paper.

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DISCUSSION AND CONCLUSIONS

The Bonn conference, held in October 1979, provided detailed reports on four subjects: soils, water, energy, and biological resources. Each report described the specific research and development proposals nominated by scientists at the conference as most likely to lead to significant increases in food production and, therefore, most deserving of support.

The follow-up conference on "Selected Issues in Agricultural Research in Asia" in Jakarta (October 1982), of which this volume reproduces the proceedings, explored in a regional context, inter-disciplinary research issues arising from specific Bonn recommendations. A wide range of disciplines was represented at Jakarta and the breadth of participants' experience was considerable. A number of recommendations emerged, identifying suggested action programs for both national research systems and for regional cooperation. Some recommendations were addressed specifically to IFARD or ISNAR, others were of special interest to other IARCs and to donor agencies.

The following commentary summarizes the discussions that took place after the plenary sessions and at the working group meetings.

Cooperation Between National Research Systems and the International Research Support Community

The first session of the conference concerned the way in which relations between national and international research organizations might be structured to optimize both technical and socioeconomic results. Deliberations took into account the recent expansion in funding for agricultural research in Asia, at both national and international levels, and examined this trend in the context of the comparatic advantages of different sources and systems of support.

The plenary speakers, Dr. Madamba and Dr. Swaminathan, followed by Dr. Gamble, presented a perspective of the evolution and development during the recent past of national agricultural research systems (NARS), international agricultural research centers (IARCs) and international associations (IAs). They noted that although in relation to agricultural GDP resources spent in support of the NARS of developing countries doubled between 1975 and 1980, the absolute level of funding, even in the 1980s, is probably insufficient. In order to meet food production goals, most developing countries are likely to have to plow back at least 1% of their agricultural GDP into research. Currently, the level of their research funding is little more than half of this minimal figure.

Because of inadequate funding over a long period of time, many NARS suffer chronically from a shortage of trained professionals. In addition, their research and support facilities are often limited. These factors restrict the comprehensiveness of NARS research programs. The frustrating research environment has frequently induced staff resignations, resulting in what has become known as a "brain drain." Apart from problems which stem from lack of adequate financial support, many agricultural research institutions operate in such a way that there is inadequate dialogue between scientists and administrators. Furthermore, research all too often remains a subject to which government planners and policy-makers pay only lip service on the part of many governments. There is a notable lack of political will and commitment towards agricultural and natural resources research.

Indeed, there is a widespread tendency for governments to ignore the potential role of NARS in national development. Research leaders are rarely involved in the planning and policy-making processes. This situation has begun to change for the better over the past few years, and in some Asian countries — India, South Korea, Philippines, Indonesia, Bangladesh, and Pakistan — viable mechanisms have developed for the implementation of national agricultural research and development programs. Nevertheless, even in these countries, there is still room for progress in the involvement of research policy-makers in national planning. In order to win ground, each NARS must reflect the needs, priorities, and aspirations of the people of its country. It must be capable of relating its technological goals to socioeconomic and cultural issues, of taking advantage of collaboration with other research institutions, of exercising flexibility in its use of funds, and of continuously monitoring and evaluating its own operations.

The conference recommended that a much greater awareness about the need for sustained and expanded support for agricultural research should be generated among national leaders, particularly ministers of finance and of agriculture. The necessity of adequate levels of funding to ensure continuity in research particularly needs to be stressed.

The conference also recommended that the international agricultural research community consider carrying out an in-depth study of the investment returns accruing from research in selected NARS and in the IARC research network. The study could include the possible social and economic consequences of such investments. It was also suggested that in order to convince their governments to sustain funding for research, directors of NARS should make case studies of successful research ventures (e.g., rice, wheat) within their own countries. Such studies might also be of value to the IARCs in their discussions with members of CGIAR.

The conference endorsed two proposals put forward by IFARD for a regional approach towards establishing closer liaison with national policy-makers. This approach involves arranging two short seminars during occasions in 1983 and 1984 when ministers of finance and agriculture from Asian countries will be meeting together. The first seminar, for finance ministers, would take place at the same time as the annual meeting of the Governing Board of the Asian Development Bank in May 1983. It was proposed that as part of the seminar IFARD, in conjunction with ADB, IRRI, ICRISAT, AVDRC, and SEARCA, should organize, a half-day presentation to illustrate the importance of the national agricultural research system in terms of achieving and sustaining a dynamic agricultural production effort.

The second seminar, for ministers of agriculture, would take place at the time of the FAO Regional Conference in June 1984. It was suggested that this gathering might be opportune for reviewing recent advances in agricultural research, as well as for discussing constraints responsible for the gap between potential and actual yields at the farm level. IFARD will explore whether such a seminar could be arranged immediately prior to the FAO Regional Conference, using FAO, the United Nations University, ISNAR, and appropriate international and regional agricultural research centers to help organize the seminar.

Another topic discussed in some depth by the conference was the need for some mechanism within the NARS, which would enable them to undertake a more profitable dialogue both with other NARS in the region, and with international organizations.

It was recommended that the NARS should consider exchanging scientists in order to capitalize to a greater extent on regional expertise, as well as to broaden the horizons of NARS personnel, without necessarily losing them from the national system.

A somewhat similar recommendation was made with respect to national scientists, who might join the staff of IARCs for fixed term appointments, so that they would later return to their home institutions with broader perspectives, training, experience, and competence.

In many countries, the NARS is a large and complex structure which comprises the central national agricultural research institute; decentralized and/or specialized public research institutes; universities, colleges, and schools of agriculture; farmer-sponsored organizations; and research institutes supported by industry or private organizations. Because of the its size and complexity, the national agricultural research system's effective management requires experienced and competent administrators. Such personnel are difficult to find. Many people in administrative positions in agricultural research have moved into them from a strictly scientific post, without any specialized training in the organization and management of research.

The conference recommended that a very high priority should be given to organizing training programs in agricultural research management. At the present stage of many NARS, it would probably be advisable for such training programs to be entrusted to international organizations, such as ISNAR, IFARD, or SEARCA, working either jointly or separately, but in either event in close collaboration with the appropriate NARS and IARCs. National research systems should explicitly acknowledge the importance of such training programs, designed to familiarize senior personnel with recent developments in fields such as research planning and management, determination of priorities, project formulation and evaluation, promotion of inter-disciplinary and inter-institutional cooperation, data processing, information storage, retrieval, and dissemination, research recording systems, and the organization of structured linkages and feedback relationships between national research and development agencies.

Another useful approach towards management training is the use of international study tours which enable management personnel to profit from the lessons and experiences of other countries. The meeting was informed that Indonesia is embarking upon a major program of this nature.

The conference recognized how very important the role of the international research community could be in strengthening and stimulating the NARS. Possible inputs include training, research, technical assistance, and information services. Such activities should be seen as being supportive while national agricultural systems are in their formative stages, however, and must not be regarded as perennial substitutes for strong NARS. In this vein, the conference noted with concern the dependence of some NARS on expatriate scientists. While such persons may be essential to some NARS for the time being, it appears that posts continue to be filled by expatriates working on international terms of service, because local contracts are unattractive to well trained national scientists.

The conference recommended that the NARS should streamline their personnel, incentive, and career structure, and salary and benefits policies, in order to attract national researchers to work at field stations within their own country.

As national systems mature, international research systems, particularly the IARCs, may need to enter into a different kind of partnership with them. Thus, stronger NARS will less often serve merely as network sites for adaptive testing of IARC material. Instead they will become more of a location for implementing genuine collaborative core research programs. Nevertheless, the strengths of the international system, particularly that of the IARCs, in terms of research planning, implementation, and reviewing, cannot be denied. There would appear much for national systems to gain by following some features of the CGIAR organization model.

In terms of planning and priorities, much remains to be done at the national level. There is a real need to direct international assistance towards strengthening weaknesses in national systems to enable them to serve national goals more successfully. There also appears to be a need among donor agencies to integrate their collective activities better, in order to avoid duplication, even competition.

Currently, most donor assistance adheres to the project mode of support, the shortcomings of which were discussed in Dr. Gamble's presentation. A possible alternative to the project approach is that of establishing country-level research support groups (RSGs), comprising both the host country NARS and those external donors prepared to provide a specified minimal level of support annually to the NARS. Such an RSG would integrate support for national agricultural research within the framework of national goals in a manner analogous to how country consultative groups for overall aid integrate their advice and expenditures with national development plans.

It was agreed that in countries with a strong NARS, a research support group may not be practical. Where the NARS is less developed, however, the RSG might well be relevant. While the conference felt that the concept offered a useful vehicle for donor dialogue and for the better utilization of external resources for research, it was of the opinion that the initiative for a research support group must come from either the NARS or the national government. Nevertheless, it recommended that ISNAR develop the research support group concept further, including specification about how it might be made operational.

Another recommendation related to research coordination was that a directory be compiled which contained information on expertise available at different national research systems in frontier areas of science. This directory would be of value in helping to fill critical gaps in internal competence in developing national research systems through programs such as TCDC (Technical Cooperation among Developing Countries). Its compilation might be a task for IFARD, in collaboration with ISNAR and other regional/national institutions.

Land Resource Inventories in Relation to Farming Systems Research

The Bonn Conference Report noted that "(most) countries have begun ... detailed, systematic inventories of soil conditions in relation to potential and present land uses." The relevance of such inventories to farming systems characterized by smallholdings and simple technologies is difficult to define, however, as is their value in helping to predict crop performance. A further difficulty with land resource inventories is making effective use of them in farming systems research.

The second session of the conference recognized the importance of obtaining estimates of the food production potentials of different soils under increasingly intensive cultivation practices. For a proper evaluation of a nation's soil, some form of comprehensive soil classification system is obviously necessary. An effective system could be of significant importance both in land-use planning and in promoting efficiency in farming systems research.

Dr. Miranda's paper introduced the concept of the benchmark soil survey and described its value in relation to agrotechnology transfer. He postulated that research results or "best farmer" practices obtained under representative reference agroclimatic conditions, from a benchmark soil classified at the family level in the Soil Taxonomy, were transferable, or could be extrapolated to other soils with similar properties. The conference recognized the desirability of having soil survey information presented in a form and language more comprehensible to the user. For this to happen, however, farming systems researchers and planners, as well as other potential users, would first have to communicate to the soil survey personnel the quantifiable soil information which they considered important for their purposes. Under these circumstances, soil surveys could play a much more important role in promoting or facilitating agrotechnology transfer to the small farmer.

The conference held divided views on the potential value of the benchmark soil concept for agrotechnology transfer. In general, participants felt that Soil Taxonomy as a soil classification system was a useful instrument for international comparison of soils with similar characteristics. However, the use of this system of the soil family level was rather restricted and some speakers felt that it was only of value when comparing soils at the great group level, and that this was too broad to be of a great deal of value.

This position was not shared by other speakers, however, who felt that although the benchmark concept had certain shortcomings and needed further refinement, it offered genuine possibilities for improving information exchanges on soil potentials and could be used for international comparisons. The ongoing benchmark soils projects in Hawaii, Puerto Rico, and Indonesia were reported to be giving encouraging results which were useful for soil interpretation and also for agronomists concerned with technology transfer. The methodology is also proving applicable for the on-farm testing of the black-soils farming systems technology developed at ICRISAT's headquarters station.

Where the method is meeting with only limited success, this should perhaps be attributed to a failure to measure appropriate soil characteristics. Refinement of the methodology is necessary to enable the incorporation of crop and management information as well. Such information is likely to be required before technology can be transferred to similar soils in other locations.

The value of the benchmark soil survey classification for agroforestry was considered doubtful because we lack adequate information regarding the specific nutrient, water, and spacing requirements of individual tree crops. The value of this classification for wet ricelands was also questioned. On such lands it was suggested that IRRI's land unit-system approach might be more appropriate.

Discussion gave most emphasis to soil. Participants recognized, however, that land and water resources cannot be separated, even if in many instances water resources were more readily modified. Currently, three-quarters of the farm land in Asia and the Pacific is rainfed, and a substantial part of this land could be irrigated were this economical. Irrigation would limit crop losses from drought, at present one of the major agroclimatic constraints for agricultural production. This point needs to be kept in mind while considering the emphasis suggested for soil classification.

Several speakers suggested that in view of the importance of socioeconomics in relation to soil use, the term "cropping systems," which had been used in the plenary paper, should be changed to "farming systems." It was pointed out that the optimal combination of crops for a particular situation was heavily influenced by socioeconomic factors. Cognizance had to be taken of this fact when formulating recommendations for soil use, and also in soil interpretation.

In spite of the many reservations expressed about the current value of the benchmark soil concept to agrotechnology transfer, it was generally agreed that the concept was promising enough to justify extensive further research. Benchmark soils would appear to be a particularly useful basis for selecting the most appropriate sites for new experimental stations, or for locating field trial plots, so that the dominant soil families in a given area are certain to be included.

The cost of carrying out a benchmark soils investigation was of concern to some participants. It was pointed out that in the past when simple soil analyses represented the ultimate in laboratory back-up, the cost of a field trial rose by 5% to 10% to include laboratory fees. After plant analysis became fashionable, costs went up by perhaps 20%. It is possible that the widespread use of benchmark soils for farming systems research could increase experimental costs by 30% or more, unless detailed soil inventories were available to the researcher.

The end result of spirited discussion was that, the conference recommended that the countries of the region be urged to step up their soil inventory activities, and to follow common soil classification bases in order to improve communication and cooperation, particularly among farming systems researchers. The USDA Soil Taxonomy was identified as the system now adopted most widely in the region.

Furthermore, as there are not sufficient soil taxonomists available in Asia, the conference recommended that in order to accelerate soil inventory work some priority should be accorded to increasing their number. For farming systems technology transfer between areas within a single country or between neighboring countries, an Asian soil map is required. It was recommended that as an initial step towards preparation of such a map the Soil Management Support Services Project of the Soil Conservation Service of the United States Department of Agriculture (USDA) be asked for its assistance. (The soil map which the conference envisions would have a scale of 1:1 million, and would use the great group level of classification).

Three IARCs and 15 NARS have already indicated their intention to participate in a seminar on "Minimum Data Sets Required in Agrotechnology Transfer," to be sponsored by ICRISAT and held at ICRISAT headquarters in March 1983. The seminar will work towards the establishment of an international benchmark sites network for agrotechnology transfer (IBSNET) currently being supported by USAID through the University of Hawaii. The conference recommended that countries of the Asian region be encouraged to participate.

Overcoming Technology Gaps

The third session of the conference considered three technology gaps: one that exists between the NARS and the IARCs, a second one within the network of various NARS, and a third between the NARS and the farmer. The featured speaker, Mr. S.W. Sadikin, suggested that these gaps vary considerably for different commodities, and can be classified in Asia into four groups:

1. those where Asia is in the forefront of world technology;
2. those where research in typically Asian commodities or topics lags behind research on the same themes elsewhere in the world;
3. those where the commodities are not typically Asian but are of importance in the region and for which adequate research expertise has not yet been developed;
4. those where research concerning social and economic aspects of Asian farming systems is at issue.

Some participants felt that socioeconomic studies should be an integral part of the commodity research described under items 1 to 3. Others felt that such studies merited a separate listing to stress their importance. There was general agreement, however, that socioeconomic research needs to be more closely integrated with technological research. Such integration is characteristic of the IARCs, whose style of operation could in this respect serve as a model for other research organizations.

Certain socioeconomic research topics needing close attention were specified. These included issues relating to the management of small farms, and the question of how to motivate independent farmers to participate in collective endeavors.

It was felt that some Asian countries had already managed to elimiate the gap between IARCs and the NARS, particularly where rice-based farming systems and collaboration with IRRI were concerned. Their success could be attributed to the availability of international funds, the high level of expertise available from IRRI, and the high motivation of farmers to increase rice production. Good working relationships between IRRI and the national groups, and continuity in the leadership of both, undoubtedly also helped.

It was suggested that collaboration might advance to a further stage at which some of the core operations of IARCs, such as IRRI, would devolve upon the NARS. This could lead to shared research programs, rather than to the NARS simply implementing field trials on behalf of the IARC. The shared research approach is about to become operational through an AARD/IRRI link in Indonesia. Other IARCs such as ICRAF are attempting to develop programs along similar lines.

It was noted that this type of approach – indeed, technology transfer in general -- is more difficult where there is no international center of excellence for the commodity and where its production is largely exported without any guarantee of a stable world market. Coconuts provide an example of how fluctuating export prices, by reducing farmer motivation and creating insecurity about the long-term future of the industry, discourage research support for the crop.

Returning to the question of the gap between IARCs and NARS, one speaker made the point that the flow of technology was not all one-way, and that the NARS contribute to the success of the IARCs. Donor support for the IARCs is not necessarily forthcoming because of the direct research achievements of the IARCs. Funds are also generated by what the farmers of developing countries achieve as a result of the transfer, through the NARS, of new IARC technology. Thus donors are apt to assist the IARCs more readily if their applications for support are consistent with or related to requests from the NARS. It must be conceded, however, that for the present IARCs themselves are probably more adept than NARS at formulating grant proposals.

There is inadequate documentation concerning the profitability of investment in agricultural research. To stimulate both donor and recipient government funding, recognition is necessary that a good deal of such research, by its very nature, must be a long-term activity. Politicians are sooner impressed by prompt and effective problem-solving by their research services than they are by reports about the cost-effectiveness of research in general. To gain political support, the NARS should probably devote more effort to publicizing their short-term successes, e.g., the control of brown plant hopper that was destroying rice crops in Indonesia.

Since the first session of the conference had dealt in some depth with relations between NARS and IARCs, discussion during this session focused on interactions among the NARS of different Asian countries in and between national research services and the farmer. There was a consensus that more intensive contact among agricultural researchers and research leaders from within the region would improve results in a very cost-effective way. At present the main obstacle to pursuing such a policy is the lack of funding for international travel.

At the regional level, two types of meetings might prove especially useful. The first of these would bring together research leaders from small groups of countries with common interests. The ASEAN Agricultural Research Coordinating Board provides a good example of this type of meeting. For the five ASEAN countries, this board provides a forum which is able both to identify common interests and priorities, and to take effective action towards the initiation of technology transfer and new research. It should be possible to establish similar mechanisms elsewhere in the region.

The second type of meeting of particular potential value would involve a larger number of countries, but it would be carefully structured around one specific topic. The IRRI rice-based cropping systems network, for example, meets annually on a rotation basis in each of its 13 network countries. In order to justify the expense of such meetings, they need to be well prepared and to address a high-priority area of common interest. Several groups already meet in this way, including the Association of Natural Rubber Producing Countries, the Asian and Pacific Coconut Community and the S.E. Asian Regional Committee of the International Board for Plant Genetic Resources (IBPGR). The newly established Economic and Social Commission for Asia and the Pacific's Regional Coordination Center for Coarse Grains, Pulses, Roots and Tubers (ESCAP-CGPRT Center) should also provide effective forums for technology transfer. This conference itself is, of course, yet another example of the second type of recommended meeting.

The proposed IFARD directory of available agrotechnology expertise in the Asian region would be a valuable supplement to such meetings. Its compilation should be given high priority, for the directory will assist scientists in identifying opportunities for fruitful interaction. Fuller use remains to be made of the AGRIS and CARIS systems.

Apart from the need to overcome technology gaps impeding information flow among various NARS, there appears to be room for improving collaboration within individual country systems. The conference addressed itself to some of the specific internal communication problems of NARS. The first of these involves the difficulty of establishing working relations between government and university researchers, or among researchers in government, industry, and the private sector. Institutional structures, including rivalry and competition for scarce funds, often prove to be serious barriers to technology transfer and collaborative research at the national level. It is possible that wider use of professional associations might help break down some of these barriers. Alternatively, were the research support groups mentioned earlier to be established, university and other non-government research institutions might participate in the RSG group.

Communication between different areas of specialization is also often full of problems because research is so rigidly institutionalized. Even within a monocrop research program, there is often difficulty in establishing multi-disciplinary coordination, especially in the integration of socioeconomic and biological activities. Such problems are magnified when it comes to farming systems research which may require collaboration among specialists in annual crops, perennial crops, and livestock. The difficulties are compounded even further when the subject area overlaps ministerial responsibilities, as with agroforestry and, sometimes, with nutritional aspects of food production.

A third in-country technology gap that was discussed concerned the poor linkages between national research systems and political planning authorities. Although in a different category from the two previous communication problems, this gap may be the most formidable obstacle to technology transfer.

At the regional level IFARD's proposal to organize briefing sessions for finance and agriculture ministers sounds promising. There would seem to be considerable merit in trying to arrange a similar exercise at the national level. Towards this end the NARS might set up communication units like those of such instrumental importance to the IARCs. Although the primary role of a communication unit in an NARS would be to reach out to extension services and farmers, it might also have a very important public relations and propaganda role in preparing suitable material for NARS figures who must try to influence political decisions relating to research.

The ultimate aim of the technology transfer process is to provide farmers with benefits accruing from agricultural research. The conference felt that at present the process was seldom satisfactory. There were weaknesses both in the interaction between research and extension services, and in the extent to which researchers had an opportunity to work directly with farmers. The change in approach which has been brought about through farming systems research during the last few years, however, represents a major advance by involving the research worker, extension officer, and farmer together in on-farm verification trials of technology.

More still must be done. An educational process is required, starting with the leaders of research and extension services, so that they will better appreciate the need to establish structured mechanisms which will ensure that their staff work together and communicate effectively. Research workers also need to be more understanding of the problems of the extension services. In addition it is essential that they come to realize how many non-technological factors enter into farmers' decisions.

The conference recommended that countries take positive steps to realize this educational process, possibly by providing a kind of in-service training, or by making research methodology a component of agricultural scientists' postgraduate training program. Teamwork with socioeconomists would also help to reorient agrotechnology researchers. At the same time there is a need to familiarize farm-level extension workers with the research methodology involved in on-farm verification of technology. To accomplish this will probably require formal training, wherever possible at the graduate level.

Some Asian countries already have structures to coordinate agricultural research and extension services. Wider use of personnel exchanges among NARS, a proposal referred to previously, would help to bring such structures to the notice of countries where research/extension coordination remains shaky.

At the present conference, the role of women in relation to technology transfer and change was discussed primarily in connection with preparations for a seminar on this topic which IRRI will be holding in 1983. As portrayed by Dr. M.S. Swaminathan, the concept of this seminar was strongly supported by the conference. Some participants felt that the theme, "women in rice farming," should be expanded to "women in rice-based farming systems."

Discussion stressed that women are not a homogeneous group. It will be necessary to devote attention to ethnic, social, cultural, educational, and age groups if any effort to determine the most appropriate technology and its impact on women's role is to be meaningful.

Changes in women's role in farming can also have effects on their role in the household and can, therefore, affect other members of the household indirectly. Relevant information may be drawn from past changes in women's roles in western societies.

Income-generating activities for women usually start with cottage industries. It was suggested, however, that in the long run, the scope for achievement is much greater through group activities.

In the Philippines women are heavily involved in agricultural research and extension. Women extension workers are particularly effective because when a farmer's wife has been convinced, her husband usually follows suit. Women extension workers are, on the whole, better than men in performing jobs which require tact and patience. As a result of maternity leave, however, women field workers average only 220 to 230 days on the job per year, as compared to 260 days for men.

Efforts to change the role of women need to take into account what is possible within the cultural context. It is important to recognize that change can be disruptive. The current and future needs of women, as well as their future role in a changing society need to be considered. Keeping tomorrow in mind would seem particularly important where agriculture is now undergoing very dynamic changes.

Dr. B. Lundgren's paper on agroforestry at the fourth and final plenary session of the conference led to animated discussion.

Agroforestry is a collective name for land-use systems and technology where woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or in temporal sequence. This broad definition incorporates farming activities under agroclimatic conditions varying from the humid tropics, where tree gardens are commonly found, to arid or semi-arid regions where browse trees may be an important component of the prevailing pastoral system. Both ecological and economic interactions occur between different components of the system.

Although the practice of agroforestry is far from new, little has been done in the way of exploiting its potential, either in terms of technology, or of institutional development. Indeed, there are foresters and agriculturists who continue to dispute even the general definition given above. Part of the reason for their discontent is the inappropriateness of the term "agroforestry" itself, which suggests an interface between agriculture and forestry rather than a type of farming system that is widely practiced. As a result of uncertainty in many quarters about the essence of agroforestry, few countries or institutions provide adequate agroforestry training. Funds for agroforestry research and development are also often in short supply.

Although the practice of assigning an inter-disciplinary team to work towards the improvement of farming systems, particularly systems with a cereal base, has been widely adopted in Asia during the past decade, the same approach has not won acceptance in the study of agroforestry systems. Agroforestry is still by and large the concern of forestry institutions with rather narrow, discipline-oriented perspectives. Even where it has been identified as a subject for research, a pure forestry rather than a farming systems goal is likely to be paramount.

The conference recommended that both national and international bodies devote more attention to exploiting the potential of agroforestry, properly institutionalizing this activity in their organizational structures, particularly with respect to research. There was, however, a strong weight of opinion that the upgrading of interest in agroforestry did not require the creation of new institutions, not any more than recent emphasis on farming systems research in most countries may have done. Rather it was felt that the need for farming systems research involving tree crops of various types should be recognized. Research programs should be established which utilize tree crops as part of their methodology for optimizing land output. Participants also acknowledged a need to train personnel doing research in this field to adopt an inter-disciplinary approach, which would include social and economic inputs at an early stage.

Another reason why agroforestry has been neglected is that limited information on the subject has been disseminated. In order to improve this situation, appropriate, accessible data banks need to be established, particularly ones with complete information on the tree and shrub components of agroforestry systems. Such data banks would make it possible to utilize development agency funds currently available for the identification, preparation, and formulation of agroforestry development projects. Until now most of these funds have actually remained unused, apparently because it is impossible to secure adequate background information for appropriate project preparation.

The conference recognized the potential of ICRAF to contribute to the type of information-gathering needed. It recommended that ICRAF give priority to assembling and making available to national institutions appropriate information and technology from its own data bank.

In view of the complexities of agroforestry and the long-term nature of the time parameters involved in tree crop activities, the conference also recommended that international agencies establsh new criteria for the preparation, monitoring, and evaluation of agroforestry projects. An acute need exists, moreover, to identify the scope and potential of agroforestry more clearly. In this context the conference found the ICRAF diagnosis and design methodology to be a useful first approach. It recommended that the methodology be tested at the farm level, under a range of ecological and economic conditions, including diverse problems and goals in land use.

Another problem which agroforestry faces is the present state of extension services. In general, extension in the forestry sub-sector is much less developed at the farm level, especially the small farm than are equivalent services in crops and livestock. At the interface between the three sub-sectors extension is usually extremely weak. Therefore, if agroforestry research findings are to reach the farmer, there is a need to develop an appropriate extension strategy. This is of particular importance in those many areas of the world where fuelwood is scarce and where short-term tree crops on small farms would appear to have important potential for fuelwood. In the humid tropics, extension activities linked to crop production services are also likely to pertain to agroforestry which involves perennial tree crops in farm gardens. Likewise, agroforestry featuring browse trees or alley cropping in pastoral areas will certainly require the involvement of livestock services.

Probably the most important short-term goal in terms of agroforestry project activities is to increase fuelwood. Projections of the World Bank regarding the probable extent to which fuelwood supplies will be deficient in many countries in the 1990s lends force to this priority assessment. The World Bank has pointed out the very limited extent to which this deficiency is likely to be eased by the planting of large wood lots.

Thus the onus of narrowing the fuelwood production gap will inevitably fall on small farms. This implies the urgency of wider use of agroforestry in farming systems or in integrated rural development activities. The full significance of the pending fuelwood deficiency does not yet appear to have penetrated the awareness of many donor agencies. The conference recommended that the issue be brought to their attention and that they be invited to provide much greater support in the immediate future for agroforestry research and development.

The conference recognized the unique status of ICRAF as the only international organization with worldwide support founded to stimulate, initiate, and support research for the development of agroforestry systems. The structure of ICRAF, the conference felt, should ideally be such that most of its activities would be carried out on a collaborative basis with national programs. Because of the wide range of ecological circumstances under which agroforestry is deemed to have a potential contribution to make, the conference envisioned ICRAF's exploiting institutional networks fully, in order to facilitate the interchange of information. IFARD could be instrumental in assisting ICRAF. The recent workshop on agroforestry organized by SEARCA in collaboration with ICRAF in Southeast Asia was, moreover, a useful precedent. Following this workshop, the Philippines planned an agroforestry project, based on the ICRAF methodology, which fits closely into the network concept. In eight different areas of the Philippines where shifting cultivation of forest lands is widely practiced, the project will seek to determine appropriate agroforestry crop combinations and cropping patterns, both in terms of optimizing farm income and of conserving soil and water resources. A detailed background document concerning the proposed project was provided to participants as a discussion guideline for related activities in other countries.

General Conclusions

Throughout the conference, irrespective of the specific topic under discussion, certain common themes recurred which highlighted the dynamic status of the NARS in Asia at the present time.

It was generally recognized that, even though according to most research managers the resources available for agricultural research in the region are still inadequate, they nevertheless do constitute a substantial resource base in terms of manpower, physical facilities, and disbursements. Furthermore, they represent an activity in a stage of dynamic growth. Indeed, if we consider the volume of resources which has been committed to agricultural research, we must acknowledge that it has become a substantial industry. Because of its size and importance, it is necessary that agricultural research should be accountable for its performance. Currently in most Asian countries research monitoring and evaluation are still rather rudimentary and need considerable refinement before they can be regarded as effective.

Accountability is necessary both upwards and downwards. Policy-makers and planners at the "top" need concrete information on which to base decisions for allocating funds for agricultural research. Such information is essential, too, for drafting broad directives for research policy. At the same time agricultural research must also be accountable to farmers at the "bottom," both as users of the end product, and as those whose taxes ultimately pay for much of the research. Historically, accountability in both directions has left much to be desired. During the past few years, however, information and communication activities have become sciences in their own right. The emphasis given by the IARCs to outreach programs and by the NARS to on-farm testing and evaluation has done a great deal to bring research right to the farmer. Communication to policy-makers and planners has, in general, not made comparable advances. Before research managers can hope to obtain the funding levels which they consider requisite, they will have to learn to speak persuasively either to bureaucrats in power or to those who can influence them.

One arena in which information exchange has improved substantially is among research institutions, NARS, IARCs, and IAs. The IARCs have played an important role here through the use of their training and meeting facilities. Regional institutions have also been active; the creation of IFARD represents a very positive step. Opportunities, nevertheless, exist for further contacts, particularly short-term exchanges of personnel to capitalize on the comparative advantages of different institutions with respect to specific commodities or crops. It was suggested that both IFARD and ISNAR could spearhead this type of liaison on a regional basis.

Regional workshops with a research management theme could be highly useful, e.g., workshops on socio-economics in agricultural research and its integration into agronomic research programs and on the organization and management of multi-disciplinary farming systems research. It was suggested that ISNAR might publish case studies about the reorganization of traditional commodity research systems along effective farming systems lines, which include on-farm testing.

Discussion during all conference sessions stressed the rise in Asia of the farming systems approach to agricultural research. Because of the unparalleled importance of rice throughout the region, it is not surprising that rice-based farming systems have received so much study and made the most progress in terms of research methodology and results. Scope exists for the use of a similar approach to other crops and to agroforestry and livestock, areas in which the systems approach has barely begun to be applied. Most farmers in Asia practice a complex husbandry, one which involves systems rather than monoculture. Research on farming systems is much more complex, however, than monoculture research. It involves the use of multi-disciplinary teams including both biologists and social scientists, and for this reason, the management of such research is often more demanding than that of traditional research. This makes it particularly important for appropriate priorities to be defined and for research results to be cost-effective. In other words, accountability, one of the conference's primary concerns, must be carefully built into farming systems research.

Extensive reorganization and growth have taken place in NARS in recent years. Substantial external funding has flowed to these institutions. At present their major requirement is manpower, rather than additional physical infrastructure. Many research institutions in the region do not yet provide an attractive career structure for highly trained personnel. Incentives are rare to encourage staff to reside at research stations, rather than near the central headquarters of the institute. There is danger of a significant brain drain. If the high cost and effort being put into the training of specialized manpower and building modern laboratories are to be rewarding, changes in career structure and opportunities will need to take place.

The growth of Asian research institutions may largely be attributed to programs funded by external agencies. Over time these programs have bolstered both the manpower and the physical resources of many NARS. Therefore, the role of the donor agencies will need revision in the next decade. In a number of countries there is a diminished need for technical assistance personnel. Current use of local and expatriate scientific personnel in conjunction, moreover, still leaves much to be desired. Not only may there be duplications in expertise between the two groups, but duplication of activities among donor agencies may also occur. In the past this was difficult to prevent because few NARS had adequate planning mechanisms. The situation is now changing, however, and there was considerable interest in Dr. Gamble's paper, outlining ISNAR's approach to improving integration of all agricultural research activities at the national level. The suggestion was also made that regional activities which would optimize the use of personnel and capitalize on the lessons of experience should be a prime recipient of future donor assistance to agricultural research in the region.

CLOSING REMARKS

Professor Dr. Ing. B. J. Habibie
Minister of State for Research and Technology
Republic of Indonesia

It is a great pleasure for me today to have this opportunity to deliver the closing remarks at this conference on "Selected Issues in Agricultural Research" which was hosted by the (Indonesian) Agency for Agricultural Research and Development, organized by the International Federation of Agricultural Research Systems for Development and the International Service for National Agricultural Research, and sponsored by the German Foundation for International Development, the German Agency for Technical Cooperation, and the Ministry for Economic Cooperation of the Federal Republic of Germany.

As the Minister of Research and Technology, I am especially interested in the outcome of your conference and deeply appreciate the assistance provided by the Federal Republic of Germany in making the conference a success. I am convinced that your deliberations on the four main topics will greatly benefit science and technology in Asia, as well as agricultural research and its contribution to economic development in Indonesia.

When I looked at the list of participants, I was very impressed by the range of experience and expertise represented. Such diversity will guarantee that the action programs you have developed, for both national research systems and regional cooperation, will be of the highest caliber. I am sincerely interested in these action programs because research on agricultural problems has a high priority in our national development planning.

The solutions to these problems will make a major contribution to rural development in Indonesia and, on a larger scale, help to solve the world's food supply problem. I am especially pleased that the International Service for National Agricultural Research (ISNAR) and the International Federation of Agricultural Research Systems for Development (IFARD) have organized this meeting since it is extremely important that national research systems in Asia are strengthened, that these national systems cooperate together on common research issues, and that the national systems achieve a level of expertise which enables them to collaborate with international research centers as equal partners in development.

The mandate of my ministry is research and technology. There are obvious similarities between our objectives and those of ISNAR and IFARD, both of which are directly involved with agricultural research systems.

As you may know, agriculture is extremely prominent in the economic development programs of Indonesia. The authority for Indonesian development flows from the guidelines of state policy to the president, and thus the government pursues development objectives stated in our five-year plans (PELITA). Agriculture has been distinguished as the sector central to the national development effort in each national five-year plan since 1968.

The present PELITA III (1979-1984) states that current capabilities are to be directed towards increasing food production; improving farmers' incomes and standards of living; providing fuller and more gainful employment opportunities; increasing exports and reducing agricultural imports; increasing the production of agricultural products required by the industrial sector; and conserving and utilizing natural resources.

In response to the central role of agriculture, as defined in our five-year plans, the Agency for Agricultural Research and Development was established by presidential decree in 1974. Creation of this agency clearly indicates the emphasis given to the role of science and technology in supporting through research the nation's large and extremely important agricultural sector.

I would like to tell you about two of many recent examples which prove the usefulness of agricultural research in Indonesia. As you know, in the 1975 to 1978 period, the brown plant hopper devastated several hundred thousand hectares of the rice crop in Indonesia. With the introduction and dissemination of rice variety IR36, r. e production in Indonesia has both overcome this plant hopper problem and vastly increased total production. In 1968 we produced only 10.4 million metric tons of rice; in 1982 more than double that amount, a crop of some 22.3 million tons is anticipated. The role of agricultural research in this achievement has been pivotal, for it was the research system which developed high-yield, pest-resistant rice varieties and their associated technologies.

The second example concerns a fish disease which destroyed many hundreds of tons of freshwater fish in Java, causing farmers losses on the order of 30 billion rupiah. Within three months of the initial onslaught of this disease, AARD researchers were able to identify its cause and to recommend farm practices to overcome it. The cost of this AARD research was less than 30 million rupiah. The application of science and technology eliminated in a short time a major threat to freshwater fish production.

These achievements do not mean that we should now be complacent, however, and relax our emphasis on science and technology in agriculture. Rather, these examples indicate the great value of a well-trained staff, and a research system sufficiently equipped to respond to future threats. Only if we can maintain and increase our support for agricultural research will we be able to assure the continued increases in agricultural production so necessary to our continued economic development.

I am convinced that closer cooperation between agricultural institutes in Asia will enhance the regional research and technology capabilities so that we will be better equipped to solve our agricultural problems on all fronts.

I would like to express my personal appreciation for the valuable time that you have spent in this conference.

Finally, with this remark, let me hereby declare the conference on "Selected Issues in Agricultural Research" officially closed.

ACTIVITY OF THE GERMAN FOUNDATION FOR INTERNATIONAL DEVELOPMENT

Dr. O. Anders, Dr. K. Klennert[1]

Abstract

The German Foundation for International Development (DSE) is an institution of the Federal Republic of Germany, the objective of which is to foster relations between the Republic and other countries on the basis of a mutual exchange of experience in the field of development aid. The emphasis of DSE's work is on the transfer of specialized technical knowledge in educational planning, management, public administration, technical vocational training, agriculture, and rural development. These activities are carried out in two types of programmes: (a) conferences, symposia, and expert meetings, and (b) introductory and advanced training courses. The Food and Agricultural Development Centre (ZEL) is the division of DSE that is active primarily in the following areas of agricultural and rural development promotion: plan production and protection, animal production, agricultural engineering, agricultural training, marketing, forest production, and ecosystem maintenance.

The German Foundation for International Development (DSE) is one of the central institutions in the Federal Republic of Germany charged with the conception and implementation of development policy measures. According to its statues, the objective of DSE is "to foster relations between the Federal Republic of Germany and other countries on the basis of a mutual exchange of experiences in the field of development aid." DSE pursues this objective within the framework of the Technical Cooperation Programme of the Federal Republic of Germany for the promotion of economic and social development in the countries of Africa, Asia, and Latin America. In the realization that the central problems of development policies cannot be solved in national or regional isolation, DSE has long sought to strengthen its contacts with the United Nations and its specialized agencies, and also with other specialized institutions at the international level. The emphasis of DSE work within such cooperation is on the transfer of specialized technical knowledge.

The fields of activity are as follows:

1. educational planning; school and out-of-school education; technical materials; promotion of universities and sciences; documentation (Division II in Bonn);
2. international dialogue on management and planning decisions in economic and social development (Division III in Berlin (West));
3. briefing of German experts for overseas assignments (Division IV in Bad Honnef);
4. improved efficiency of public administration within the process of socioeconomic change (Division V in Berlin (West));
5. technical vocational training as a basis for industrial development (Division VI in Mannheim);
6. agriculture and rural development (Division VII in Feldafing).

In order to carry out their various tasks, the DSE divisions have adopted two types of programme events: conferences, seminars, symposiums, and expert meetings serving the exchange of experience at international and national levels among high-ranking personalities and scientists; and initial and advanced training courses (individual and group programmes) in the Federal Republic of Germany and in developing countries for specialists and higher-level personnel from developing countries.

The selection of participants is undertaken by DSE in close consultation with the governments of its partner countries or, respectively, with its partner organizations. Accordingly, most of the invitations are extended via the diplomatic missions of the Federal Republic of Germany. It has been shown that this procedure ensures a high level of qualification on the part of the participants.

The Food and Agriculture Development Centre (ZEL: DSE - Division VII) in Feldafing near Munich serves DSE as a clearinghouse in the field of technical agricultural cooperation for the conception, implementation, and administrative supervision of advanced training courses oriented towards training needs in terms of development importance. ZEL also serves as a forum for the exchange of knowledge and experience in the field of agriculture and rural development at national and international levels. Therefore, ZEL is active primarily in the following priority areas of agricultural promotion:

1. plant production, plant protection, post-harvest protection;
2. animal production, veterinary medicine;
3. agricultural engineering and irrigation;
4. agricultural training and extension;
5. marketing and small loans;
6. planning and evaluation of environment-oriented agricultural projects;
7. basis development and self-help organizations;
8. forest production and management, agroforestry, and ecosystem maintenance;
9. fisheries and agriculture.

With regard to this conference, which was organized by ISNAR and sponsored by DSE as an incentive for future intensive and efficient international cooperation in agricultural research in Asia, DSE intended to foster a future conception and implementation of feasible agricultural research and development strategies as regional follow-up of the Bonn conference from 1979, "Agricultural Production: Research and Development Strategies for the 1980s."[2]

[1] DSE Food and Agricultural Development Centre, Wielinger Strasse 52, D-8133 Feldafing, Federal Republic of Germany.

[2] Organized and sponsored by the following institutions:
DSE (German Foundation for International Development);
GTZ (German Agency for Technical Cooperation);
BMZ (Federal Ministry of Economic Cooperation);
RF (The Rockefeller Foundation).

It is hoped that many countries will soon find it possible to make use of efficient international cooperation in the field of agriculture for the benefit of their rural populations.