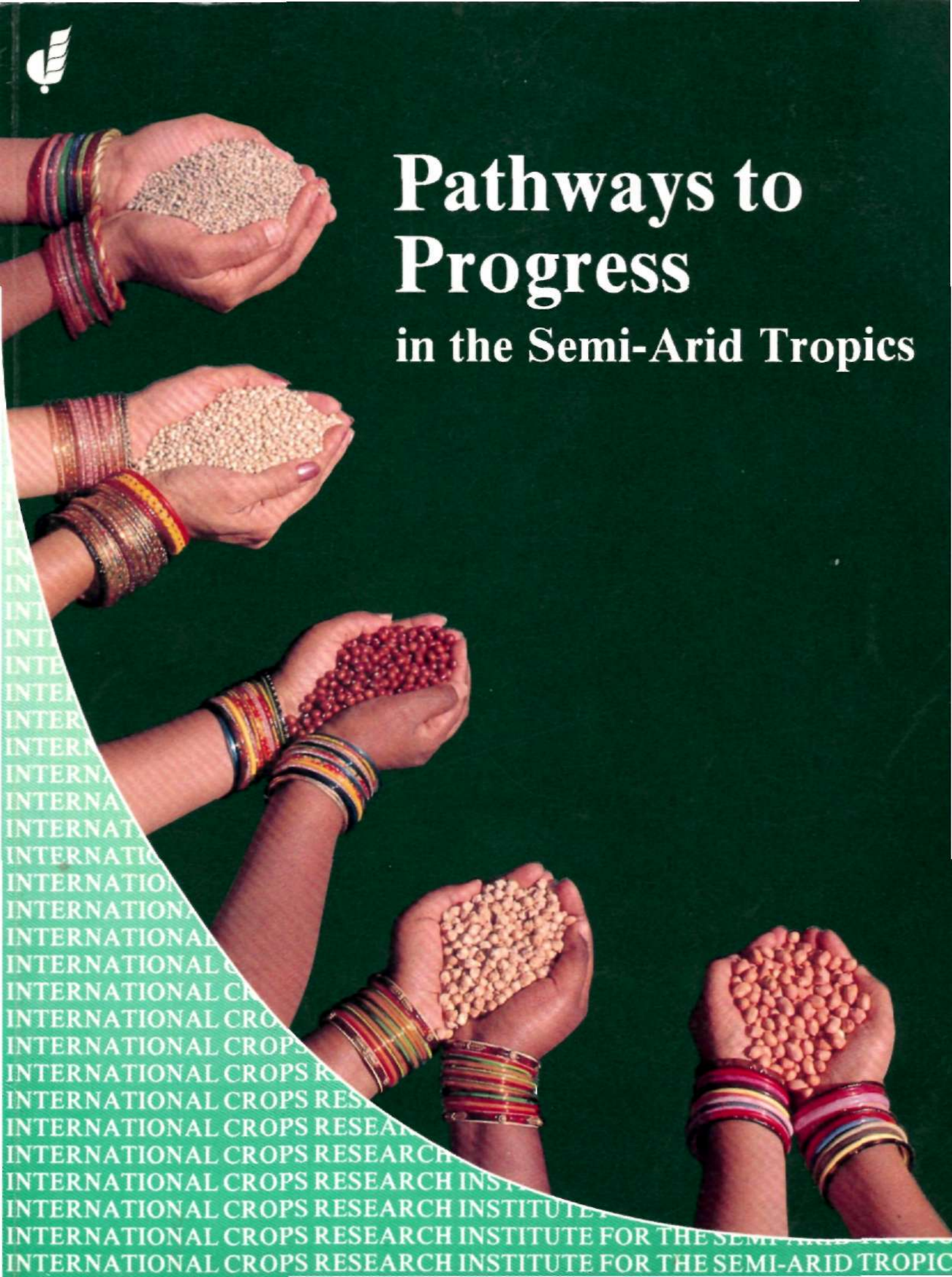
Pathways to Progress
in the Semi-Arid Tropics
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Abstract

Citation: ICRISAT (International Crops Research Institute for the Semi-Arid Topics). 1991. Pathways to progress in the semi-arid tropics: ICRISAT's strategic plan for the nineties. Patancheru. A.P. 502 324, India: ICRISAT.

At the request and with the approval of ICRISAT's Governing Board. this illustrated plan has been compiled by a task force which, over a period of 21/2 years, interacted for drafting purposes with internal working groups, a reactor panel, panel staff of the 1990 External Program and Management Review. and representatives of national agricultural research systems in the semi-arid tropics. The book therefore comprises the Institute's strategy for its operations in the 1990s in the context of priorities based on experience acquired from 18 years of research in wide-ranging locations in the semi-arid tropics. It assesses the nature and essential elements of the challenge facing the Institute, anticipates the external environment in 2000. describes the target groups and partners, the guiding values and internal environment in which ICRISAT's work is done, and the regions where the Institute operates. Major sections describe emphases in crops, environmental, and assessment research, and in human resource development and technology exchange. The document ends with an assessment of the operational pathways by which the Institute's mission can be achieved, in collaboration with national programs and with support from the donor community.

Résumé

Citation : ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1991. Les voies du progrès : le plan stratégique de l'ICRISAT pour les années 90. Patancheru, A.P. 502 324, India : ICRISAT.

Ce plan illustré a été préparé suite à la demande et avec l'accord du Conseil d'administration de l'ICRISAT, par un groupe de réflexion spécial. Pendant 2½ ans, et pour des fins de rédaction, ce groupe a travaillé en relation étroite avec des comités de travail internes, un comité de critique, les membres des Comités externes d'évaluation de la recherche et de la gestion (année 1990), ainsi qu'avec les représentants des systèmes nationaux de recherche agricole dans les régions tropicales semi-arides. Ce document présente donc la stratégie que l'Institut propose d'adopter pour ses opérations dans les années 90, en tenant compte des priorités suggérées par l'expérience acquise pendant 18 ans de recherche dans diverses zones des tropiques semi-arides. Le plan fait le point sur la nature et les éléments essentiels du défi que l'Institut doit relever, considère l'environnement extérieur vers l'an 2000, définit les groupes et les partenaires cible, les valeurs directrices et l'environnement interne dans lequel l'ICRISAT effectue ses travaux, et les zones d'intervention de l'Institut. Des chapitres importants esquissent les points saillants de la recherche sur les cultures, sur l'environnement, et sur l'évaluation, ainsi que sur le développement des ressources humaines et l'échange des technologies. En conclusion, le document présente une évaluation des voies opérationnelles qui peuvent permettre à l'Institut de mener à bien sa mission, en coopération avec les programmes nationaux de recherche agricole et avec l'appui des bailleurs de fonds.

Resumen

Citación: ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1991. Los caminos hacia el progreso en los tropicos semi-áridos: el plan estratégico de ICRISAT para los noventas. Patancheru, A.P. 502 324, India: ICRISAT.

A solicitud de la Junta Directiva del ICRISAT y conseguida su aprobación, este plan ilustrado ha sido compilado por una panel de trabajadores que, durante dos años y medio, obró mutuamente con otros grupos internos, un jurado de crítica, miembros del jurado de la Revisión del Programa Externo y Dirección, y los representantes de los sistemas nacionales de investigación agrícola en los trópicos semi-áridos. Este libro, por lo tanto, abarca la estrategia del Instituto en lo que concierne sus operaciones en los años noventa en el contexto de las prioridades fijadas a base de la experiencia adquirida durante 18 años de investigación en una gama amplia de localidades en los trópicos semi-áridos. El libro valora la naturaleza y los elementos esenciales del reto ante el Instituto, anticipa el ambiente externo en el 2000, describe los grupos sujetos a analisis y los grupos asociados, los valores principales así como el ambiente interno en el que se lleva a cabo el trabajo del Instituto, y las regiones en donde opera el Instituto. Las secciones principales del libro ponen más énfasis en la investigación del medio-ambiente, los cultivos, la tasación, y en el desarrollo de los recursos humanos e intercambio de tecnología. El documento se cierra con una valoración de los caminos operacionales por los cuales se puede alcanzar la misión del Instituto, en colaboración con programas nacionales contando con el apoyo de la comunidad donante.

Cover: Seeds of ICRISAT's mandate crops (top to bottom): pearl millet, sorghum, pigeonpea, chickpea, and groundnut.

Pathways to Progress in the Semi-Arid Tropics

ICRISAT's Strategic Plan for the Nineties

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Patancheru, A.P. 502 324, India

1991

The International Crops Research Institute for the Semi-Arid Tropics is a nonprofit, scientific, research and training institute receiving support from donors through the Consultative Group on International Agricultural Research. Donors to ICRISAT include governments and agencies of Australia. Belgium. Canada. People's Republic of China. Federal Republic of Germany. Finland. France, India, Italy. Japan. Netherlands. Norway. Sweden. Switzerland. United Kingdom. United States of America. and the following international and private organizations: African Development Bank. Asian Development Bank. Deutsche Gcsellschaft fur Technische Zusammenarbeit (GTZ), International Board for Plant Genetic Resources. International Development Research Centre. International Fertilizer Development Center. International Fund for Agricultural Development, The European Economic Community. The Opec Fund for International Development, The Rockefeller Foundation. The World Bank, United Nations Development Programme, University of Georgia, and University of Hohenheim. Information and conclusions in this publication do not necessarily reflect the position of the aforementioned governments, agencies, and international and private organizations.

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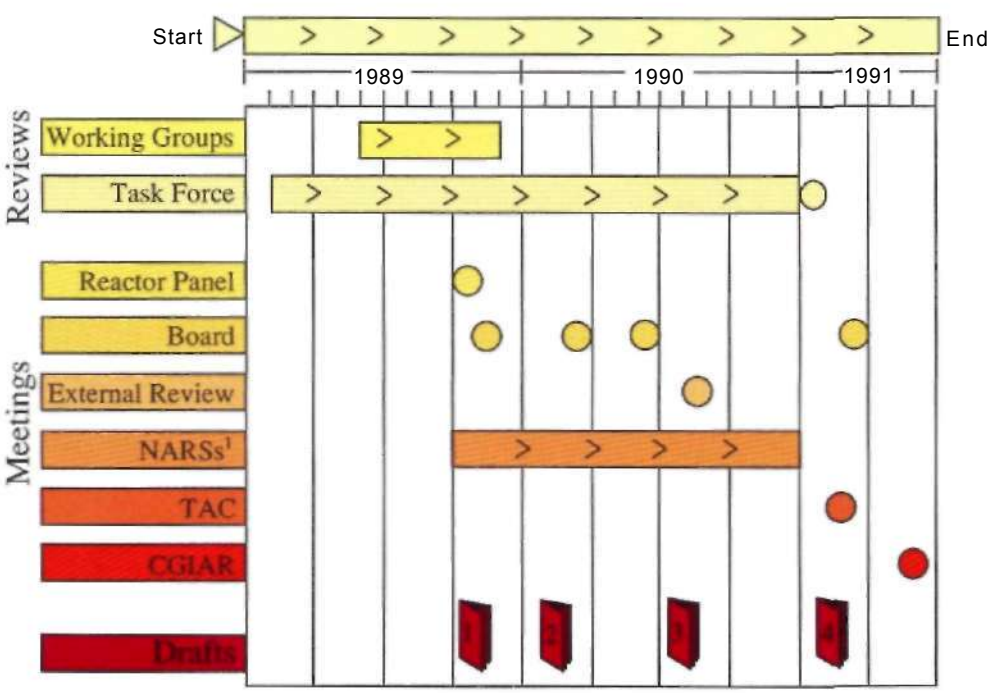
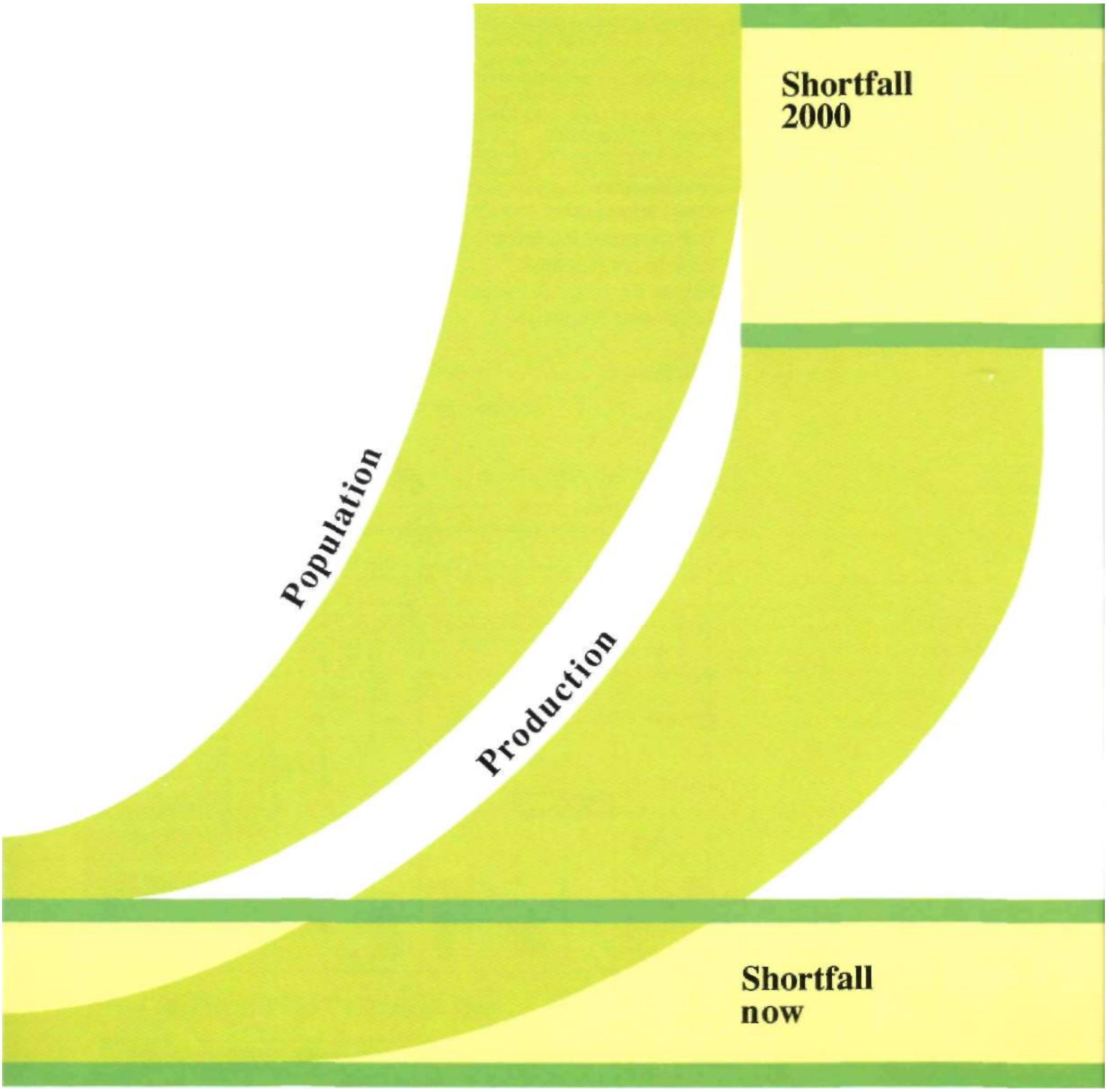


Time Chart for ICRISAT's Strategic Plan

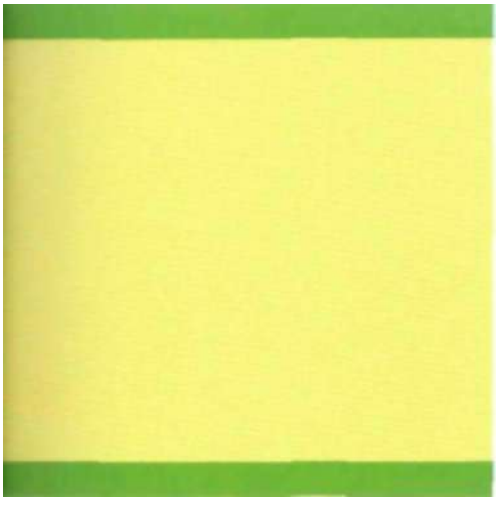
1. The third draft was discussed on a personal basis with representatives of 21 NARSs in the SAT.

Contents


Shortfall
2000
Population
Production
Shortfall
now

The Challenge

New challenges confront the last decade of this century. ICRISAT, as a research center charged with helping improve world food production in the semi-arid tropics (SAT), must continue to adapt to environmental, social, and political changes to meet these challenges. The research and education strategy outlined on the following pages for 1990 to 2000 is designed to do this.



If present trends of underproduction and population growth continue, the net food production shortfall in the Third World will be 100 million tonnes by 2000. Africa will be the major victim of this deficit, but Asia also will experience severe shortages. Global growth in the demand for cereal feed for animals in the SAT will also continue to rise.

The productivity of ICRISAT's mandate crops must be increased within the SAT to guarantee adequate supplies of food for the small-scale farmer's household and to assure that grain surpluses are available for sale as food, feed, and other uses. Surpluses will provide food for urban populations and income for the farmer.

ICRISAT, an agricultural research and training center within the Consultative Group on International Agricultural Research (CGIAR) system, must fit its mandate crops into different farming systems, while addressing a range of ecologies and demands and providing an array of options to farmers.

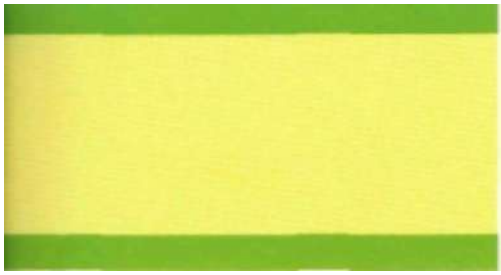
The CGIAR Goal

Through international agricultural research and related activities, International Agricultural Research Centers (IARCs) contribute to increasing sustainable food self-reliance in developing countries so that the nutritional level and general economic well-being of low-income people are improved.

ICRISAT's Mission

The rainfed SAT and other resource-poor regions growing ICRISAT mandate crops must be made more productive and their agriculture more profitable and sustainable. Only then can people in these regions improve their lives and contribute effectively to national development and achieve food self reliance.

- We will foster, facilitate, and conduct research on mandate crops, resource management, technologies, and institutions.
- We will aim to increase the productivity, versatility, and stability of ICRISAT's mandate crops and suggest appropriate ways of fitting our crops into existing and improved farming systems.
- We will emphasize a more judicious use of natural and human resources.
- We will undertake our mission in partnership with National Agricultural Research Systems (NARSs) and other institutions.
- We will encourage NARSs increasingly to accept research responsibilities in order to solve their own problems and quickly provide technologies to their farmers.
- We will *adjust our* research to meet *shifts in* research *responsibilities within* this partnership.



The Essential Elements

Research

Research is at the heart of all ICRISAT activity. Our major goal is to carry out relevant, quality research in a center of excellence. We will follow a multidisciplinary approach to solve fundamental problems. At our centers we will develop principles and methodologies to support the applied and cooperative research of our regional teams, networks, and the national agricultural research systems. Good research requires continuity, a critical mass of scientists, stability of funding, and flexibility. Creativity thrives in an atmosphere of openness, objectivity, and responsibility.

Training and Education

Strengthening the skills of scientists and technicians in national agricultural research programs is a key element in ICRISAT's mission. More than 1945 candidates have completed special training courses at ICRISAT in the past 16 years. Others have undertaken postdoctoral work before taking up research positions in their home countries. A holistic approach to training will emphasize sustainable agriculture and constraints to the adoption and use of technologies at the farm level. To satisfy national program needs, coordination and cooperation with other CGIAR Centers, national universities, and regional organizations is crucial. ICRISAT is conscious of the demand for degree-level education in many national systems and will seek funds to support scholarships.

Technology Exchange

ICRISAT will continue to communicate with national agricultural research systems through visits, training, networks, workshops, conferences, publications, and personal contacts. The major channel for transferring technology and for gathering information is through the eight crops networks in Asia, Africa, and Latin America. In the decade ahead, in addition to our traditional publications, we will provide a growing number of short-run products such as pamphlets, slidesets, posters, and videos for quick dissemination. We will work closely with our partners' libraries and documentation centers, while assisting the national programs to publish and disseminate their own research results. And we will explore what organizational advantages may accrue from coordinating information retrieval and dissemination functions and human resource development at management level.

The Global and Political Environment

An easing of global and regional political tensions, major improvements in economic policies, and a reduction in the debt situation of the developing world provide an optimistic outlook for agriculture in developing countries in the 1990s. Increasing public concern for the global environment will result in major policy changes on such issues as the ozone layer, destruction of forests, high-input agriculture, water quality and availability, energy resources, waste disposal, and soil degradation. A global economic per capita growth rate of 3% is forecast for the decade, with stronger growth in Asia and slower growth in Africa. Population growth will remain a major problem, both in Africa and Asia.

The Physical Environment

The SAT is the target area of ICRISAT's research. It is a harsh region characterized by inadequate and uncertain rainfall, large areas of infertile and fragile soils, low capital

availability, and weak institutions and infrastructure. SAT agriculture will have to be high on the agenda of national planners, since increased production from its marginal lands in rainfed areas will be necessary if expanding demand for food and feed is to be met by 2000. Nearly one-third of the inhabitants of the SAT live in poverty. That fact and the periodic recurrence of drought and famine guarantee the region's high priority on the list of donor concerns.

Sustainability

Sustainability, a word used often in this document, means the ability to maintain or increase food production over the long term. In our case, this requires that the resource base on which crops are produced—the fragile environment of the SAT—must not be damaged in the push for higher yields. It involves farming systems that make more efficient use of low inputs and timely application of water while enriching nutrient-poor soils and preventing erosion from runoff in the unpredictable, intensive rainstorms common to much of the SAT. Assuring former participation is necessary; reducing poverty is imperative. Sustainability of agriculture underpins our research. It is the key to increased food production in the SAT.

Partners

ICRISAT's principal research partners are scientists in the national agricultural research systems of the 49 countries in the SAT. It is through them and their extension agencies that we reach the farmer. In some of the more advanced countries, these programs are capable of producing their own improved technologies from the materials we supply them. Other systems are still developing and need our full support, as well as stronger financial support from their governments. We also work closely with universities and research organizations throughout the world (mentor institutions) to bring the benefits of their research to the SAT.

Women in Agriculture

Women will continue to play a vital role in agricultural development in the SAT as farmers (especially in Africa), field workers, homemakers, and increasingly, as research technicians and scientists. ICRISAT is aware of the considerable barriers women still face to full participation in development in many countries and encourages removal of those obstacles. We will conduct special training courses for women through both research and extension services within the SAT, and actively seek nominations for women from national programs for all ICRISAT training and fellowship programs.

New Technologies

We will continue to assess the usefulness of new technologies to increase the efficiency of our research. Biotechnology will become increasingly useful as a tool in our crop improvement research. We will cooperate with mentor institutions to develop new technologies. ICRISAT's comparative advantage lies in the applied aspects of new technology through testing of transgenic plants in different environments and testing for reaction to typical SAT stresses. When advances in the field of new technologies are useful and cost-effective, we will apply them to improve our crops.

New Crop Uses

Increasing productivity of our mandate crops will not increase income for farmers who cultivate them, unless there is an equal or greater increase in demand. The increase in

demand is tied to alternative uses. We will identify new quality characteristics for new uses and determine their importance. Our efforts and resource allocation will be based on socioeconomic research to determine the impact of food qualities important to traditional consumers and by the traits required by these new uses.

Assessment Research

Assessing the reasons for a project's success or failure is an important tool in planning future research projects. Because we must become more cost-effective and accountable, this area of research will receive increased emphasis. Determining the feasibility of a project's success and ICRISAT's comparative advantage to undertake it will play roles as important as the desirability of the project when allocating resources to research. Impact assessment studies will be conducted in full cooperation with scientists in NARSs.

Mandate

ICRISAT's mandate is to:

1. *Serve as a world center for the improvement of grain yield and quality of sorghum, millets, chickpea, pigeonpea, and groundnut and act as a world repository for the genetic resources of these crops.*
2. *Develop improved farming systems that will help to increase and stabilize agricultural production through more effective use of natural and human resources in the seasonally dry semi-arid tropics.*
3. *Identify constraints to agricultural development in the semi-arid tropics and evaluate means of alleviating them through technological and institutional changes.*
4. *Assist in the development and transfer of technology to the farmer through cooperation with national and regional research programs, and by sponsoring workshops and conferences, operating training programs, and assisting extension activities.*

Options

Several issues and options were considered and debated during the Institute's strategic planning exercise. Those that were wholly accepted have been incorporated into this document. Others, however, were partly accepted or rejected after discussion at various levels, and are recorded here for guidance to readers.

Cotton as a Mandate Crop

The Governing Board decided not to include cotton in the mandate, but to give it more emphasis in cropping systems research because it is an income-generating crop within the SAT.

Modifying the Legumes Mandate

The debate centered on whether we should continue to include chickpea as a mandate crop and whether ICRISAT should have global or regional responsibility. Also whether chickpea could be replaced in part by other pulses such as cowpea, black gram, and mung bean. The decision was made to retain the global mandate for chickpea.

The Millets

It was agreed to include finger millet within our research mandate but confine and continue research leading to varietal improvement in this crop to southern and eastern Africa.

On-Farm Research

There was a clear indication from the African national agricultural research systems that direct on-farm trials should be their responsibility. A reduction in but not elimination of on-farm research was accepted. But it was agreed there is a need for cooperation in testing technologies and methodologies on-farm.

Ex-Ante Assessment versus Ex-Post Evaluation

Ex-post evaluation is potentially more informative than ex-ante assessment because the resulting data are more precise. With the shift to more strategic research, ex-ante assessment is likely to be clouded by increasingly diffuse success probabilities, which render large investments in ex-ante analysis questionable. Because more ICRISAT research findings and products are about to be released or are in the pipeline for release than previously. more ex-post evaluation relative to ex-ante assessment is required.

Training in Crop Production

Demand for group training in crop production continues to increase. We have decided not to respond, indeed to decrease such training, in favor of more training opportunities for research scholars and scientists from NARSs.

Project-Based Management System

Shifting to the project as the unit of accounting was assessed to have several disadvantages that outweigh the expected benefits. Accounting at the level of research thrusts based on recognized activities of the CGIAR Technical Advisoty Committee will be more cost-effective. A reliable summary of expenditure allocated to each research project can be prepared by each unit leader using current accounting procedures.

The External Environment in 2000

In order to be well-positioned and effective in 2000, ICRISAT must anticipate the probable external environment at that time.

The Global Outlook

Major improvements in economic policies and the reduction of Third World debt improve the climate for agricultural growth.

By 2000, improvements in international relations will have eased global and regional tensions. Better economic policies and the reduction of Third World debt will improve the climate for growth. An improved political and economic climate will allow a global economic per capita growth rate of 3% (with stronger growth in Asia and weaker growth in Africa). This relatively optimistic scenario may be adversely affected by growing restrictions on international trade.

Increasing public concern for the global environment will bring about major policy changes on such issues as the ozone layer, destruction of forests, high-input agriculture, water quality and availability, energy resources, waste disposal, and soil degradation.

To sustain the productivity of rice and wheat in Asia, their cropping systems will need to diversify.

Asia will be driving the world's economy, with a substantial annual economic growth affecting half the world's people. Agricultural growth, however, except for rice and wheat, will generally lag behind growth in other sectors. The agricultural goals in Asia will be diversification and greater sustainability through crop rotations.

Stable, sustainable agricultural systems are a major goal of ICRISAT's research in Africa.

Major political and economic problems will continue to plague sub-Saharan Africa, although significant improvements will be made. Improvements in the political situation in southern Africa will strengthen the region's economy and enhance trade and the growth of the private sector. Political stability and better policies could provide the basis for improvements in western Africa. The removal of intraregional trade barriers will stimulate demand, but agricultural production will fall short of demand. Foreign exchange problems will oblige governments to emphasize local food supplies. Institutional development in sub-Saharan Africa is far behind the rest of the world. The emphasis during the 1990s will be towards more sustainable agricultural systems in this region and elsewhere.

For ICRISAT, Latin America will largely remain a region in which we react to important opportunities within a global strategy primarily oriented towards Asia and Africa.

Agriculture

A higher world growth rate for livestock products is projected, but the SAT poor will still depend on alternative sources of protein.

In 1988, the Technical Advisory Committee (TAC) Secretariat of the Consultative Group on International Agricultural Research (CGIAR), quoting figures from the FAO study "Agriculture: Towards 2000" (1987), projected real growth in agricultural production of 1.1% between 1983 and 2000. The output of livestock products and coarse grains (i.e., ICRISAT mandate crops) will grow fastest, while demand constraints will cause lower growth rates in starchy roots and in the main export commodities of the developing world. The study projects slightly higher cultivated area growth rates in sub-Saharan Africa than in either Asia or Latin America.

While livestock products and coarse grains will lead the way in world agricultural growth, per capita consumption of livestock products in the developing countries will remain low. The poor will continue to depend on alternative sources of protein, except in western Africa.

The Semi-Arid Tropics (SAT)

The SAT is a harsh environment. Most of the 49 developing countries with major areas in the region rank among the poorest in the world. Poverty and the periodic recurrence of

drought and famine will keep the problems of the region high on the agenda of donor concerns. Economic growth in the SAT, except in Asia and southern Africa, will lag behind that of other regions. The utilization of its products in regions of higher growth is a key to improvements in the SAT.

The semi-arid tropics are characterized by inadequate and uncertain rainfall, large areas of infertile and fragile soils, low capital availability, and weak institutions and infrastructure. Farming in the SAT is often a vicious cycle where the producers, rational but lacking managerial skills, undervalue entrepreneurship and overly fear risk. Meanwhile, most planners and officials accord the region low priority, although the political rhetoric may indicate otherwise. Real prices for many SAT products will continue to decline.

Urban populations will increase rapidly. However, in 2000 the people of the semi-arid tropics will be, as they are now, predominantly agricultural producers or laborers. Virtually all farmers will be smallholders. Women will play a dominant role in agriculture in southern Africa and in the labor force in general, with males seeking employment in industry. Few SAT farmers will be completely subsistent—they will also consume goods produced off the farm.

Laboratory work at SADCC/ICRISAT.

Women in Development

Women provide much of (he labor for growing ICRISAT mandate crops and are the predominant farmers in southern and eastern Africa. They are also homemakers who use all mandate crops for staple foods for their families, as well as pigeonpea for fuelwood and groundnut tops for fodder. Because of the significant contribution of women to SAT agriculture, crop improvement strategies must involve them directly to be truly effective.

ICRISAT is conscious of the considerable barriers to women's full participation in agricultural development. Women farmers are regarded as passive targets by the majority of research departments, extension services, and credit organizations. Female-headed households have greater labor constraints. The percentage of women working in national and international research systems and extension agencies is low. Measures specifically favoring women will therefore guarantee a more active role for them in developmental efforts.

There are several possible means of attaining more efficient development and improved gender parity at the same time :

conducting crop production training courses at ICRISAT exclusively for women from both research and extension services within the SAT;

giving special consideration to female cooperators;

encouraging exchanges of scientists and postdoctoral researchers that result in larger numbers of women at ICRISAT research stations;

requesting sponsors of trainees to practice affirmative action in recruitment; and

establishing contact and working with organizations that involve women at the grass roots level in technology transfer.

These suggestions address the feasibility of involving more women in agricultural science. The involvement of women in the Institute itself is equally important at all levels, and avenues for spouse employment will be explored.

Many developing countries will continue to invest in irrigation in the semi-arid tropics regardless of its cost because they recognize its importance in elevating and stabilizing food crop production. This global trend, however, will not exclude the SAT's dependence on rainfed agriculture to satisfy human, animal, and industrial needs. Even in India, which has made major strides in irrigation, an estimated 60-70 million hectares must continue to be cultivated under rainfed conditions. Without adequate improvements in rainfed areas, agricultural growth targets will not be met.

Africa contains the largest land area within the semi-arid tropics. While many African countries have invested in irrigation, improvements in agriculture have been marginal except in a few commercial farming areas. Domestic food and feed production in Africa will continue to rely largely on rainfed farming.

While self-sufficiency in food for the rainfed SAT population is a laudable objective, the opportunity for income growth in marginal areas will depend largely on markets in better endowed regions. The future of ICRISAT's mandate crops is tied to rainfed agriculture, and the long-term demand for food, feed, fuel, and commercial products made from those crops.

The needs of SAT farmers are increasingly complex, and must be addressed by research.

A shift from traditional towards modern agriculture is inevitable in the SAT. The self-sufficiency of the SAT farmer, however, will be challenged by increasingly complex needs. Crop research should be geared to the nature, needs, and prevailing problems of the region's farmers. Subjects requiring investigation include animal feed, feed lots, and beverages derived from mandate crops in association with other crops. Protection of farmlands, grasslands, and forests from overgrazing and proper use of water resources will figure strongly in our medium- and long-term research efforts and policies.

In parts of Asia, Africa, and Latin America, maize cultivation has expanded into areas far more suited to sorghum because of aberrations in price policies and resource allocations, and because the overall productivity of maize is higher than that of other traditional dryland cereals. The situation may change with the spread of efficient management techniques combined with improved sorghum and millet cultivars. For example, the complexity of the food security issue in the Southern African Development Coordination Conference (SADCC) countries has become more apparent with time.

The long-term demand for **sorghum and millets** will depend not only on such basic factors as population and income growth, but on the development and supply of these crops for both humans and animals. It is inconceivable. in these circumstances, that any cereal will replace pearl millet in the Sahel. If past trends continue, the net food production shortfall in the developing countries in 2000 will be 100 million tonnes. The implication for cereal feed is that the estimated requirement in 2000 will be 2.5 times that of 1980. Although the dominant cereal feed has always been maize, sorghum and pearl millet will bear increasing shares of this burden.

Grain legumes are an important source of protein and will remain in high demand by poor people in the SAT.

Grain legumes are a cheaper source of protein than animal products. They have a strategic role in the national food security of poor countries, particularly for the poorest sections of the populace. The demand for grain legumes is assured by traditional South Asian food habits and the probability that income growth in this decade will not be sufficient to permit a major shift to animal protein.

Pigeonpea is grown primarily in India. Its perennial nature, its nutrient-recycling ability, its leaf-litter drop that acts as a mulch, and its drought resistance make it pre-eminently suitable for SAT environments throughout the world. Pigeonpea has been transformed by research into a modern crop that, while remaining adapted to the SAT, has become potentially useful in other regions as well. If its potential is adequately demonstrated, it will be adopted more widely as a commercial crop in Asia, and eastern and southern Africa.

The adaptation of **chickpea** to SAT environments is being attempted primarily because of its short growth cycle. Cessation of growth, development in cool weather, and susceptibility to diseases have limited the spread of this crop. The success of research programs in removing these constraints will determine the future role of chickpea. The yield of kabuli chickpea grown as a winter crop, for example, is almost double that of spring-sown crops in the West Asia/North Africa (WANA) region.

Sand damage on a farm in the Sahel.

Women farmers in Kenya working together to build terraces to reduce the erosion of topsoils.

Because many developing countries of the SAT are acutely short of cooking oil, groundnut will continue to be important in satisfying the growing demand. In its adaptation to SAT environments and soils, cowpea matches groundnut, but groundnut has the edge in profitability, diversification, and end use. The adaptability of groundnut to a wide range of environments—from the sandy soils of the Sahel to favorable irrigated environments—assures its future in world agriculture.

Rich in oil, groundnut is an important cash crop with an assured future.

Groundnut could play an active role in the transition from subsistence to commercialized agriculture in developing countries. India, for example, spent US $ 365 million in a single year (1986/87) importing vegetable oils. The demand for oilseeds in developing countries is expected to grow at a compound rate of 3.9% annually—a higher rate than that for cereals because there is a greater demand for vegetable oils than for cereals as income rises. The potential role of groundnut in the tropics is comparable to that of soybean in the USA.

Improving nutrition and alleviating poverty require increased food supplies, lower prices, and greater purchasing power for the poor. Expanding employment opportunities and income generation must accompany efforts to increase food production. In the semi-arid tropics, this means increasing the complementarity between rainfed and irrigated agriculture and, in western Africa, development of groundwater supplies and technologies to use them efficiently.

Increased food supplies are needed for the poor in the SAT.

In the rainfed SAT, livestock products, agroforestry, and horticulture are comparatively labor-intensive and profitable. They provide greater opportunities for employment and improved income than increased production of traditional annual cereals, which are usually characterized by lower demand as income increases, and vegetable and livestock products become more affordable. Later, as more cereals are used for feed and the demand for livestock products increases, the demand for feed cereals will increase.

In western Africa, technologies that integrate several components of resource management (such as operation-scale research at the ICRISAT Sahelian Center in Niger) will become increasingly important to national research strategies because of a growing realization that in SAT western Africa, improved seed alone is unlikely to bring the large yield increases experienced in rice and wheat. In southern Africa, on the other hand, the seed component alone has effected significant change in certain areas.

The Consultative Group on International Agricultural Research (CGIAR)

International agricultural research under the CGIAR is an effective form of development assistance. The CGIAR generally accepts the proposition that the best way to help the poor is to reduce the cost of their staple foods, and the only way small-scale farmers can have lower prices and better incomes is through significant increases in productivity. Research aimed at improving their agriculture and the productivity of marginal areas will therefore continue to receive strong support.

Consultative Group on International Agricultural Research.

Because the CGIAR will continue to be concerned with both efficiency and equity, the growing concern for sustainability will require resources for both. The CG Centers are broadening their focus and improving their rapport with private industry, particularly commercial forestry, fertilizer and seed production, and food processing. Reduction of CGIAR support for cereal breeding for yield is likely because of increased involvement of private industry in that activity.

While recognizing that the impact of the international agricultural research centers is substantial and will increase, the CGIAR is concerned that weaknesses of national research programs will limit the effectiveness of the IARCs. The Group will continue to press for more effective linkages and cooperation with the national programs. Although national programs will strengthen, many will still be plagued by nonrecurrent

The Research Environment by 2000

Research will be multidisciplinary in nature, with better integration of the biological, physical, and social sciences. The complexity of such research will necessitate closer cooperation of international agricultural research centers, universities, and other research organizations. In such an environment, rapid scientific advances will be common. The cost of research will increase, recruitment of well-trained staff will be more competitive, and the need for constant updating of facilities, equipment, and training will be essential. Meanwhile, the problems of intellectual property rights and free use of research findings will pose ever-increasing problems and will need to be addressed.

The research environment in 2000 will be characterized by several major improvements.

- *Use of satellite imagery for more accurate predictions of weather, drought, diseases, and yields.*
- *Exchange of research information on national and international computer links.*
- *Wide use of geographic information systems to assimilate and analyze environmental and agricultural records.*
- *Genetic-cytoplasmic male sterility systems that facilitate hybrid seed production.*
- *Molecular genetic maps for major cereals and legumes.*
- *Identification and cloning of several genes that control individual genetic traits associated with agronomic fitness.*
- *Effective manipulation of the genomes of cereals and legumes through genetic transformation.*

These advances will necessitate various changes in research emphasis.

- *Balance environmental preservation with increased production.*
- *Balance utilization with crop improvement.*
- *Increased disease and pest management studies related to climate and soil factors.*
- *Germplasm collection targeted for selected characteristics.*
- *Breeding for specific traits emphasized over broad-based adaptation.*
- *Breeding of hybrids over open-pollinated cultivars.*

The focus on basic research in the agricultural plant sciences will be modified as necessary.

- *Regulating plant senescence and controlling flower initiation.*
- *Relating the structure and function of root systems to soil physics and fertility.*
- *Partitioning nutrients to enhance harvestable components.*
- *Understanding the impact of environmental constraints on assimilate distribution.*
- *Regulating survival and recovery under conditions of heat and drought stress.*
- *Manipulating multigenic traits.*
- *Examining the pleiotropic effects of introducing alien genes into crop genotypes.*
- *Optimizing the design of agroforestry systems and other types of intercropping or sequential cropping.*

budgets and an oversupply of networks. By 2000, the stronger national programs will carry out some of the international and regional applied crop research currently done by the IARCs. They will also undertake more strategic research and production training.

The CGIAR have added programs in forestry, agroforestry, and activities concerned with soils and irrigation. ICRISAT will always collaborate with centers that deal with activities and crops important to its mandate.

A larger and more complex CGIAR with more disparate units may lead to greater centralization. This could lead to a more corporate-like structure, or perhaps to the system's regionalization. Among the CG Centers, ICRISAT has already adopted a corporate structure.

Target Groups and Partners

ICRISAT was created by the CGIAR in 1972 on the recommendation of the Technical Advisory Committee (TAC). The action was a response to the evident success of the new high-yielding varieties of irrigated rice and wheat. Development agencies believed that a similar approach could succeed in improving agriculture in nonirrigated uplands where rural poverty was so conspicuous. Given the huge numbers of poor people who will be living in the semi-arid tropics in 2000 and the growing contrast between their condition and that of the rest of the world, the need to continue stressing equity in ICRISAT's mission is clear.

Target Groups

Small-scale farmers: our primary target.

ICRISAT's primary target group is the small-scale farmer in the SAT, with emphasis on the drier areas of the zone. These farmers cultivate their land with their families and limited hired labor and have limited access to inputs or irrigation water. ICRISAT will help to improve their livelihoods by widening decision-making options in their agriculture. Our secondary target group of commercial farmers and farmers outside the semi-arid tropics who cultivate our mandate crops will benefit from the spillover effects of our research for the SAT farmer.

Because the CGIAR has endorsed the first priority objective of its Technical Advisory Committee—to increase sustainable food production in the developing world—ICRISAT must be able to provide breeding materials and suitable cultivars of its mandate crops to all who endeavor to fulfill this basic objective. Similarly, while our crop improvement mandate is focused on the SAT, it is not restricted to this region. We must strive to ensure that producers of our mandate crops will benefit from our research wherever our crops are grown.

Partners

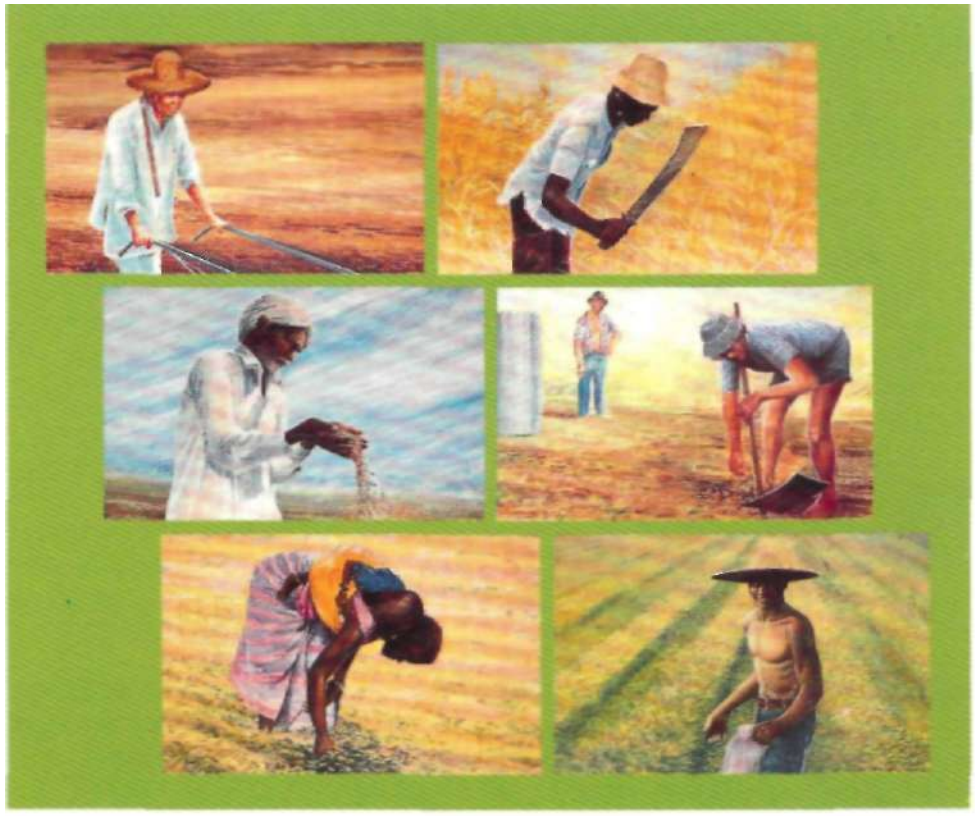
National Agricultural Research Systems (NARSs)

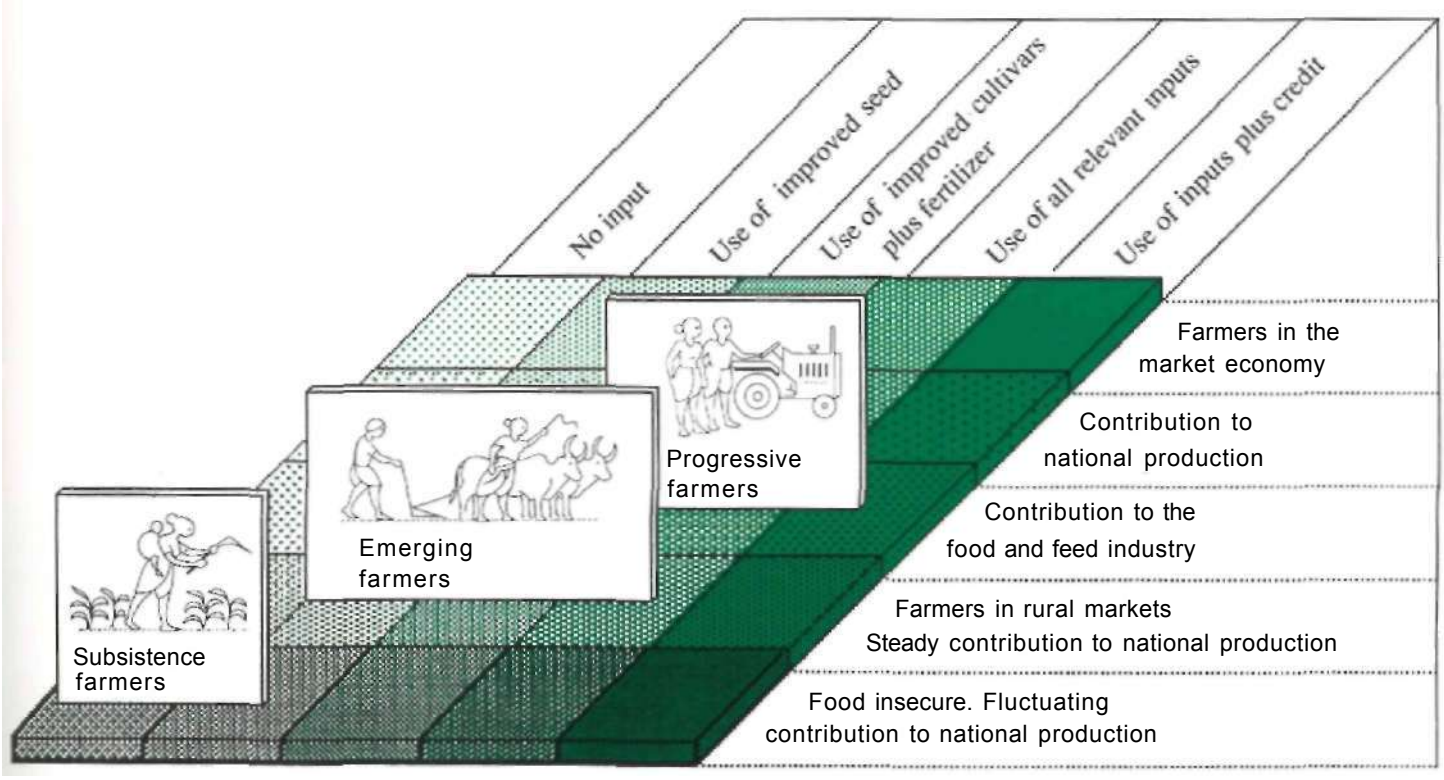
NARSs: our principal partners.

The principal partners in our research work are the leaders of national programs responsible for the conduct and effectiveness of agricultural research in the countries we serve. Most are administrators with backgrounds in agricultural science. In large countries their jobs are complex and demanding, while in smaller countries their resources are meager. These administrators are frequently obliged to implement research in accordance with national policies that do not substantially support rainfed farmers or sustainable agriculture. In addition, leadership in these programs changes frequently. ICRISAT's relations with the NARSs are therefore complex and require constant attention. We must react to their changing needs through continual dialog, remaining cognizant that our global, regional, and long-range goals may not fully match their national, short-range needs.

To ensure continuing good relations with our partners, we will adhere to a principle of working through the national coordinating institutions for agricultural research in those countries where such an organization is defined by statute, or in consultation with the natural apex agricultural research organizations in countries or regions where no statutory coordinating institute exists. This principle does not mean that we will restrict our present policy of making breeding lines/germplasm, methodologies, or research results freely available to all who request them.

According to the 1988 TAC study, national research capacities vary in three respects: among countries, among programs, and over time. ICRISAT is evolving an ability to differentiate the national programs according to their strengths and to serve each according to its needs and capacities.





Our target group: SAT farmers

Our Partners: the NARSs

The national agricultural research systems of the SAT countries are diverse. Their variance in size, capacity, and capability is reflected by what they require from ICRISAT. Furthermore, they are hampered in their productivity and output by shrinking operational budgets. Of the 49 national systems in the semi-arid tropics, some have the potential to generate technologies: others only to adapt them. Effective adaptation, however, requires technical competence and efficient national capacity to borrow technologies and to test, screen, and adapt these technologies to specific local conditions.

Applied research focus for NARSs.

As national research programs develop greater institutional capacities, they can increasingly assume more responsibility for the generation of technology. Their capability for undertaking applied research has improved dramatically in recent years. The CGIAR would like the NARSs to participate more substantially in generating technology, and supports the view that they should also undertake some of the regional and international work presently done by the IARCs. Our responsibility to continue assisting countries that cannot support large national programs is clear.

At the same time, an increasing tendency for the IARCs to move towards strategic research will give stronger national programs a disproportionate share of the benefits of international agricultural research. ICRISAT is aware of a concern among the weaker national programs about this trend.

The CGIAR would like to see IARC assistance to the national programs change in two basic areas.

- Education and training. Some production agronomy training should be shifted to the NARSs with backstopping provided by the CG centers. Support for degree-related education should be strengthened, as should short-term training on research methods, specialized skills, and the training of women.
- Institution building. Although it is the responsibility of the International Service for National Agricultural Research (ISNAR) to improve the organization, planning, and operation of the national programs, the other CG centers can assist by strengthening commodity and resource management, research programs, and research station management.

Regional networks merit support.

Regional or subregional organizations of national research programs exist in Asia and Africa, and network steering committees assume regional roles where formal organizations are nonexistent. Such regional organizations relate better to the orientation of the international centers than do individual national programs and merit support and strengthening.

National Scientists

ICRISAT's immediate partners are the scientists of national institutions in the SAT countries. National scientists are responsible for producing cultivars and new technologies for the farmers in their countries. ICRISAT undertakes research that contributes to and complements their efforts. We obtain their assistance in planning our research when they attend our field days, workshops, and conferences, and when we attend their national planning meetings. Most ICRISAT trainees are national research scientists and technicians.

We divide the work on the principle of comparative advantage. We introduce genetic diversity by bringing together a substantial germplasm collection, including most of the

A national program office in Pakistan, working on chickpea and pigeonpea.

available natural landraces, and incorporating this diversity into freely-available breeding materials. We exchange advanced materials through our networks of international trials and through field days when national scientists can choose breeding materials directly from ICRISAT fields. Our major thrust remains enhancing germplasm and broadening the base for developing agronomically superior materials that can better resist diseases, insects, and other pests. These materials, in the hands of national scientists, can bring a significant increase in productivity in the harsh environments of the semi-arid tropics. We utilize our resources to concentrate on difficult problems. We take a multidisciplinary team approach, incorporating the physical, biological, and social sciences.

In India, our partner scientists work mainly in the state agricultural universities in nationally coordinated programs. We have established cooperative agreements in crop improvement research with several universities and our cooperation helps to strengthen these institutions. Our scientists participate actively in workshops and planning meetings of nationally coordinated programs, in conferences, and in the meetings and operations of professional societies. Our contacts with our Indian partner group are extensive, frequent, and close.

In African countries, ICRISAT's emphasis has been on regional efforts, with multidisciplinary teams of scientists working at several locations in western, eastern, and southern Africa. Because ICRISAT regional teams generally work on government agricultural research stations with inadequate facilities, ICRISAT is committed to providing the facilities required for its regional research. In Sadore, Niger, we have established the ICRISAT Sahelian Center (ISC), to serve as a base for our efforts in western Africa. ICRISAT utilizes the network approach to complement the work of its regional teams in sub-Saharan Africa.

We act as a catalyst in technology transfer to NARSs.

Though extension is not our function, we act as a catalyst in technology transfer to national systems. Because most Sahelian countries do not yet have sufficient numbers of trained personnel to develop extensive research networks, ICRISAT scientists function within the national system upon request. The cultivars and improved technologies they develop are tested on farmers' fields by extension agencies. ICRISAT assists by establishing and evaluating the trials.

Improved technology for deep Vertisols in India has been tested on-farm and in pilot projects. On-farm research is undertaken through national program research and extension

agencies to obtain farmer feedback. ICRISAT currently advises extension and action agencies wishing to use this technology.

The Private Sector

More private companies are becoming involved in the seed business.

Private agribusiness will play an increasingly important role in agricultural development over the next 10 years. Private companies in Asia, Latin America, and Africa are building their own research programs. Large agribusiness concerns are disseminating the products of research as they spread their operations worldwide. And we expect an increasing involvement of the private sector to affect the supply and demand of seed across national frontiers.

Private research will both collaborate and compete with ICRISAT. Increasingly, private agricultural research will be an important source of demand for ICRISAT's research output. It will provide a new source of research support and open new vistas for the adaptation and transfer of ICRISAT's research products.

ICRISAT's relationship with private agricultural research will be guided by the recognition that both public and private research institutions are part of the national agricultural research systems. The private sector often has an advantage over public research institutions in the identification of new uses for agricultural commodities and in meeting location-specific demand for agricultural technologies.

In its relation with agribusiness, ICRISAT will respect national policies governing private research while ensuring that private-sector use of our research does not preclude public-sector access to our products.

ICRISAT will actively review and make decisions regarding the disposition of intellectual property arising from its future activities.

Guiding Values

ICRISAT was the first center created following the establishment of the CGIAR. The Center's raison d'etre is embedded in equity—a dedication to helping the poorest of the poor in the semi-arid tropics to improve their food supply and their economic well-being.

The Institute is an international organization with a corporate structure and is part of a freely interacting family of similar institutes. Its planning process is imaginative and effective, and involves staff at all levels. ICRISAT accepted the need to develop and strengthen a commitment to long-term research in sub-Saharan Africa ahead of the CGIAR system as a whole.

We have learned through our economic studies and the impact of our crop improvement work that increasing the efficiency of resource use in the SAT leads directly to gains in equity. From its inception, ICRISAT accepted a farming systems approach to research, and a low-input road to increasing productivity and conserving natural resources.

ICRISAT is interested in useful outputs and encourages the utilization of its results and products. Since our early years a standing committee of our Governing Board has been concerned with the transfer of technology developed from ICRISAT research.

Our Governing Board concentrates on technical issues, fulfillment of the mandate, and governance. The Board acknowledges its accountability for its actions and holds management and staff accountable in turn. ICRISAT accepts the need for reviews and values them, but feels there is a need to streamline the process in order to devote more time to research.

ICRISAT values good stewardship of the resources made available to it. Because resources are limited, coordination and reduction of nonproductive overlap are essential. We seek cooperation with other centers and mentor institutions. We work in partnership with the national research programs and are aware that the difficult problems of the semi-arid tropics require new approaches to attain outstanding achievements. These problems will not be solved by marginal changes.

The Institute expects much of its staff and rewards excellence generously. It creates conditions for quality research and high standards of performance, and offers opportunities for training and professional growth to all categories of staff. A need exists for nonmonetary recognition for quality work. ICRISAT knows that research often benefits from controversy and competition in an atmosphere of creative tension. It also recognizes that creativity thrives in an atmosphere of openness, objectivity, and responsibility.

Although our research facilities are excellent, continuous improvement is needed. Innovative research is promoted by allowing greater flexibility in the use of resources and by encouraging the acceptance of risk in research planning.

Internal Environment

Organization

In 1986, the Governing Board approved a management reorganization that gave ICRISAT a corporate and decentralized structure. The Office of the Director General is the Institute's corporate center. It includes the offices of the Deputy Director General, the Assistant Director General (Administration), and the Assistant Director General (Liaison). It is responsible for interpreting CGIAR and Board policies, budget formulation and control, donor and CGIAR relations, research and training coordination, administrative policies and standards, information, and internal audit.

The Office of the Deputy Director General manages research support services at ICRISAT Center. There are five Directorates: three Program Directorates (Cereals, Legumes, and Resource Management) at ICRISAT Center and two Executive Directorates for southern and western Africa. Small units in eastern Africa and at our sister institutes Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) in Mexico and the International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria report to the appropriate Program Directors at ICRISAT Center.

Although our corporate structure has been in place for only 5 years, there are indications of a positive effect on the overall management brought about by decentralization. A review by the Governing Board is recommended.

The Global Center

The concept of international centers with global responsibilities is central to the CGIAR's own strategy. This concept has also contributed to the success of the system. According to TAC, the key characteristics of the CG Centers are:

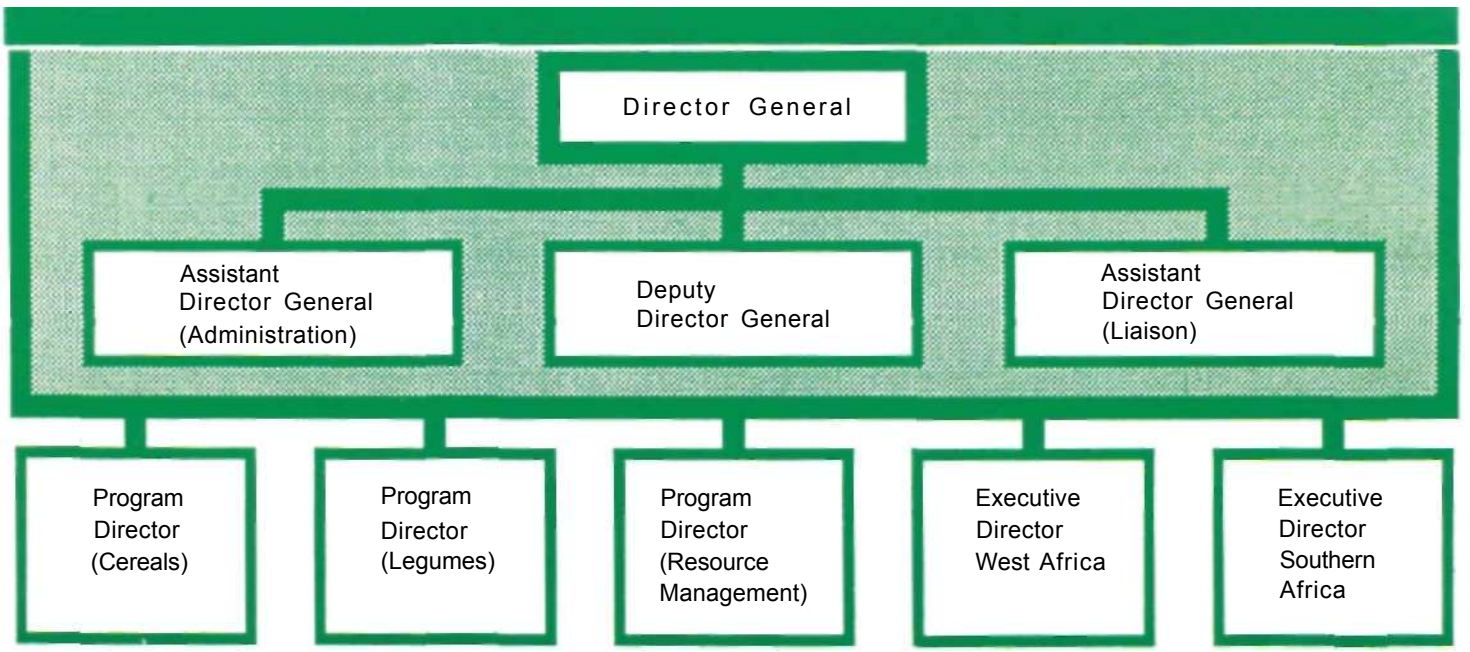
- *attention to problems requiring international solutions*
- *international status*
- *governance that protects them from political pressures, and regional or national influences*
- *international mobility of center staff, germplasm, and knowledge*
- *openness to all partners seeking collaboration.*

The continuing challenges facing international agricultural research, both long-term trends and short-term technological demands, reinforce the need for strong, high-quality, dynamic units at the global center.

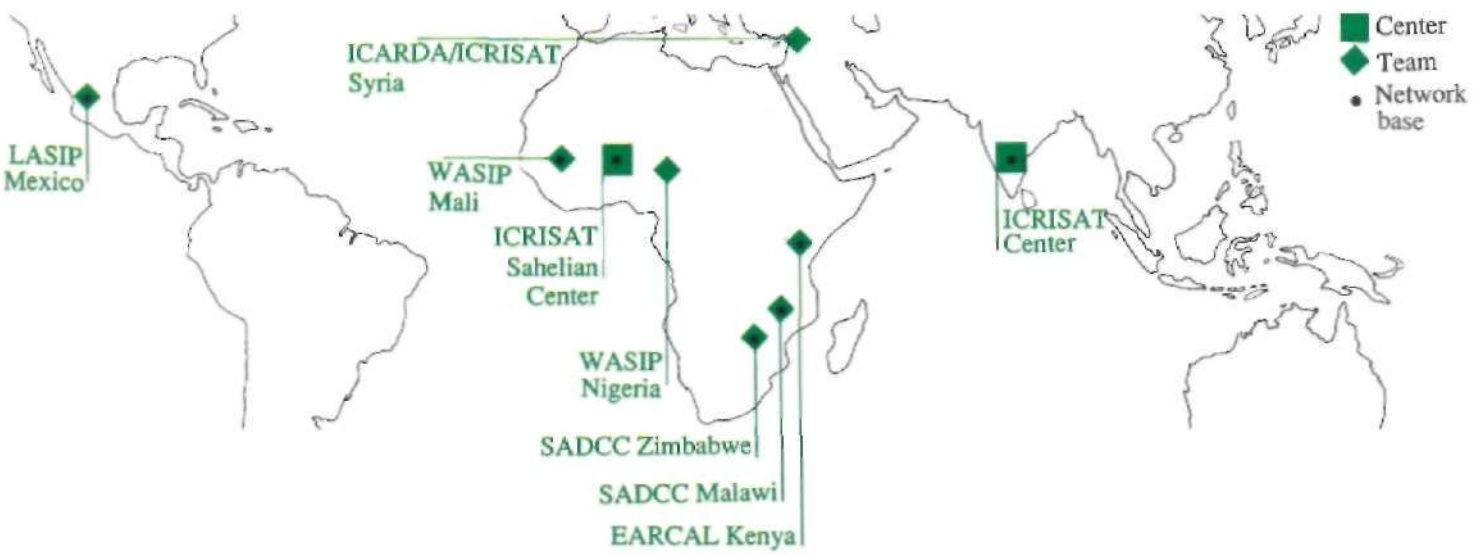
ICRISAT's mandate is unusual because it is both global and regional—global in its commodities mandate (sorghum, millets, chickpea, pigeonpea, and groundnut) and regional in its area mandate (the semi-arid tropics). ICRISAT Center, the heart of our global system, carries out most of the strategic research and develops methods used throughout the ICRISAT family. It supplies improved germplasm to its own regional programs, to national programs, and to the private sector. It is both the central repository for the germplasm, and the principal center for information concerning its mandate crops. It trains scientists and technicians and provides information to its partners. It supplies short- and long-term scientific and technical backup for its regional programs and the national programs. It also provides management, logistic services, and guidance.

Centers, Teams, and Networks

ICRISAT's strategy for combining research with technology exchange is based on the concept of centers, teams, and networks. This concept was first developed in 1979 when



Organogram of the office of the Director General and the five directorates.



Geographical distribution of ICRISAT's Centers, Teams, and Networks.

ICRISAT decided to create the ICRISAT Sahelian Center (ISC), after unsatisfactory experience with a dispersed model of regional cooperation, in which individual scientists were located in different countries and ecosystems throughout western Africa. The concept was discussed in detail during the 1984 external program review (EPR), and it received the EPR panel's endorsement.

ICRISAT Sahelian Center is now able to undertake long-term strategic research.

ICRISAT Center in India is the global center where most of the strategic and basic research and most of the advanced training will be done. ISC is a regional center in the Sahel where some strategic research and advanced training will also be conducted. Both function on land controlled by ICRISAT and have the capacity to undertake long-term research, such as that on rainfed farming systems for sustainable agriculture. The two centers represent long-term commitments: ICRISAT Center to the semi-arid tropics and ISC to the Sahel.

ICRISAT's research teams located in the regional centers and otherwise on land allocated by national programs provide bases for applied research and contribute improved germplasm, components of technologies, and information. These teams also provide the technical core for regional networks and regional human resource development programs. The regions that are served by such teams are currently southern Africa (for sorghum, millets, and groundnut), eastern Africa (for sorghum, millets, and pigeonpea), western Africa (for sorghum, pearl millet, groundnut, and resource management) and Latin America (for sorghum).

ICRISAT Center's support to regional programs is essential.

Applied research at ICRISAT Center supports regional activities for legumes in South, Southeast, and East Asia. The same is true in principle for sorghum, millets, and resource management, but in practice the applied research undertaken mainly serves India alone. ICRISAT also participates in regional research at ICARDA for kabuli chickpea in West Asia and North Africa.

ICRISAT also supports or participates in five formal cooperative research networks: separate sorghum and pearl millet networks in western Africa; a sorghum, pearl millet, and pigeonpea network in eastern Africa; a sorghum network in Central America; and a cereals and legumes network in Asia. We have also initiated a global cereals research network. The coordinators of these networks, when they are ICRISAT staff members, are also members of the regional research and training teams and participate in the research. These networks assist national scientists and enhance their participation in cooperative research.

Culture, Strengths, and Weaknesses

ICRISAT is proud of its concern for individuals and appreciates the need for constant improvement in performance to keep motivation and morale at peak levels. Research at ICRISAT is goal-oriented, but the desire to succeed and the demand for quick results sometimes inhibit us from applying ourselves to difficult problems. To avoid wasteful repetition, we document both our failures and successes. We believe in high standards of performance throughout the Institute.

Rewards to individuals are not balanced by rewards to the team.

The philosophy of interdisciplinary, field-oriented research is well-established, but it needs strengthening in practice. Rewards to individuals through praise, salary increments, and promotions are not adequately balanced by rewards to the team.

The Institute deals fairly with its employees and is firm in dealing with unsatisfactory individual behavior. It is as open in its dealings with staff as host-country mores will allow, but communication needs to be improved. It copes well with the external pressure and demands placed on it by the system and by its host governments. There is need for more orchestrated debate on strategic and researchable issues.

Personnel relations in the Institute are good, and personnel policies are responsive to changing needs. Although personnel administration is well-organized for locally recruited staff, improvement is required for internationally recruited staff. The Institute provides opportunities for cross-cultural interaction between international and national staff, as well as between various cultural groups.

Retraining and redeployment of middle-level staff and a more selective voluntary retirement policy are planned.

One of the problems facing ICRISAT is an excess of middle-level support staff at ICRISAT Center and an inadequate turnover policy. Scientists can achieve much because of the size of their support staff, but a large support staff requires more time and effort for administrative activities at the cost of research. Scientists sometimes do not see themselves as supervisors even when teams of 10 or more people report to them.

Innovative measures will be taken to redeploy middle-level support staff through re-training. The Institute will review its policies concerning staff appraisal, promotion, and turnover to encourage competent staff to stay and others to leave. A more selective voluntary retirement policy may be needed to replace the current flexible blanket scheme. Recruitment of staff on flexible-term employment will also be encouraged.

A more responsive system of resource allocation and technical support is being evolved to cope with changes without affecting the quality of research. There is a need to improve quality standards for experimental procedures and reporting of results.

Management information systems have lagged, partly because of insufficient administrative computerization. Although information on costs is available, its dissemination and use in decision-making is limited. Cost-effectiveness in terms of research investment and impact on SAT economies is difficult to quantify because the adoption of a new technology is dependent on national program efficiency and local policy environments.

We fully understand that our mission is to work with the national programs, and we work hard to ensure good relations with them. Although there have been some complaints from national programs about lack of service or sensitivity, the overwhelming evidence is favorable. In a 1986 survey, 50% of Indian scientists responding to a questionnaire from the CGIAR Secretariat ranked ICRISAT's service as "very good", 40% as "good", and 10% as "fair".

Future Ventures

Crops Research

Goals for Crops Research

ICRISAT's research strategy is founded on two institutional benchmarks: the area mandate of the SAT. and the emphasis on dryland agriculture.

These requirements cannot be modified without fundamentally altering the intent of the founders, but the crop commodity component of the mandate does have flexibility.

ICRISAT's mandate crops include three cereals (sorghum, pearl millet, and finger millet) and three legumes (groundnut, pigeonpea, and chickpea). Changes in this mandate are not presently envisaged, but it may be reviewed before 2000 to accommodate possible shifts in commodity demands and NARS capabilities to promote self-reliance.

Yield Improvement

New cultivars of our mandate crops with higher yield potentials have been produced, and further advances are achievable. Our goals are to continue to increase the yield potential of new cultivars, reduce fluctuations by adapting cultivars to specific environments, and to help stimulate sustained production in farmers' fields so that gaps between yields on research station trial plots and those on farmers' fields are reduced.

Quality Improvement

Improvements in physical crop yield translate into improved crop value only if commodity characteristics valued by processors and consumers are maintained or enhanced. Food quality characteristics must be maintained for traditional consumers. The importance of quality characteristics in new uses of mandate crops will be determined so that more diversified demand can be met.

Crop Introduction to New Environments

Introducing crops to new environments where there are fewer yield-reducing pests and diseases is a proven method of increasing agricultural production. We will attempt to introduce pigeonpea, now grown as a field crop mainly on the Indian subcontinent, to new areas in eastern Africa and southern Asia. We will also explore the potential of adapting chickpea to new environments.

Pigeonpea will be introduced into new regions in eastern Africa and southern Asia.

Intensification and Sustainability

Growth in income and market integration lead to more diversified market demand. At the same time, the enclosure of uncultivated lands in many SAT countries means that biomass previously harvested from these areas must now be produced on cultivated land. Thus subsistence crops such as pearl millet, sorghum, and pigeonpea will need to meet these demands to enable farmers to earn income. Our cereal and legume crops can provide biomass for fodder and soil amelioration to sustain the farming systems of which they are an integral part.

Imperatives for Crops Research

Flexibility, relevance, continuity, and opportunities are important to planning.

Detailed long-term planning of crops research may not be useful in a fluid research environment. The appropriate response to fluidity and instability in the external environment is not rigid and over-detailed planning, but to establish principles for research that define a flexible strategy and its limits. Such a strategy should ensure the relevance of research projects that are able to exploit new opportunities while maintaining continuity in research direction.

Our crops research should maintain its international character by being internationally relevant, by linking research in high- and low-income countries, and by drawing on the world germplasm collection. At whatever level it is conducted, crops research should satisfy disciplinary standards of excellence.

The scope of ICRISAT's crops research encompasses the whole commodity system from crop production to end use. Research attention, however, will focus on the intersection between the commodity systems of the mandate crops and farming systems in the SAT. Economically important commodity problems outside this focus will receive attention only when ICRISAT has a comparative advantage.

Focusing on Problems

Strategic research will help to solve some applied research problems.

Problem-oriented research is not confined to applied problems, but encompasses strategic research problems whose solution helps solve those of applied research. Research problems tend to transcend disciplinary boundaries, and solving them efficiently requires a multidisciplinary approach.

Exploiting our Comparative Advantage

Research responsibilities will be distributed among ICRISAT's centers, programs, teams, and networks to exploit their locational advantages and to make efficient use of resources.

ICRISAT Center has global responsibilities; it supports all the regional programs through strategic and basic research, while also serving as a regional program for Asia. Techniques developed at the Center are adapted to regional needs and conditions by regional teams and programs. Networks ensure the transfer to national programs of regionally developed research products.

Modus Operandi for Crops Research

Crop improvement comprises three broad domains of activity. Each requires the expertise of different disciplines.

Genetic Improvement, Diversification, and Adaptation

Genetic resources. ICRISAT's extensive collection of germplasm accessions is an important source of genetic variation to be exploited through breeding. If this germplasm pool lacks the required genetic material, appropriate methods of bioengineering will be considered.

Breeding. The initial emphasis of ICRISAT's breeding programs was to overcome the yield constraints that were important over considerable areas of the SAT. This resulted in many new cultivars being released, primarily in India, and in segregating material being

made available to breeders in both public and private sectors. We expect the demand for such material to increase as NARSs improve their capabilities to use it.

Better environmental adoption of crops through increased genetic diversity requires detailed knowledge.

Improved understanding of production conditions in SAT regions, changing requirements of national programs, and new types of demands for our crops require that we make our materials more genetically diverse. In particular, breeding material will have wider environmental adaptation (e.g., through photoperiod insensitivity). It will be better tailored to fit into specific cropping systems, and will have a wider range of valuable characteristics. This broader diversity will be exploited by integrating improved genotypes with sustainable management practices. To accomplish this, considerable knowledge of crop production conditions and constraints in different countries is required. We will need to redefine screening objectives, adapt techniques, and modify the balance of breeding responsibilities between ICRISAT and the national programs.

National programs can provide location-specific information to guide breeding research.

We will undertake strategic research to better define agroecological zones and to understand the mechanisms of adaptation of our crops. We will ask the NARSs to provide such specific information as farmers' needs, the characteristics of environments, or production constraints at specific locations that are necessary to guide our breeding research for them.

The expected partial shift in use of our mandate crops - from food to animal feed, forage, and for industry - will require adjustments in breeding emphasis and screening techniques and the scope of screening will be widened to include the biochemical composition and nutritive value of whole plants.

To ensure the sustainability of packages of management practices using new cultivars, the stability of the cultivars themselves must be ensured by screening them for resistance to a range of abiotic and biotic constraints.

A shift of emphasis is planned in our breeding programs.

Our breeders will give more emphasis to studies of the genetic factors leading to increased production, and to the nature and inheritance of the traits involved. They will continue to evaluate early-generation breeding material, and make it available to NARSs with strong breeding programs. We shall, however, continue to produce finished products for countries that have not yet developed adequate research capacities. Many of our partners already have the capacity for identifying farmers' needs for new cultivars and evaluating those cultivars in farmers' fields.

The success of any breeding strategy depends on the capability to produce seed of improved varieties in sufficient quantity and quality. Stimulating countries to develop efficient seed industries will be an important component of our technology transfer.

We will exploit our existing advantage in biotechnology research.

Biotechnology. Biotechnology cannot be an independent research area in a crops research institute. ICRISAT's capacity to fully exploit new techniques is constrained by market conditions in the recruitment of excellent biotechnologists and by the discipline's high demand for capital investment. These constraints can be mitigated by collaborating with private or public mentor institutions with location advantages. ICRISAT's advantage in the applied aspects of biotechnology research lies in its facility to test the effects of introducing new genes into breeding populations in different *environments.* The long- *term* benefits to ICRISAT will ultimately depend on our ability to exploit this advantage.

ICRISAT biotechnology research will be guided by four principles.

- *Use biotechnology to enhance applied aspects of plant breeding where it is cost-effective.*
- *Utilize and apply proven techniques from cell and molecular biology.*
- *Seek collaboration with mentor institutions.*
- *Adhere to national regulations for the import and testing of transgenic organisms and plants.*

Combining biotechnology and breeding research. Although the methodology of breeding will continue to be soundly based on conventional techniques of hybridization and selection in segregating populations, by 2000 we will increasingly use new methods of genotype and population improvement. New techniques, such as molecular genetic maps,

K.V. Ramaiah

An International Sorghum Field Day in which NARS scientists choose ICRISAT breeding lines.

A.B. Chinna

Long-term (strategic) crop production trials on a watershed at ICRISAT Center.

the use of molecular probes for the detection of diseases, and recombinant DNA technology to introduce genes into breeding populations will assume greater importance.

Results of other research programs will be incorporated into our breeding programs, and involvement of national programs will be especially important in screening for location-specific constraints.

Environmental Characterization, Crop Adaptation, and Prevention of Crop Losses

Emphasis on multidisciplinary research.

Characterization and adaptation. The adaptation of crops to the environment is of prime importance in the SAT, and requires precise knowledge of critical environmental parameters determining crop performance.

Physiologists, supported by agroclimatologists and soil chemists, will characterize the crop environments in terms of physical and chemical parameters with emphasis on:

- *Heat stress*
- *Drought and waterlogging at different stages of crop growth*
- *Nutrient deficiencies from poor or acidic soils or inadequate nitrogen fixation*
- *Daylength and temperature effects.*

Physiology research will continue to complement work on the genetic improvement of our crops. Physiologists will participate in breeding for adaptation to particular environments by: defining requirements for yield potential, quantifying physiological crop performance parameters by studying specific constraints to crop growth, and identifying chemicals that control these constraints.

Pests and diseases are major constraints to crop production in the tropics, and information on their occurrence, evolution, distribution, biology, epidemiology, and economic importance is a requirement for the determination of crop improvement research strategies.

Entomologists screen genetic material to identify resistance to major insect pests. This work will be continued in collaboration with NARSs, in environments and under pest pressures relevant to specific agroecological zones. Entomologists will also study the inheritance of insect resistance factors when suitable genetic markers become available.

Pathologists will continue their basic studies on pathogen variation and the nature of crop resistance, to assist breeders in increasing the available levels of resistance. The effect of the microclimate in the crop and canopy on disease and pest incidence will be studied to establish relationships between weather and disease outbreaks.

The scope of virology will be extended to include all crops.

Virology research at ICRISAT has been extended from groundnut to our other mandate crops. Virologists will continue their basic studies on the characterization of major viruses, and biotechnology techniques will be employed to induce resistance to them in our crops.

The importance of nematodes in crop loss and variability is recognized; it will be studied through regional surveys, and by increasing emphasis on nematology research.

Cropping systems research will emphasize the identification of biological principles to guide crop improvement research in the design and selection of cultivars productive in SAT cropping systems. Production agronomists will integrate the findings of other disciplines to determine guidelines for the management of new cultivars as components of SAT farming systems.

Information gained by all disciplines will be incorporated into systems models of plants and crops that can be used to predict crop performance in particular environments, and to guide experimental research.

Prevention of losses. Although ICRISAT emphasizes host-plant tolerance of, or resistance to, important pests and diseases in its approach to pest management, we recognize that host-plant resistance alone rarely provides sufficient protection. It is best used as a component of integrated pest management (IPM), i.e., incorporated into environmentally and economically acceptable packages that farmers can use.

The complexity of IPM requires our research to focus on exemplary projects of limited scope on economically important crop pests. Storage pests will attract only marginal attention.

Commodity Utilization

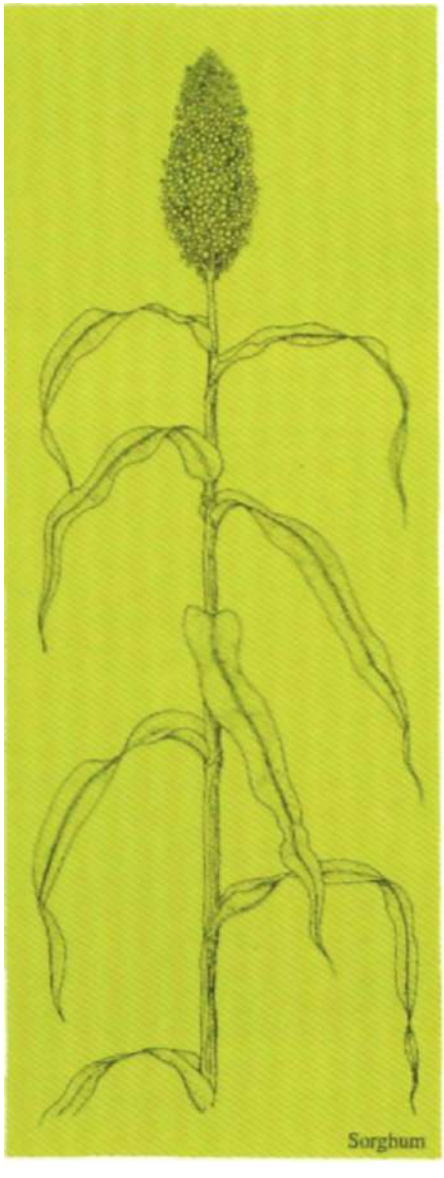
The value of crops research is derived from the value of a crop's utilization and the market demand for commodities derived from that crop.

Food technologists and biochemists can provide guidance to breeders by quantifying a cultivar's characteristics. The scope of this research will be expanded from characteristics of our crops when used as human food to feed, fodder. or industrial processing.

Economists will determine the economic value of specific quality characteristics, and identify demand prospects for commodities derived from our crops.

Strategies *for* Mandate Crops

Sorghum


Sorghum

Two important lessons from the past, and anticipated changes in demand shape the strategy for sorghum. The first lesson is that high-yielding single stem material is ill-suited to the conditions of farmers in unfavorable locations where crop recovery from stresses depends on the crop's ability to tiller. The second lesson is that location-specific vield reducers cannot be effectively addressed by centralized applied research.

The structure of sorghum demand will change significantly. In India, demand for food sorghum will remain high and demand for sorghum fodder will increase as bullocks continue to be the main source of draft power on small farms. The demand for sorghum grain as animal feed will increase throughout the SAT with the demand for milk. Industry's demand for sorghum will rise from its presently low levels, and the sorghum processing industry could become a major catalyst for sorghum production toward the end of the 1990s.

Our strategy in applied sorghum research is to breed for specific abiotic and biotic constraints rather than for broad adaptation, and to assist NARSs to breed for specific uses rather than for multiple or nonspecific uses. Our objective is to increase crop value and increasing yield stability will take preference over maximizing yield potential. Important constraints that will attract research attention in both Indian and African sorghum-growing areas are grain molds, shoot fly. and stem borer in rainy-season sorghum, and lodging under terminal drought stress in postrainy-season sorghum. Research on fodder sorghum will be conducted in western and southern Africa.

With the increasing dispersion and regional diversification of applied sorghum research. ICRISAT Center will focus on breeding methods and techniques, the study of the biology of mechanisms providing resistance to physical and biotic stress, the heritability of these traits, and the effects on agronomic crop performance of introducing them into advanced breeding lines.

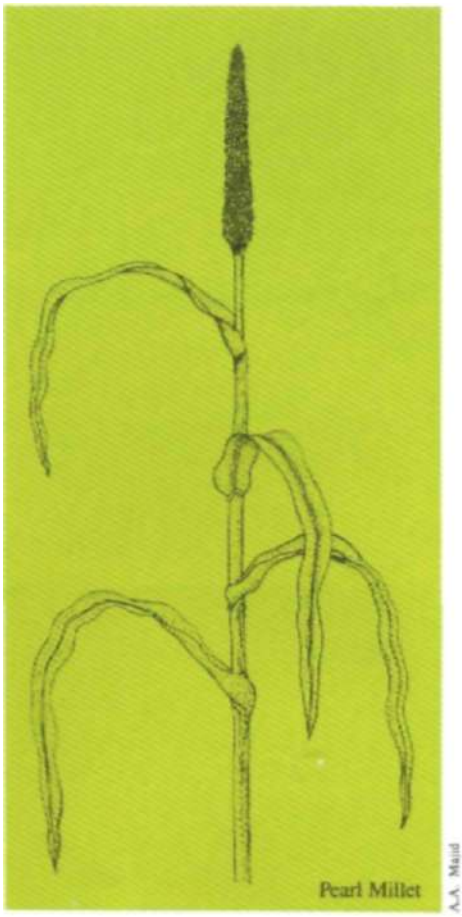
Pearl Millet

Yield increases in pearl millet hybrids have been more than three times higher than those of other cereals, and genetic gains in yield of pearl millet varieties have been on a par with average gains in other cereals. Fodder yield, disease resistance, and grain quality have also been improved. Advances in breeding methods will allow even more dramatic progress in the future. High-yielding cultivars based on ICRISAT material or produced by ICRISAT are widely grown by farmers.

Pearl millet success in India is due to both the close integration of disciplinary research and the full collaboration of public and private sector breeding programs. The private sector has lately been more successful in delivering hybrids based on ICRISAT material, and investment in pearl millet breeding by private industry is likely to grow so long as ICRISAT continues to supply germplasm for new hybrids. The prospects for pearl millet improvement are not matched by prospects for its demand. Production of pearl millet for food will be largely restricted to dry regions, such as Rajasthan in India, the Sahel, and parts of southern and eastern Africa. However, the demand for pearl millet for fodder will increase throughout the SAT, and to meet this we have started to work on pearl millet/napier grass hybrids in southern Africa.

The strategy for applied pearl millet breeding is to breed open-pollinated cultivars of specific maturity for specific regions and agroecosystems; to concentrate on the genetic diversification of parents for pearl millet hybrids to provide broad-based resistance to downy mildew, and to emphasize the cultivation of top-cross hybrids. Applied breeding will be complemented by research on stresses limiting millet production, emphasizing seedling emergence, temperature, and drought stress. Pearl millet entomologists will identify resistance to earhead caterpillar and stem borer, and transfer it to breeding lines.

At ICRISAT Center, increased multidisciplinary strategic research, comprising genetics, physiology, and farming systems research, will be conducted on pearl millet in close collaboration with mentor institutions. In western Africa the contribution of varieties to the effectiveness of technology packages will be evaluated.



Finger Millet

Finger millet has been added to our mandate crops because of its importance in eastern and southern Africa, where it is used both for food and traditional brewing. Finger millet research in these regions is recent, but accessions have been collected and evaluated and a hybridization program started.

Groundnut

Global and regional research will continue to focus on the major disease stresses that depress groundnut yields across the SAT. The problem of aflatoxin contamination in groundnut, and its threat to humans and livestock, will continue to receive research priority. We will also continue to produce high-yielding, stable genotypes selected for earliness to avoid diseases and drought, preadapted to specific agroecological zones and cropping systems and suitable for both high- and low-input production systems. Stability will be ensured by including appropriate resistance factors in groundnut adaptation characteristics.

We shall continue to seek sources of resistance within cultivated and closely related wild groundnut species and use these in breeding programs. There has already been considerable success in exploiting resistance factors, but more emphasis on understanding their nature and inheritance is needed. Where appropriate, advances in cell biology will be applied to access genes from distantly-related species and other sources. Recent developments in this field should also accelerate the conventional breeding process.

The demand for groundnut crops as fodder will increase throughout most of the SAT. Use in industry for oil extraction, oil cake, and confectionery will grow throughout the developing world.

Pigeonpea

Our research strategy for pigeonpea will be to build on our success with short- and extra-short-duration genotypes. We will introduce the crop into new areas, while exploring the biomass potential of perennial pigeonpea and continuing to develop hybrids.

A snack in Rajasthan: pearl millet on the cob.

Research on short- and extra-short-duration pigeonpea will emphasize the cropping systems characteristics of the cultivars, and breeding will decrease in importance as the scope for improving the new genotypes is increasingly exploited. The sustainability of short-duration pigeonpea production will depend on our success in designing IPM alternatives to chemical control of *Helicoverpa armigera,* a major pest.

Pigeonpea is a field crop in parts of eastern and southern Africa, but its potential is yet unexplored. A limited research effort has been launched in Kenya and Malawi. Constraints need to be identified and feasible ways found to overcome these constraints.

Research on hybrid pigeonpea will focus on breeding male steriles for use in hybrid seed production. This research has been conducted in close collaboration with the national program in India, and the private sector is interested in the production of hybrid seed.

Crop improvement research on medium- and long-duration pigeonpea is currently in progress with the Indian NARS. Traditional crop improvement, although important, will be a subsidiary activity and could be transferred to the NARSs. ICRISAT's work will concentrate on incorporation of resistance to yield reducers, on strategic studies in entomology, pathology, and virology, and on cell biology.


Pigeonpea

A.A. Majid

Chickpea

Chickpea is a widely used crop with a relatively short history of intensive crop improvement. ICRISAT has the global mandate for chickpea and ICARDA a regional mandate. Thus the two centers share the research responsibilities for this crop. Research on the brown-seeded desi type which accounts for 85% of the world's production (mainly grown in the Indian subcontinent, Pakistan, Ethiopia, and Mexico) is carried out by ICRISAT. ICARDA and ICRISAT both work on the white-seeded kabuli, most popular in the Mediterranean region. Chickpea is grown on small-scale farms as a food and cash crop receiving few or no inputs.

It is an important source of protein where substantial quantities are produced and consumed. Chickpea has a yield potential of over 6 tonnes/ha, but it also has major yield constraints, most of which have been identified. This makes it a challenging but also a very promising crop for genetic and agronomic improvement. The agronomic requirements and the biotic/abiotic stresses are now much better understood than 5 years ago.

Several breakthroughs have been achieved. For instance, the combination of ascochyta blight resistance and frost tolerance enable sowing during the winter season in the West Asia/North Africa (WANA) and Mediterranean region. This results in yield increases from 50 to 100%.

For eastern Africa and the southern part of the Indian subcontinent, short-duration genotypes with resistance to wilt and root rot have been bred. Chickpea can now be grown where it was not profitable earlier and can fit into specific rainfed and irrigated cropping systems.

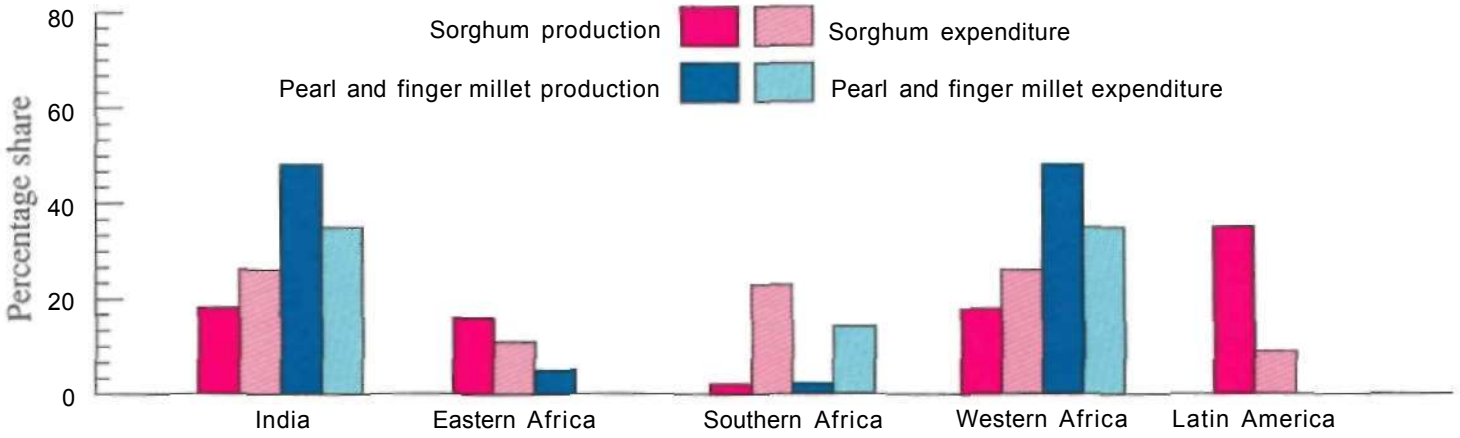
The success with chickpea in Turkey in reducing the fallow period and diversifying the cereal-based cropping system could apply to many countries such as Nepal, northern Pakistan, Iran, Iraq, Ethiopia, and Kenya.

Further progress will be made in the 1990s, especially in enhancing yield stability; adapting the crop to new locations and, most importantly, by improving resistance to abiotic and biotic stresses, so that the high yield potential can indeed be achieved.

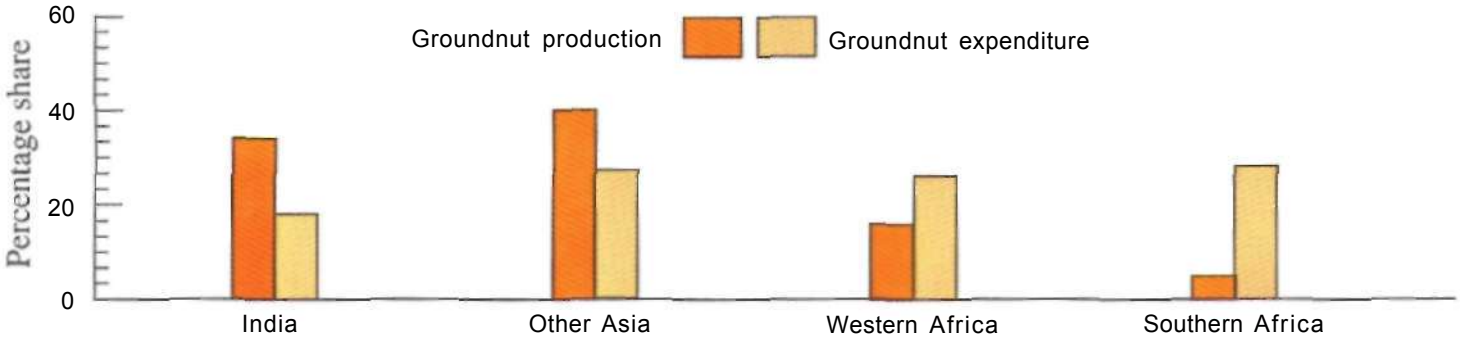
ICRISAT's activities in applied chickpea improvement are extended through the Cereals and Legumes Asia Network (CLAN) and through the East Africa Cereal and Legumes (EARCAL) Network in Ethiopia and Kenya. In cooperation with ICARDA we will continue to exploit the potential of winter-sown chickpea in wheat and barley rotations in the WANA region.


Chickpea

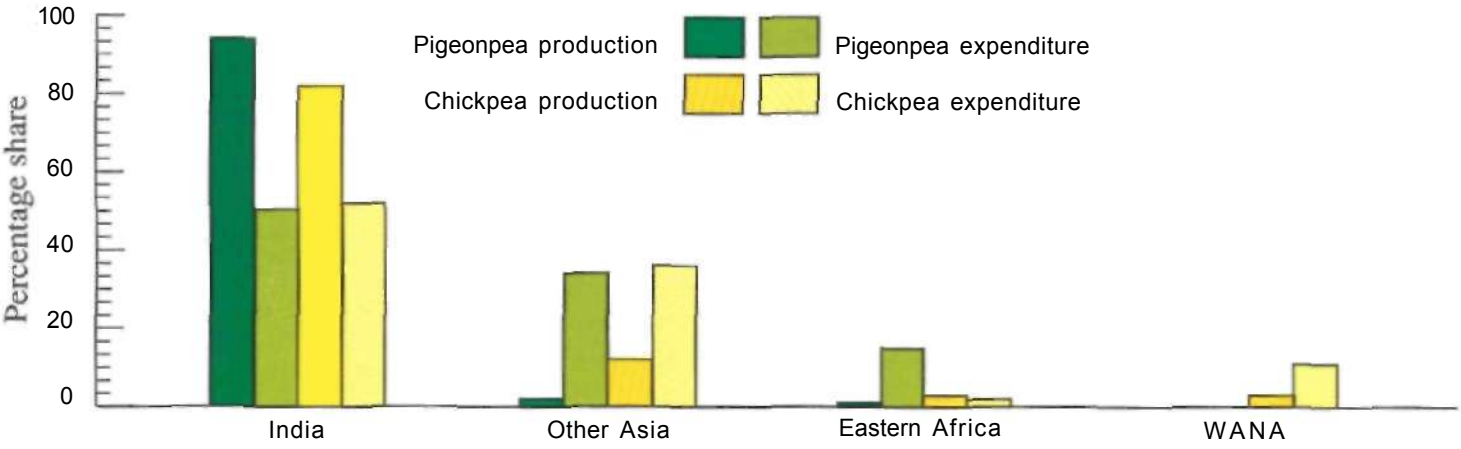
A.A. Majid



Sorghum and millets production and expenditure shares



Groundnut production and expenditure shares



Pigeonpea and chickpea production and expenditure shares

Notes. 1. Data in the above three graphs are from the U.S.Department of Agriculture, and reflect the position in 1991.
2. Expenditure data for sorghum, millets, and groundnut include infrastructural development.
3. Zero data for pearl and finger millet expenditure in Eastern Africa.

Environmental Research

The Environmental Mandate

We find no better definition of our goals for environmental research than the second and third components of ICRISAT's mandate:

- *To develop improved farming systems that will help to increase and stabilize agricultural production through more efficient use of natural and human resources in the seasonally dry semi-arid tropics.*
- *To identify constraints to agricultural development in the semi-arid tropics and evaluate means of alleviating them through technological and institutional changes.*

The identification and management of constraints lies at the center of ICRISAT's work on the environment and on genetically determined responses to environmental factors that set limits to crop production.

As the management of environmental resources is central to ICRISAT's mandate, it was appropriate that the development of experimental watersheds at Patancheru began almost before the Institute opened its gates. Strong farming systems and economics programs evolved during the 1970s and 1980s to deal with the physical and biological components of crop environments and with the economic and social environments of farmers and their families. The merging of those programs into a joint Resource Management Program in 1985—balanced by complementary programs for cereals and legumes—was a major advance in research coordination.

Lessons from the 1970s and 1980s give valuable guidance.

In developing a strategy for environmental research in the 1990s, many lessons can be learned from the successes and failures of the 1970s and 1980s. Technological packages developed on the watersheds at ICRISAT Center gave excellent returns but proved unremunerative when tested at three benchmark villages covering a range of soil types and climates in peninsular India. Corrective action was followed by trials that focused attention on the additional constraints of pests and diseases prevalent on wet Vertisols. ICRISAT's concepts for watershed development and the planning and implementation of programs for dryland agriculture are now being utilized in India.

The management of environmental resources is central to ICRISAT's mandate.

These early trials, on-site and on-farm. demonstrated that consistent yield increases could be achieved by introducing new cultivars into new cropping systems along with better management of the environment. It became clear, however, that an institute with a global mandate could not afford to continue developing large packages of technological practices that needed long periods of testing and adaptation in different environments. Emphasis in managing the environment has therefore shifted from the development of products to the understanding of processes. This provides a basis for ICRISAT's collaboration with national programs on strategies for adaptive research to overcome various constraints to local and regional productivity.

A continuum of research will be extended all the way to utilization in farmers' fields.

At the same time, we must continue diagnostic research and surveys to direct basic research toward resolving the problems faced by farmers in their own fields. We recognize the importance of maintaining a continuum from strategic research to adaptive research and of extending this continuum to the actual utilization of technology. We need to develop a more systematic method for deciding the optimum array of research projects along the continuum at any time and in accordance with the available resources.

Conditions Favoring Environmental Research

Several current indicators favor emphasis on this component of the research strategy.

Improving crop production hinges on effective management of the environment.

First, after a long period in which ICRISAT (like its sister institutions) was able to increase yields of its mandate crops mainly through breeding and the use of fertilizers, further improvements in production will increasingly depend on the evolution of more

effective ways of managing the environment. The practicality of this approach is already evident in the resource management work of the Legumes On-Farm Testing and Nursery (LEGOFTEN) in India, the Cereals and Legumes Asia Network (CLAN) in Asia, and operational scale research in western Africa.

Sustainability

Can agricultural production in the SAT be increased to meet the needs of expanding populations without threatening the resource base on which food supplies depend? This question is addressed throughout this section in terms of soil and water conservation; maintenance of fertility; and diversification of cropping systems for food, fodder, and fuel. The Brundtland Report on "Our Common Future" stresses that environmental degradation has occurred both in the high-input systems of intensive farming (e.g., pollution caused by the excessive use of fertilizer and pesticides) and in low-input subsistence farming (e.g., loss of organic matter through overgrazing and erosion).

We believe farming systems can be developed that increase production, protect environmental resources, use inputs efficiently, and maintain genetic diversity. For example, the application of fertilizer to a nutrient-deficient soil stimulates the growth of leaves that protect the soil surface from impaction by raindrops, and plant material left after harvest contributes to soil organic matter.

ICRISAT recognizes the need to quantify sustainability and to establish protocols for the long-term trials suggested by the TAC Sustainability Committee. Medium- to low-input systems will receive major emphasis. These include water conservation measures in dryland agriculture, integrated nutrient management, and the use of low-cost tools and machinery.

Second, international concern with the sustainability of agricultural production has focused attention on components of the environment endangered by damaging agricultural or industrial practices and on long-term implications for food supplies, particularly in developing countries.

Third, expansion of ICRISAT's work in Africa has opened the way for new environmental research in eastern and southern Africa, complementing—on a smaller scale—the work of the existing resource management team in western Africa.

National programs are keen to work on environmental and sustainability issues.

Fourth, environmental scientists both at ICRISAT Center and at the ICRISAT Sahelian Center already enjoy good relations with national programs keen to develop joint work on the environment in general and on sustainability issues in particular. This partnership is complemented by effective links with mentor institutions offering environmental expertise — e.g., the Soil Conservation Laboratory of the Queensland Department of Primary Industry (Australia) at ICRISAT Center and the Institute of Hydrology (UK) at ISC.

Fifth, ICRISAT already actively collaborates with several CGIAR and nonassociated centers with strong environmental mandates — International Council for Research on Agro-Forestry (ICRAF), International Fertilizer Development Center (IFDC), the International Board of Soil Research and Management (IBSRAM), and the International Benchmark Site Network for Agrotechnology Transfer (IBSNAT). We expect to use joint resources and expertise more effectively with these centers.

The 1990s provide an invigorating climate for environmental research.

ICRISAT's research on environmental problems is therefore evolving in an invigorating climate, favorable in terms of international, and particularly of donor, concerns and priorities. The main challenge in developing a research strategy for this field is to select from a multitude of problems those that appear, at the outset, to be solvable by ICRISAT, and that, if solved, would have substantial regional benefits for rural families in the SAT.

Priorities for research must also take account of ICRISAT's strengths in agroclimatology, agroforestry, land and soil management, microeconomics, and access to benchmark sites for which unique records exist.

The discussion that follows addresses broad strategic issues through a series of questions whose answers provide a basis for assigning research priorities.

Which Regions?

Climate and Soil

Maps of climatic zones and major soil types are a valuable aid to research.

Maps delineating the SAT as a set of climatic zones have appeared in many ICRISAT publications and are complemented by maps of the major soil types on which ICRISAT scientists have worked — mainly Vertisols, Alfisols, and the sandy soils of western Africa. Land capability mapping using geographic information systems will be added, initially for western Africa.

Priorities for environmental research based on an index of regional importance determined by rainfall, soil type, population, area, and the prevalence of one or more mandate crops suggest that emphasis should shift from the deep Vertisols on which much of ICRISAT's early work was concentrated to more difficult soils holding relatively little water, coupled with problems such as crusting and high bulk density. Feasibility and resources of supplemental irrigation should be further investigated.

A shift in emphasis from deep Vertisols to more difficult soils is planned.

Without spreading limited resources too thinly, ICRISAT will maintain a rational balance between developing new technology for the management of light sandy soils in western Africa and Alfisols in Asia, and adapting existing Vertisoi technology to new regions such as Ethiopia. Research on climate and soil in relation to crop production will expand to eastern and southern Africa to support breeding and agronomy, and within Asia to support the Cereals and Legumes Asia Network.

Feasibility

Research will focus on obstinate constraints to productivity.

More attention will be given to environments where one or more constraints to productivity is particularly obstinate. Study of such constraints, including soil quality, will include the likely economic and social consequences of alleviating them. Assessment of feasibility should also include the availability of expertise, physical resources, and funding for ICRISAT and the national research programs, universities, and mentor institutions with which it collaborates.

In addition to feasibility, the strategy for choosing regions for research must include an assessment of the sustainabiliry of existing and potential production systems. A system that currently produces well at the expense of the environment merits as much if not more attention than a sustainable but relatively unproductive system.

Features of Desirability and Feasibility by Region

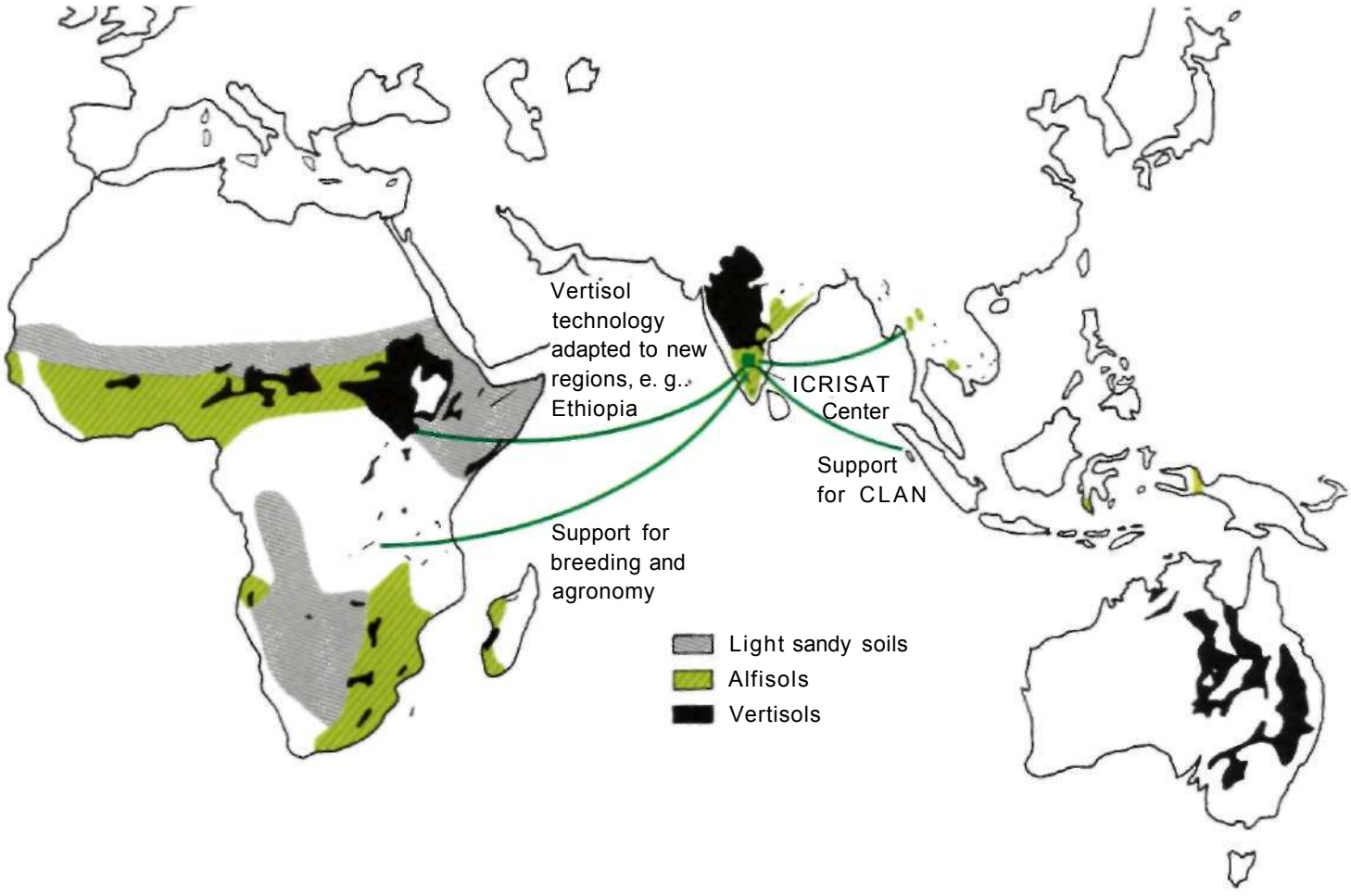
In Africa, we need to improve the targeting of agricultural research to cope with a diversity of climatic, edaphic, demographic, and market environments. Our Resource Management Program will concentrate in the Sahel on the millet-growing area (the southern Sahelian Zone) and the drier sorghum region (the Sudanian Zone). There is scope for expanding the area under agricultural production in parts of the African SAT, but at present these areas are underpopulated and market infrastructure is undeveloped. Elsewhere in Africa, the prospects for technical change depend mainly on the length of the growing season, the availability of supplementary water, or the economic feasibility of crop management solu-

tions. In the wetter SAT, pests and diseases inflict heavy damage on ICRISAT-mandate cereals, especially on sorghum. The somewhat drier Sudanian zone may hold more promise for technical change in sorghum and millets than the wetter regions to the south, and will receive greater attention.

There is increasing demand for biological or chemical innovations in Asia because farmland is scarce.

In Asia, the need for targeting is less pressing than in Africa. Because land is scarce in much of the continent, there is increasing demand for biological or chemical innovations to increase yields. In the low-rainfall, hard-rock regions of peninsular India, irrigated farming that exploits relatively scarce groundwater and farm resources limits the scope of rainfed agriculture. In contrast, in parts of peninsular India that enjoy better climates and soils but have less exploitable groundwater, rainfed farming plays a major role.

To balance the emphasis on feasibility, we believe there is a case for allocating part of our resources to research on cropping systems in parts of the SAT where adaptive research has failed to generate technical change. Good candidates are postrainy-season sorghum and chickpea cultivated on residual soil water where water/nutrient interactions are paramount; and pearl millet grown in dry tracts and exposed to damage by wind and heat.



ICRISAT Center support to the SAT in Africa and Asia.

Which Resources and Constraints?

An important element of our research strategy is the identification and examination of resources that may limit production, particularly those that dominate a specific system in a defined environment. Concentrating on dominant constraints appears to offer the best return for research investment. In practice, however, feasibility, availability of expertise, and demands on resources must all be taken into account.

For presentation, specific constraints are differentiated but their interaction lies at the heart of our work.

Water

Research will tackle problems created by the extremes of water supply.

The central problem of SAT agriculture is the erratic distribution of rainfall. Drought is common but after storms crop growth may be checked by waterlogging or by leaching of nutrients. Research will therefore stress the importance of tackling problems created by extremes of water supply in terms of climate, soil, crop physiology, agronomy, and economics.

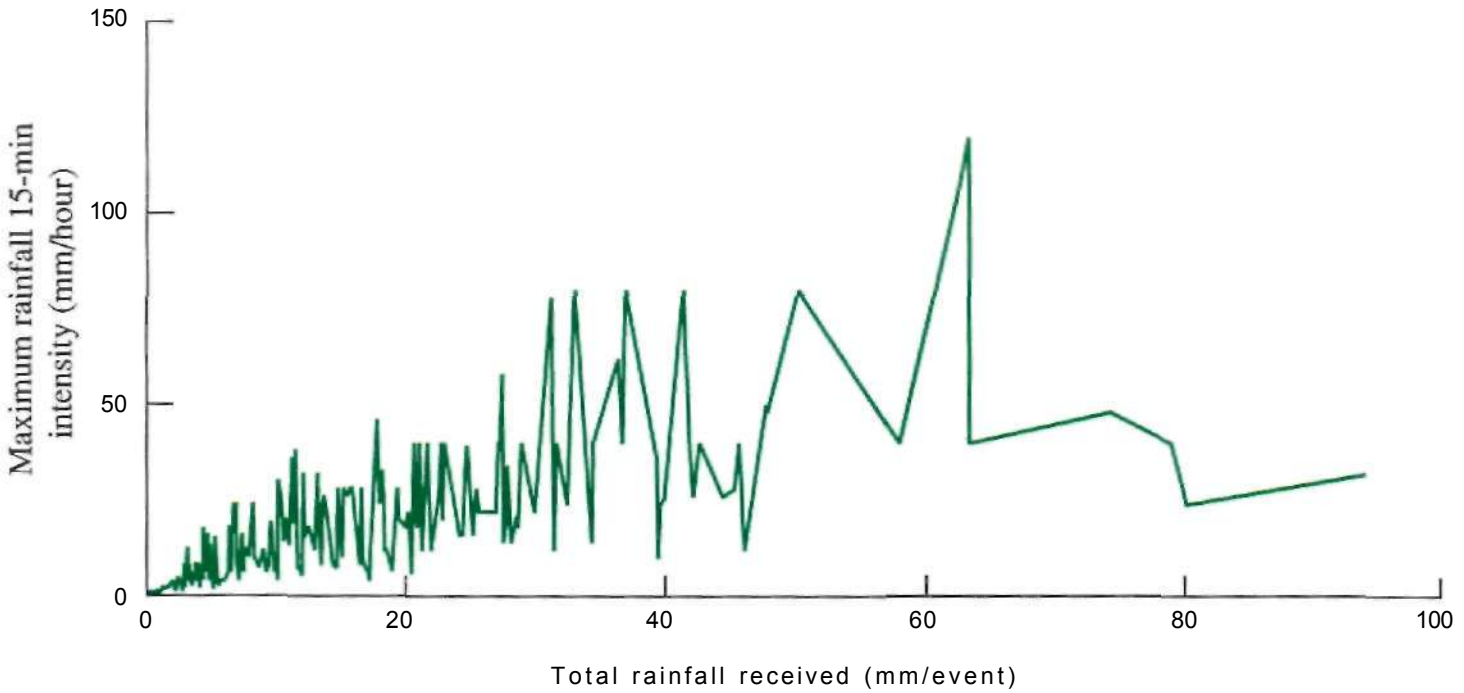
Most of our research on increasing the availability of water to crops will focus on inhibiting runoff and encouraging the development of vigorous root systems. However, many SAT farmers in Asia and Africa have access to limited supplies of water. ICRISAT will therefore be concerned with needs for supplemental irrigation needs (particularly for western Africa), with systems for collecting runoff, and with identifying periods when small applications of water are most effective.

ICRISAT does not have the resources to embark on subsurface hydrology, but will be concerned with institutional aspects of groundwater extraction for agriculture — a sustainability issue of increasing concern in India's SAT. Special attention must be given to the conservation and efficient use of water on the fragmented landholdings of farmers with limited resources, and to the reasons why farmers grow rice or sugarcane using water intended for supplemental irrigation, which can produce more food per unit of water applied.

Climate

Other important climatic constraints are temperature, saturation deficit, and—especially in regions such as Rajasthan and the Sahel—wind as an agent for mechanical damage. Our

Management of water: an absolute necessity in the SAT.



Example of the problem of rainfall variability: 15-minute rainfall intensity events at ICRISAT Center between 1984 and 1988.

strategy will be to coordinate laboratory studies with accurate on-site and on-farm measurements and particularly to explore the extent to which climate can be ameliorated by the use of trees to provide shelter and shade.

Soil

Effective interaction between soil scientists and other specialists promotes prompt action.

Major soil factors other than the availability of water include the tendency of Alfisols to develop a hot, impermeable crust, the availability of major and minor nutrients, and soil pH and salinity. Our strategy recognizes that progress is most rapid when there is effective interaction between soil scientists in the Resource Management Program and physiologists and agronomists throughout the Institute, especially on problems of seedling establishment. Proper attention must be given to whole plants and not simply to tops, which are easier to observe and measure.

In a recent experiment on postrainy-season sorghum grown on a deep Vertisol, we marshalled a large labor force for the time-consuming sampling and analysis of plants, soils, and weather. We shall continue to capitalize on this resource by similar work on other benchmark soils and other mandate crops.

In regard to nutrients, ICRISAT is committed to work on nitrogen and phosphorus in relation to alternative sources, availability to roots, and losses. Much of this work is organized collaboratively with national programs to develop integrated systems of nutrient management. Studies will include projects on pasture legumes and on the management of organic matter.

Basic research is needed on fertility from crop residues in Africa.

We recognize the need to develop more diagnostic research on soil problems to ensure that our program of basic research is appropriately focused. And we anticipate an expansion of our interdisciplinary research on nitrogen and phosphorus, on micronutrient sensitivity, and on problems caused by acidity or alkalinity. The improvement of fertility following the application of crop residues will receive particular attention in western Africa where basic research is needed to understand what physical or biological mechanisms are involved and what economic factors determine the relative value of residues for grazing and for soil amendment.

Pests and Diseases

Detailed study of the interaction of pests and diseases with the environment is necessary.

The pests, diseases, and weeds that reduce yields of ICRISAT mandate crops have life cycles and behavior patterns strongly dependent on the state of the environment—temperature, relative humidity, leaf wetness, soil moisture, etc. This field of research has expanded with new staff appointments and will concentrate initially on the influence of climate and microclimate on important diseases and pests, including nematodes that have recently been recognized as a major cause of yield reduction of our mandate crops in the SAT. Together with scientists in national systems, we will monitor the problems of diseases, pests, and weeds in various cropping systems in different agroclimatic zones of the SAT Soil biology will be developed as an additional discipline to link the work of soil scientists with the crop programs.

Labor and Employment

Labor-intensive technologies are needed where populations are expanding rapidly.

In the unmeehanized farming systems of the SAT many crop operations depend on human labor alone, which provides employment, and thus income, for landless laborers and farm families. With limits to arable land in many SAT countries, the capacity of agriculture to

absorb the growing rural labor force—thus providing income and stemming the flood of migrants to the cities—will depend on the capacity of land-use systems to provide employment. We will therefore emphasize research on remunerative cropping systems for areas of the SAT that are land-scarce and labor-abundant; and we will refrain from research that might threaten the widespread substitution of mechanical for human labor.

Exposing roots for detailed measurement.

Farming in the Sahel: family labor and draft power.

Although physical effort is an important component of production in SAT agriculture, skills and production knowledge must not be ignored. Traditional skills are often unrelated to new technology and may limit its adoption. The characterization of traditional skills will therefore receive more attention to allow us to assess prospects for the adoption of more complex technologies.

Rural poverty results from the chronic lack of gainful employment. The best opportunity of employment for the rural poor is often to exploit common property and open-access resources to such an extent that the resource base is threatened. We will explore strategies for alleviating this form of pressure on resources.

Institutions and Policies

The institutional environment must be understood to implement sustainable production systems.

Social institutions, such as property rights, social customs, and traditional norms of good conduct, facilitate economic exchange, allow the coordination of economic activities, and affect the distribution of income. However, as previously abundant resources become scarce due to population growth, resource degradation, or technological change, the autonomous adaptation of institutions to govern their exchange typically lags behind. Examples are the often incompletely specified land titles in sub-Saharan Africa, the total absence of rights to groundwater in India, and the erosion of institutions governing the use of common property and open-access resources within the SAT.

To implement sustainable agricultural production for which cooperation between individuals is often essential, the institutional environment must be understood. As this is largely new territory for us, we will conduct pilot studies initially, and will seek cooperation with other research organizations, such as the International Food Policy Research Institute (IFPRI). Government policies affect the private allocation of production resources and may distort production patterns. The broad impact of price and trade policies on supply, demand, and income, is better examined by specialized national and international research institutes. We will concern ourselves with such studies only when our initiatives are indispensable.

Which Systems of Production?

Strategies for the selection of crops and cropping systems will be determined by assessing the extent to which they will:

- *make efficient use of limited rainfall and nutrients;*
- *provide farmers with multiple outputs—food, fodder, fuel, and fiber (both for farm consumption and as sources of income);*
- *avoid degrading the environment.*

We therefore intend to explore the potential of a range of cropping systems in which our mandate crops are associated not only with other cereals and legumes but with complementary cash crops, such as cotton. Choosing the best cropping system for a given environment calls for a very careful assessment of physical, biological, and economic constraints.

Crop systems

Balancing environmental resources among intercropped species is applicable to both trees and crops.

To achieve consistent yields, annual crops in the semi-arid tropics must fit the distribution of rainfall and regimes of temperature and daylength. Our strategy is to design and test systems of cropping, including pastures, that make the most effective use of rainfall, however it is distributed during the season. In the Sahel, where the onset of the rains and the duration of the rainy season are highly correlated, we will experiment with contingent

cropping systems to exploit water available in wetter years. In this area of research, ICRISAT will combine the expertise of breeders, agronomists, and agroclimatologists.

In the Sahel, an improved millet/cowpea system developed at ISC to match a very undependable rainfall regime is now being tested on an operational scale by several national programs, and expansion to others is planned. Other grain legumes and pasture legumes have been introduced to diversify cropping systems. Also in the Sahel, collaboration with the International Livestock Centre for Africa (ILCA) and ICRAF over the next decade will be directed at developing systems combining crops, trees, and animals to maintain ecological equilibrium.

In the rice-growing regions of the SAT, there is an urgent need to diversify and intensify cropping on rice fallows and in upland rice systems by using legumes. This research is conducted in India with support from the Indian Council of Agricultural Research and in the rest of Asia through the Cereals and Legumes Asia Network.

Agroforestry

Fish-eye view of agroforestry research.

Research on agroforestry is a logical extension of our earlier experience with intercropping. We will continue to seek general principles that govern competition for environmental resources among intercropped species and use these principles to exploit genetic variation of both crop and tree species. We will also monitor long-term changes in soil properties.

At ICRISAT Center, special attention will be given to the potential of perennial pigeonpea as a woody species providing food, fodder, and fuel. At the Sahelian Center, scientists will work on the effectiveness of shelter belts to protect seedlings against wind erosion and on genetic variation of indigenous species (e.g., *Faidherbia albida).* At both centers, agroforestry will be closely associated with the work of national programs, with ICRAF, and with regional networks such as Forestry/Fuelwood Research and Development in Asia and Agroforestry Research Networks for Africa.

ICRISAT believes that its agroforestry program will benefit from the adoption of forestry by the CGIAR. but the Institute will not become involved with work on trees unrelated to food or fodder production.

As we recognize the need to strengthen the capacity of Sahelian national programs to undertake agroforestry research, we have requested funds from the Government of Japan for degree training of a cadre of Sahelian scientists.

Which Time Scales?

Each research project has a time scale, from less than a year to a decade or more.

Our environmental research operates on three time scales: less than 1 year (seasonal); a few years (annual); and a decade or more (secular). Each time scale is associated with a particular style of research, and the scale of a project determines the resources needed to reach valid conclusions.

Seasonal

In most of the environments where ICRISAT is currently operating, environmental changes within a growing season are mainly a consequence of rainfall. We shall extend work *on* the analysis *of* rainfall probabilities *in different ecological* regions and *use them* in models of water balance to estimate seasonal differences in the amount of water available to crops in different soils. Associated with rainfall distribution are seasonal

changes of temperature and humidity, which affect seedling establishment, phenology, water-use efficiency, and the epidemiology of fungal diseases and pests. We must therefore develop more efficient networking to make information on all aspects of seasonal climate readily available to crop scientists throughout ICRISAT and within national research systems.

Seasonal: less than 1 year
Annual: a few years
Secular: a decade or more

Annual

There is usually a carryover from one season to another in soil conditions, the potential for pests and disease epidemics, and the resources of farming families. We have used annual differences of yield chiefly to assess the relative stability of cultivars (or short-term success or failure of treatments), and to provide material for testing models of crop growth or water balance. In the future, we need to give more attention to fluctuations in output and ways in which they can be buffered, as demonstrated in the analysis of regional differences in response to drought in western Africa.

Secular

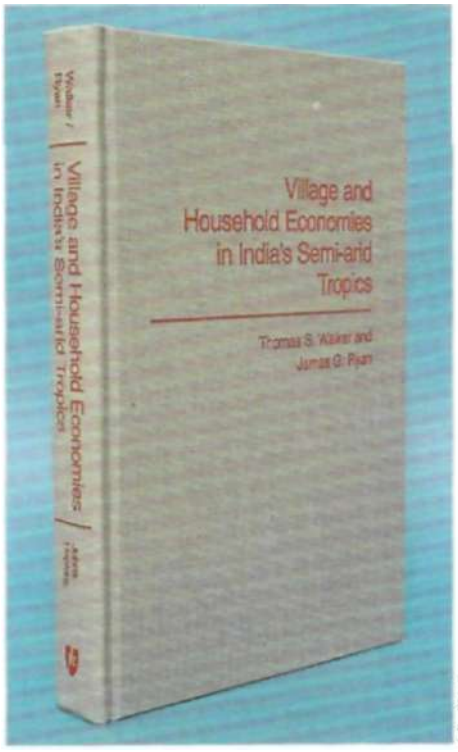
Because climate is never static, we must monitor our records carefully over the next decade to assess the extent to which various climates in the SAT may be changing. However, changes attributable to the so-called "greenhouse effect" are unlikely to be expressed unequivocally during the next decade. The best way to prepare for climatic change is to seek better understanding of how existing agricultural systems respond to significant weather variations in consecutive seasons.

In contrast, changes of land use in the SAT are well-documented. Over the past 30 years, about 30% more land has been brought into intensive cultivation. Much of this area was formerly forest or grazing land and its resources are now threatened by erosion and loss of fertility.

Secular changes in economic and social environments have been well-documented in our village-level studies in both India and western Africa. Our future strategy is to conduct broader inquiries both in space and time on farming practices in the SAT as a basis for more effective targeting of research. We shall also continue to monitor some of our study villages to identify factors that condition agricultural and economic development.

We shall focus on secular changes in the environment that are man-made, particularly if they are irreversible in terms of human time scales (e.g., erosion) or a threat to the health of people or livestock. This is the core of our concern for the sustainability of agricultural systems. Our work must be carefully coordinated with activities in other CG institutes through the CG Working Group and national programs. Candidate topics that match current expertise are the design of cost-effective land management systems that reduce erosion, the maintenance of fertility through integrated nutrient management, and integrated pest management.

In many trials, measurements needed as a basis for planning and corrective action will need to continue over a decade or more. Implications for the long-term allocation of research resources are clear: donors who have advocated more research on sustainability must be persuaded that long-term support is essential for success. Similarly, national programs must be persuaded to monitor environmental changes that may extend well beyond the lifetime of the CG system.



Published secular research data.

Staff of the Resource Management Program and Information Services

Towards sustainability: ICRISAT research and field evidence from South Asia and Africa.

Assessment Research

General Issues in Technology Assessment

ICRISAT's principal products include breeding lines, cultivars, screening and breeding methods, and farming practices. Historically, most assessments and reviews of ICRISAT products have taken place during the technology development phase. These include in-house project reviews, annual project progress reports, reviews of regional programs by program/executive directors, external research unit reviews by consultants, and external program reviews by panels of experts.

Positive findings, however, do not mean success unless they are put to use by our scientist partners and SAT farmers. A more systematic evaluation of the diffusion and impact of ICRISAT outputs is therefore central to technology assessment. Case studies of technological components and packages and documentation of the diffusion of plant material and information—currently the primary means of assessment at the transfer phase—are insufficient.

Systematic evaluation of impact is essential to technology assessment.

Improved systematic evaluation of the effectiveness of ICRISAT inputs into strengthening national programs is critical. Technological and institutional assessment is especially useful for regional research programs and networks.

Impact

Widely Grown Pearl Millet Cultivars

A downy mildew-resistant pearl millet cultivar, WC-C75. was released in India in 1982 when hybrids became susceptible to this devastating disease. Eight years later, WC-C75 remains resistant to downy mildew, and it is now one of the most popular open-pollinated pearl millet varieties in India. WC-C75 will he grown in India on over I million hectares in 1991.

When hybrid MBH 110 exhibited susceptibility to downy mildew in 1989. ICRISAT variety ICTP 8203 was released as an alternative. The same year. it was extensively grown in Maharashtra, and 200 tonnes of ICTP 8203 seed were produced in Namibia for distribution to farmers.

Pearl millet variety ITMV 8001. which was released in Niger in 1985. is rapidly replacing local cultivars in the African Sahel. It is estimated that ITMV 8001 was grown in 50 000 hectares in Chad in 1989.

Hybrid ICMH 451 was released in 1988 and is presently grown on over I million hectares in India.

Pearl millet hybrids HHB 50 and Pusa 23. which were bred by the Indian national program in 1988. arc based on ICRISAT-bred seed parents. They arc adapted to the arid northwest of India where most of the pearl millet in the subcontinent is grown. grown.

WC-C75: an Indian success story.

Incentives and Organization for Assessment

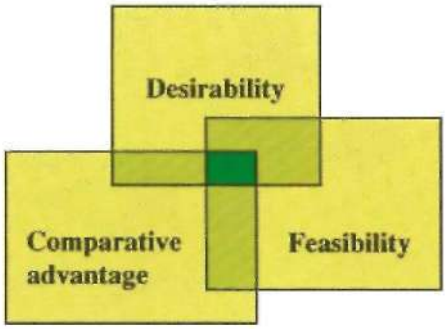
Incentives for conducting research on research within the CGIAR are weak (ISNAR is probably the exception because assessment is important to its mandate). In spite of its recommendations, the CGIAR's multivolume Impact Study did not lead directly to increased resource allocations for such research. One of the few institutional incentives for

impact appraisal is the prestigious King Baudouin Award, presented biennially. Few other incentives exist for increasing investment in research on research, which some scientists unfortunately view as competition for scarce resources. Although the scope for greater monetary award for scientific achievement is limited, the potential recognition of such achievement should be fully exploited.

To stimulate more investment in technology assessment, ICRISAT will attempt to make budgetary allocations more in line with documented past and projected future impact. Program directors will be expected to support the processes that reward research showing high historical or expected impact, and scientists should have confidence in the system of allocating funds according to perceived impact.

A simple organizational modification is unlikely to substantially improve the scope for technology assessment without a fundamental change in the incentive structure. For example, a separate technology assessment wing would lead to compartmentalization, inhibiting evaluations. In order to derive implications for future research and transfer, scientists involved in generating and exchanging technology should be involved in its assessment through decentralized, interdisciplinary research within the program from which the technology is generated. However, the need for unbiased assessment requires that assessment teams include staff from outside the concerned program.

Criteria for Assessment



Assessment research is essential for establishing priorities. The criteria used in technology assessment can be classified into three broad groups: desirability, feasibility, and comparative advantage.

Desirability refers to the consequences of technical change on economic growth, on equity in the distribution of benefits across social groups and geographic regions, on nutritional status and food security, and on sustainability.

Feasibility refers to the potential for breakthrough or technological success, cost-effectiveness, and the time frame of research.

Comparative advantage, for an IARC such as ICRISAT, refers to incentives for research between the public and private sector; to the international scale of the research and the scope for spillover benefits; and to the complementarity of the research effort with national programs, associate centers, regional research organizations and networks, and other CG Centers.

These three groups overlap. For example, economic growth is also linked to several criteria under feasibility and comparative advantage.

In the past, desirability has been the major criterion for ICRISAT's investment decisions on research. This emphasis is reflected in the relatively large allocation of research resources to varieties rather than hybrids, to crop and resource management research in the Sahel, and in past allocations to associated nitrogen fixation in cereals in India.

Strict adherence to desirability criteria could result in the neglect of opportunities for technical change. In the future, feasibility and comparative advantage will play as important a role as desirability in allocating resources to research.

Because agricultural research has a long gestation period and is conditioned by a changing economic, political, and institutional environment, prior targets may have lost their relevance by the time results are achieved and disseminated. Furthermore, studies have conclusively shown that agricultural research within a commodity or agroecological system does not have much leverage on equity, nutritional status, or food security.

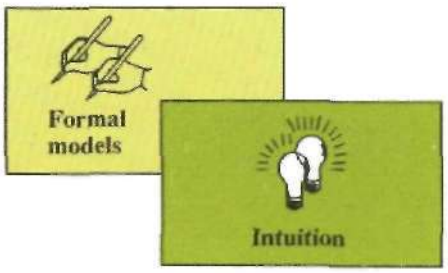
Policies aimed at enhancing the performance of inputs and making credit markets more accessible to farmers will achieve better distribution of the benefits of technological change than attempts to design specialized technologies for targeted societal groups. The national research systems are in a much better position than the international centers to assemble information and to make decisions on location-specific targeting.

Formal Models and Intuition

Formal models of research assessment attempt to order subjectivity through consistency and logic by relying on scoring techniques, the economics concept of supply and demand, "consistent" decision software, and interactive "expert systems." Declining budgets often beget greater emphasis on accountability, which in turn increases the demand for formal modeling. Yet few agricultural research organizations use formal models to decide on resource allocation because of their poor track records, excessive costs, or the uncertainty of agricultural research.

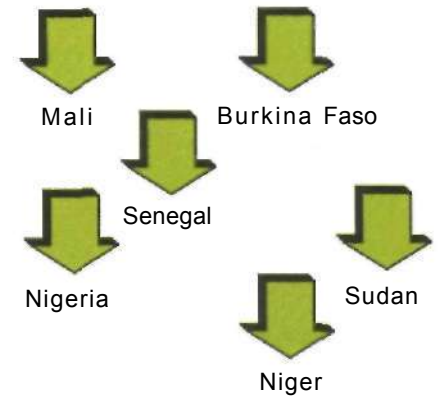
Although ICRISAT research administrators have used formal models in decision-making on research expenditure since 1972, they have not relied on them. Intuition and expert opinion have always played leading roles in our research investment decisions. But we have recently decided to spend more resources on research on research, and we will use this opportunity to do more research on the economics of research and development.

More systematic ordering of intuition is a priority. In particular, more reckoning of the probability of success and its expected benefits are needed in proposed projects to ensure that work is not carried out on problems of minor importance. To achieve that aim, more and better information on the size of yield reducers and productivity constraints is required. Formal models based on economics concepts — i.e., models structured to provide an expected value to new information or to supply curve shifts — are preferred to others that merely order preferences in a consistent manner.



Learning from experience:

Africa 1975:
dispersed model



Now:

regional approach

ICRISAT Sahelian Center, Niger

Pearl millet
Groundnut
Resource management

Nigeria Team

Sorghum

Mali Team

Sorghum

The Usefulness of Ex-Post Evaluation

ICRISAT has used both ex-ante and ex-post evaluation in its planning and assessment of research. Ex-ante evaluation attempts to predict, on the basis of certain assumptions, the consequences of planned research. Ex-post evaluates the results of completed research to determine reasons for its success or failure. We find ex-post evaluation the more useful tool in planning future research and are using it increasingly over ex-ante evaluation.

Negative results are unsuccessful only when scientists and research administrators fail to document and incorporate information from such an experience into future work plans and investment decisions. Nor should impact evaluation be restricted to ICRISAT-related technical change; much can be learned from the documentation of other successes and failures in SAT agriculture, such as the introduction and diffusion of soybean in the rainy season fallows of central India.

Data problems encountered in ex-post analysis are much greater in Africa, where infrastructure is less developed than in Asia. Consequently, the need to verify information is more pressing. We have commenced some rapid rural surveys to gather preliminary information on ICRISAT-related varietal change in western Africa.

Decision-Making Considerations in Research Resource Allocation

The Commodity Mandate

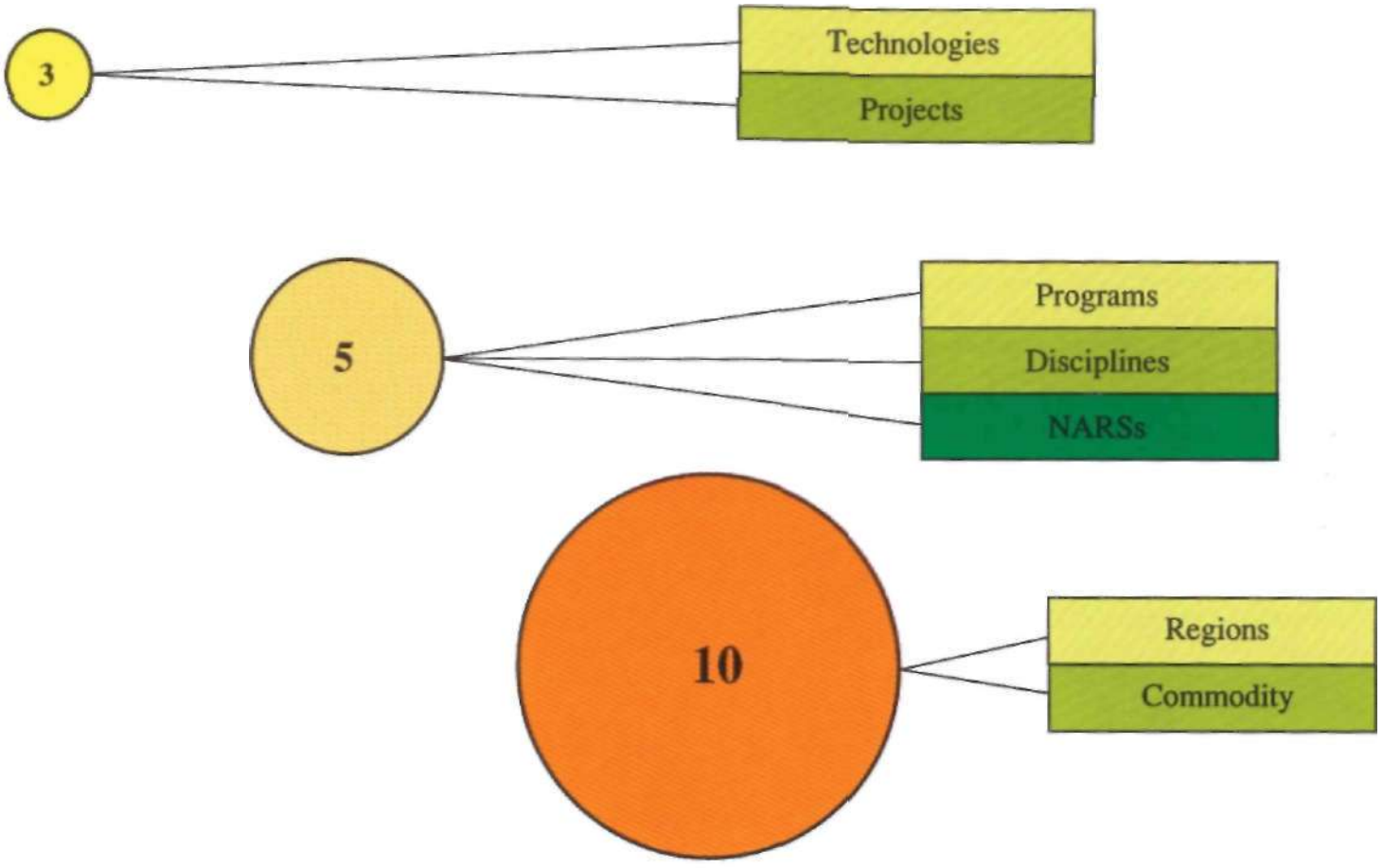
ICRISAT's commodity mandate is amenable to change, as demonstrated by the addition of groundnut in 1974. Most scientists and administrators recognize that an immutable crop mandate is not in the best interest of rural people in the SAT. Although executive decisions on IARC crop mandates must continue to be taken at the highest levels of the CGIAR system, the centers' roles in determining crop mandates should be leading ones.

In an IARC such as ICRISAT with a fixed area mandate and commodity mandates involving a plant breeding component, 15 years is a reasonable period of time for an initial assessment of the crop's demand and supply prospects for technical change within the

SAT. Although the present mechanism of the external program review appears appropriate, greater in-depth evaluation of the existing commodity mandate and alternatives are necessary than can be provided through the existing mechanisms of external reviews.

ICRISAT's crop mandates have existed for a decade or longer. Because information concerning them is more available and reliable than when the mandate decisions were initially taken, more informed decision-making is now possible. Nevertheless, information is far from perfect and decision-making on a crop mandate requires a great deal of judgment. For example, secondary data compiled on a regional or national basis are often deficient concerning the production of specific coarse grains, pulses, and oilseeds—the commodities of comparative advantage in the SAT.

The considerations influencing an IARC's decision to invest in a crop include prospects for technical success, potential demand, possible spillover benefits, the state of private and public sector research in both developed and developing countries, and political considerations affecting core funding by donors. Given the limitations of data and the importance of considering multiple criteria, the need for commissioning crop-specific expertise on the modifications under consideration and for setting a proper time horizon are obvious. Although ICRISAT scientists and research administrators are in a good position to evaluate potential modifications to the crop mandate, a focused analysis should rely on a blue ribbon panel that includes outside experts.



Assessment of research.

Note: The frequency of assessment in years is given in bold.

Regions

Decisions on regional resource allocation raise thorny considerations. We must perform a juggling act to satisfy partners of dramatically disparate strengths and interests. The choice of locations for experimental sites will inevitably be made on the basis of administrative feasibility, since political and social concerns in some SAT countries preclude site selection based on either desirability or comparative advantage. Correspondingly, we must face difficult decisions concerning the regional locus of research (on-farm, on-station, or laboratory), as well as the number and location of subcenters. In most cases, the answers must depend on comparative advantage.

The justification for regional emphases are part and parcel of an institute's long-term research strategy. Consideration of regional deployment should be reviewed simultaneously with mandate reviews once every 10 years. Two guidelines will improve decision-making in this difficult area.

First, the expertise existing within the Institute needs to be marshalled more systematically to ensure that decisions are based on the best available information. Similarly, more information on constraints on decision-making should be communicated to staff who have a stake in the outcome although they don't take part in the decisions.

Second, the regional distribution of ICRISAT's budget within its mandate crops should be related to the region's share of production within the SAT. Deviations should be justified, for example, in terms of spillover effects to other regions or regionally different technological feasibilities.

Budgets should be related to regions' share of production.

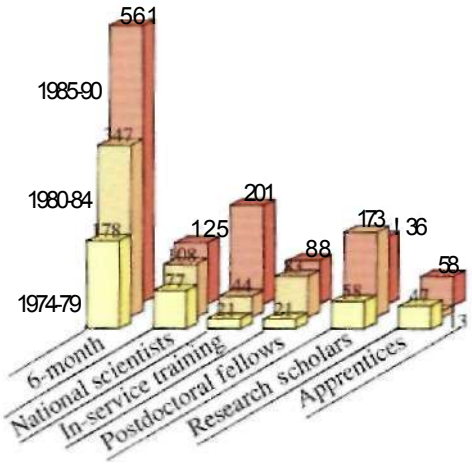
Programs

ICRISAT invests in various scientific disciplines that work within each program through a variety of projects. Because the basis of our research is administered at program level, the disciplines contributing to the Cereals, Legumes, and Resource Management programs should be fully assessed at a global in-house review every 5 years. The decision to invest in particular disciplines is based on perceptions of constraints or problems limiting productivity. Considerations of comparative advantage or available expertise within national programs and the private sector can also be important in decisions about disciplinary research resource allocation.

These reviews should be scheduled prior to external program reviews and should include representatives from all ICRISAT locations, regional representatives of national programs, and other consultants. Each review should serve as a forum in which ideas concerning change are consolidated to form a strategy for the next 5-year period.

Internal in-house reviews should be held every 2 to 3 years at each center or within each program to assess current and proposed projects within or across disciplines for their progress, scientific content, methodology, and potential impact.

Progress within projects should continue to be measured during annual planning meetings.



Numbers of training participants.

Human Resource Development

Rationale

ICRISAT believes in close partnership with the national programs. We are judged not only by increased output of our mandate crops, but by our assistance in developing the capabilities of the national programs to solve their own agricultural problems. Because ICRISAT has a great deal of pertinent knowledge and skill to transfer to the national programs, assisting them in their human resource development will continue to merit high priority.

Issues

Training Needs of National Programs

Our perceptions of the human resource needs of national programs have been based on the number of nominations for training at ICRISAT, input from ICRISAT scientists, and the recommendations of workshops rather than on the identified needs of the national programs. In the future we will use surveys and discussions with the national programs to identify their needs for human resource activities related to our mandate.

Better feedback from NARSs is planned so that we can provide what is needed.

Training and research needs of the programs will be considered together and not as separate exercises. Because ICRISAT can meet only a small fraction of the many training needs of the SAT countries, we will assign priorities to their requests in relation to ICRISAT's major thrusts, and cooperate with other IARCs and the stronger NARSs to secure sufficient funds for appropriate training opportunities.

Broader Approach to Training

Present in-service training is oriented towards experiment station research and research methodology for our mandate crops. Since individual national program scientists are responsible for a wide range of crops and duties, a systems approach will be encouraged in our training programs. Participants will be given adequate exposure in our courses to the constraints to technology adoption and use that exist at the farm level and to issues of sustainable agriculture in the SAT.

Coordination of Human Resource Programs

Coordination of all our training programs is vital.

Excellent opportunities exist for close support and coordination between ICRISAT Center and the regional programs. Increased opportunities for training staff and scientists will maximize our capacity to meet training needs where local experts are unavailable. Local resource personnel, especially from universities, will be utilized to promote regional effort and pool resources, and to avoid duplication.

Intercenter Cooperation

Human resource development of the national programs requires a holistic approach that goes beyond the mandates and capacities of individual commodity centers. IARCs generally plan and conduct their training separately, even though their methodologies are similar and their mandate areas overlap in some regions. Greater intercenter coordination in determining training needs and in planning courses of common interest would benefit

national programs. ICRISAT supports the recent efforts of the centers to collaborate in identifying lead centers for organizing and conducting common courses, such as experiment station management, on-farm research, agroclimatology, and agroforestry. These cooperative efforts will make maximum use of resources and help to avoid excessive disruption of the normal functioning of the national programs.

Cooperation with Universities

Universities play an important role in human resources development for national research programs in the SAT. To augment and complement their activities, we will expand our links with them and develop cooperative programs in human resource development for individual countries or regions.

Training of Women

Given the importance of women in agriculture, particularly in Africa, ICRISAT increased the number of women participants in its training programs from 10% in 1980 to 21% in 1989. This trend will be further improved by a determined effort to identify and encourage women to participate in our training activities.

In-Country Training

Recent experiences in organizing in-country crop monitoring tours and specialized courses revealed the opportunity for achieving more significant impact on local research personnel by orienting the training towards particular needs and practices in a country. We will expand in-country training (particularly in Asia) using local experts as resource staff, including earlier training participants at ICRISAT, to strengthen the training capacity of the national programs.

Courses

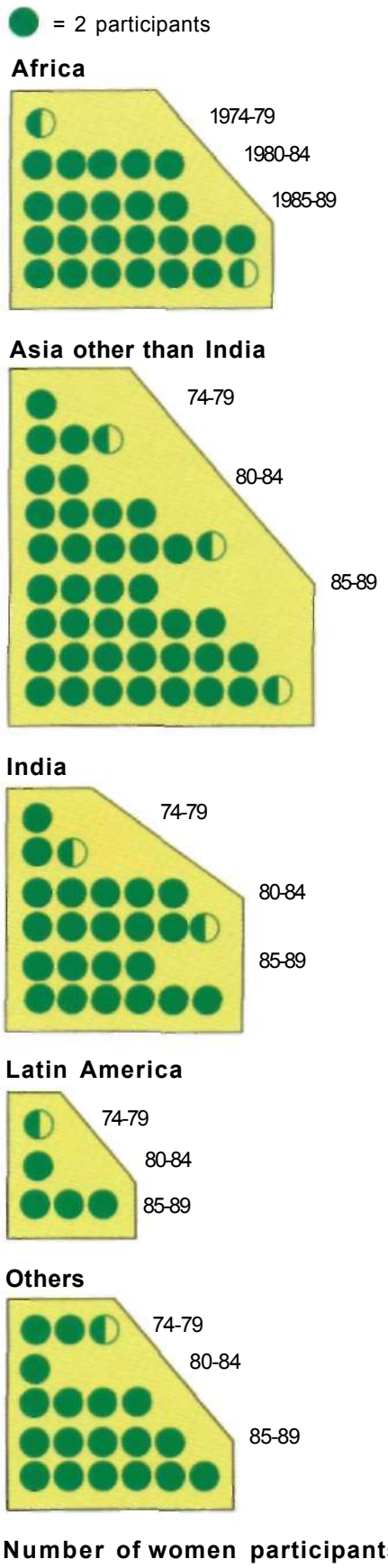
Full-Season Group Courses

Full-season group courses (6 months) in Production Agronomy, Crop Improvement, and Resource Management will be reduced. ICRISAT has contributed to a high demand for in-service training of technical staff for 15 years. For some countries, however, the need for this kind of training is becoming less urgent than their need for scientists. In addition, larger national programs, assisted by international centers and local universities, should be developing the capacity to carry out such training for themselves and perhaps for some of their neighbors.

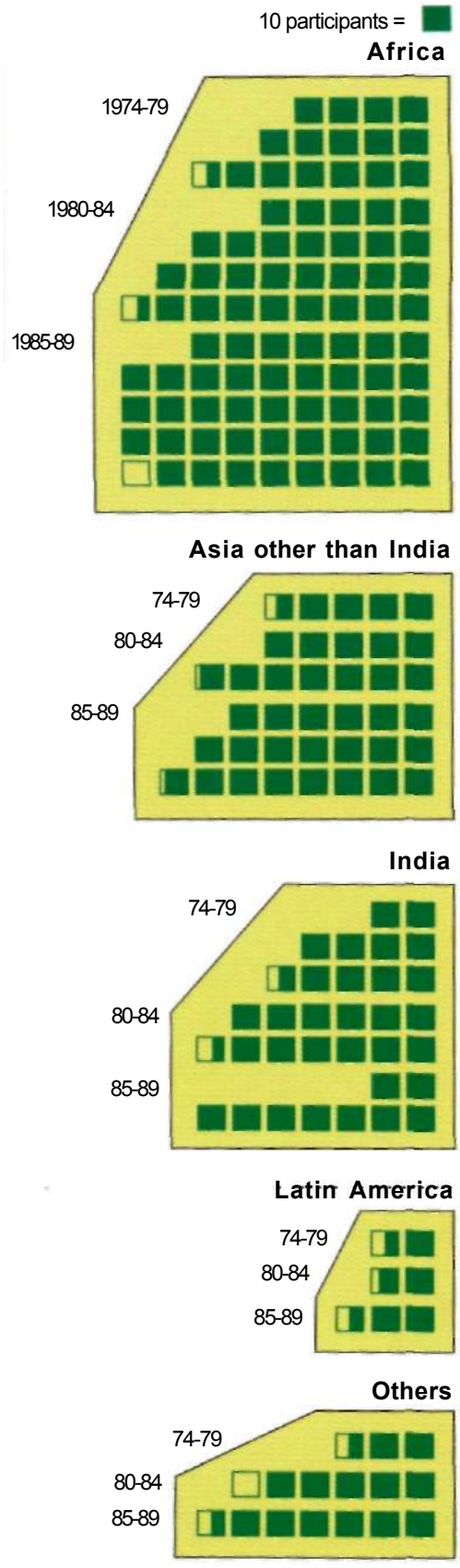
ICRISAT will redress its division of effort between large-scale, in-service training and specialized scientist training. We will examine the efficacy of conducting such in-service training in collaboration with larger national programs, other IARCs, or regional programs. This review will be conducted in close consultation with national programs.

Specialized Short-Term Courses

Specialized short-term courses in specific disciplines provided at ICRISAT Center, the regional centers, and in in-country groups will continue to be offered to meet the growing needs of national programs for new techniques and technologies. Special emphasis will be given to a course in experiment station management in cooperation with other IARCs, and training in efficient management of resources for sustained agricultural production in the SAT.



Number of women participants.



Number of training participants.

Scholarships and Fellowships

Degree Scholarships

There is a continuing demand by national research programs in the SAT for degree-level education. ICRISAT has in the past provided only research opportunities for graduate students at its centers. Undergraduate education has been supported only under special bilateral projects with individual countries or regional organizations. Because such opportunities for national research staff are few, we will endeavor to provide full degree scholarships to the extent possible, and simultaneously work *to expand joint* programs with national programs, universities, and donors.

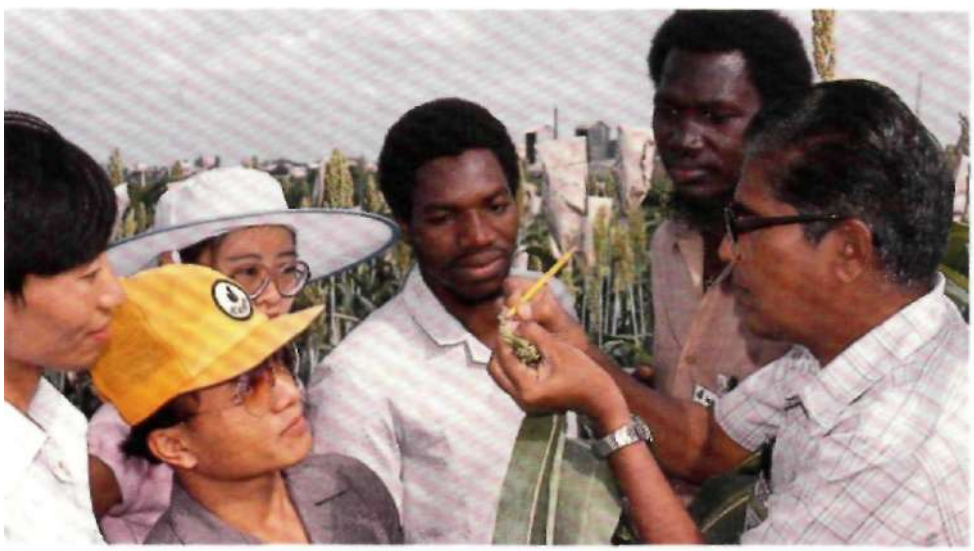
Postdoctoral Fellowships

ICRISAT's postdoctoral fellowships provide recent PhDs with research experience before assuming research positions. Most of the postdoctoral fellows in the SAT have come from India and many from non-SAT countries. Demand from Africa and the rest of Asia has been sporadic and low. We will develop an action program to attract more candidates from these countries to come to ICRISAT.

Senior Fellowships

These fellowships enable national and university scientists in mid-career to work alongside ICRISAT scientists, improving their skills and promoting closer understanding and development of long-term comradeship. Asian national programs and some in Africa have developed considerable strength in recent years and will benefit more from senior fellowships than from lower levels of human resource development. ICRISAT has a great deal to offer and to gain from closer professional and personal relationships with such scientists.

Our present in-service fellowship has not attracted senior national program scientists in expected numbers due to the low level of financial support and status accorded to it. We will establish a new category of Senior Fellowships for more senior national program scientists based on a competitive international standard. Stipends will be commensurate with qualifications and experience. Staff exchanges between ICRISAT Center and national programs will be undertaken for mutual benefit of scientists.



Learning breeding techniques at ICRISAT Center.

Technology Exchange

ICRISAT's assessment of and response to national program needs through technical cooperation, technology transfer, and information are embodied in the fourth component of its mandate: *Assist in the development and transfer of technology to the farmer through cooperation with national and regional research programs, and by sponsoring workshops and conferences, operating training programs, and assisting extension activities.*

Assessing National Research System Needs

Bilateral Agreements

Our goal is to strengthen the research capabilities of individual national systems and to help them participate fully in regional cooperative research networks. Our strategy is to balance our bilateral and multilateral commitments with our regional and global responsibilities for research and technical cooperation.

In our bilateral associations with individual countries in a region, we will try to focus on priority problems involving ICRISAT's mandate in each country, taking into account each country's research capabilities, government policies, and donor requirements. The interaction will be based upon memoranda of understanding and work plans. This approach permits bilateral arrangements to be logically grouped into multilateral regional arrangements (such as SADCC and the Cereals and Legumes Asia Network), thus providing strong feedback from national programs to us and to each other and ensuring that our research programs remain relevant to their needs.

Effective networks are created by logically grouping bilateral associations into regional arrangements.

Participation in National/Regional Planning Meetings

National and regional planning meetings are attended by key personnel in crop improvement, production and utilization who plan annual or long-term strategies for their countries. The invitation of ICRISAT personnel to such meetings has been limited in the past. We will take the initiative to ensure our participation in future meetings to listen and learn, and to explain the catalytic role we can sometimes play in addressing national problems.

Participation in Country Meetings on Commodities

Many SAT countries hold coordinating meetings on special crops for research and development projects. ICRISAT regularly participates in such meetings in India on invitation and this cooperation is widely appreciated and of mutual benefit. Our staff will participate whenever it is possible in such meetings elsewhere upon request.

We will improve our database on NARSs' needs through closer participation in sun'eys and meetings.

It is obvious that occasional trips undertaken by ICRISAT staff during one cropping season will generate limited information concerning crop production, constraints, or research needs. Long-term surveys conducted jointly by ICRISAT and national program staff are more useful, enhance partner relationships and provide first-hand information about countries' agricultures. On occasion, it may be necessary to contract surveys to outside agencies for specific purposes. Such surveys will clearly describe not only the physical and biotic constraints to productivity, but government policy, socioeconomics, and supply and demand, with a focus on farmers' experiences of market forces.

Visits from national agricultural research directors to ICRISAT locations are important for obtaining feedback. During the past 5 years, 30 research directors from African countries have visited ICRISAT Center to review our activities and exchange ideas about

Visits of national research directors to ICRISAT locations bring important feedback.

Examples of Technology Exchange

1. Technical Cooperation

- ***Research Networking.*** *ICRISAT works with active networks for cereals and legumes in Asia, sorghum and millet in western and eastern Africa, groundnut in southern Africa, and sorghum in Latin America and the Caribbean.*
- *The SADCC/ICRISAT Regional Sorghum and Millet Improvement Program in southern Africa provides funding for research support and training to build up the capabilities of national programs in the SADCC region.*
- ***The Cereals and Legumes Asia Network and the East African Regional Cereals and Legume Network*** *have full-time coordinators funded by ICRISAT. ICRISAT scientists also assist in the coordination of other networks, such as CLAIS, the sorghum network in Latin America, and SAFGRAD. the food grain research program in central and western Africa. Effective networks involve national program scientists directly and accountably in well-focused research. Network steering committees, chaired by national program representatives, control funds to support approved research projects.*
- ***Response to National Program Needs.*** *A good example is the Mali program described "extremely cost-effective" by the evaluation team. Under bilateral agreement ICRISAT provided a breeder and an agronomist (o work on sorghum and millet within the national research system.*

2. Technology Transfer

- ***The LEGOFTEN project.*** *In response to a request from the Government of India, the Legumes On-Farm Testing and Nursery project was undertaken to demonstrate improved technologies developed by ICRISAT for our three mandate legumes. The project was carried out on farmers' fields in collaboration with Indian scientists and extension workers. Similar assistance will be given in other Asian countries.*
- ***Field Days.*** *ICRISAT holds annual International Field Days for sorghum and millet scientists. The Field Days provide unique opportunities for our partners to select germplasm, suggest future research, and become acquainted with our methods, programs, and personnel. Field Days for each crop are held in alternate years: pearl millet was featured in 1989; sorghum in 1990.*

3. Information

- ***SATCRIS.*** *Documentation and information retrieval services are provided by ICRISAT's Semi-Arid Tropical Crops Information Service (SATCRIS) from a comprehensive database covering our mandate crops and associated information. This is a vital service to scientists at ICRISAT and throughout the SAT.*
- ***Newsletters.*** *ICRISAT publishes three international legumes newsletters semiannually. The newsletters serve as a communications link for all those interested in the research and development of groundnut, pigeonpea, and chickpea.*

making ICRISAT's work more relevant to their needs. These visits will be increased and their scope widened to include directors of extension and heads of university departments of crop science. The resulting feedback will greatly assist ICRISAT's response to changes in national programs' priorities as they strengthen and as new technologies are introduced.

Workshops and Conferences

Numerous international conferences, specialist workshops, and smaller seminars have been sponsored by ICRISAT and collaborating research and donor organizations throughout the 1970s and 1980s. Their primary objectives were to assemble specialists to exchange information on topics of particular importance to ICRISAT and to recommend priorities for future research and development. Meetings at an international level, followed by published proceedings, will be increasingly replaced during the 1990s by smaller regional meetings and rapidly published summary records. Topics will relate more to problem-solving in regional agricultural development than to specialist research topics. Research conferences will therefore shift away from broad subject-specific topics to discussions in smaller groups with a location- or region-specific focus.

Smaller regional meetings focused on solving problems will replace large international workshops at ICRISAT.

Technical Cooperation

Linkages between ICRISAT and regional and international organizations, as well as between ICRISAT and national programs, were greatly strengthened in the 1980s by the establishment of regional programs and networks. We will further strengthen these linkages through closer partnership in research. As national program capabilities improve, we encourage them to assume an increased leadership role in the technical cooperation framework designed to:

- upgrade research and technical skills,
- identify problems and set priorities for research,
- allocate resources to support research aimed at generating sustainable agricultural systems,
- channel the flow and analysis of information between national programs, mentor institutions, and IARCs,
- identify research and development activities of IARCs that can eventually be taken over by national systems.

West African directors of research visiting ICRISAT Center.

Cooperative Research

Partner scientists in the national programs and mentor institutions work in close collaboration with ICRISAT scientists on many research projects. We have more than 90 collaborative projects under a formal agreement with the Indian Council of Agricultural Research. Most of our research in the SADCC region is undertaken in cooperation with national program scientists. This collaboration is a major contribution to building research capacities on our crops in southern Africa.

A fund has been established under the control of ICRISAT's Deputy Director General to initiate new research projects with national program scientists in SAT Africa. This has resulted in cooperative studies on sorghum pathology in Rwanda and Kenya, on sorghum grain quality in Kenya, Ethiopia, and Sudan, and on land and water management on Vertisols in Ethiopia. We hope to involve more women scientists in these projects.

In western Africa, we work closely with scientists of the Institut de recherches agronomiques tropicales et des cultures vivrieres (IRAT) in Mali, the Centre regional de formation et d'application en agrometeorologie et hydrologie operationnelle (AGRHYMET) in Niger, the Institut national d'etudes et de recherches agricoles (INERA) in Burkina Faso, the Institut national de recherches agronomiques du Niger (INRAN), the Institut du Sahel (INSAH) in Mali, and the Institute for Agricultural Research, Samaru, in Nigeria.

Networks

Research networks comprise a cost-effective tool for technical cooperation. They enable IARCs and national programs (including universities) to work together to their mutual benefit and involve both national and international center scientists in solutions of regional and international problems.

Network collaborative research can usually be strengthened by involving more groups. Thus ICRISAT will hope to involve relevant international centers [such as the International Rice Research Institute (IRRI) and the International Institute of Tropical Agriculture (IITA)], regional organizations (such as FAO), and appropriate mentor institutions (mainly in developed countries) in its networks. Increasing input from private industry is also anticipated.

All networks must be evaluated periodically. EARCAL, the East Africa Cereals and Legumes network, and CLAIS, the Latin America sorghum network, have been in existence long enough to be evaluated. Evaluation of WASIP, the West Africa Sorghum Improvement Program, will be carried out subsequently since it is younger. Evaluation will be built into future networking proposals.

ICRISAT's aim is to enable national programs to become responsible for the operation of the networks, with scientific backstopping where appropriate. We will start by strengthening network steering committees. The shift will also include greater national program responsibility for establishing network policy and providing material and staff support. As networks mature, national programs will develop collaborative research plans and take on greater responsibility.

ICRISAT will assist in upgrading the level of accuracy and repeatability of collaborative field trials with national programs by becoming more involved in training experiment station managers. Because of our success in such training in southern Africa, similar training has been requested and will be provided for our western African and Asian collaborators.

ICRISAT will continue to identify funds to support networking activities with which it is associated, especially in Africa. In Asia and Latin America, our role will continue to be a facilitating one in support of such activities by providing genetic material, specialized training, and research backstopping.

Countries participating in the CLAIS Network (sorghum)

Brazil
Costa Rica
Dominican Republic
El Salvador
Guatemala
Haiti
Honduras
Mexico
Nicaragua
Panama
Puerto Rico

The networks for which ICRISAT has responsibility focus on one or, at best, a few crops. This focus emphasizes commodities rather than farming systems. To broaden the scope, scientists from our Resource Management Program will be included, and closer interaction will be engendered between ICRISAT's networks and regional networks associated with other IARCs or agencies that deal with other important crops or farming systems.

Because of the proliferation of networks in agricultural research, overlapping is a common problem. Coordination between networks is critical to prevent duplication of effort and the overloading of national program scientists, as well as to identify areas inadequately covered.

Staff Exchanges

One strategy that will provide stimulating change is to move experienced ICRISAT staff into national programs for 1 to 2 years, enabling them to contribute to strengthening national programs, while learning firsthand about their problems. Equally important is to fill the vacated positions at ICRISAT with national program scientists who will bring in new ideas and learn from their association with multidisciplinary teams. Women scientists who participate can improve ICRISAT's understanding of the role of women in SAT agriculture. A scientist exchange policy will therefore be included in projects when special outside funding is requested.

Exchanges of staff between 1CRISAT and national programs will stimulate both.

Seed Technology

ICRISAT will continue to supply breeder seed to all interested parties for multiplication and dispersal to growers. A seed industry is essential for successful transfer of new cultivars from national programs to farmers' fields. Here the private sector will play an increasingly important role. We will encourage national program scientists to obtain training in seed production technology as part of our regional activities.

A seed industry is vital to successful transfer of cultivars to farmers.

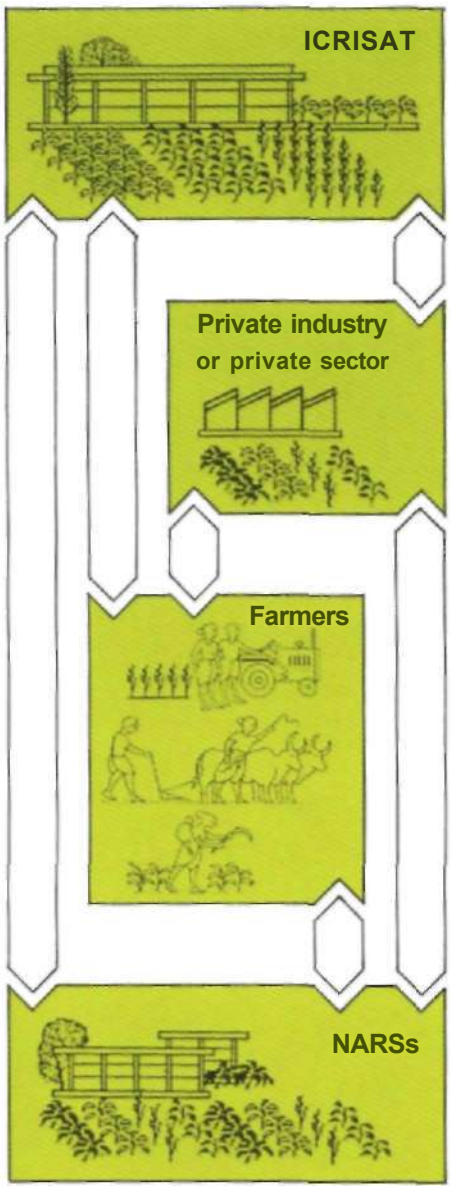
Financial Assistance

Because ICRISAT is not an aid agency, most of its technical cooperation activities can be achieved only with external project funding. Since many national programs have underutilized facilities and staff, however, they are generally receptive to human resource development and collaborative research activities. In such situations a small amount of funding can have a large effect. For example, funding enables national program scientists to participate in workshops, training, and visiting programs. Small flexible funding programs for supplies or labor provided through special projects can break bottlenecks that stall or prevent the success of many collaborative experiments.

Bilateral Projects

Bilateral projects are developed between ICRISAT and individual countries and interested donors to assist in institution building. Such projects allow for provision of infrastructure for research activities, training, and disciplinary technical assistance. ICRISAT scientists work in national programs alongside national scientists and provide on-the-job training while carrying out research on mandate crops. This type of focused collaboration is expected to increase.

Technology Transfer



Technology transfer and feedback.

The major interest groups in the transfer of technology are researchers, extension workers, decision-makers, farmers, and the private sector.

ICRISAT's role in technology transfer complements that of the national programs by remaining sensitive to their needs and not assuming or encroaching on their roles. ICRISAT and the national programs jointly evolve mechanisms for obtaining feedback from farmers.

As each project is implemented, its objectives and results will be assessed and further planning will evolve. Answers will be sought at the farmers' level concerning the adoption of a given technology. Discussions must be held frequently with officials, and field days must be conducted to transmit research results to participating farmers. Similarly, traveling workshops impart on-the-job training to scientists, and frequent field visits must be made to exchange views with the farmers.

Adaptive Research

Adaptive research on ICRISAT's mandate crops, particularly legumes, which are grown in many agroecological zones, demands a good understanding of crop environments. Agronomic manipulations can produce substantial yield improvements, even with traditional cultivars, and will receive more research attention in the future.

Technology transfer projects can demonstrate impact through increased and sustained production. In the 1990s ICRISAT's technology transfer projects will be characterized by the following components:

- National program leadership in planning and implementation and in requests for ICRISAT services.
- Association of ICRISAT and national program project staff over 3 to 4 years.
- Sustained funding.
- Base-line data collecting on the goals and priorities of farmers (both male and female) and their constraints.
- Appropriate training prior to project implementation.
- Large-scale demonstrations of the technology choices on farmers' fields over several seasons by national scientists.
- Farmers' participation in group discussions, workshops, field days, and training.
- Frequent reviews of progress, constraints, and modifications.
- Adequate supply of quality seed and informal training for farmers on seed-production methods.
- Cropping-systems perspectives for introducing the technology.
- An adequate flow of information.

Farmer Feedback

Conventional technology transfer usually means transplanting research results from experiment stations to farmers' fields. Previous failures resulted from not knowing farmers' priorities or not giving opportunities to farmers to choose, improvise, and adapt from a range of choices. Our future strategy in this area will be to employ methods to bring scientists closer to farmers so that farmer participative collaborative research can be engendered.

Sustainable adoption by farmers is the only sure way to judge the effectiveness of a technology. Evaluation of farmers' adoption can be carried out at several stages and over a period of time, culminating in the assessment of impact on production in a given area.

Impact analysis can be effected easily for certain technology changes, such as introduction of improved cultivars. The difficult task is to measure improvements in farmers' decision-making processes that help them follow up their own initiatives and make their own demands on their national research systems, as espoused in "farmer first" approaches to development. Well-defined case studies can provide reasons for successes or failures and serve as guides for future technology transfer activities.

Institution Building

As noted earlier, the SADCC/ICRISAT Regional Sorghum and Millet Improvement Program has budget components for networking and comprehensive training. Another vital service component is assistance in improving research facilities and providing limited support for operations in the 10 SADCC countries. Examples of this are physical improvement of stations (e.g., fields, irrigation, and seed storage), and assistance for off-season crossing, generation advance, and seed increase. Machinery repair and small but essential items such as pollinating bags and seed envelopes are also provided.

This type of assistance enhances the capabilities of national programs to undertake research. Combined with training, the assistance substantially improves the capabilities of station managers to carry out their work.

Information

SAT farmers will make new demands for more location- and system-specific information as they become more articulate and build their entrepreneurial skills. As national programs become more farmer-oriented, they are more likely to welcome assistance from international centers in marshaling data for use in extension work. At the same time, information-intensive programs, such as integrated pest management and sustainability, will assume greater importance.

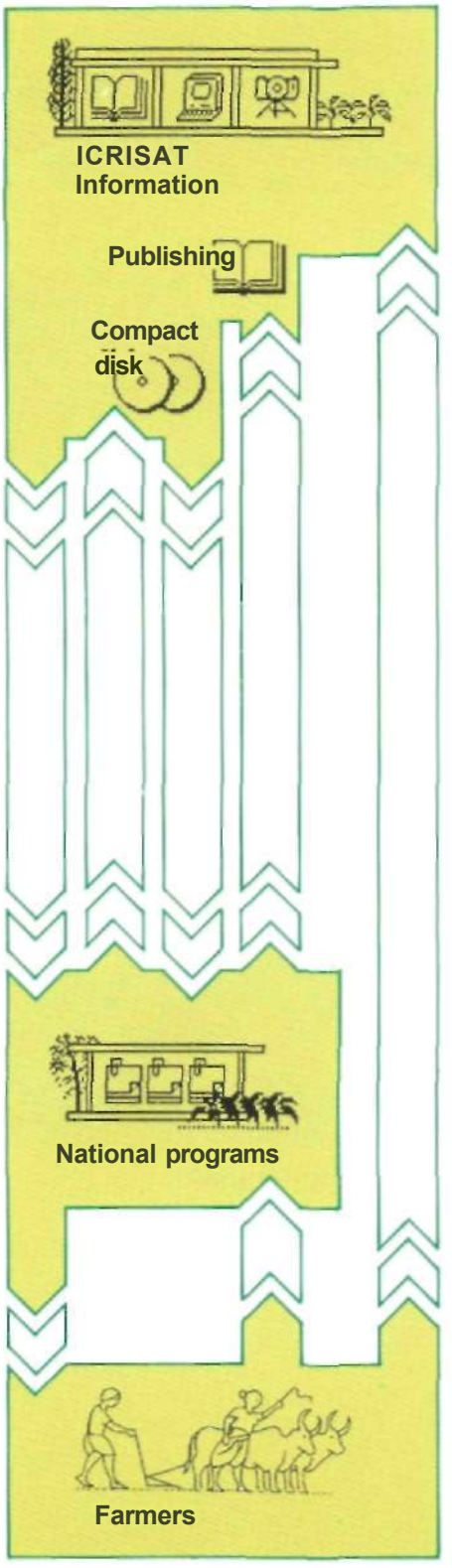
With well-developed information systems, ICRISAT enjoys comparative advantage over the national programs in both the retrieval and dissemination of information. In the past, information was accorded less priority than research. But, though the complexities and costs of handling information increased during the 1980s, in 1991 information is regarded as an integral part of research work.

Information Retrieval Strategies

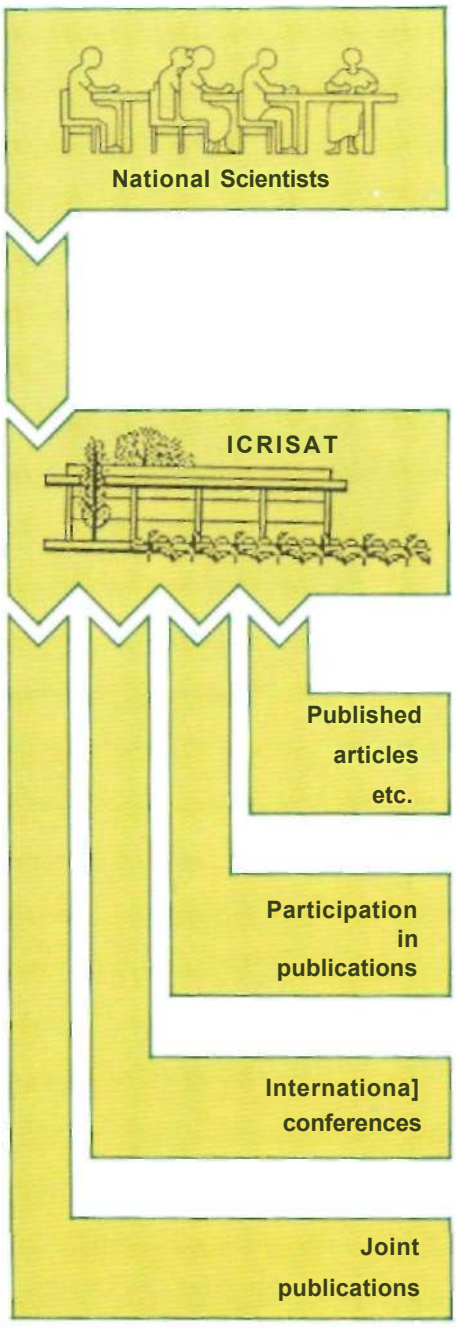
ICRISAT will continue to provide documentation, retrieval, and delivery services to national programs. It will increase its work with their libraries and documentation centers with improved collaboration of other IARCs and relevant national programs. These collaborative efforts will be effected through its own SATCRIS activities and such regional information networks as SACCAR (the Southern African Centre for Cooperation in Agricultural Research). The major objective of such networks will be to enable national research programs to become self-reliant in information management by 2000. Specifically, the networks will:

- Coordinate members' information activities to facilitate the sharing of resources, the joint undertaking of projects, and the avoidance of unnecessary duplication of effort.
- Assist national programs' efforts to improve their capacities for managing and delivering information through technical advice and training.

Sustainable adoption by farmers is the measure of a technology's success.



Communicating with our partners.



Information dissemination.

- Assist members in identifying and reaching end users for particular information services, products, and technologies.
- Upgrade skills of national program information personnel through short-term training, seminars, and workshops.

We will continue to adopt new information technologies to improve our capabilities in handling information and facilitating its access by scientists.

Information Dissemination

Information dissemination will undergo profound change in the 1990s. Because ICRISAT is a source of information for the entire SAT, we will deal increasingly with nongovernmental organizations with wide-ranging interests in technical publications. ICRISAT will therefore change from its present dissemination techniques, by which publications and audiovisual aids are conceived and created in international centers and distributed by mailing list, to a technique much more responsive to demand by national programs.

Published and publishable information will be stored on compact disks so that ICRISAT can package and customize it in hard-copy, electronic, or audiovisual mode. Conventional publishing procedures will be maintained, but with proportionately diminishing budgets.

ICRISAT will thus be able to handle an increasing number of short-run products (pamphlets, slidesets, posters, videos, etc.), as well as conventionally produced books, bulletins, and tapeslide programs. We will explore with other IARCs what potential there may be for increasing the availability of CGIAR publications via sales and distribution outlets that permit purchases to be made in local currencies. By pursuing an energetic program of public awareness. ICRISAT will communicate its range of products through the media in French, Portuguese, and Spanish, as well as in English.

Finally, ICRISAT will assist national program scientists in obtaining publishing outlets for their research findings by:

- organizing seminars on methods of scientific communication;
- publishing articles, papers, and chapters in its newsletters, conferences proceedings, and books;
- inviting leading national program scientists to participate more actively in preparing data for publication in journals;
- involving an increasing number of national program scientists in multicountry or regional disease/pest surveys and other research problems determined during international or regional conferences; and
- expanding its program of copublication to include more national program organizations.

Our Regions

Asia

ASIA

India
Myanmar
Pakistan
Sri Lanka
Thailand

The success of the green revolution assured many countries in Asia of food security and even surpluses in cereals. Pressure is now increasing to make agriculture in Asian countries sustainable and more income-oriented by diversifying cropping and farming patterns. Legume crops and feed grains will be important in these pattern shifts. Economic growth in Asia can provide market opportunities for the products of semi-arid tropical agriculture. To support these opportunities, ICRISAT will need to do more to help national systems meet the requirements of a wide range of agroecological conditions and improve their research capabilities.

Asia for us consists of three geographic entities: South Asia. Southeast Asia, and East Asia (West Asia is included with North Africa for chickpea research). Five ICRISAT crops are important in South Asia. Groundnut, sorghum, and chickpea are the most widely cultivated ICRISAT crops in Southeast Asia, and pigeonpea is considered a crop of potential importance in this region. Our major crops in East Asia are groundnut and sorghum, which must often fit into rice-based cropping systems. Since crops vary from country to country, we will respond to different needs according to comparative advantage in research, technology, and human resource development. To back-up its input, ICRISAT will encourage the stronger national programs to assist smaller or emerging national research systems.

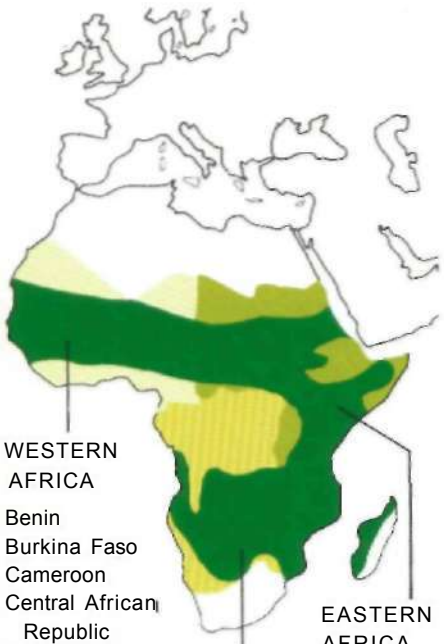
ICRISAT Center will serve as our regional center for Asia. We will work with our partners in Asia including India through the Cereals and Legumes Asia Network. This network will bring national programs and ICRISAT scientists together to work on common problems and to share technology, ideas, and materials. The contacts with each country are built on formal agreements backed by jointly developed and agreed work plans.

ICRISAT's strategy will include working with other regional and international organizations, including the Australian Centre for International Agricultural Research (ACIAR), the Asian Vegetable Research Development Center (AVRDC), the Canadian International Development Agency (CIDA), the Center for Coarse Grains, Pulses, Roots, and Tubers (CGPRT), FAO, ICARDA, the International Development Research Centre (IDRC), IITA, IRRI, Winrock International, and the cooperative research support programs of various American universities. We will explore ways to encourage cooperation among these groups to reduce duplication of effort.

ICRISAT will also facilitate bilateral projects involving donors and national programs, such as the pigeonpea production project being implemented by Sri Lanka with Asian Development Bank funding. This type of adaptive on-farm research can be expanded to meet national program requests. Similarly. ICRISAT will participate in multilateral research projects on integrated pest management and working groups on groundnut diseases. Most networking activities in Asia will be supported by special grants.

Our long-term strategy in Asia will thus be to facilitate research to meet national and regional priorities. Scientific cooperation and support will include adaptive on-farm research and strategic studies. Agroecological studies will help us to focus our involvement. Regional cooperators will contribute genetic material for trials and nurseries of our mandate crops. ICRISAT's responsibilities will include the coordination, distribution, and maintenance of its germplasm collection. Increasing use will be made of senior fellowships to involve more Asian scientists from both the public and private sectors in our work. Expertise identified in one part of the region will be encouraged to help backstop network activities in other parts. The present trends to turn over responsibility for network activities to the national programs will continue.

Sub-Saharan Africa



WESTERN AFRICA

Benin
Burkina Faso
Cameroon
Central African Republic
Chad
Gambia
Ghana
Guinea
Guinea Bissau
Mali
Mauritania
Niger
Nigeria

SOUTHERN AFRICA

Angola
Botswana
Madagascar
Malawi
Mozambique
Namibia
Zaire
Zambia
Zimbabwe

EASTERN AFRICA

Ethiopia
Kenya
Somalia
Sudan
Tanzania

This largest area of the SAT consists of three geographic entities—western Africa, eastern Africa (including Sudan), and southern Africa. Sorghum and millets are major food crops in all three regions. Groundnut is an important food and cash crop in western and southern Africa, and chickpea is important in eastern Africa. Pigeonpea is grown throughout eastern and southern Africa and has potential for increased use throughout the continent.

The manifold problems facing African governments are highlighted by a recent World Bank report. Population growth rates in Africa are the highest in the world, and environmental degradation is advancing. Changes in policies affecting the agriculture sector have elicited an encouraging response from small-scale farmers in various countries.

New heights in crop production have resulted from 2 years of good rains in western Africa, and grain production statistics for our cereals have shown a general upward trend during the 1980s in western Africa. While demonstrating the critical importance of weather fluctuations in the SAT, these trends also indicate that improved technologies and changing policies have made significant contributions. By adopting policies that promote the production of sorghum and millets, Nigeria and some SADCC countries have recently shown the way to the rest of the semi-arid tropics. Demand for sorghum in Nigeria currently outstrips supply.

The potential for expanding food production exists, despite environmental constraints. A target agricultural growth rate of 4% per annum is necessary to avert chronic food shortages. The major increase must come from increased productivity because area for cultivation cannot be further expanded in most countries. The principles for increasing productivity are known, but converting them into practicable and profitable technologies for use by small-scale farmers is fraught with difficulties. They can be overcome.

Policy changes within countries are necessary to spur agricultural development. Realistic exchange rates and expansion of regional/subregional trade cooperation would help. A corresponding coordinated effort is required from the donors and interested institutions at country or regional level. Expanded input into policy research will help guide the necessary changes. ICRISAT will contribute through microeconomic studies and by providing support to other research agencies, such as IFPRI.

When properly supported, small national programs can be efficient. Many African programs have demonstrated creativity with small, well-focused research teams. In the 1990s we will help the smaller national programs improve their abilities to select efficient and appropriate technologies. We will help the medium-sized programs to focus on a few important commodities, to develop components of technologies for others, and to become more efficient adapters of technology from elsewhere. And we will help the larger national programs to attain full capacity for developing technologies on their own.

Closer links will be developed with faculties of agriculture.

We will also develop closer links with faculties of agriculture and agricultural colleges. We will continue to improve research facilities on national experimental research stations in Kenya, Mali, Niger, Nigeria, and within the SADCC countries. Regional programs of both ICRISAT and national research organizations will be assisted from ICRISAT Center by staff transfer when special expertise is needed.

Project-funded regional programs such as the groundnut project in southern Africa will become the responsibility of the region, in accordance with SACCAR plans, to service the region and solve regional problems. ICRISAT will provide a backup service and will continue to conduct strategic research on global or panafrican problems from core funds, in collaboration with the regional project, in cooperation with SACCAR.

We plan to use the above model with our regional Sorghum and Millet Improvement Program.

Institution-building is a long-term endeavor requiring firm commitment. Our regional programs can contribute by strengthening research and training programs in our mandate areas and improving and maintaining facilities. We can also improve the science and

technology bases of sub-Saharan countries. We have a regional center in Niger for western Africa and one in Zimbabwe for southern Africa. We have teams in Kenya, Malawi, Mali, and Nigeria. Our analyses indicate that we may be underinvesting in eastern Africa. Networking will ensure that regionally adapted technologies and regionally developed breeding lines and cultivars are successfully transferred throughout the continent.

To achieve these goals, we will coordinate our efforts with regional organizations, sister CGIAR centers, non-CGIAR centers, our sponsors (FAO, UNDP, World Bank), and donors.

More research investment in eastern Africa may be called for to balance efforts we are now making in southern and western Africa.

Latin America

The demand for locally adapted cereals and legumes in Latin America far exceeds production. Our success through LASIP based at CIMMYT for Mexico and Central America has encouraged other organizations to take a lead in the regional transfer of ICRISAT-based technologies to farmers. The transfer of breeding material to NARSs and training of scientists will continue to be a vital function for us in this region. These activities can be accomplished through cooperation with strong NARSs and other organizations in the region.

We see a need for assistance to NARSs in South America where demand for sorghum is increasing rapidly. This increase will have to come from marginal acid soil areas where our cereals are highly adapted.

We propose to assist the stronger NARSs in Latin America to obtain funds for regionally significant cooperative research in line with TAC's recommendations. We are also investigating the possibility of developing a cooperative program with our sister institute CIAT, to incorporate our mandate crops into the farming systems of South America.

We will maintain a close association with the CLAIS network in Central America to ensure that ICRISAT-based technologies continue to reach NARSs in this region.

Latin American national programs may assume responsibility for the sorghum network now supported by ICRISAT.

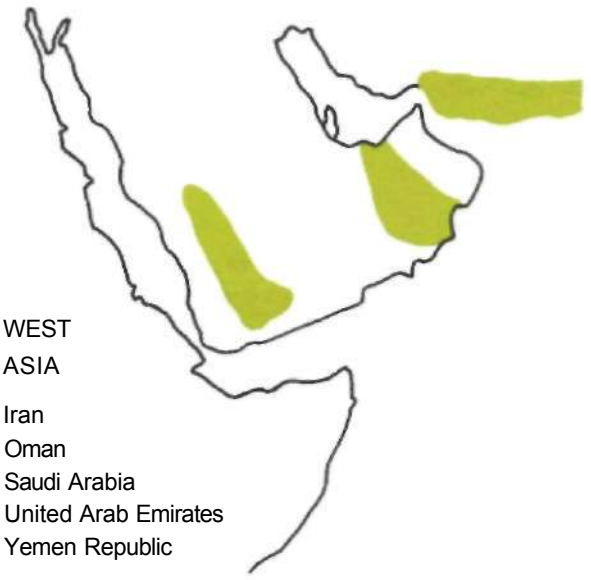
West Asia/North Africa

We intend to transfer some sorghum research to the arid countries of the West Asia/North Africa (WANA) region. Human resource development will be an important component of our cooperative activities with those countries. These efforts, initially supported by special funding, will foster the use of sorghum for food, feed grain, and fodder. We will look to ICARDA for leadership and continued cooperation on kabuli-rype chickpea for this region. The crop shows high potential for growth in productivity and production there and for use with lentils in rotation with wheat and barley.

We expect to transfer some research on sorghum to WANA and will look to ICARDA for continued leadership on kabuli chickpea.

LATIN
AMERICA

Argentina
Bolivia
Brazil
El Salvador
Guyana
Mexico
Nicaragua
Paraguay
Venezuela



WEST
ASIA

Iran
Oman
Saudi Arabia
United Arab Emirates
Yemen Republic

Priorities

Decentralization and distribution of research responsibilities among centers, programs, teams, and networks maximize our use of resources, concentrate our focus on regional problems, develop closer links with NARSs and foster a better understanding of issues facing the farmers.

All ICRISAT locations contribute to international, regional, and local priorities to varying degrees. ICRISAT Center contributes the most to international priorities, but ICRISAT's major contribution to agroforestry research is made at ISC, to research on *Striga* resistance of sorghum by WASIP-Mali, and to sorghum utilization by SADCC/ICRISAT in Zimbabwe. Regional shares in ICRISAT resource allocations relate generally to each region's share in SAT production of our mandate crops, but they are tempered by this transnational approach and by other considerations.

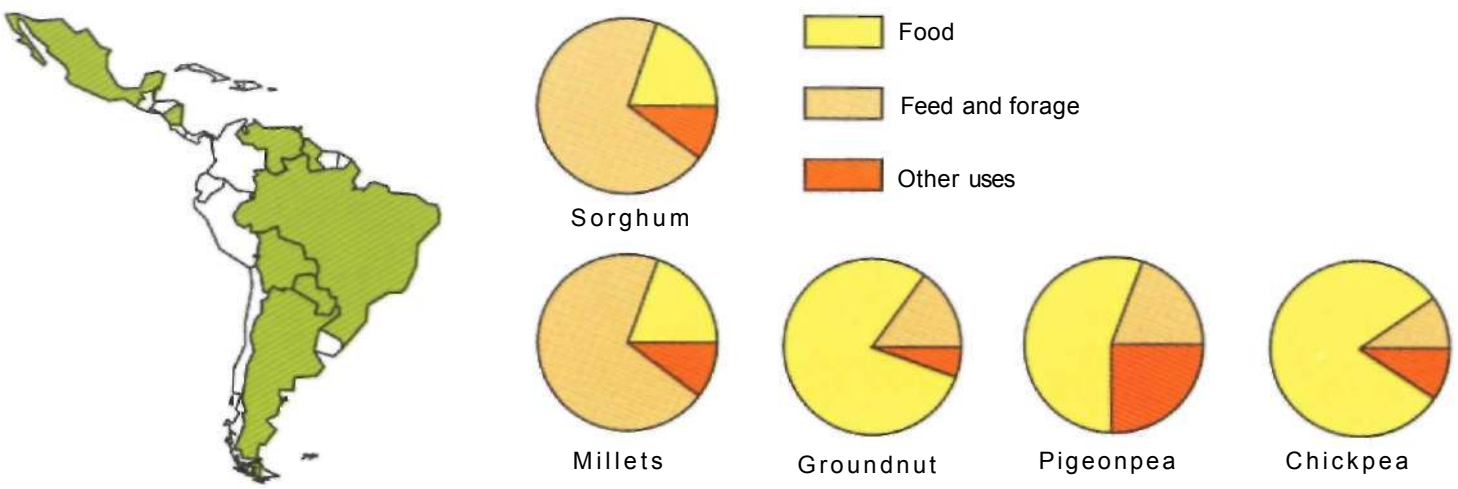
When we compare regional resource allocations with production shares we note some imbalances. The most apparent are with sorghums in southern Africa and in Latin America.

The large resource allocation to sorghum and millets in southern Africa reflects the common priorities of the SADCC Governments which recognize that policies that promote the production of maize have increased instability in food production. They have requested ICRISAT to help improve stability by stimulating the production of our more drought-tolerant cereals. ICRISAT's past emphasis on food production did not relate well to the use of sorghum mainly for feed. With the shift in emphasis in the next decade, we will give more attention to the food and feed in the semi-arid tropics.

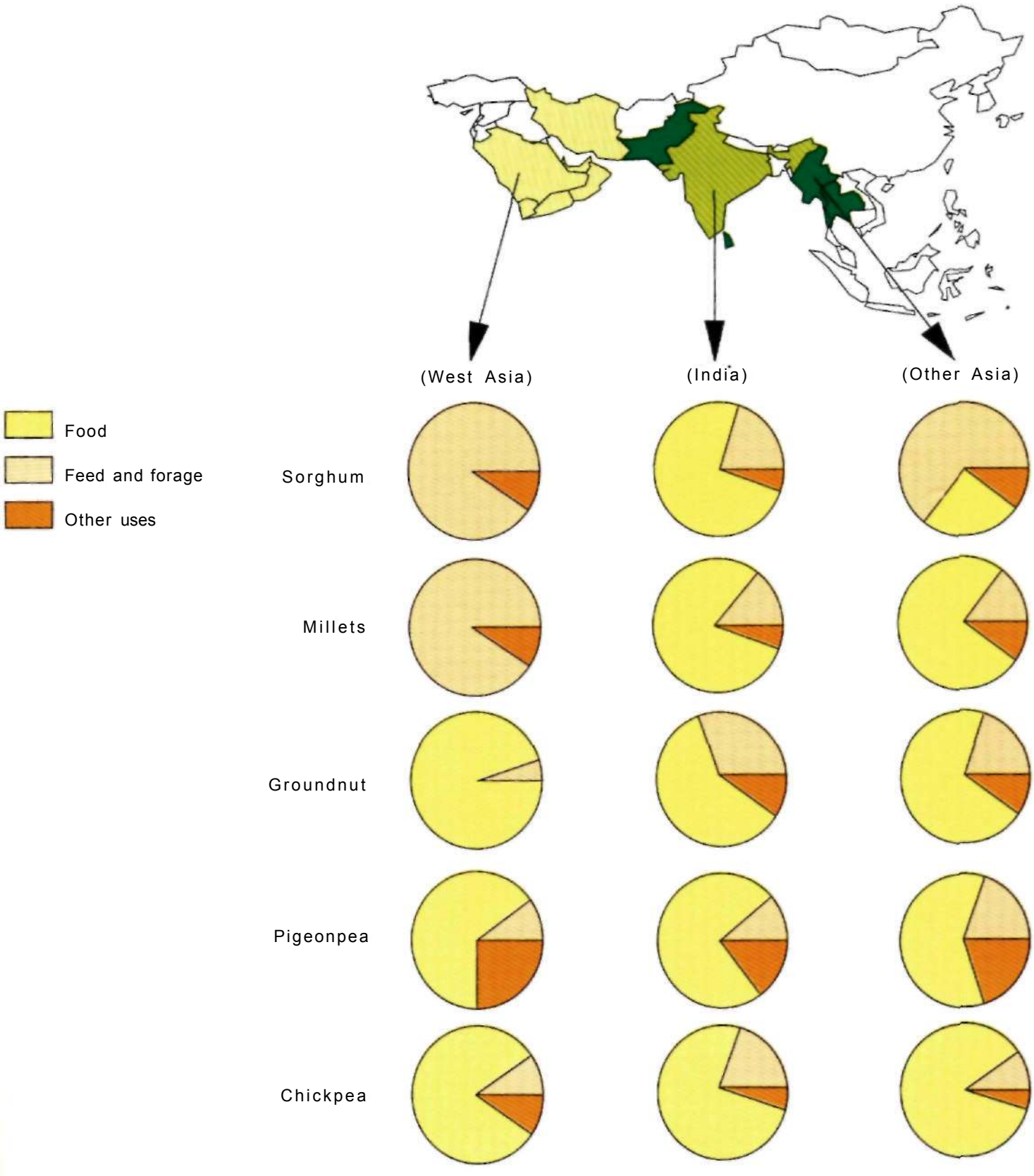
The occurrence of biotic and abiotic stresses that are of special significance to the African continent, the drop in production, and the importance of groundnuts in the diet and as a cash crop, justify expenditure above the production share of the crop.

The opportunities for using pigeonpea and chickpea in the rice- and wheat-based cropping systems in Asia need to be fully explored with the aim of developing sustainable cropping systems.

Resource allocation across the SAT within our cereals programs indicates a shift from food grain towards the use of both sorghum and millet as feed and fodder. Sorghum will mainly be used as food in India and eastern and western Africa. In other parts of Asia, WANA, southern Africa, and in Latin America, the use of sorghum for feed and forage is certain to increase. The trend for pearl millet is similar, but its use as food in marginal agricultural areas is guaranteed.



Relative uses of mandate crops in Latin America.



Alternative uses of mandate crops in Asia.

Alternative Uses

Although legumes will continue to be used mainly as food, their uses for feed and forage will increase in importance. There will be more emphasis on quality and on diversification of utilization. The potential of legumes for income generation will be more energetically-explored. Groundnut, especially, holds great promise for SAT farmers as a cash crop for industrial use.

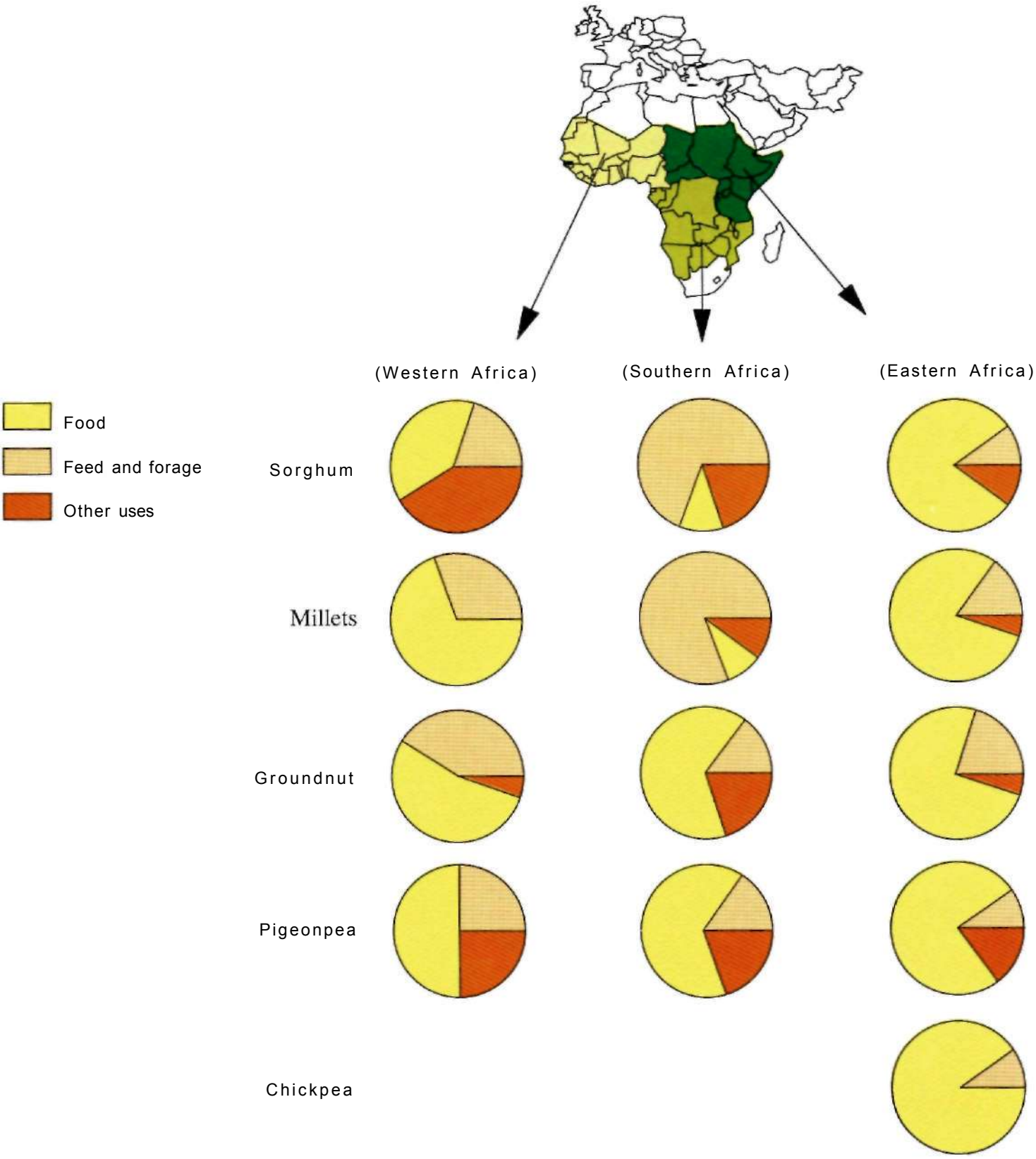
Regional Research Emphasis

ICRISAT Center will have global responsibility in strategic research and regional responsibility for Asia. Africa will continue to be served by ISC, SADCC, EARCAL and WASIP. The Latin American Sorghum Improvement Program will serve that region. We will strengthen feed grain research in the WANA region. All regional centers and programs (including ICRISAT Center for Asia) will carry out mainly applied and some adaptive research. Responsibility for some locally important strategic research will be assigned to regional programs.

Types of research (% distribution)

	Basic	Strategic	Applied	Adaptive
		At present[1]		
ICRISAT Center	16	29	43	12
ISC	9	23	52	16
SADCC/ICRISAT	6	7	63	24
		Future		
ICRISAT	20	40	30	10
ISC	9	21	50	20
SADCC/ICRISAT	6	20	54	20

1. Calculated from ICRISAT's Research Project Management Information System (RPMIS) database.



Relative uses of mandate crops in Africa.

Crops Research

The strategic research thrust at ICRISAT Center will be towards understanding mechanisms of genetic resistance/tolerance to abiotic and biotic stresses, and elucidation of fundamental processes. There will be decreased emphasis on production of finished products and considerably increased attention to producing breeding lines with specific traits or combinations of traits for use by NARSs in their breeding programs. All the crop improvement programs will breed material with specific crop duration to fit the requirements of specific regions and agroecosystems and so sustain productivity. Increasing food production and sustaining the natural resource base are dual objectives of ICRISAT.

The disciplinary mix within programs may change and shifts in emphasis are expected as more information becomes available.

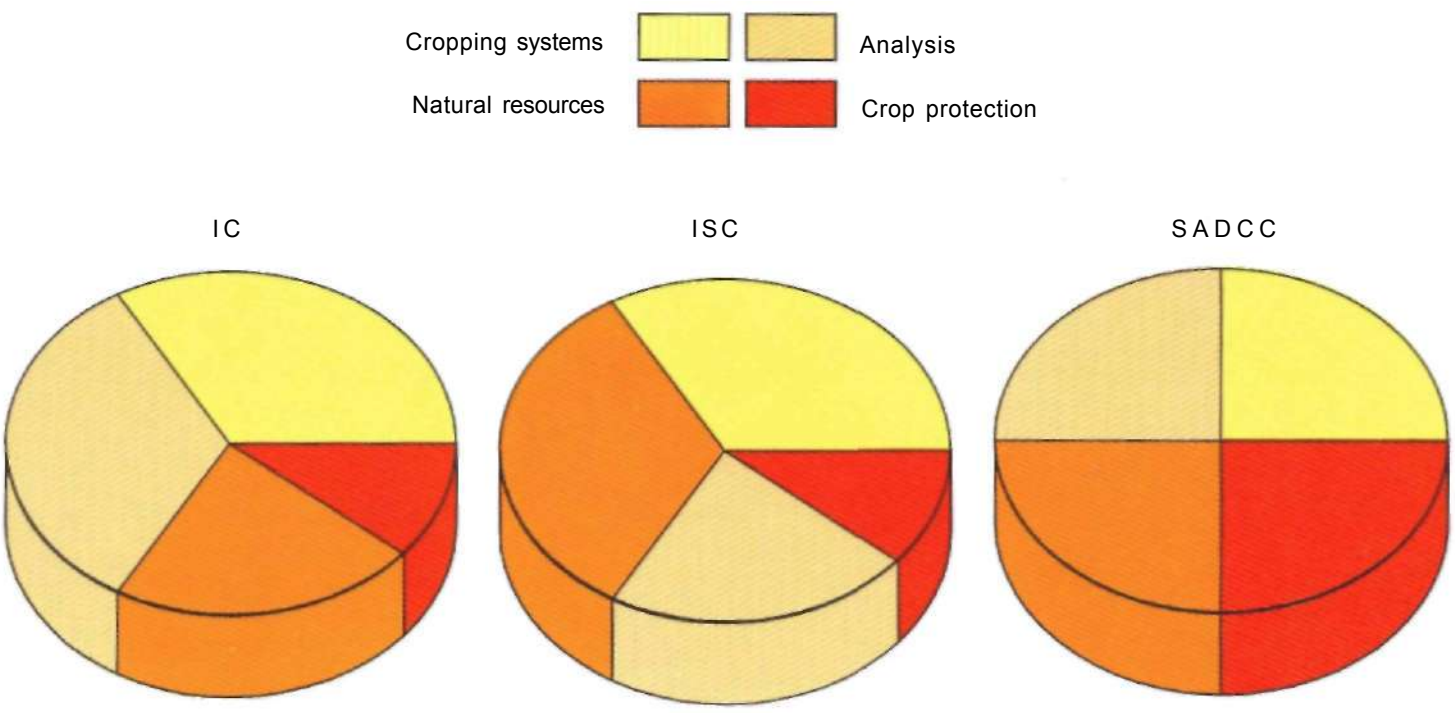
Research emphasis in the Genetic Resources Program will shift from collection and documentation to evaluation and conversion in collaboration with the crop improvement programs.

Environmental Research

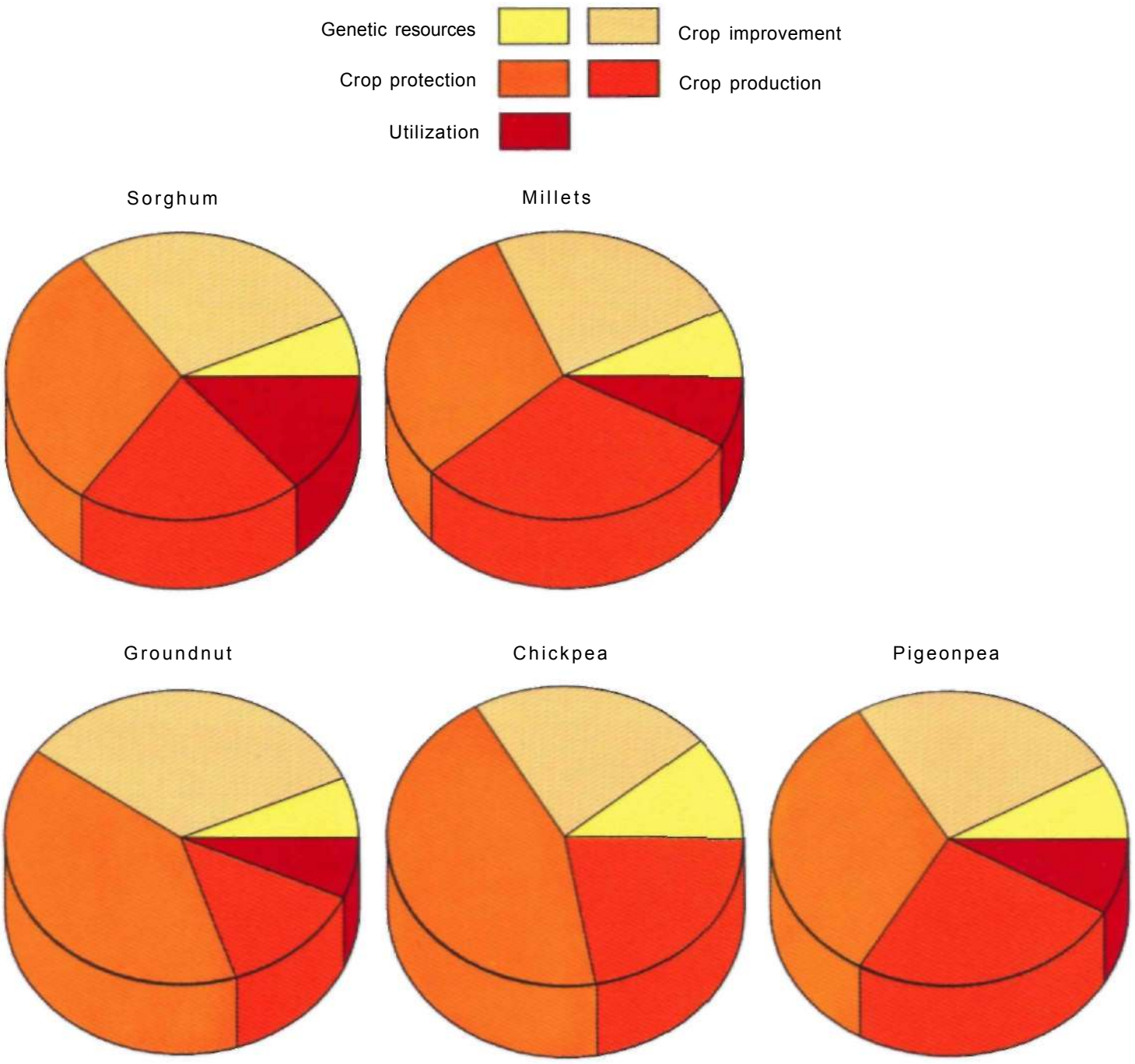
Environmental research will be carried out mainly at ICRISAT Center and at the Sahelian Center. Increasingly, the Resources Management Program will complement the work of the crop improvement programs in Asia and eastern Africa. Interdisciplinary team effort is required to understand and solve the complex interaction of constraints on production.

Assessment Research

Assessment research will become an integral part of our research effort. Technology assessment will be carried out jointly by the research programs and the Economics Group in the Resource Management Program. More rigorous ex-post evaluation is needed.



Environmental research (%).



Crop research emphasis (%).

Human Resource Development

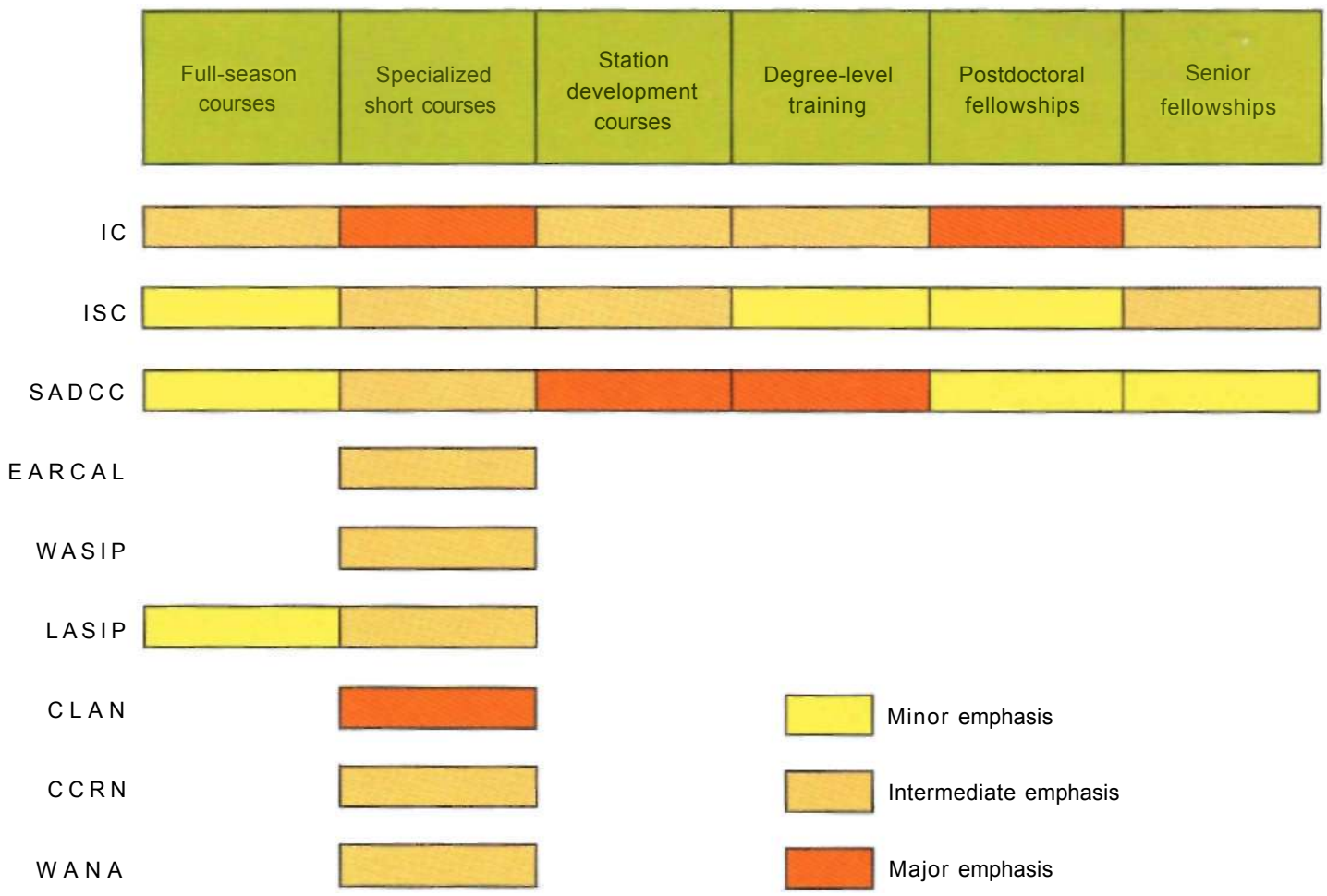
Human resource development will continue to merit high priority, with increased emphasis on specialized short-term training courses. We will provide more opportunities for SAT scientists to work alongside ICRISAT scientists to improve their research skills and develop cooperative links for future collaborative activities.

Technology Exchange

ICRISAT recognizes the need to continuously adjust its database to ensure that it accurately reflects ongoing changes within the national programs. Our improved database will assist our human resource development program by focusing on more specialized courses to fulfill the various needs of our partners. It will also identify national programs with whom we can conduct cooperative research and to whom we can transfer network coordination activities.

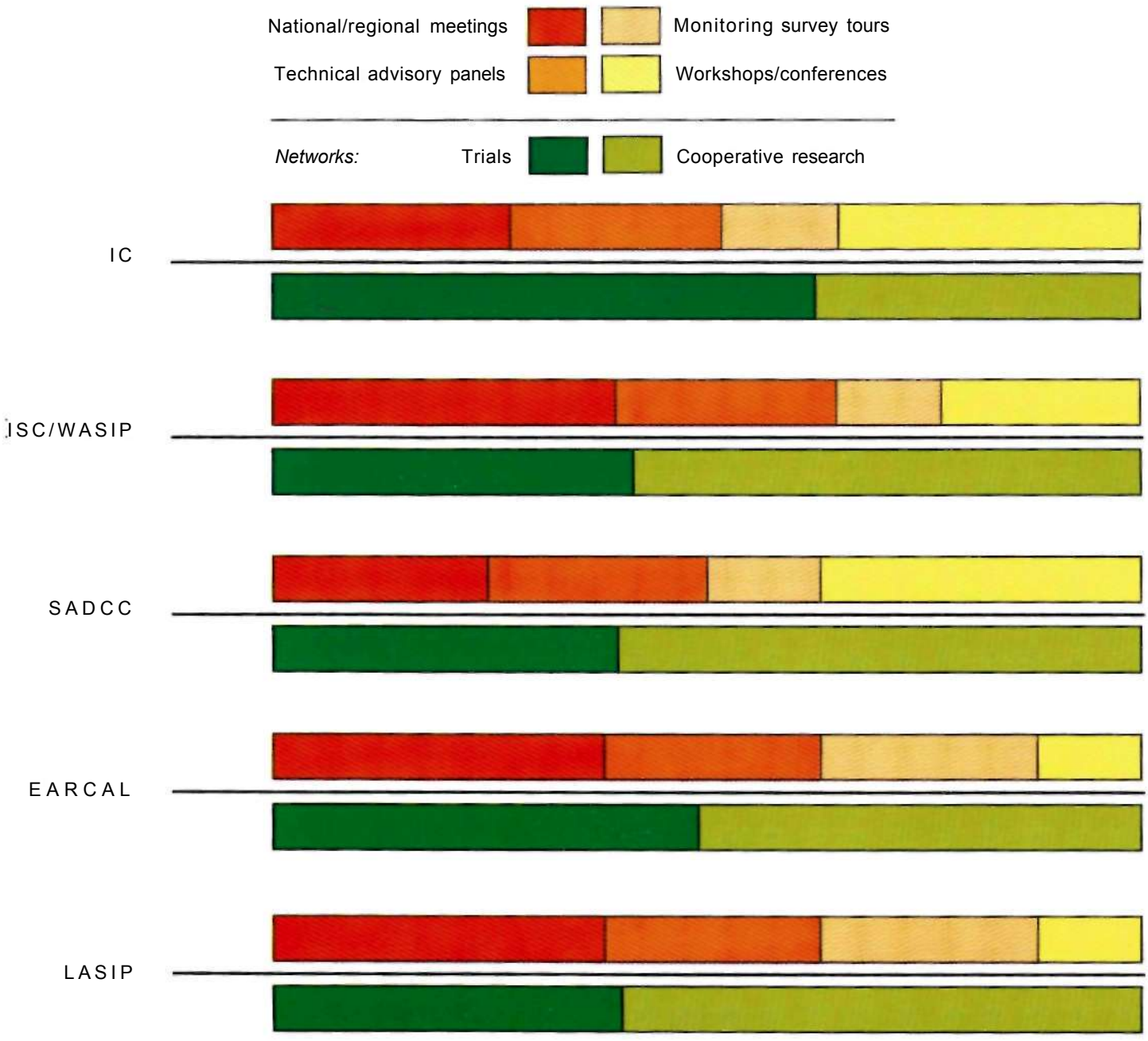
In addition, we will encourage staff exchanges of mid-career scientists between ICRISAT Center and the national programs.

The emphasis in the information field will shift from broad-based publications towards customized publishing on more specialized subjects. Similarly, we will de-emphasize large conferences on general topics. We will support smaller meetings on subjects with topical or regional interest.



Human resource development.

Assessment of needs as expressed by NARSs:



Technology exchange.

Operational and Administrative Implications

This section highlights the main operational implications from the previous analyses. It links the strategy to the forthcoming Operational Plan. Trade-offs are implicit in the choices made, and these will be fully reflected in the Operational Plan which will highlight our response to the changing research environment. The section below summarizes research thrusts and interactions with national programs that enhance the implementation of the mandate, and considers required changes in emphasis and the allocation of resources. To make this strategic plan fully operational will require us to continue to find a significant proportion of our funds from non-CGIAR sources.

Decentralization

ICRISAT expects to continue to decentralize its research and training programs. We will provide backup support from ICRISAT Center to scientists in our decentralized teams and networks.

Particularly during the last 5 years, we have developed regional programs for sorghum, millets, and groundnut research in both southern and western Africa. A similar regional unit for all ICRISAT mandate crops (but particularly sorghum, pigeonpea, and groundnut) is in the process of development for eastern Africa. Through cooperation with national programs and with sister centers we hope to develop regional activities in South America where sorghum demand outstrips supply. Using ICRISAT Center as a regional base, we have substantially increased our activities in South and East Asia over the last 5 years.

Sorghum research in South and East Asia is likely to follow the pattern already established for legumes; that is, using ICRISAT Center as a regional base, to increase the relationship with, and involvement in, activities in other Asian nations. It will also require greater emphasis on feed grains as end uses. Some decentralization and relocation of staff from ICRISAT Center into other parts of Asia will be necessary. At ICRISAT Center we will separate, financially and administratively, global activities from activities targeted to the Asian region.

The organizational structure set up by the Governing Board in 1986 favors and supports a decentralized mode of operation. More decentralization will require more managerial and administrative support in regional programs, particularly in eastern Africa and for Asia at ICRISAT Center, and probably stronger central administrative support in audit, fiscal, and personnel. Management-level coordination would improve the efficiencies of training and communication activities.

Involving the National Programs

ICRISAT believes it works well with national programs but we must reach out farther to establish working partnerships that are appropriate to what is possible and to our partners' resources, priorities, and national policies. We will continue to develop annual or biennial plans with national partners in Asia and southern Africa. Networks seems to be the effective approach for working with NARSs in western and eastern Africa.

In southern Africa we work closely with the regional organization, SACCAR, and receive advice from technical advisory panels in which national research systems are represented. In western and eastern Africa we collaborate in commodity and farming systems networks and through our ecoregional research centers and teams.

We will share responsibilities for international and regional research and training with stronger national programs. The NARSs will need to make changes in their research

priorities. We will encourage stronger NARSs to provide leadership in collaborative research networks and support the NARSs in smaller countries.

We will support visits by directors and deputy directors of national programs to ICRISAT Center and regional research locations, as well as continue with monitoring tours and international field days.

We will catalyse operational scale adaptive research in Asia and western Africa where we have resource management research programs. We will participate in country surveys and trials for integrated management of selected major insect pests. Formal bilateral agreements are prerequisites for the success of such projects.

India has a strong national agricultural research program, but its needs are great. Excellent opportunities exist to improve our already good cooperative relationship with India. We have initiated a dialogue with our host country to make our relationship more streamlined and transparent. The development and implementation of regular, formal, work plans will help and allow India to show how it contributes to the international research and training effort for the SAT. We expect India to become a full partner in CLAN. India will increasingly assume responsibilities for its own applied and adaptive research, for international responsibilities for research on medium- and long-duration pigeonpeas, breeding of postrainy-season sorghums, and breeding of sorghum for *Striga* resistance in India.

Crops Research

ICRISAT's mandate crops will continue to be the important food crops of the SAT, particularly the cereals and groundnut. Pigeonpea and chickpea are more regional in their importance. Our crop improvement programs will ensure that food uses are of first priority when they develop new cultivars and breeding lines for particular agroecological and socioeconomic situations. Germplasm enhancement and concentration on globally or regionally important yield-reducing stresses will continue to be our main areas of emphasis.

We will increase the use of cell and molecular biology to solve difficult problems of host resistance to pests and diseases, and adaptation to heat and drought stress. Research on abiotic stresses will decline.

We predict a regional leveling off in demand for sorghum as a food grain and an increase in its demand for feed, forage, and industrial uses. We will adjust our research emphases accordingly, but confine our attention in nonfood uses to a few exemplary uses that also have significant future potential. We will also develop cooperation in India to ensure that breeding populations maintain stalks with acceptable fodder quality and yield.

We will continue our emphasis on pearl millet among the millets. We have started a forage breeding project on pearl millet in southern Africa and are increasing research emphasis on forages and the use of crop residues at the Sahelian Center in cooperation with ILCA.

Research on finger millet, a cash crop, will be confined to eastern and southern Africa. Future research emphasis will be guided by the needs of NARSs. We will seek consultant advice on future trends in the production of and demand for the minor millets.

We need to give more research attention to groundnut in Asia and in eastern Africa even at the expense of research on other commodities, because there seems to be good growth potential. Groundnut research at other African locations will be rationalized to bring our efforts in line with production shares. An IPM approach is warranted to increase aflatoxin control.

Pigeonpea production is increasing in Asia and eastern Africa partly because of ICRISAT research. In India it is now replacing cotton. We shall increase germplasm selection and adaptation for new areas and increase agronomic research to improve awareness of the crop's potential. Research on medium- and long-duration pigeonpeas will decline. Pigeonpea is susceptible to insect attack. We will catalyse a cooperative research network

involving mentor institutions. NARSs, UN agencies, and the IARCs in an IPM approach to deal with *Helicoverpa armigera,* a major pest of pigeonpea, chickpea, cotton, and several other crops.

Chickpea may be the best pulse crop for postrainy-season cropping in the rainfed SAT. It combines drought tolerance with good productivity and stability. Improved crop husbandry is the major need. Existing programs of research will continue but biotechnological research is needed to deal with the serious problem of ascochyta blight in the WANA region.

Research Techniques and Approaches

ICRISAT sees the need to make greater use of the new techniques of biotechnology. The strategic issues and choices have been discussed in the sections of this document dealing with crops research. In brief, it is agreed that the Institute will use biotechnological methods where needed to facilitate crop improvement research. We will use proven techniques with high probabilities of success and seek collaboration with mentor institutions, including those in the private sector, to develop new technologies to fit our needs.

The use of biotechnology in crop improvement will require, initially, a large outlay of funds, but it is anticipated that this allocation of resources will be counterbalanced by a reduction in the time needed to develop new cultivars and breeding lines. We will remodel existing facilities and construct new ones where necessary, acquire the needed equipment, appoint new scientists with the required training, and retrain scientists and support staff.

Strategic research in cell biology, entomology, pathology, and physiology will support breeding projects. Interaction with agroclimatologists, soil scientists, cropping systems/production agronomists, and economists will increase. Such research cooperation is essential for all our crops, and thus teamwork will be encouraged and supported.

Increased Emphasis on Hybrids

Hybrids are better adapted to the variable environment of the SAT. Demand for cereal hybrids will increase in areas with developed seed industries and the availability of inputs. This trend will dominate across Asia, Latin America, and most of sub-Saharan Africa. In eastern and southern Africa, where hybrid maize has replaced sorghum and millets, only hybrids of these crops will compete successfully in desirable environments, and produce an acceptable yield in marginal environments. The development of hybrids in pigeonpea will increase its productivity and use. Interaction with the private seed industry will grow. In western Africa, except for Nigeria, open-pollinated improved cultivars will still be required. The regional requirement for such cultivars will be met mainly by the regional programs in Mali (sorghum) and Niger (pearl millet) and stronger NARSs within the region.

Breeding for Specific Characters and Conditions

Our breeding strategy will be to incorporate region-specific combinations of resistance to both abiotic and biotic constraints into breeding lines. Regional programs will undertake crop improvement for specific agroecosystems. This emphasis will require substantial strategic research at ICRISAT Center to become effective. We also aim to breed for specific crop duration for specific regions or farming systems. Short-duration groundnuts are needed for rice-based farming systems in Asia. Short-duration chickpeas are desirable for postrainy-season cropping, and short-duration pigeonpea for wheat-based systems in Asia and Africa. Short-duration pearl millet cultivars are required where growing seasons are short and unpredictable.

We will look to ICAR to produce medium- and long-duration breeding lines of our pulse crops for use by NARSs.

More Disease and Pest Management Studies

We will develop pest and disease management projects applicable to the needs of both commercial and subsistence farmers. These projects will involve the integration of host-plant resistance, natural control, cultural practices, and strategic chemical applications into appropriate farming systems.

Viruses are major yield reducers of our legumes, especially groundnuts. Most national research programs are weak in this area of specialization. We will improve the Virology Unit at ICRISAT Center to backstop regional programs and NARSs. We will also need to strengthen our research in nematology, particularly in drier, sandier soils and for pigeon-pea and groundnut. Weed research will largely be done by NARSs.

More Processing and Utilization Studies

We will increase research related to the utilization of our mandate crops. Our emphasis will, however, remain oriented towards crop improvement, that is, we will undertake research to measure the traits and characteristics of the crops that are related to end use, and utilize and recommend them in crop improvement. We will look to NARS laboratories and the food processing industry for advice about which traits are important and to carry out priority research on utilization and end use.

The various ICRISAT research teams will undertake utilization-related studies relevant to the regions in which they are situated. The strengths of NARSs and industrial research will help decide priorities. We are well set up for such studies at ICRISAT Center, in southern Africa, at ISC (through cooperation with ILCA), and in Mali (through cooperation with IER). We will need to create modest laboratory facilities for these purposes in Nigeria and in Malawi. Most of the research will deal with sorghum. ICRISAT Center will also work on the utilization of pulses, and SADCC/ICRISAT-Malawi will test oil quality in groundnut lines.

In an effort to improve the marketing efficiency of our partners and target groups, we will undertake a limited expansion of research relating to policy analysis to help governments decide on appropriate price policies for our mandate crops. Market research will help define the best possibilities for nontraditional uses. These studies will be either contracted out to the private sector or undertaken in collaboration with organizations such as CGPRT or IFPRI.

Crop storage research is necessary to lessen the effects of periodic shortages and famines, and thus is vital to the success of agriculture in the semi-arid tropics. Several aspects require study, such as the storability of grain for later utilization, storage structures, and prevention of losses. We will undertake limited studies on storage pests, but will depend upon mentor institutions and national programs for research on the storability of our cultivars.

Environmental Research

More Sustainability Studies

ICRISAT is currently one of the leaders among the IARCs in bringing sustainability concepts to the forefront of international agricultural research. The convergence of our commodity and area mandates, and the level of expertise we have developed give us

considerable advantage in this area of research. Because the SAT remains central to our mandate, our research in resource management is likely to increase in the next few years in relation to research on crops.

We have developed but must improve upon methods for determining priorities in strategic resource management research. We will build upon our considerable experience in research on multiple cropping, watershed management, and rural appraisal and constraint analyses. Through our skilled labor force at ICRISAT Center we can undertake large-scale projects that integrate measurements of soils, water, roots, crop characters, and climate.

Particular emphasis will be placed on the importance of quantification, including the development of long-term experiments involving both cereals and legumes, the measurement of productivity loss through soil erosion, and the development of practical crop models for different agroecological zones. Continuing emphasis will be placed on poorly endowed areas (e.g., the Sahelian zone of western Africa), and greater emphasis on agroforestry research, on the use of faster and more efficient means of measuring socioeconomic constraints, and ex-post evaluations of improved technologies. We will institute a geographical information system to improve the effectiveness and integration of crop improvement and resource management research.

Collaboration and Comparative Advantage

Recent changes in the mandate of the CGIAR should help ICRISAT increase its research in resource management and on issues of sustainable agriculture both in Asia and western Africa. Where ICRISAT has a comparative advantage and has demonstrated research performance, we expect the system will support us. Examples are agroforestry research in the SAT (which fits efficiently into ICRISAT's mandate), cropping systems research in both Asia and western Africa, and resource management research (including the use of supplemental irrigation) for the major soil regions (the Vertisols, Alfisols, and very sandy soils) about which ICRISAT has gathered a wealth of knowledge and expertise during the last 17 years.

Resource Management for Other Regions and NARSs

We will increase the Resource Management Program's collaboration with crop scientists in regional teams for areas in eastern Africa and Southeast Asia which meet our land-scarce, labor-abundant research criteria.

Collaboration with national programs will be increased in areas where those programs need strengthening (e.g., surveys of production and marketing of our mandate crops, agroclimatology, geographical information studies, and land and water management).

We will look for new skills in social sciences to support the shift towards research on institutional constraints, gender issues, and research on research.

Assessment Research

More Evaluation of ICRISAT's Effectiveness in Strengthening NARSs

Positive results in agricultural development mean little unless those results are put to use by the target and partner groups. Evaluation of the extent of diffusion and impact is therefore central to technology assessment. Because ICRISAT does not interface directly with farmers, measurement of our impact cannot be precise. Limited involvement in adaptive research will help such assessment, but we will find it more often in the research of scientists outside ICRISAT.

ICRISAT is well established. More emphasis can now be placed on ex-post evaluation and in-depth village-level studies reduced. One of the objectives of ex-post evaluation is the documentation of an attractive rate of return to investment in agricultural research. But the overriding purpose is to generate information for planning future research by establishing reasons for success or failure and to support the new emphasis on the use of feasibility criteria. Additional information is needed on seed production, seed marketing, and on rates and determinants of adoption of packages of practices and individual components of them. Obtaining such factual data, however, is a difficult and expensive task.

Increased Attention to Assessment Research

Constant or declining budgets demand the need for accountability, which in turn increases the demand for formal modeling to order subjectivity in allocating resources for research. We will respond to this demand and hope to contribute significantly to research on objective measures for assessing priorities. Intuition and expert opinion, however, will continue to play leading roles in our investment decisions on research.

Because 5 years is an appropriate period for major reviews of ongoing disciplinary investments or regional initiatives, we will make priority assessment an important agenda item of our global in-house reviews and undertake the necessary ex-post evaluations beforehand. Projects will be reviewed every 3 years at program level.

Human Resource Development

Even though ICRISAT programs have trained more than 1900 scientists and technicians to help improve food production in their countries, many national programs are still unable to maintain effective research programs. While our training programs continue to meet an urgent need, requests for additional training are increasing annually. We will work for better coordination of training programs across centers and with the stronger national programs.

Utilizing carefully negotiated plans and guidelines, we will assist national programs to develop their human resources. Five-yearly assessments of need and 3-yearly assessments of internal priorities will be applied in training activities, as in research.

We expect to recruit more research scholars than before, but will decrease our involvement in the provision of scholarships for postgraduate education. We will conduct special training courses exclusively for women from national research and extension services in the SAT. The creation of the Senior Fellow category will provide opportunities to improve the research and management skills of senior men and women scientists and administrators in SAT countries.

Continued Decentralization of Training

Training for South and Southeast Asia will be coordinated from ICRISAT Center, where we will continue to provide in-service training and training of postdoctoral fellows to meet worldwide needs of the SAT. Regional programs in eastern, southern, and western Africa will expand their capacities to assist national research systems through short-term and specialized training, with assistance from ICRISAT Center when required.

Technology Exchange

Closer Involvement in Planning for both Applied and Adaptive Research

We will assist national programs to plan and carry out their adaptive on-station and on-farm research, and will help identify appropriate adaptive technologies, adopting a facili-

tating role. The national programs will be responsible for demonstration and extension of production-increasing technologies or packages.

To upgrade our competence in adaptive on-farm methodology we will need to strengthen our links with such sister institutes such as IRRI that have the required expertise and experience.

We will strengthen existing networks in western and eastern Africa and encourage the development of cooperative research networks for legumes and cereals in southern Africa and Asia. ICRISAT will provide sustained scientific support and limited financial support for selected trials and other cooperative research. We believe that networks with clear objectives and high standards of accountability will multiply our effectiveness, enable strong NARSs to assist weak ones, and help young scientists from the NARSs to develop professional skills and standards.

Large international conferences are becoming prohibitively expensive. We can afford them only limited support. We will concentrate on smaller conferences with regional, problem, or disciplinary focus.

Institution Building

In recent years ICRISAT has been extensively involved in institution building. We have assisted several NARSs directly to improve their research capacities with our mandate crops, provided funds and directions for creating research facilities, purchasing farm equipment and developing seed-production capabilities. These contributions have been valuable and much appreciated. As we shift towards more strategic research, ICRISAT's direct involvement in institution building will decline substantially. Because of the great benefit such activities provide to our partners, however, we will assist NARSs in the process of raising funds to undertake them.

More Customized Publishing through a Wider Range of Media

By providing a wide range of media to reach collaborators with varying levels of information needs, our information dissemination will become increasingly customized. We hope to strengthen and modernize our information and communication services for the benefit of scientists, planners, and policy-makers in the SAT. Simultaneously, we expect to strengthen the information and communication functions for non-ICRISAT regional institutions such as SACCAR and INSAH and in our regional centers. Changes in staff skills will be required, and keeping pace with improvement in equipment is foreseen.

Resources

ICRISAT is an effective research and training institute of scientific excellence and with measurable impact. We have worked hard to make it so. We expect to receive the support and contributions necessary to achieve our plans, with the CGIAR providing support for most of the core activities. ICRISAT has been and will continue to be keenly aware of the funding situation within which it has to operate. We will respond by setting priorities that realistically relate to changing contributions.

Most of what is currently required of ICRISAT to meet the needs of the future can be met at current levels. But the full implementation of this strategic plan will require additional core resources. The demand for ICRISAT's results, assistance, and services by our partners will grow beyond what is currently foreseen in the Medium-Term Plan for 1989-93. After finalizing its last Priorities and Strategies paper in 1987, TAC stated that "ICRISAT has a portfolio of research problems that relate to the commodities and the

continent targeted for increased attention" (Africa). Because of financial constraints the growth in core funds allowed to ICRISAT in the Medium-Term Plan was very modest. Resources were transferred from ICRISAT Center to meet the growing needs in Africa.

We will need additional funds to undertake the proposed activities in biotechnology and IPM. ICRISAT and the system is underinvesting in groundnut research and in the SAT of eastern Africa. Additional funds either to NARSs or to ICRISAT are needed for research on our crops in Latin America.

We should be able to increase our attention to gender issues at ICRISAT Center within existing resources but will need additional skills and funds for such work in southern Africa—where the need seems greatest. The increased activities on sustainability, including agroforestry, will also require new skills and funds.

We know that our plans for enhancing human resource development and communications seem ambitious, but they are merited by the need to enable the rainfed SAT to contribute more effectively to the required increases in food and feed production. Our experience showed that affirmative action to increase the numbers of women in the internationally recruited staff will increase our costs.

ICRISAT has relied more on locally recruited scientists and senior administrative staff than the other IARCs. One of the consequences of increasing decentralization will be the need to increase the numbers of internationally or regionally recruited staff in non-Indian locations and we are advised to increase the numbers of internationally recruited managerial staff at ICRISAT Center.

In the interest of accommodating economic and scientific change, we will use a range of appointment strategies for both regionally and internationally recruited staff. We will also utilize senior fellowships to involve more SAT countries in the conduct of research and training at ICRISAT locations. We envisage posting ICRISAT Center scientists for short periods in national programs and in regional locations in Africa and Latin America. Transfers of managerial staff across the Institute will facilitate the maintenance of administrative policies and procedures.

We will need to see a reversal in the decline in funds for recurrent expenses and maintenance that we have experienced in recent years. As is true for any research center of significance, we will need a steady flow of capital funds for new research and other modifications of facilities to fit new research and other needs.

SACCAR wishes to assume greater responsibilities over the next 10 years for supporting and operating regional activities, particularly for groundnut. This will allow ICRISAT to confine its involvement to global and strategic research, but, again, a shift from complementary to core funding will be needed.

The levels of funding depend very much on the types of support the donors are willing to provide. Whether ICRISAT maintains its institution building, NARSs strengthening, network coordinating, and production training roles or not, a modest increase in funding for global and strategic research and improved scientific communications seems necessary and warranted by the challenges of the future and the successes of the past.

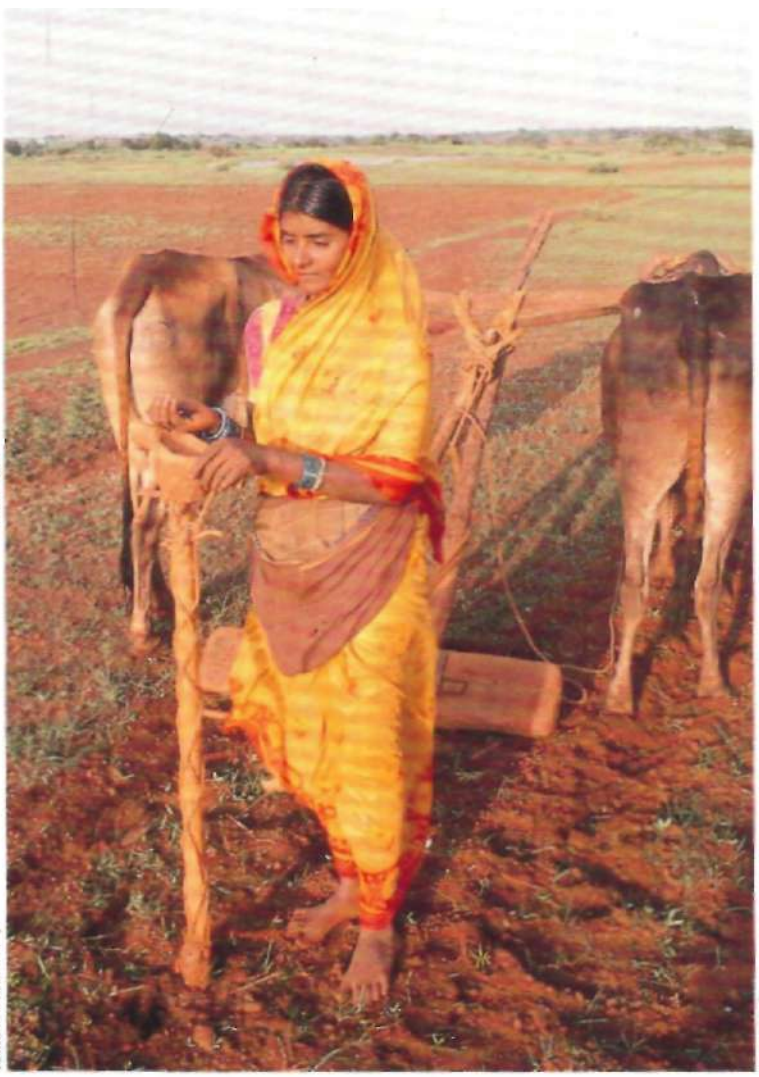
Coping with Change

Because ICRISAT is an institution with a complex mandate, and not merely a number of programs with specific tasks, it must respond dynamically to change. We have made a major change in location, for example, from Burkina Faso to Mali in the interest of the program, while retaining strong linkages with and the goodwill of the government of our former host country.

By 2000, if ICRISAT has been effective in implementing its mission, we will have completed portions of our tasks in applied and adaptive research and handed these activities over to national programs. In southern Africa, for example, SADCC aspires to self-reliance in regional activities. We endorse these aspirations while remaining responsive to

the concerns of national programs, donors, and our employees, and react to these concerns with flexibility and imagination. We will continue to develop appropriate regional programs and to foster close liaisons with each country to sharpen our perception of individual national research needs.

The role ICRISAT will retain, despite dynamic change in its programs and projects, is that of a provider of new scientific methodology and improved germplasm of its mandate crops, and a coordinator of scientific and information exchange. We expect to continue to be a vital contributor to agricultural development well into the 21st century. Our experiences with change, such as terminating research areas and altering the crops mandate, will be thoroughly examined and carefully documented. These strategies will enable ICRISAT to fulfill its global mandate and maintain its reputation as a center of excellence.



The end-product of ICRISAT's research: prosperous farmers.

Appendix: Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
AGRHYMT	Centre regional de formation et d'application en agrometeorologie et hydrologie operationelle (Niger)
AVRDC	Asian Vegetable Research Development Center (Taiwan)
CGIAR/CG	Consultative Group on International Agricultural Research (USA)
CGPRT	Centre for Coarse Grains. Pulses, Roots, and Tubers (Indonesia)
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
CLAIS	Comision Latinoamericano de Investigadores en Sorgo (Guatemala)
CLAN	Cereals and Legumes Asia Network
EARCAL	East African Regional Cereals and Legumes Network
EPR	External Program Review
FAO	Food and Agriculture Organization (Rome)
IARC	international agricultural research center
IBSRAM	International Board for Soil Research and Management (Thailand)
IBSNAT	International Benchmark Sites Network for Agrotechnology Transfer (Hawaii)
IC	ICRISAT Center (India)
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas (Syria)
ICRAF	International Council for Research on Agro-Forestry (Kenya)
IDRC	International Development Research Centre (Canada)
IER	Institut d'economie rurale (Mali)
IFDC	International Fertilizer Development Center (USA)
IFPRI	International Food Policy Research Institute (USA)
IITA	International Institute of Tropical Agriculture (Nigeria)
ILCA	International Livestock Centre for Africa (Ethiopia)
INERA	Institut national d'etudes et de recherches agricoles (Burkina Faso)
INRAN	Institut national de recherches agronomiques du Niger
INSAH	Institut du Sahel (Mali)
IPM	integrated pest management
IRAT	Institut de recherches agronomiques tropicales et des cultures vivrieres (France)
IRRI	International Rice Research Institute (the Philippines)
ISC	ICRISAT Sahelian Center (Niger)
ISNAR	International Service for National Agricultural Research (the Netherlands)
LASIP	Latin American Sorghum Improvement Program (Mexico)
LEGOFTEN	Legumes On-Farm Testing and Nursery
NARS	national agricultural research system
SACCAR	Southern African Centre for Cooperation in Agricultural Research (Botswana)
SADCC	Southern African Development Coordination Conference (Botswana)
SAFGRAD	Semi-Arid Food Grain Research and Development (Burkina Faso)
SAT	semi-arid tropics
SATCRIS	Semi-Arid Tropical Crops Information Service
TAC	Technical Advisory Committee (of the CGIAR) (France)
UN	United Nations (USA)
WANA	West Asia/North Africa
WASIP	West African Sorghum Improvement Program (Mali; Nigeria)

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