DRAFT II
September 1988

IRRI Strategy 1990-2000

International Rice Research Institute

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Preface

Formulating a strategy is much more than writing a document. The process by which the strategy is developed is a major determinant of its value. This document results from a continuing intensive process of internal debate, worldwide external consultation, and joint thinking by all IRRI staff. A strategy cannot be imposed from the top, nor can it be simply the sum of individual views: hence we have tried to balance the two.

A strategy should be a guide for focused programming -- but not a straitjacket. The world in which IRRI operates is constantly changing, so our strategy must allow room for responding to new opportunities and unexpected problems. The complexity of the issues that IRRI faces make it impossible to resolve all questions at once. The attempt to do so, however, helps establish priorities, and resolution of the most significant issues becomes part of the strategy itself.

Why do we need a more formally structured strategy? IRRI's early achievements arose from strategic thinking, but not from such a formal and complex process of strategy formulation. Changes since those days necessitate a more detailed examination of the Institute and the directions that it should take.

- First, IRRI itself has changed -- in age, size, complexity, and momentum.
- Second, the physical and economic characteristics of rice production and consumption -- and their long-term prospects -- also have changed.
- Third, rice research and scientific advances of potential relevance to rice have reached new levels. The physical resources and scientific capabilities of many national programs are much better than they were decades ago.
- Fourth, the funding system for international rice research has changed. In IRRI's early days, two major donors provided most of the funds . Today, about 20 international centers and dozens of national programs compete for increasingly restricted funds from more than 50 donors.

Thus, we face the challenge of defining our place in a changing world. We hope to develop a vision of the future, so we can better anticipate tomorrow's problems and begin searching for innovative solutions today.

Reduced to its simplest form, our strategy addresses the following questions:

- First, what is the basis for formulating a strategy? Chapter I takes a look towards the year 2020 at the world in which IRRI will operate: the world of rice and the world of science and rice research.
- What is IRRI? Chapter II introduces our goal, objectives, and the principles and beliefs that guide our actions. It describes IRRI's resources, current program structure, strengths and challenges for the future.

- What directions will IRRI take? Chapter III analyzes and debates the broad strategic issues that we face, then describes our proposed position.
- What programs will be implemented? Chapter IV describes the proposed program structure, its rationale, objectives, and content.
- How will we implement the strategy? Chapter V indicates the operational strategies and management procedures that we propose to follow.

Definition of Terms

The following are definitions for some key terms used in the strategy.

ecosystem - the four broad sets of rice growing conditions characterized in terms of water regime and chosen as the focus for program thrusts: irrigated; rainfed lowland; upland; and deepwater and tidal wetland.

environment - a more general term for the variety of rice growing conditions within the four main ecosystems, especially the "favorable" and "unfavorable" conditions; and the general physical and biological setting for agricultural production.

goal - the ultimate purpose that guides the activities of an organization. It includes identification of the target beneficiaries.

objective - what an organization aims to produce from the use of its own resources as a contribution to the goal. Objectives are end-products as far as the organization is concerned; they have to be combined with other factors and knowledge, outside the control of the organization, in order to achieve the goal.

mandate - what an organization is empowered to do by legal or constitutional authority.

levels of research - describes the type of work being undertaken.

- **Basic research*** is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, **with no particular application or use in view.**
- **Strategic research** selects, evaluates, and develops, from available knowledge and emerging concepts, tools to solve existing and anticipated applied research problems. It links basic and applied research.
- **Applied research*** is also original investigation undertaken to acquire new knowledge. It is, however, directed primarily toward a specific aim or objective.
- **Adaptive research** is systematic work, drawing on knowledge gained from applied research, to produce new materials, products, and devices, and to adapt existing technology to specific circumstances.

national rice research system - the aggregate of science and technology institutions (including universities) and their activities related to rice research in a given country (also used synonymously are "national programs;" "_____ rice research programs.")

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*These definitions are from "The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development" (1979) OECD, DSTI/SPR/79.37.

Acronyms used

CGIAR

CGIAR	Consultative Group on International Agricultural Research
IARC	International Agricultural Research Centers
CIAT	International Center for Tropical Agriculture
CIMMYT	International Center for Maize and Wheat Improvement
CIP	International Potato Center
IBPGR	International Board for Plant Genetic Resources
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres
ISNAR	International Service for National Agricultural Research
WARDA	West Africa Rice Development Association

Non-CGIAR

AVRDC	Asian Vegetable Research and Development Center
ICLARM	International Center for Living Aquatic Resources Management
ICRAF	International Council for Research in Agroforestry
ICIPE	International Centre of Insect Physiology and Ecology
WINROCK	Winrock International Livestock Research Training Center
IIMI	International Irrigation Management Institute
INTSOY	International Soybean Program
FAO	Food and Agriculture Organization of the United Nations

CHAPTER I:

Toward 2020: IRRI'S environment

"When there is no vision, the people perish."
(Proverbs 29:18)

Warming trends

By the middle of the next century, it is predicted that increased concentration of "greenhouse gases" will have raised the mean global surface air temperature by 3 to 5 °C (M. Schlesinger, 5 Sep 1988 pers. comm.). This equals the temperature increase since the end of the last ice age. As a result, mean global sea level will rise by at least 40 cm, and coastlines will recede by as much as 40 m.

A 2 to 3% depletion in atmospheric ozone has occurred over most of the rice-growing regions in the last 18 years. This depletion is expected to continue up to and beyond 2020, with definite hazards to human health and possible reductions in rice yields. Rice itself plays a role in the production of greenhouse gases--about 17% of atmospheric methane comes from fermentation of organic matter in flooded ricefields. Nitrous oxide and ammonia result from the volatilization of nitrogenous fertilizers used on rice. Both these processes contribute to and are stimulated by increases in temperature. Thus, the warming trend feeds upon itself.

Other aspects of life on our planet are also warming up. The globe is already crowded with 5 billion people. There will probably be 8 billion in 2020 (Fig. 1). So Malthus is right, so far, about population growing exponentially. Fortunately, he has, until now, been wrong about food production only growing arithmetically; for the most part, it has kept up with the exponential growth in demand. However, we have not yet been able to distribute the total amount of food over space and time in such a way that widespread hunger and malnutrition in some regions are avoided.

An increasing proportion of the world's population lives in cities. By 2020, about 55% of the people in countries now classified as "developing" will live in urban areas. By 2000, 25 cities will hold more than 10 million people each (IBRD 1984); 20 of those cities will be in developing countries, 13 of them in Asia. Many

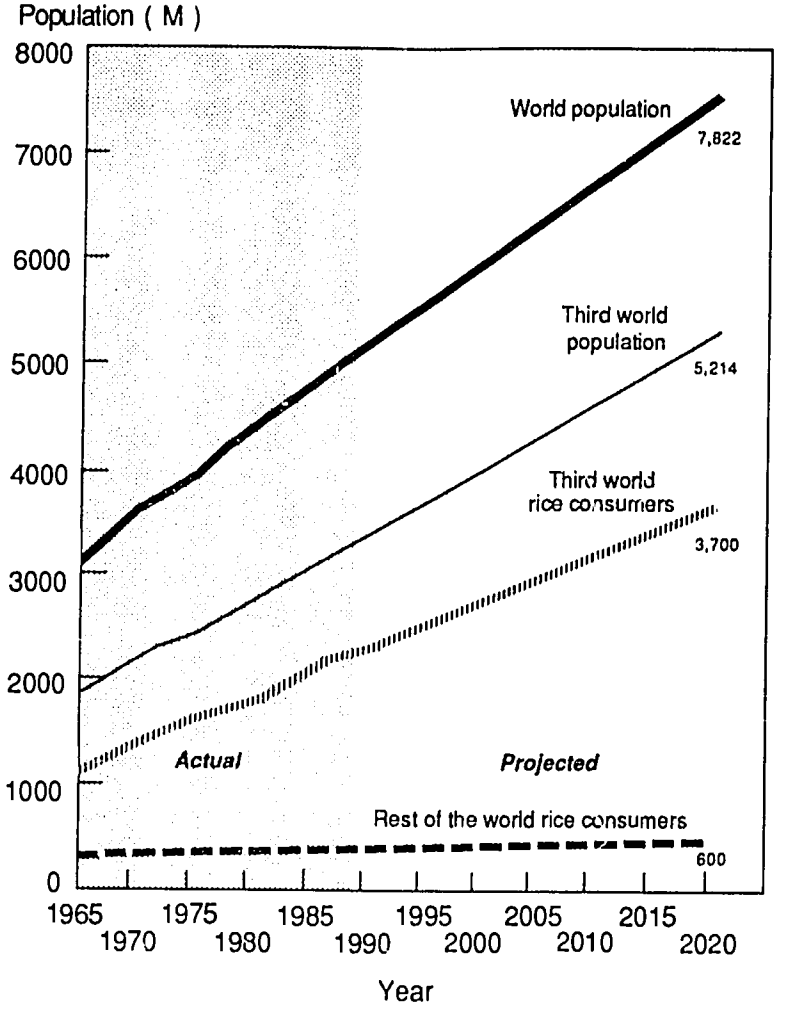

Figure 1. World and third world populations and number of rice consumers, 1965-2020 (FAO 1986, UN 1986, and IRRI 1986).

of these newly urbanized people will have followed the well-trodden path, from rural poverty to urban poverty and, finally, to absolute destitution. The political heat will rise, and with it the importance of stable and plentiful supplies of food, especially rice and wheat. Clean water will become even more scarce and expensive. Waste disposal could become an insurmountable logistical problem.

Finally, the "heat is on" our natural environment. We consume more and more nonrenewable energy to grow food. To cook it, we cut down vegetation faster than it can regenerate. Food production systems have had to be intensified to keep up with exponential population growth. Insidious costs in erosion, soil degradation, and water pollution have been incurred.

We do not consider this vision to be alarmist, but merely realistic. There is much in man's current armory of knowledge and in the achievements of the past

to allow us to be optimistic. However, in terms of IRRI's part of the picture--rice--we feel that complacency with past achievements is unwarranted. Even maintaining the *status quo* would be unacceptable, characterized as it is by major disturbing and unresolved questions about distribution of benefits, food security, and production sustainability. Relaxation of efforts to increase the long-term effectiveness of international rice research efforts would be a serious mistake.

The world of rice: dealing with uncertainty

Research is an investment in the future, and a research strategy should be based on the future--on future problems as well as on opportunities, and on desirable goals for which to strive.

The risks of looking as far ahead as 30 years are obvious. However, 30 years ago, walking on the moon was dreamed of, but not technologically possible. We must take the risks inherent in crystal ball gazing, and of asking "why not?" instead of "why?" Otherwise, we face unacceptably high risks that the right answers will not be found.

Much research is conducted because of inadequate information about current phenomena. Our present understanding of the physical, biological, cultural, and economic circumstances surrounding the production and marketing of rice is less than perfect. Yet we must use the best possible information as a basis for prediction, bearing in mind that envisioning 30 years ahead is an art, inspired more by history and imagination than by science and empiricism.

Two types of uncertainties should be considered: those related to problems and those related to the potential to solve those problems. For example, problems such as global warming, Third World debt, or disease and insect epidemics may affect the production and distribution of rice. But the potential to **solve** such problems, whether through scientific discovery, public policy, or development investment, also may change in ways not thought of now. Research strategy formulation aims to minimize the problems by maximizing the potential to solve them.

Even the most optimistic visions of the future recognize the importance of minimizing the risk of staple food shortages. Recent droughts in major food-producing countries serve as a warning signal. World rice stocks are equivalent to about 17% of annual consumption--enough for about 2 mo. Other foods can be substituted for rice to a degree, but for many consumers this is not a short-run option. The margin for error may not be sufficient.

The demand for rice

About 80 to 100 million additional people must be fed each year, most of them in that collection of poorer countries dubbed the "Third World." Rice is the staple food of poor people: half the world rice production is consumed by those who produce the crop, mostly resource-poor farm households. Virtually all consumers who **depend** on rice as their major food source live in the Third World (Fig. 1),

most of them in Asia, where 90% of the world's rice is grown and eaten (Fig. 2). Asia also has the largest proportion of the world's poor and malnourished people.

Dependence on rice for food energy is much higher in Asia than in other regions (Fig. 3). Rice provides from 35 to 58% of the calories consumed by 2.5 billion Asians. In Latin America and Africa combined, about 0.5 billion people obtain about 10% of their food energy from rice. Thus, about five times as many people in Asia depend on rice five times more than people in the rest of the Third World.

Regardless of region, most rice-dependent economies have high population growth rates, low rice yields (except for China and Indonesia), and low GNP. Their resources for food imports are limited and food aid is only a short-term palliative. A world in 2020 that still relies significantly on food aid will have failed.

When people are poor and hungry, it is not possible to discriminate among countries, or between the rural and the urban areas. Who is worse off, the hungry slum dweller in urban Asia or the hungry African farmer? Therefore, absolute numbers of such people are what is important in decisions about allocation of scarce research resources. About half the populations of South Asia and sub-Saharan Africa receive inadequate calories for an active working life, according to a recent World Bank Policy Study (IBRD 1986). About 470 million of those people live in South Asia, and 150 million in sub-Saharan Africa--a ratio of more than 3:1.

To meet the projected growth in demand, making allowances for substitutions for rice in diets as incomes increase, we estimate that the world's annual rough rice production must grow from today's 470 million tons to 625 million tons by 2000 and to 758 million tons by 2020--an increase of 61%.

Rice supply

Where will the rice come from? At least 90% of the world's rice farmers and consumers will still live in Asia. But Africa has the highest imports relative to domestic production--and the highest rate of growth in imports. Only about 4% of the world rice production is traded on the international market (Fig. 2); most countries rely almost entirely on domestic production.

Perhaps more important to research planning are the types of ecosystems that must supply the rice. Water regime is the main determinant of the type of rice varieties and production practices used. In reality, the growing conditions with respect to flooding levels are on a continuous gradient, and precise divisions are difficult to make. Hydrological data are also inadequate. For planning purposes, however, we can consider four broad ecosystems, classified according to the type of water regime: irrigated, rainfed lowland, upland, and deepwater and tidal wetland (Table 1). (For more details on the characteristics of these ecosystems, see Annex A).

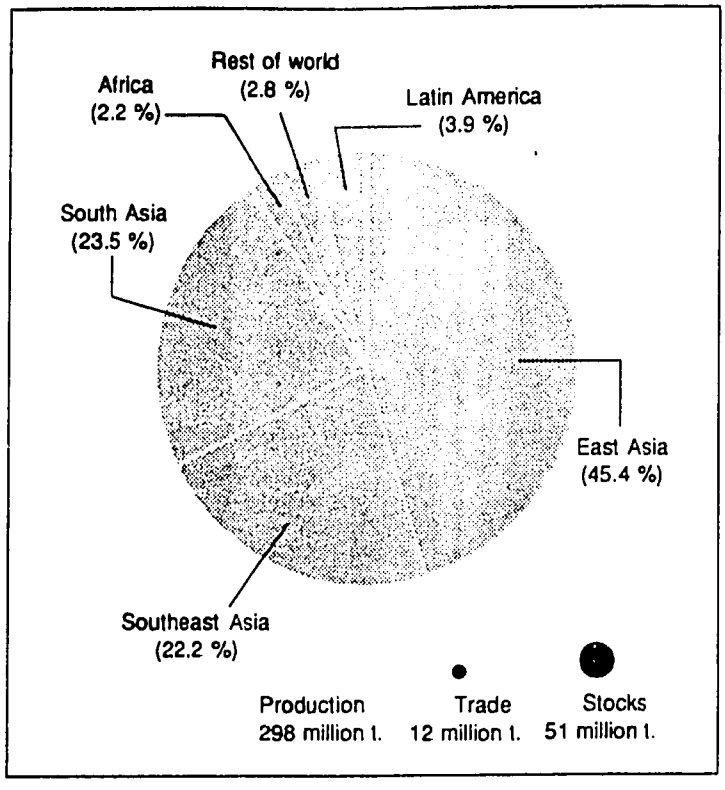

Figure 2. Regional distribution of world rice production and relative size of trade and stocks (milled rice), 1987 (FAO 1988; IRRI, in press).

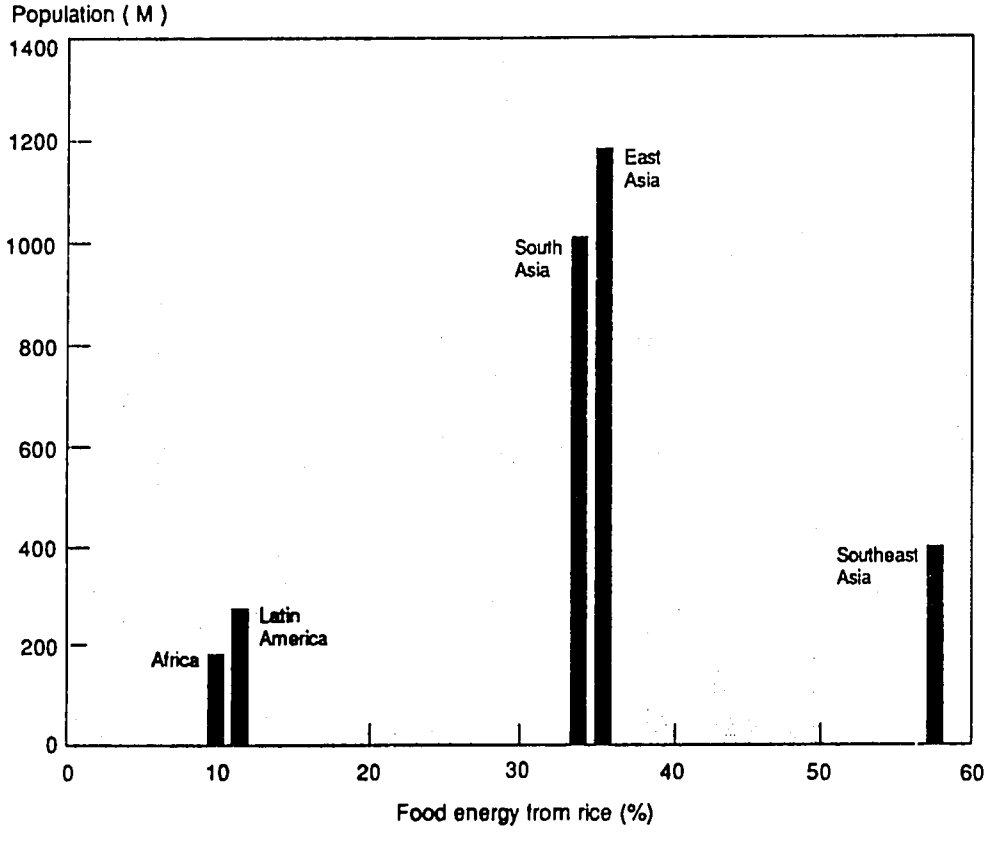

Figure 3. Population and importance of rice in the diet, by region,1985.

TABLE 1. Harvested area, yield, and production from four categories of rice ecosystems, 1985.[a]

Ecosystem	Area		Yield	Production	
	million ha	% t	(t/ha)	million	%
Irrigated	67	49	4.7	313	71
Rainfed lowland	40	29	2.1	86	20
Upland	18	13	1.1	21	5
Deepwater/tidal wetland	13	9	1.5	19	4
Total	138	100	3.2	437	100

[a]Compiled from detailed analysis of the relative importance of each ecosystem in the 37 major rice-producing economies of the developing world (IRRI 1988).

Many factors will determine the relative contribution of each ecosystem to rice supplies in the future:

- Actual production potential, and the chances for its enhancement.
- Amount and proportion of research directed to each system.
- Public and private investment in production and infrastructure.
- Water availability.
- Rate at which irrigated and rainfed lowland areas can be expanded.
- Loss of land now being farmed.
- Actual and predicted prices of rice and those of alternative crops.
- Population growth rates, migration, and urban encroachment.

Whatever the combined effects of these and other factors, the irrigated areas will continue to dominate production. Irrigated land now comprises less than half the total harvested area, but contributes more than 70% of total production.

The great production gains of the 1960s and 1970s were on the irrigated and favorable rainfed areas, where short-duration semidwarf varieties could express their high yield potential. Yields of irrigated rice in most countries are still about 3-4 t/ha--but the potential is at least 6-8 t/ha.

The less favorable environments produce from 20 to 25% of the world's rice. In the next two decades, they must sustain many millions of farmers and consumers who so far have realized few of the benefits of advanced rice technology.

There is potential for expanding the cultivated area of each ecosystem. For example, about 18 million ha of deepwater and tidal wetlands in South and Southeast Asia are not utilized. Latin America and Africa also have large areas of unused wetlands. The contribution of those areas could be enormous, if we could overcome the most significant technical production constraints (such as excess water and salinity). The upland ecosystem also has potential for

improvement, although maximizing farm incomes there depends on a wider range of farm enterprises than it does in other ecosystems. In upland areas, we have to think more in terms of farming systems with rice as a component.

Resources and inputs

It is claimed that there is enough potential farmland in the world to feed future world populations. However, global generalizations are of limited value in rice research planning. The persistent experience, of hungry populations coexisting with adequate, and even surplus, world food production, means that we cannot rely on better distribution systems, even within countries, to feed people. Land availability must be considered country by country.

Most Asian countries already have high ratios of population to arable land. Temperate and tropical Latin America still has large unused areas, but many of them have major soil fertility problems. On the African continent, only in Central Africa is there much scope for the expansion of agriculture, but again the ecosystems are fragile.

Land quality is as important as quantity. In many areas, the rate of land degradation is alarming--not least because it increases the pressure to bring less suitable soils under cultivation. A recent assessment by the World Commission on Environment and Development (WCED) presents many examples of land degradation that are pertinent to rice production. "Without conservation measures, the total area of rainfed cropland in developing countries in Asia, Africa, and Latin America will shrink by 544 million ha over the long term because of soil erosion and degradation..." (WCED 1987). Continuous rice cultivation in upland areas has been shown to result in significant increases in soil loss. Research in the Philippines measured annual soil losses of 0.073 t/ha in primary forest, 0.146 t/ha in grassland, and 43.5 t/ha in 12-yr-old rice swidden (Kellman 1969). Even higher levels have been measured on 9% slopes in northern Thailand (Vergara and Briones 1987).

Irrigation is particularly important in rice production. Poorly designed and implemented irrigation systems have caused soil waterlogging, salinization, and alkalinization. FAO and UNESCO estimates of these losses indicate that some 10 million ha of irrigated land are being abandoned each year (Szabolcs 1985). Research has some repair work to do.

Water is the most critical of all the resources used in cultivating modern rice varieties. The costs of bringing new areas under irrigation are high relative to returns, and new irrigation investment has slowed. This makes increasing the efficiency of water use in rice production even more important.

As with land, the trends in both amount and quality of water available for the next century are disturbing. A view of water as an inexhaustible gift of nature is no longer valid. Research by the Water Technology Centre in India points to increasing shortages of water of suitable quality for domestic, industrial, and agricultural uses unless attempts are made to improve the efficiency of its use

(Sarma 1986). Although the existence of largely untapped sources of groundwater, especially in the humid tropics, somewhat lessens concerns about the amount of available water, the problems of quality appear to be growing. Apart from salinity and alkalinity, there is some evidence of pesticide pollution in canals, ponds, and ricefields in Asia. Pollution levels in some areas are already serious, and in some are affecting fish farming. Even with lower rates of increase than those in recent years, it is estimated that pesticide applications will double by the year 2000.

Fertilizers, while less problematic than biocides, can also have harmful effects when used inappropriately. In theory, nitrogen recovery can reach 75% in well managed systems. But efficiency in using nitrogen fertilizers is low. Both surface and groundwater can become polluted by chemical fertilizers (CGIAR 1988). However, it is unlikely that either supply, price, or effectiveness will constrain fertilizer use. As research at IRRI has demonstrated, even at high levels of energy input, there is no evidence yet of a decline in the energy input:output ratio (IRRI 1987). Rice farmers are likely to continue to use increasing amounts of fertilizer as a means of raising production.

The outstanding feature of this brief overview of the resources used in rice production is the long-term vulnerability of production systems. This is of particular significance in the favorable areas, where production depends on relatively high levels of crop intensity and inputs (water and chemicals). The evidence is incomplete, but the cumulative effect of stresses on natural resources should not be underestimated. In Thailand, for example, rough rice yields in the Chiang Mai Valley were increased from 4 to 7 t/ha by changing from traditional to intensive practices. Ten years later, yields have slipped back to original levels, despite continued high inputs of lime and other fertilizer (Gypmantasiri et al 1980). Yields of some modern varieties under optimal management at experimental sites at IRRI, Los Baños, and at three other locations in the Philippines have declined by 0.1 to 0.3 t/ha per year over a 20-yr period (Flinn et al 1984).

We do not yet understand all the causes. Certainly, we cannot assume that the production systems upon which the basic food supply of hundreds of millions of people depend can be sustained to 2020 without intensive research efforts.

People

People are a "resource" of their own farm enterprises. They are also a source of demand for food, jobs, and income. They are our target beneficiaries.

The numbers of marginal farmers and rural landless in Asia will increase to more than 1 billion by 2020. Many will be forced on to highly erodable, marginal land where cultivation cannot be sustained for long. Or they will migrate to urban areas in search of a livelihood. Either way, a large proportion will be categorized as low-income rice consumers and/or producers.

As consumers, the amount, the price, the security of supply, and the quality of the rice they eat will significantly affect their welfare. As producers and as

entrepreneurs and laborers in the input supply and postproduction processes, their welfare will be directly related to costs and returns.

The majority will be women and children. Women provide most of the labor in rice production and are most directly responsible for the basic well-being of children. There is evidence that, if women are able to earn more, families tend to be smaller. The poorer the household, the more important it is that women have independent access to real income, which could be derived from rice-based products as well as from rice itself.

Rice prices

Both current and predicted prices of rice have important implications in setting research priorities. First, if the price is low, we should seek additional opportunities to increase both the income of rice farmers and alternative jobs in rice-dependent regions. Second, rice farmers face a cost-price squeeze because the cost of commodities that the farm family buys may not fall with declining rice prices. Third, low projected prices will be a disincentive to investment in the rice sector, including investment in research. Finally, low prices discourage farmers from increasing production and, hence, from adopting new technology.

The thin residual and changing structure of the world market for rice makes forecasting prices a hazardous undertaking. For example, even though it is expressed in constant dollar terms, the trend line of international prices in Figure 4 shows some extreme fluctuations, caused to varying degrees by factors such as droughts and oil price increases. Total world rice supply has maintained a fairly steady upward progression since 1950, in contrast to the more volatile price. Price has tended to decline, but is highly sensitive to relatively small shifts in supply and to other economic factors. Thus, even a small shortfall in production would invalidate any predictions of continuing low prices. Both FAO (1981) and IFPRI (1984) forecast that demand will exceed supply by the year 2000, and that prices will rise.

On the basis of a country-by-country examination of potential production and demand, Barker et al (1985) support that view. Given that Asia dominates both the demand for and the supply of rice (Fig. 2,3), their analysis is particularly relevant. After studying the 8 countries that produce 85% of Asia's rice on 88% of its riceland, they conclude:

- The demand for rice in Asia in 2000 will be around 570 million metric tons of unmilled rice--a 58% increase over the 1980 level. That takes into account such factors as growth rates in population and per capita income, and trends in substitution for rice in the diet.
- Rough rice production will rise to around 484 million tons by 2000, given current trends in the expansion of irrigated areas and in technology development and adoption. There will, therefore, be a shortfall of 86 million tons, or 15% of demand.

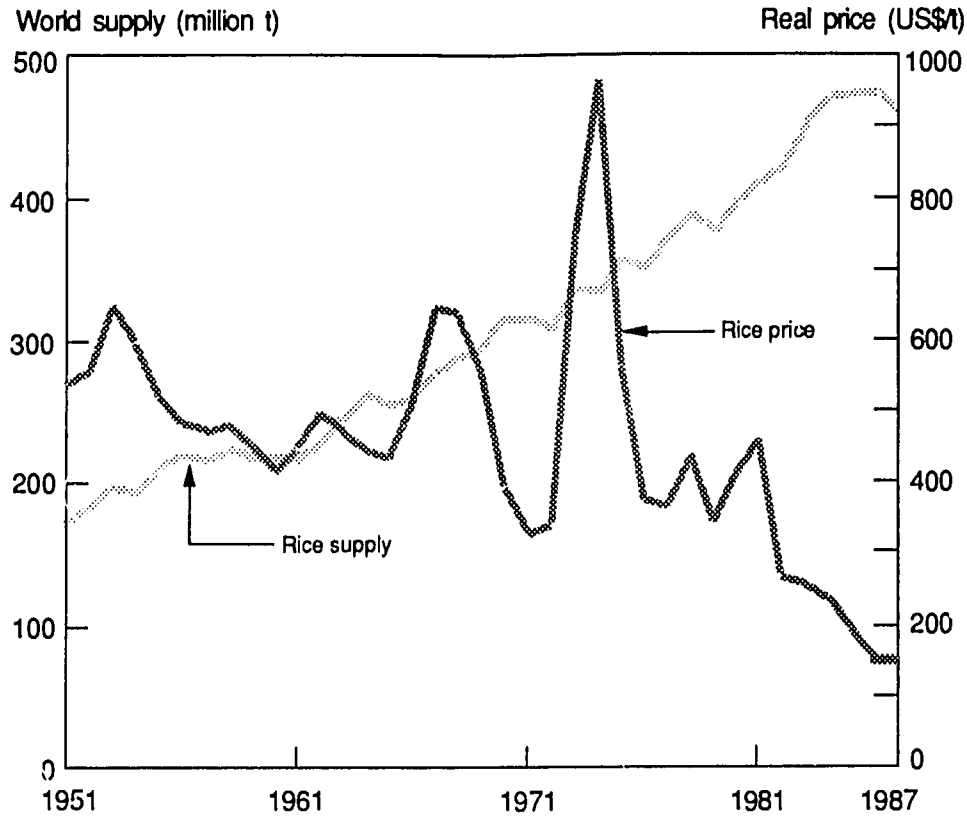

Figure 4. World rice supply and price, 1951-87 (IRRI, in press).
Price (f.o.b. Bangkok) given in constant dollars, base year 1985.

- Prices will rise in the late 1990s, given that large quantities of rice cannot be traded without affecting the price, even if the deficit were partly covered by wheat imports.

This analysis leads us to conclude that, unless yield levels can be raised, the demand for rice will significantly exceed supply toward the year 2000. Expansion in harvested area, international trade, and substitution of other food staples will not be enough to make up for the difference without much higher prices relative to incomes than at present.

The world of rice research

Looking toward 2020, we anticipate a radically different world rice research effort. In the arena of international development, it is to be hoped that the present terminology classifying countries as developing or developed, as Third World or First World, will be obsolete. The donor-recipient tone inherent in such terms will have given way to terms more representative of international cooperation for mutual benefit, based on shared resource contributions and responsibilities. We expect that many of the major rice-dependent countries will sustain strong,

independent rice research programs in specialized areas. For example, one forecast predicts that by 2020, the Gross Domestic Products (GDP) of China and India will be greater than those of most European countries. Although comparatively low-income in terms of GDP per capita, these countries already are starting from positions of considerable scientific strength; their potential contributions to new knowledge by 2020 are hard to conceive in present-day terms.

In contrast, some countries with small populations and very low income levels and resource endowments cannot aspire to the critical mass needed for even a scaled-down version of a full-fledged research system. These countries will continue to rely on regional cooperation and networking, based on specialization by different countries. They also will need to draw upon the research output of advanced national programs and regional and international institutions.

Thus, the future global rice research system will be more extensive, more advanced, and better linked than today's system, that is characterized by heterogeneity. In rice-dependent countries, a wide range of human and financial resources is devoted to rice research, with much variation in research direction.

A database of the human and financial resources devoted to agricultural research in each country is being developed by our sister institution, ISNAR. Some data illustrate the heterogeneity among the major rice-producing low-income countries. Numbers of agricultural researchers range from 8,389 in India alone to 6,101 total in the 9 major rice-producing countries of the African continent (that includes 4,246 in Egypt).

As a general rule, however, good **quantitative** data are scarce. There is a lot of **qualitative** information available at IRRI, although much of it is not formally recorded. Our collaborative work with national programs is based primarily on this information. We will be including the collection of this kind of information in our "rice-related database." That will improve the basis for strategic decisionmaking with the national programs. The plans of individual countries for human resource development will become increasingly important in IRRI's potential contributions to development of their national research programs.

In terms of the needs of Africa and Latin America, the strategic plans of IITA, WARDA, and CIAT are most relevant. The work of other international centers and agencies, such as ICRAF, IIMI, and IFDC, will be pertinent to concerns about crop and resource management and rice-based farming systems.

Frontier science

Strong links with advanced laboratories working in rice and rice-related research will be equally important. For example, biotechnology research, such as embryo and haploid breeding, are well-established in Japan. In the future, protoplast culture, cell fusion, and recombinant DNA technology are possibilities. Linking up with both the public and private sectors active in such work will be essential to

maintaining the efficiency of IRRI's programs and to optimally exploiting IRRI's comparative advantage.

Other scientific frontiers, such as ecology, physiology, systems science, and rural sociology, also are relevant to IRRI's strategy. Recent advances in computer, satellite, and digital communication technology are revolutionizing the processes of exchanging information, developing skills, and learning, but exploitation of their potential is only beginning. New technologies are being developed at least as fast as they can be effectively used. Mankind has rapidly moved from the printed word to wireless, telephone, radar, and finally laser-disk technology. These innovations have improved the accessibility of extensive information.

We believe that the pace and magnitude of all these scientific advances impose upon us two responsibilities: First, we must stay abreast of these developments to carry out training, collaborative research, communication, and networking as effectively as possible. Second, we must think the unthinkable and apply the kind of ambitious vision that put man on the moon to scientific ideas that could make life better for man on earth.

IRRI's Conclusions

Five main issues emerge from this brief analysis of the rice scene and the rice research setting:

1. Forecasts of rice production tend to pay insufficient attention to the technical factors affecting long-term security and stability of rice supply.
2. These factors are equally significant to the unfavorable and the favorable rice ecosystems. The future needs of populations depending on the unfavorable areas should be addressed more directly.
3. The world will continue to rely heavily on the favorable ecosystems in the foreseeable future, particularly to feed urban consumers. The vulnerability of these systems demands continued and, in some aspects, increased attention.
4. In the world of science, classifying countries into "developing" and "developed" is becoming increasingly irrelevant; in the world of rice science, directed to improving people's lives, it is inappropriate.
5. Rapid scientific advances in many fields have potential to help IRRI and our partners to achieve our goals.

Chapter II:

What is IRRI?

Mandate, goal, objectives

Definition of terms

The **Mandate** stated in IRRI's Articles of Incorporation is taken as a "given." (Full text provided in Annex B.)

The **Goal** is the ultimate purpose that guides our activities, it identifies our target beneficiaries.

The **Objectives** are distinguished from the goal, in that they are not only end products as far as use of IRRI resources is concerned, but also intermediate products that must be combined with other factors and knowledge to achieve the goal. Most of the other factors are outside our control, although we will try to influence some of them, directly or indirectly.

The **Program objectives** defined in Chapter IV are more specific. They follow from analysis of the main strategic issues and identification of the critical research entry points for each program area, and are consistent with our general objectives and the goal. They are expressed in terms of outputs that we can produce using mostly our own resources.

The goal

The goal statement constitutes an indispensable criterion against which to test the relevance of the Institute's objectives and activities.

Our goal is

> *To improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.*

This statement has two important implications: First, the well-being of low-income people who depend on rice for food can only be assured if, at a minimum, adequate supplies of rice can be made available at prices that are as low as possible relative to income. Second, the well-being of rice farmers--and their husbands--is measured not only in terms of income, but also in terms of reduced risk and uncertainty, increased opportunities, and decreased mental and physical discomfort caused by toiling in hot, humid, and muddy ricefields.

The Objectives

Our general objectives are

> *To generate rice-related technology and knowledge of long-term environmental, social, and economic relevance, and to enhance national rice research systems.*

The two objectives are complementary. Achievement of the goal and the relevance of our work depend largely on partnership and information exchange with national scientists, extension workers, and policymakers. To this extent, helping to develop national rice research capacity contributes directly to developing rice technology and discovering knowledge of relevance to developing countries.

IRRI can only generate technology and knowledge (the objective); it cannot generate higher incomes or feed people more adequately (the goal). Our efforts will focus on generating technology and knowledge with a maximum probability of increasing farm incomes through increased output (quantity and quality) and/or decreased costs. Rice is an excellent source of energy (which is more limiting than protein in most diets). We see the route to improved nutrition as being primarily through improvement of rice varieties used in food production systems. That will increase incomes, generate nutritious nonrice products, and sustain adequate supplies of rice over the long term.

The dominant role of women in rice production and consumption in developing countries is well-known. When we speak of "relevance" in this context, we mean our continuing recognition of the fact that technology has different effects on different beneficiary groups (e.g., women, children, the elderly). It is inefficient to develop technology without full knowledge of and sensitivity to the social and economic systems where it will be applied.

Guiding principles

What is sometimes called the "culture" of an organization (i.e., its principles, values, and beliefs) can influence both the nature of the strategy that it formulates and the effectiveness with which the strategy is implemented. A summary of IRRI's guiding principles is important context for the remainder of this document.

Role and responsibility. The driving forces of agricultural and economic growth are trained people, effective institutions, improved technology, developed rural infrastructure, and appropriate public policies. IRRI's role is to contribute to the improvement of rice technology, the enhancement of human resources in research and related activities, and the formulation of appropriate public policies. We are part of an international scientific community, prepared to cooperate with other institutions as needed.

Rice consumers number about 45% of the world's population. As we respond to the challenge of the research needed on rice, we strive for excellence

through rigorous research and for relevance through cooperation and dialogue with scientists, administrators, and rice farmers.

Concerns. Our main concern is people--the producers and consumers of rice. We belong to the worldwide community committed to alleviating poverty and hunger by applying science to improve the productivity of human, natural, and institutional resources devoted to all aspects of rice production. We commit ourselves to the preservation of rice genetic resources. We value present ricelands, as well as potential new rice areas, as the living base for generations to come, and promote their wise use and conservation.

Beneficiaries. Our target beneficiaries are rice farmers--especially resource-poor farmers--and rice consumers--especially those with low incomes.

Partners. We work worldwide with all research institutions that share our goal, particularly the national rice research programs of countries where our target beneficiaries live. Rice research has no political boundaries. We search for new solutions to old and emerging problems through personal and institutional efforts and through partnerships with other institutions, both public and private.

Management. We strive to maintain and enhance

- A research environment conducive to innovation and creativity.
- A multicultural, institute-wide social system that encourages all staff members to learn from one another, sharing resources and knowledge and freely exchanging ideas and information.
- Management policies that encourage open communication in all directions and that continue to promote our standards of scientific integrity, honesty, commitment, enthusiasm, and efficiency.

We believe in

- Decentralized management based on visible leadership, interactive problem analysis, and shared responsibility.
- Compensation levels based on performance, fully competitive against market standards.
- Openness in all our research undertakings.

Our guiding principles have resulted in high standards of performance. We state them here as a reminder that they will not be compromised.

IRRI today

Program structure

IRRI now has 13 research departments, 8 global research services, and 5 research support services (Table 2).

Table 2. IRRI Organization 1988.

Research Departments	Global Activities	Research Support Services
Agricultural Economics	Communication and Publications	Analytical Service Laboratories
Agricultural Engineering	International Rice Germplasm Center	Computer Services
Agronomy	International Rice Testing Program	Experimental Farm
Cereal Chemistry	International Network on Soil Fertility and Sustainable Rice Farming	Pesticide Residue Laboratories
Entomology	Rice Farming Systems Program	Phytotron
Water Management	Library and Documentation Center	
Multiple Cropping	Training and Technology Transfer	
Plant Breeding	Seed Health Unit	
Plant Pathology		
Plant Physiology		
Soils		
Soil Microbiology		
Statistics		

Teams of IRRI scientists from various research and global research departments focus on nine interdisciplinary, mission-oriented program areas (Table 3).

Table 3. Research Program Areas

Genetic Evaluation and Utilization	Constraints on Rice Yields
Control and Management of Rice Pests	Consequences of New Technology
Irrigation Water Management	Cropping Systems
Soil and Crop Management	Machinery Development and Testing
Climatic Environment and Rice	

The IRRI staff includes 95 internationally recruited scientists (64 core staff, 10 on special projects, and 21 visiting scientists); 87% are stationed in Los Baños--the highest proportion among the international centers that carry out agricultural research within the CGIAR system. Another 2,284 scientists and research support staff are nationally recruited.

IRRI's core budget has increased in real terms by almost 4% annually over the past 10 years. The core budget for 1987 was US$26 million, with a further $5 million for special projects. The proposed 1988 budget is $27.7 million, with $8.6 million for special projects--for a total of $36.3 million.

Achievements

In terms of human benefit, our achievements in the irrigated and favorable rainfed ecosystems unquestionably have been one of the bright spots of the 20th century. They are well-documented elsewhere and will not be reported here (Chandler 1970, IRRI 1985).

A strategy, however, must be concerned with what we hope to achieve. What has been achieved is relevant primarily because it has given us the confidence that is perhaps our greatest asset. The confidence that we have in ourselves and that others have in us will be a key factor in helping us meet the research challenges that lie ahead.

Strengths

A central strategic intention is to build on our strengths and to draw on the strengths of others. Among our most important comparative advantages are

- **Disciplinary depth.** The knowledge and experience that has accumulated within IRRI's highly specialized disciplinary structure is reflected in the more than 90 awards that the Institute has received, and in the enthusiasm and creativity that has been maintained for more than a quarter of a century. This gives us the critical mass needed for the conduct of high standard research.
- **Technical support.** The locally recruited staff contribute significantly to IRRI's scientific achievements. The technical and general service support is of exceptionally high quality.
- **Political neutrality.** We are able to act as a reference point for any query concerning rice science from anywhere in the world.
- **International character and credibility.** We have a strong convening and coordinating capacity and the ability to work with any research institution, anywhere. IRRI has proven itself by tackling issues that cannot be addressed by individual countries.
- **International assets.** We have been able to collect and conserve more than 83,000 accessions of rice germplasm and more than 125,000 rice publications. These assets have been and will continue to be available internationally.

Challenges for the future

We are aware, both from our own reflection and from review processes, that we are not immune to the ageing process. As in any other institution, this can affect not only physical assets, but also the working environment and the research results. We see the following as concerns, and challenges:

- Our present organizational structure makes it difficult to establish problem-focused interdepartmental programs. Wide dispersion of our resources over a large number of departments and support units also constrains formation of the critical mass of scientific knowledge necessary for a breakthrough within an acceptable time span.
- Overlapping division of labor and the expansion of our work program, in conjunction with centralized decisionmaking processes, make a review of the structure more urgent.
- Ageing of our technical facilities, combined with a period of rapid growth, forces us to replan the use of existing buildings and facilities and consider rehabilitation, or even replacement.

We will introduce a system of delegated decisionmaking based on a division of labor conducive to the minimization of administrative procedures. With the new CGIAR planning process, our activities will become less oriented to individuals and more oriented to group efforts.

In times of rapid growth, attention can become diverted from effective financial management. IRRI will demonstrate utmost care in the management of funds. This implies a sharper focus on areas of high priority, comparative advantage, long-term relevance, and high return. To achieve this, we will intensify our dialogues with clients and partners and establish participatory planning and monitoring systems.

We believe that the ability to recognize areas of concern is a sign of strength in itself, and a criterion against which a dynamic institution can be judged.

Beyond IRRI's lifetime

We identify several important functions for which there will be a continuing need well into the 21st century, and beyond. Beyond IRRI's lifetime, a politically neutral clearinghouse will be required to act as the coordinating center of a "global rice knowledge network." Its main functions will be:

- To house one of several duplicate collections of the world's rice germplasm and to perform the many evaluation, research, storage, and service functions that this responsibility entails.
- To collect, evaluate, select, and make accessible information on global rice research resources (human, financial, physical); current rice research and development programs; rice and rice-related research results.
- To organize and convene computer conferences, task forces, seminars, and meetings, in order to exchange knowledge and to focus its application to emerging problems.

CHAPTER III.

Strategic issues and priorities

Although IRRI deals only with rice, many of the development issues related to that commodity are of major global significance, and are interdependent. The range of possible research entry points is extensive and difficult decisions must be made.

Here, we deal with the major questions under two broad categories: policy issues and resource allocation priorities. The policy issues are discussed first because that analysis provides important background to understanding the resource allocation options.

Policy issues

Disciplinary strength and interdisciplinary problem focus

A recurring dilemma in the management of modern science is that, as budgets become tighter and investors demand measurable returns, research becomes subject to increasingly formal planning and more specific management controls. This often means questioning the traditional disciplinary structure of research, since it is recognized that the solutions to many problems require interdisciplinary approaches.

A center such as IRRI, with its mission-oriented mandate, should excel in **both** disciplinary and interdisciplinary research. An overly strong disciplinary bias could diffuse the focus on specific objectives, and weaken and unbalance the integration of efforts among problem areas that is needed for effective programming. But too much emphasis on integrating several disciplines carries the risk of losing the scientific depth needed for real advances in knowledge.

To many, a disciplinary research environment appears to prevail at IRRI. The Institute is sensitive to this, and will initiate a program management structure that permits the pursuit of excellence on both dimensions.

Many of the critical problems in rice production are specific to particular ecosystems. Four main ecosystems will be used as research foci, with the contributions of several disciplines integrated toward solving the problems of each ecosystem. Two additional broad research program areas--applied and

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strategic research--also will promote interdisciplinary work on problems that are not specific to any one ecosystem. The research program thrusts are

- irrigated ecosystem
- rainfed lowland ecosystem
- upland ecosystem
- deepwater and tidal wetland ecosystem
- cross-ecosystem: applied research
- cross-ecosystem: strategic research

The rationale for this program management matrix is explained more fully in Chapter IV.

We emphasize that the proposed research structure is intended to facilitate appropriate and necessary cross-disciplinary integration. It is not intended to sacrifice intensive and effective contributions of single disciplines when and where they are needed.

In summary, IRRI plans to implement its programs through a matrix management structure that will balance disciplinary strength with an increased focus on multidisciplinary approaches to problem solving. IRRI believes that standards of excellence can and will be achieved along both axes of the matrix.

Efficiency and equity

An efficient research system would allocate resources to return equal marginal social benefits per unit of research input, regardless of where that input was made. It would not be concerned with who received the benefits. Equity demands, however, that we be concerned with **how** the benefits from research investments are distributed. These issues permeate many public policy debates, including many of the strategic questions discussed here.

Perfect equity, that is, being equally fair to everyone, is an elusive goal. Deciding to select certain strategic directions will, by definition, leave out those who might have benefited from the directions that are **not** selected.

The dilemma can be considered on two levels. First, those who are excluded from the initial investment choices. IRRI's concentration on high-yielding rice varieties tailored for the irrigated and favorable rainfed lowland environments has returned limited benefits to those populations dependent on the less-favorable environments. Second, the distribution of benefits among those affected by the initial investment in the favorable environments. At both levels, we find consumers and farmers. Among farmers, we find early and late adopters; small and large farms; varying degrees of access to credit, water, and fertilizer. The conventional wisdom is that consumers have benefited the most from rice technology in the last 25 years, because increased supplies have lowered prices. But farmers in the favorable ecosystems also have benefited.

An international center has limited ability to address equity concerns at the second level. Much depends on public policies on prices, agrarian reform, and credit; on national research and extension capabilities; and on the character of

local farms and farmers. However, research programs based on knowledge of and contact with groups of target users and beneficiaries can generate knowledge tailored to their needs.

It cannot be claimed that IRRI has neglected equity concerns. If IRRI had concentrated all its efforts over the past 25 years on the **unfavorable** environments, the current price of rice would be significantly higher and millions more would be hungry. The efficiency gains from IRRI's research have, in fact, benefited the majority of rice consumers.

Another dimension to the equity issue can be described as "being fair to future generations." As was discussed in Chapter I, many current production practices--in all ecosystems--are not sustainable over the long run. This tends to erode the concept of "favorable" and "unfavorable" environments, since human intervention is transforming large parts of the so-called favorable areas into unfavorable ones. Thus, sustainability emerges as a criterion for resource allocation among ecosystems.

How long the benefits for an ecosystem will last is more important than past or current distribution of benefits. If 90 people benefit from an investment and 10 do not, but the 90 will continue to benefit for only 5 years, where should we direct our research efforts?

To summarize, IRRI's goal statement is explicitly oriented to equity. It specifies the direction of effort toward the "well-being of rice farmers and consumers, particularly those with low incomes." IRRI staff have always been, and will continue to be, strongly conscious of this mission. Although we recognize the limitations on the extent to which an international research institute can, with its resources alone, address equity concerns, we will continue to strive to reduce those limitations. For example, we recognize that equity concerns can be addressed by targeting research to improve the production efficiency of specific groups. Consideration of the plight of producers and consumers in the unfavorable ecosystems has been built into the program management matrix by creating three separate program thrusts for those ecosystems. Our strategies with respect to women in rice research, production, and consumption will be pursued with vigor.

Our position on regional balance means that we will seek opportunities for effective contributions to the needs of rice producers and consumers in Latin America and Africa. Finally, by maintaining a strong emphasis on sustainable farming systems in all our work, we will be continuously promoting the equity concerns of future generations--beyond 2020.

Women and rice

The role of women is independent of rice ecosystems and has both efficiency and equity implications. IRRI has always been sensitive to this question (as is demonstrated by the logo designed in 1960). There has been some progress in regard to women in IRRI itself, in national rice programs, and as users and

beneficiaries of rice technology, but much remains to be done. This must be reflected in our strategy for the next decade.

Women in IRRI. We recognize and uphold the principle of affirmative action in the recruitment of all staff. At present, 13% of our Board of Trustees, 6% of our internationally recruited staff, and 20% of all locally recruited research and nonresearch employees are women. We have intensified efforts to recruit qualified women scientists and administrators.

Women in national rice programs. Our objective is to increase the proportion of women in our graduate and postdoctoral fellow programs (now 20%) and short-course training groups (now 19%) to at least 35% by the year 2000. To achieve this, we will reserve a number of training positions exclusively for women. We will also initiate a program of incentives, including a series of awards, to recognize and encourage outstanding rice research by women scientists.

Women as users and beneficiaries of technology. We will continue to promote the integration of women's concerns into all research projects in IRRI and in national programs. Although numerous studies document the important role of women in agricultural production and consumption, few demonstrate the translation of these roles into research programs. Increasing user participation in the research process will orient research more toward user needs, including those of women. Methodologies to clarify gender-related issues and to introduce them into the research process are being developed and demonstrated at Asian Rice Farming Systems Network sites across rice ecosystems. Because women's roles vary considerably across a wide range of sociocultural factors and because decisions about the relative importance of efficiency and equity concerns--including the role of women--can only be made by individual countries, the ultimate responsibility for designing and transferring technology lies with the national programs.

Research relevance

It is difficult to predict what research will produce and who will benefit. One way to improve predictability is to develop an intimate understanding of the environment, production systems, and problems of prospective users and beneficiaries of research results, orienting the research accordingly. This implies close contact with farming communities. IRRI faces several constraints in this respect. Responsibility and cultural advantage for working with farmers lie with the national programs, while we are an international institute that is moving "upstream" to conduct more strategic research.

To maximize the relevance of our research, we will increase our direct activities in the regions and collaborate more closely with our partners in the national programs, conducting on-farm work where appropriate. We will focus on developing methodologies for farming systems research and on improving our

understanding of the farming systems within which rice is produced. However, our research will be on rice, not on other components of the systems.

We will work toward establishing an International Rice Research Advisory Council, with appropriate representation from national programs, that will provide input into the formulation of our research programs and the associated review processes.

Rice consumers also are our beneficiaries. We will include information and research on their number, location, income status, and nutritional needs and preferences in our rice-related database.

Private sector

In many areas of advanced science, particularly biotechnology and informatics, the private sector is playing a leading role. We therefore include private institutions among those with which we will collaborate in conducting strategic research. This implies the possibility of doing patentable work and, if necessary, purchasing appropriate patented work for use in developing countries.

Resource allocation priorities

As IRRI formulates and implements its strategy, we must strike an optimum balance of effort devoted to several alternatives. None is an "either...or choice"; the effort expended on one often will affect another. The most important are

- The four main rice ecosystems (irrigated, rainfed lowland, upland, and deepwater and tidal wetland).
- The three main regions (Asia, Africa, Latin America).
- Conducting research **and** enhancing national rice research systems.
- Levels of research (adaptive, applied, strategic, and basic).
- Securing previous yield gains **and** seeking new thresholds.

At present, IRRI allocates its resources mainly according to departments. The intended shift to interdisciplinary program budgeting will necessitate a new set of criteria. Achieving the optimum resource allocation in terms of our goal and objectives will not be simple. The optimum cannot be derived empirically; many of the criteria, particularly those related to equity, are subjective. Striving for the optimum must be a continuous process. There should be room to maneuver, so that adjustments can be made as new knowledge becomes available and new opportunities appear.

Hypothetically, an ideal methodology could be approached if it were possible to define all possible alternatives in advance; to forecast complete social costs and benefits for each, suitably weighted to account for equity goals; and to select the set that would give the highest net present value. However, the range of alternatives for IRRI is so extensive that that is not feasible, even if data were available. A two-stage sorting process is proposed, based on the goal and objectives.

First, broad allocations can be made on the basis of criteria relating mainly to our goal. These include

- Rice farm households (numbers and income distribution).
- Rice consumers (numbers and income distribution).
- Characteristics of current production systems (environmental degradation, vulnerability to pests and diseases, and alternative farm enterprises).
- Country (or regional) characteristics (rice research capability, level of wealth, policy environment, and extension services and infrastructure).

Second, having made indicative allocations to broad program areas on the basis of these criteria, research activities of "long-term environmental, social, and economic relevance" to each program can be defined and appraised according to the following criteria:

- Other institutions' research programs and capabilities.
- Probability of achieving research objectives.
- Costs, minimum scale, and time period required.
- Potential benefits, in terms of value of extra production (quantity and quality) and increased net farm income; reduced risk to farmers; increased stability of production; and decreased environmental degradation (or environmental enhancement).

One important feature of this two-stage process is that it separates consideration of the probability of achieving the goal from the probability of achieving research objectives. In the extreme case, the probability of producing a certain research output would be 1.0. But a research investment is difficult to justify if the probabilities of it being used and contributing to the goal are 0.0. For example, if a country has a policy of subsidizing rice imports, with diversification to other crops, there would be little point in targeting research to its rice production problems. Hence, assessing the probability of goal achievement should precede and take priority over objective achievement.

Another feature is that, as we implement the strategy, the two-stage process will become iterative. Accumulated information and analysis at the second and more specific level will be used as a basis for broader program allocation at the first level.

Not all of the criteria listed here will be applicable to all program allocation decisions. We have used them selectively and subjectively to arrive at the position statements for the resource allocation choices explained below. These choices will be refined over time.

Balance among rice ecosystems

Allocation of our scientific resources among the four main ecosystems is perhaps the most difficult of the choices the Institute faces. Few of the many factors that we must consider are static; not all can be objectively quantified. It is risky to oversimplify by focusing only on categories based on water regime; rice-growing

environments are considerably more diverse than that (Garrity et al 1986). Characterization also depends on such factors as climate, soil, topography, and drainage. IRRI's potential contribution to solving the problems of the ecosystems is limited, because agricultural enterprises other than rice must be considered.

A short statement defining precisely what we will do in each ecosystem is not feasible. Similarly, a categoric declaration of resource shares to each ecosystem has only partial value. The important first step is to recognize the different production constraints, possibilities, and socio-economic characteristics of each ecosystem, including the fact that those people living in and depending on the nonirrigated ecosystems have not yet benefited significantly from improved rice technology.

The second is to put in place a management structure that will facilitate generating information, appraising by specific criteria, and monitoring and controlling programming. The proposed structure will improve the flow of information among the ecosystem program areas, since individual scientists will be working simultaneously in several environments.

Area, yield, and production. A database of key parameters is being developed for the four main ecosystems in the 37 major rice-producing developing countries. Some preliminary information on harvested area is given in Figure 5, broken down by subregion. It shows the overall dominance of Asia; the importance of the irrigated ecosystem in East Asia, especially China; and the significance of rainfed upland and deepwater/tidal wetland lowland in East India, Nepal, Bangladesh, and Burma.

It is equally important to consider area, yield, and production according to the favorable and unfavorable environments within an ecosystem. Each ecosystem has varying degrees of favorable rice-growing conditions; those must be estimated on a country-by-country basis. For example, IRRI research on the Asian upland ecosystem shows that, in the aggregate, 15% of upland rice is grown under favorable conditions--long growing season and fertile soil (Fig. 6) (Garrity 1984).

Much better information is needed on the characteristics, production constraints, and research opportunities of the ecosystems. Refining the database is part of the strategy itself; that will minimize the degree to which allocation decisions are based on subjective judgments.

Rice farm households and consumers. Rice farmers depend on the crop for both household food and cash income. Nonfarming rice consumers, mostly in urban areas, also depend, to varying degrees on each ecosystem.

Because the four ecosystems are found in varying proportions, not only within countries, but even within individual farms, data on the number of rice producers in each ecosystem are not reliable.

The number of consumers who depend on the production from each area is easier to estimate. A good indication is already given by current production

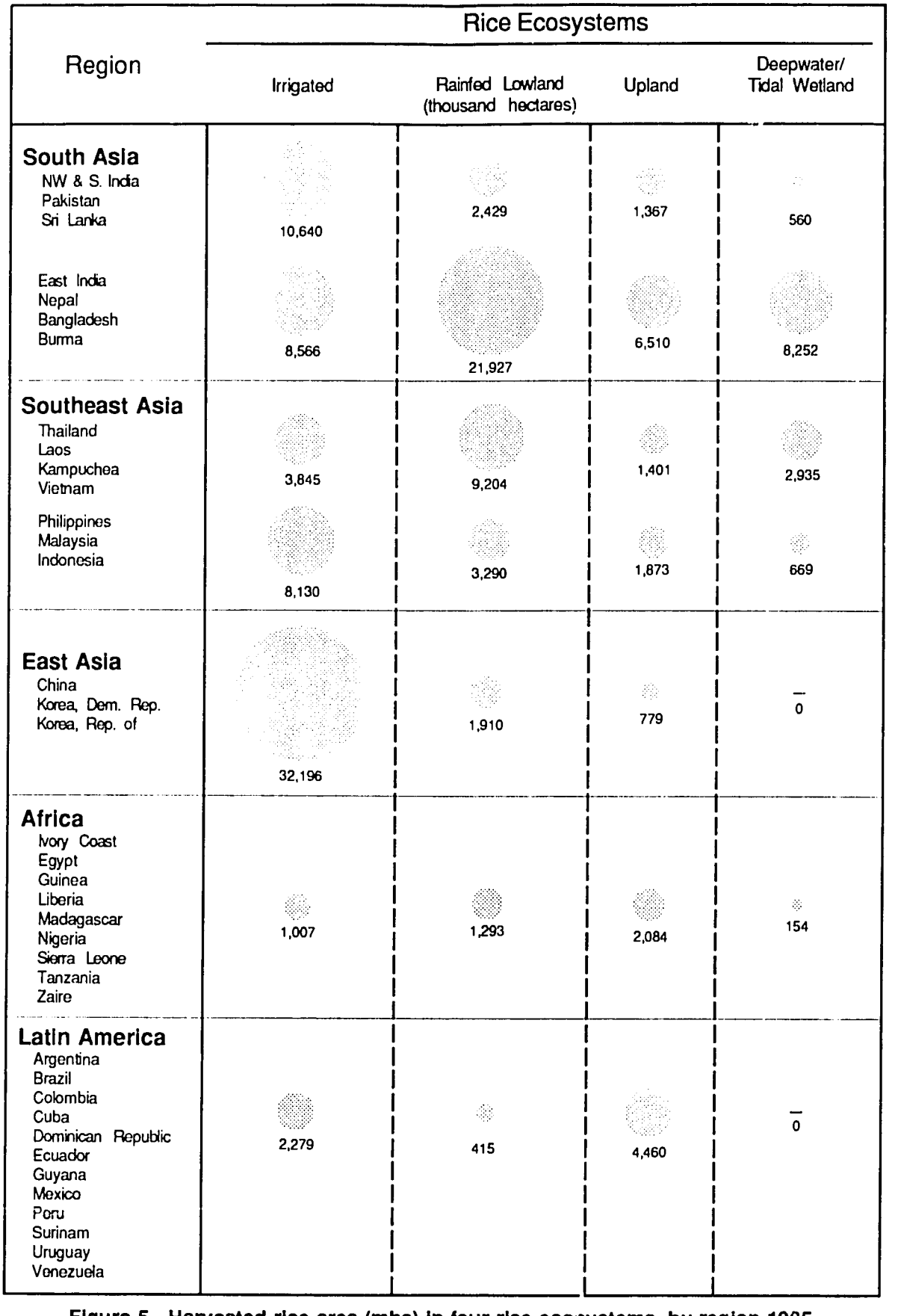

Figure 5. Harvested rice area (mha) in four rice ecosystems, by region 1985. (IRRI 1988)

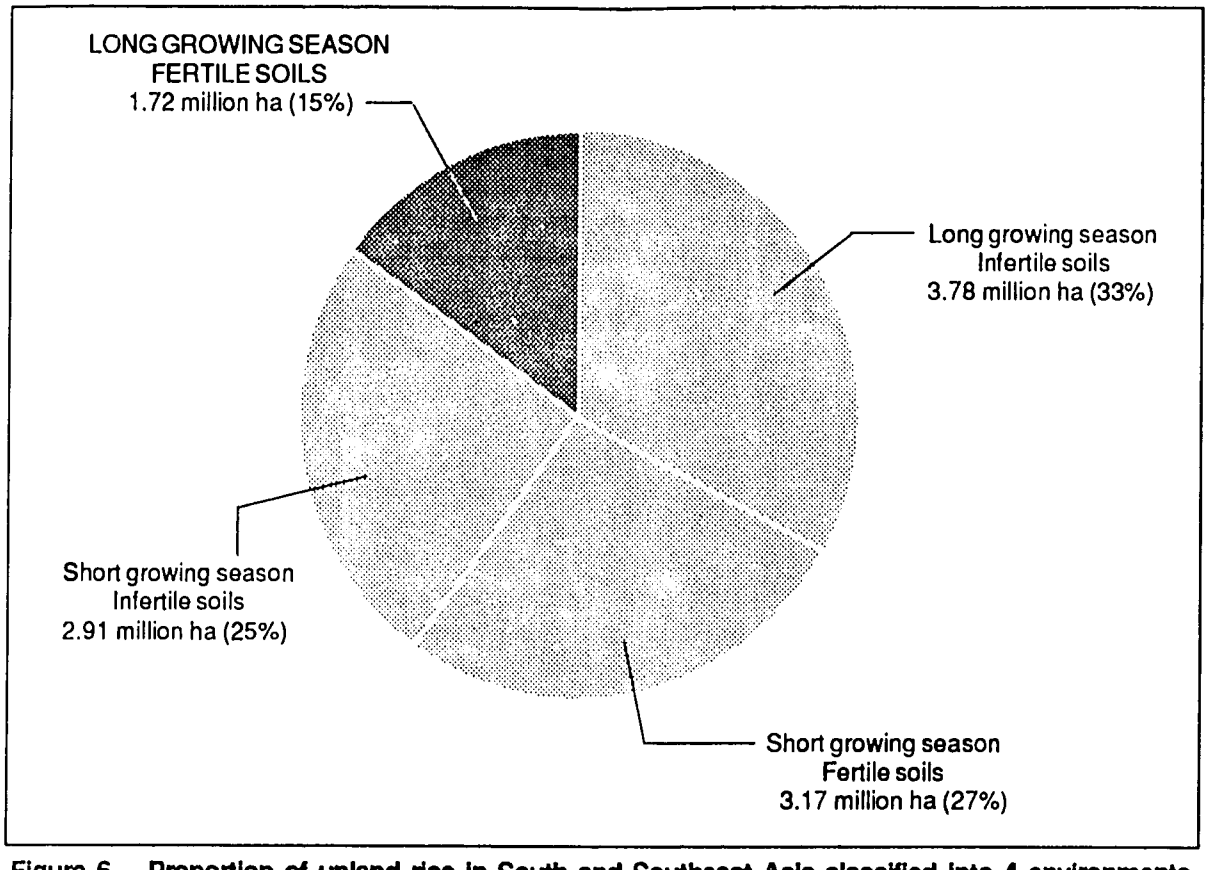

Figure 6. **Proportion of upland rice in South and Southeast Asia classified into 4 environments. (Garrity 1984).**

levels: irrigated, 72%; rainfed lowland, 19%; upland, 5%; and deepwater/tidal wetland, 4%. This estimate can be refined by considering the degree of importance of rice in the diet in each country. In India, for example, rice consumers number about 700 million and irrigated lands feed about 406 million, or 58%.

Characteristics of current production systems. Environmental degradation tends to be most serious in the irrigated and upland ecosystems. The vulnerability of intensively farmed "favorable" environments was described in Chapter I, but it cannot be overemphasized, given the number of consumers who depend on those areas. The scope for alternative enterprises is least in deepwater/tidal wetlands and greatest in the uplands.

Potential production benefits. IRRI scientists projected the total value of expected benefits from research on the four ecosystems in South and Southeast

Asia to the year 2000 (IRRI 1982, 1987). The total value of additional rough rice production was distributed as follows:

irrigated = 57%
rainfed lowland = 29%
upland = 4%
deepwater/tidal wetland = 10%

These data clearly indicate that, if only efficiency criteria are considered, irrigated rice should continue to receive priority.

Comparative advantage. We must also consider the research programs and capabilities of other institutions, particularly those of national programs and sister IARCs. This will allow us to identify gaps and decide where IRRI has a comparative advantage in filling them. For example, WARDA, IITA, and CIAT will, to a certain degree, be directing their programs to the shallow rainfed and upland areas in Africa and Latin America. Those areas comprise 74% and 68%, respectively, of the planted area in the two regions. We expect substantial expansion of rice in these ecosystems over the next two decades.

Also, more than half the production of irrigated rice comes from East Asia (China and Korea), but the strengths of their national programs mean that IRRI need not give the same weight to the irrigated ecosystem as is implied by harvested area or production levels.

IRRI must also keep abreast of the research results of strong national programs and help make them available to other countries and international centers.

IRRI's position. Many of the quantitative criteria--area, production, dependent consumers, and efficiency--suggest weighting of research effort toward the irrigated and favorable rainfed lowland ecosystems. We could even argue that equity criteria also point to these ecosystems, because most farmers and consumers depend on them. But the relative strengths and research directions of other institutions, particularly the national programs, tend to indicate that IRRI should give relatively less weight to the favorable areas.

Thus, IRRI's **main area of concern** will continue to be the irrigated and favorable rainfed lowland areas. But the **proportion of our resources allocated** to these ecosystems may be less than our degree of concern.

We will continue to explore opportunities for advances in the less favorable ecosystems, taking into account factors such as the potential for production of rice vs other crops, the number of dependent farmers and consumers, and other institutions' research activities.

The visibility we give to the four main ecosystems as program thrusts will allow more targeted programming and monitoring of our efforts in these areas.

Balance among Asia, Africa, Latin America

IRRI's original mandate specified research "...for the people of Asia and other major rice-growing areas...." and training of promising young scientists "primarily

from South and Southeast Asia....' In 1982, the training scope was reworded to match that of the research, confirming our global mandate for both.

Rice production and demand. In terms of current production, neither Africa nor Latin America could be described as "major rice-growing regions of the world." Among 37 rice-dependent countries, Asia generates 94% of the total production (437 million t in 1985); Latin America produces 4% and Africa, 2%. Egypt and Madagascar, included in Africa in this calculation, account for 54% of its production. Similarly, Brazil and Colombia produce 72% of the Latin American total.

In terms of per-capita consumption, Asia is also significantly more important than the two other regions. Most Asian countries average 100-150 kg milled rice/person per year (except for countries with large wheat-consuming populations, such as Pakistan [23 kg/person] and India ([64 kg/person]). In Latin America and Africa, consumption ranges from 30 to 50 kg/person per year. Only Guyana, Liberia, and Madagascar exceed 100 kg.

But we must also consider potential for production and consumption, particularly in Africa, where we feel it is essential to explore every option for increasing secure food supplies. The main indicators of potential--growth rates in consumption and in imports--are increasing most rapidly in Africa, where 30% of world rice shipments go. This figure would be higher if barriers to rice imports in some countries, such as Nigeria, were removed.

National programs. Human resources devoted to rice research are spread thinly in sub-Saharan Africa. A qualitative assessment by IRRI indicates that the stronger programs are found primarily in West Africa, particularly in Nigeria, Sierra Leone, Liberia, and Ivory Coast. Resources directed toward developing national or regional programs should be considered in the context of current major shifts of international aid efforts to human resource development in Africa, exemplified by such initiatives as the Special Program for African Agricultural Research (SPAAR).

In Latin America and the Caribbean, the more advanced rice research programs are found in countries like Brazil, Colombia, and Cuba. However, most countries do not have adequate trained personnel or financial support. The distribution of national rice research capacity in the region is highly skewed.

IARCs and other international agencies. WARDA recently joined the CGIAR and formulated its strategy to 2000. It plans to divide its resources among research (60%); support, including training (20%); and administration (20%). It expects to collaborate with IRRI in variety testing in the Sahel and humid zone irrigated systems, in developing a Sahel-based breeding program, and in coordinating IRTP Africa.

IITA has worked on varietal improvement of irrigated and upland rice, with recent attention to rainfed lowland rice. Much of its crop management work has focused in West Africa.

IRAT's programs in most Francophone countries are concerned with varietal improvement and management, primarily for irrigated and upland rice. IRAT has also contributed to the establishment of certified seed production in some countries. Some IRAT lines are adapted to upland areas and resistant to blast disease.

In Latin America and the Caribbean, we have collaborated with the national programs mainly through the IRTP, which we implement jointly with CIAT. Some useful genetic material has been identified. CIAT has actively developed and promoted improved varieties and such farming practices, as weed control, water and pest management, and harvest technology.

Opportunities. There is scope for increased rice production in East, Central, and Southern Africa (ECSA). IRTP rice-weather trials in Kenya show that with irrigation, yields of almost 10 t/ha are possible. Rainfall, solar radiation, and temperature regimes are conducive to rice production in many areas. An increase of 0.5 t/ha in rainfed lowland yields in Tanzania would provide an additional 100,000 tons of rough rice--more than what is currently imported. Pests specific to Africa, such as yellow mottle virus, are still insignificant there.

There is also potential for an effective contribution to the needs of particular countries in Latin America. For example, some Brazilian uplands have problems common to those in parts of Asia, and some Asian lines selected for blast resistance perform well in Brazil. At the same time, some Brazilian lines were found to perform well in Asia.

IRRI's position. We will continue to focus mainly on Asia, but fulfillment of our global responsibilities, such as in germplasm conservation, information services, training, and network coordination, will include **all** regions.

IRRI's research role in Africa and Latin America may be limited by area, production, and the presence of other IARCs and research institutions. This perception is mitigated somewhat, however, by production potential, imports, and rates of growth in demand. The demand for IRRI to help build national programs in Africa will depend greatly on other donor investments. IRRI will not ignore, but will be selective, in research opportunities and obligations in East, Central, and Southern Africa and in parts of Latin America, such as in the upland ecosystem. We will consider the activities of other IARCs, wide regional and/or ecosystem applicability, and our own comparative advantage.

Conducting research and enhancing national rice research systems. Strong national research programs are important to the conduct of effective research at IRRI. Therefore, building national research capacity is as much a means to an end as an end in itself. The alternatives are complementary, with the second actually subsidiary to the first.

To a certain extent, this is not a question of a choice between clear alternatives--some capacity-strengthening activities involve research and some research activities build national research capacity. But choices are involved. In

theory, IRRI could allocate all of its resources either to research *or* to strengthening national programs. The criteria in deciding on the balance between the two are

- The strength of national rice research capability.
- The activities of countries and donor agencies in research and in human resource development.
- The relative payoff with respect to achieving IRRI's goals.
- The degree to which research and training are complementary rather than competitive.

Many countries still have undeveloped research systems, and we have a wide range of research choices to make. IRRI must be highly selective in meeting both objectives.

IRRI's position. We will maintain our commitment to contribute to the strengthening of national programs. The shift in emphasis will be to change from support of to collaboration with national programs. In other words, we will work toward the day when training, in the traditional sense, is no longer part of our activities. Over the long term, therefore, we expect to increase the proportion of our resources devoted to research and to sharing knowledge with all our partners, in a mutually supportive global research system.

Choosing among different levels of research

The CGIAR envisages a continuum of research categories, from adaptive through basic research. Two characteristics distinguish the categories: the extent to which the research can be associated with a specific, real-world problem and the extent to which time and other resources necessary to conduct the research can be specified. "Adaptive" research is closest to a specific problem. The resources needed here, including time, are the easiest to quantify. "Basic" research lies at the opposite end of the spectrum (OECD 1979).

- Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, with no particular application or use in view.
- Strategic research selects, evaluates, and develops, from available knowledge and emerging concepts, tools to solve existing and anticipated applied research problems. It links basic and applied research.
- Applied research is also original investigation undertaken to acquire new knowledge. It is, however, directed primarily toward a specific aim or objective.
- Adaptive research is systematic work that draws on knowledge gained from applied research to produce new materials, products, and devices and to adapt existing technology to specific circumstances.

The shift from adaptive to applied to strategic research is often called moving "upstream." Thus, the terms "upstream" and "downstream" do not describe categories of research, but directions of movement along the continuum.

Three main criteria will determine our choices:

1. The level of development of national research systems.
2. The research programs of sister IARCs and advanced laboratories.
3. Our comparative advantage.

IRRI's position. Given that IRRI is oriented to rice problems, we will not conduct basic research as defined here. However, we will strengthen our scientific base and increase communication with advanced laboratories to keep in touch with the cutting edge of science.

As more national programs develop their capacity to conduct adaptive and applied science, we will increase the proportion of resources devoted to strategic research and decrease adaptive and applied research.

At all levels of research, we will collaborate with national programs to ensure the best complementarity of our respective efforts.

Securing previous yield gains and seeking new thresholds.
This choice is largely applicable to high-yielding varieties in favorable environments. According to the CGIAR "impact study" (CGIAR 1985), yields in these environments have increased by an average of 500 kg/ha since the early 1960s, but the gains risk being eroded by pests, diseases, and soil and water problems. A crop-management regime in which the soil and water resources are constant in quantity and quality over time would allow sustained production without "mining" the environment. But even in such circumstances, new pests or diseases could still reduce yield levels.

Research to secure yield gains, therefore, must address two sets of problems: those of intensive rice cropping that tend to degrade and deplete soil and water resources and those caused by the appearance of new biotypes or strains of pests and diseases.

Too much concentration on securing previous yield gains would risk the ability to meet the projected demand for rice, and would tend to reduce the research resources available to raise yields in unfavorable ecosystems where yield gains have not yet been significant. Too much emphasis on seeking new yield thresholds might reduce our preparedness to react to a rapid erosion in current yields, such as through an unanticipated pest epidemic. As indicated in Chapter I, most consumers depend on rice from the favorable ecosystems. The stakes are too high to put those ecosystems at risk.

The distinction between the two research targets may be more apparent than real. "Security" research will require both deeper understanding of the biology and epidemiology of pests and diseases and access to molecular and other techniques for modifying their virulence and the resistance of the rice plant to them. Such work could raise, rather than simply maintain, yield thresholds.

A shift "upstream" by IRRI will probably result in knowledge that benefits both targets.

IRRI's position. Given their strategic importance, we believe that research should be directed toward ensuring the long-term security of increasing supplies from the irrigated and favorable rainfed ecosystems. We anticipate that many national programs will consolidate past gains and reduce the gap between actual and potential farm yields.

As we move "upstream," we will conduct more strategic research on critical problems of securing past gains and on raising the yield thresholds in all ecosystems through "environment-friendly" rice technology.

CHAPTER IV.

PROPOSED PROGRAMS

Program structure

The strategy will be implemented through four interlinked components (Fig. 7). We deal first with A and B, then with IRRI's role in Africa and Latin America. The two programming components are outlined in IRRI's proposed program structure (Fig. 8).

The proposed program structure incorporates visibly and specifically the capability to control and direct the main resource allocation choices.

- The research matrix and the international services relate closely to our two broad objectives--conducting research and enhancing national rice research systems.
- The four main ecosystems are separately defined as the first four program thrusts in the research matrix.
- Project funding will facilitate closer monitoring of the allocation of resources to the three main regions of the world and the balancing of research effort devoted to securing previous yield gains and to seeking new thresholds.
- Two cross-ecosystem programs for research are relevant to more than one ecosystem. By having one for applied and one for strategic, the move "upstream" will be monitored.

Of course, the stimulus for interdisciplinary work is provided by the very existence of the research matrix. Adherence to other policies on efficiency and equity, women in rice, and research relevance will be ensured primarily through the use of appropriate criteria for project appraisal.

The organization of IRRI's programs is more complex than is implied by boxes A and B. There are more than two program dimensions and several activities do not fall neatly into either A or B. For example, networks serve a double role: as ways to carry out research and to strengthen research capability. Also, the generation of some rice data sets will be done by research divisions (A), but the provision of data is a service (B). These examples emphasize that the boxes exist mainly to illustrate as clearly as possible how our activities will be oriented towards the strategic priorities: they do **not** indicate separation, nor do they represent a final organization chart.

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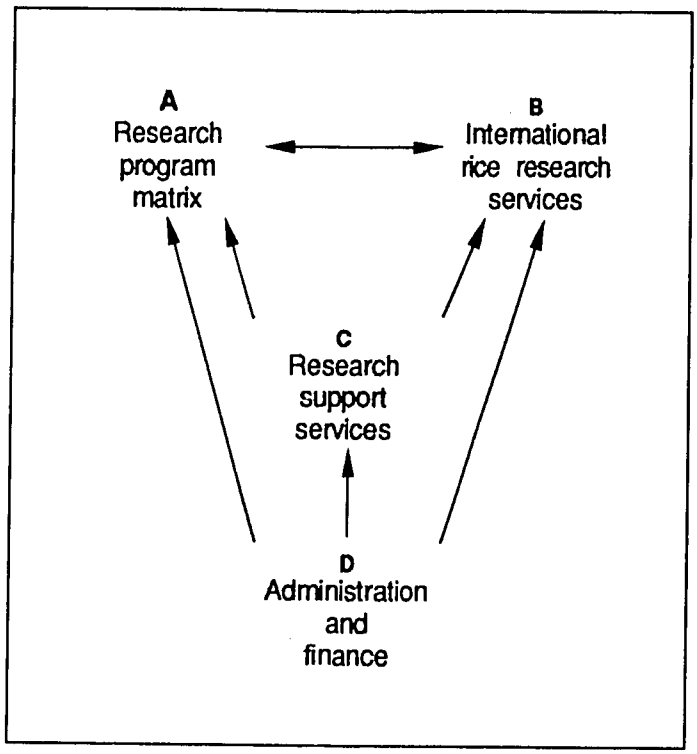

Figure 7. IRRI strategy components

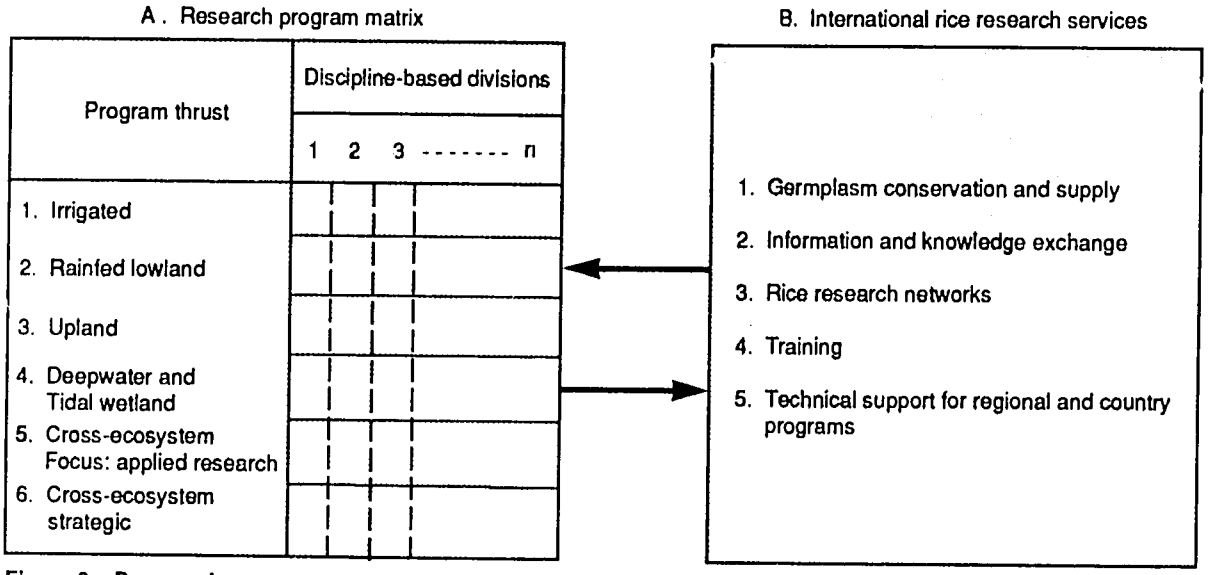

Figure 8. Proposed program structure.

Research Program Matrix

The vertical columns of the research matrix comprise disciplinary-based divisions. We feel it would be unwieldy to retain the current 13 research departments, 8 global research services, and 5 research support units. The column headings of the matrix are unspecified at this stage because we propose to combine departments into a smaller number of "divisions." This will require decisions that must be carefully studied, because we intend to retain and enhance IRRI's comparative advantage in disciplinary depth. We want to make changes that affect the disciplinary structure with care, and not jeopardize our strengths by precipitate action.

The general objectives of the **divisions** will be

- To monitor worldwide science that is relevant to IRRI's current and future research thrusts.
- To identify research institutions, globally, for potential collaboration and joint ventures in applied and strategic research.
- To enhance continuously scientific quality at IRRI.
- To implement well-defined and well-planned projects jointly through the program thrusts.
- To promote, plan, and execute discipline-oriented training, with emphasis on the acquisition of specialized research skills.

The general objectives of the **program thrusts** will be

- To formulate research projects, to budget human and financial resources, and to monitor results.
- To balance research programs in the light of IRRI's strategic priorities and policies.
- To enhance holistic approaches in view of the interdependent nature of problem-oriented research, particularly for ecosystems.
- To initiate and strengthen collaboration, information exchange, and joint learning among national systems.

We have no illusions about the problems of using a two-dimensional framework to manage the multidimensional complexities of mission-oriented research. Several points should be noted.

First, the boundaries of scientific disciplines are not watertight. For example, there is considerable osmosis between agronomy and soil science, pathology and entomology, economics and the physical sciences. Similarly, the horizontal axes of the matrix will overlap; unequivocal program-thrust classification of a project will not be easy. For example, development of a better rice thresher could be classified under the irrigated lowland ecosystem, where it is currently most needed, or it could be classified under the cross-ecosystem research thrust, since the output can also be used in other ecosystems.

Second, we are not obligated to fill every cell of the matrix, nor is it mandatory that all projects involve several disciplines. This will be particularly relevant for

strategic research, in which we may need to focus a critical mass of resources within a discipline.

Third, it has been argued that some areas of great promise lie on the boundaries between scientific disciplines. Such areas may receive insufficient attention as scientists probe deeper into their areas of specialization. The proposed structure will facilitate creative and interdisciplinary exploration around these boundaries and increase the chances of breakthroughs.

Program definition, rationale, objectives, content

Irrigated rice ecosystem

Definition. Irrigated ricelands are those that have an assured irrigation water supply for one or more crops per year, including areas served only by supplemental irrigation in the wet season.

Problem identification. On the basis of current national or regional average yields, the irrigated ecosystem can be divided into regions that have:

- Yields higher than 5 t/ha (China, Democratic Republic of Korea, Republic of Korea, Egypt)
- Yields from 3 to 5 t/ha (northwestern and southern India, Sri Lanka, Burma, Thailand, Laos, Vietnam, Philippines, Malaysia, Indonesia)
- Yields lower than 3 t/ha (eastern India, Kampuchea, Pakistan, Nepal, Bangladesh).

Production constraints in the low- (< 3 t/h) and medium-yield (3-5 t/ha) environments generally are the least location-specific, but they vary in frequency and intensity of occurrence. These problems include

- Poor input management, including low nitrogen recovery.
- Yield and quality losses from pests.
- Inadequate water supply and/or inefficient use of scarce irrigation water at both the irrigation system and the farm level.
- Inadequate drainage, leading to the buildup of salinity and alkalinity.
- Environmental stresses.

Some of these problems are also found in the high-yield (>5 t/ha) environments. But the main problems in those environments include

- A "yield plateau" of about 5 t/ha in some countries, such as in Indonesia.
- Yield instability due to pests.
- Difficulty of sustaining high yields under intensive cropping.
- Environmental degradation because of excessive input use.

Research accomplishment for the irrigated ecosystem has been significant, including the development of semidwarf varieties with a high yield potential of 10 to 11 t/ha; the shortening of growth duration from 150 days or more to around 100 days; the provision of greater yield stability through genetic resistance to or tolerance for pests and, to a lesser extent, problem soils; and associated management practices that allow the varieties to express their yield potential.

Modest improvements have been made in grain quality, grain size, and milling recovery. Improvement of quality by increasing the protein content has proved extremely difficult.

But significant challenges remain. One is to reduce further the reliance on purchased chemicals, especially pesticides, through greater adoption of integrated pest management and modern breeding techniques. This would increase the farmer's profit margin while reducing environmental degradation. Another challenge is to overcome water stagnation and waterlogging problems caused by poor drainage.

Objectives and content

1. To raise the yield threshold from the current level of 11 tons to 15 tons/ha by the year 2000.

Until now, IRRI has considered the semidwarf rice plant a "given" quantity for irrigated rice, and inputs such as fertilizers, pesticides, and water management as constraints. The objective has been to minimize levels of these input constraints, or to maximize yields from a given rice variety at certain levels of inputs. We believe that we should also consider the rice plant itself as a constraint and try to develop a new plant type.

Our target will be to produce a plant with a new architecture, to break through the yield barrier of the modern high-tillering dwarf varieties.

We anticipate that due to labor shortages and availability of better herbicides for weed control, direct seeding of rice will become a more common practice. A new plant type for direct sowing should have the following attributes: low tillering (3-4 tillers), large panicles (at least 250 grains per panicle), sturdy stems, dark green erect and thick leaves, about 100 cm tall, strong root system, and a harvest index of 0.6. Such a plant type should have a yield advantage of 20-30% over presently available varieties. We shall aim to incorporate all or some of the following traits into the new plant type: increased photosynthetic activity, increased light interception, improved assimilate partitioning, and improved nutrient use and uptake. The newer high-yielding varieties, as well as F_1 hybrids, must also have durable resistance to major diseases and insects.

We shall continue to explore the potential of F_1 hybrids in raising the yield potential of irrigated rice. It is anticipated that F_1 hybrids with a yield advantage of 20% over the best available conventional varieties will become available. The F_1 hybrids may also be suited to rainfed environments, due to their greater stress tolerance.

2. To develop crop and resource management techniques that will sustain land productivity over the long term.

Research will focus on determining the long-term effects of intensive cropping on soil fertility, soil health, soil-borne diseases, water quality, and other aspects of the plant environment; on evolving efficient irrigation techniques to increase the productive use of water; on developing farm-level drainage methods to alleviate waterlogging and buildup of salinity and alkalinity; on breeding varieties with

increased tolerance for salinity and alkalinity; and on developing techniques to manipulate and increase the availability of soil nutrients.

The very low efficiency of applied nitrogen (N) fertilizer works against the common goals of increasing productivity and incomes, and of reducing adverse effects on the total environment. We will think in terms of reducing dependence on nitrogen fertilizer by 75% without loss of yield through a combination of improving recovery rates of applied N and providing N from other biological sources, such as nitrogen-fixing organisms.

3. To ensure the security of previous experimental yield gains.

This will be achieved partly by continuous efforts in breeding for resistance to new biotypes or strains of insects and diseases and for tolerance of soil stresses, and by developing more durable resistance through the application of modern tools and techniques of biotechnology. The latter will be pursued in collaboration with advanced laboratories.

4. To reduce the gap between actual farm yields and potentially attainable yields.

Applied and adaptive research will be required to develop efficient and economical nutrient, water, pest, and crop management practices. The bulk of this work will be done by, or in collaboration with, national programs.

Rainfed lowland ecosystem

Definition. Rainfed lowland rice is grown in bunded fields where water depth does not exceed 50 cm for more than 10 consecutive days and the field is inundated for at least part of the season. The field has no access to an irrigation system, but may be on-farm water conservation facilities.

Problem identification. Rainfed lowland environments are highly diverse and unpredictable. Yields are low and unstable. Crops suffer from drought, floods, pests, weeds, and soil constraints. Most rainfed lowland rice farmers are poor. Adoption of high-yielding varieties and new crop management practices has been limited to the more favorable areas. This is mainly because appropriate technologies are not available for unfavorable areas, but also partly because most farmers cannot afford to purchase agricultural inputs.

Objectives and content

1. To develop rice varieties capable of higher sustainable yields for the different rainfed lowland environments, with particular emphasis on submergence and drought tolerance.

A range of improved genetic materials will be developed for target environments. Such rice lines will carry traits for drought resistance, submergence tolerance, yield stability, and wide adaptability in areas of unfavorable and erratic rainfall. Strategic research will determine if genes for wide adaptability and stress resistance can be transferred from wild rices to rainfed lowland varieties. That also will enable us to improve our understanding of physiological responses, especially photosynthesis and uptake of nutrients and

water, under alternately wet and dry soil conditions. The work on F_1 hybrids in the irrigated program will be studied for its suitability in unfavorable environments, with particular emphasis on yield stability through multiple stress tolerance.

2. To develop improved production practices and systems for the less favorable rainfed lowland environments.

Crop management in unfavorable environments is highly location-specific. Research will aim to develop a better understanding of the soil and crop principles underlying tillage and crop establishment practices as they relate to total land productivity. Research will include physicochemical studies in alternately flooded and drained soils; physiological effects of flooding and drought; techniques for the efficient use of rainwater and drainage of excess water and for increasing the recovery of nitrogen fertilizer; weed ecology; and studies of the biosystem of rice, weeds, and associated crops. Strategic research on impacts of climatic change is especially needed for the marginal rainfed lowlands, which will be affected most.

3. To characterize soil, climate, and socioeconomic conditions of rainfed lowland environments.

Because of their great diversity and unstable yields, matching new technologies to rainfed lowland environments will require careful environment characterization. Research will emphasize quantification of the extent and duration of environmental stresses in ricelands and socioeconomic constraints to rice system productivity, using such tools as geographic information systems. Strategic research is needed on crop simulation modeling, remote sensing, and meteorology.

As a man-on-the-moon target that will inspire work under these three objectives, we will aim at reducing the coefficient of variation of rainfed lowland rice yields to less than 50%.

Upland rice ecosystem

Definition. This ecosystem refers to rice grown in rainfed, naturally well-drained soils on bunded or unbunded fields without surface water accumulation.

Problem identification. Cultural regimes for upland rice vary greatly. In very hilly areas, a clean culture of upland rice is highly detrimental to environment conservation. On rolling land, soil conservation measures developed for other crops may be useful. Soils tend to be acid and infertile, and weed competition constrains production.

The upland farmer may choose, depending on market prices and geographic location, between upland rice and other food crops (maize, sorghum and millet, sweet potato, potato) or other cash crops (pineapple, oil palm, coffee, low-input vegetables). Upland farmers generally lack the capital to purchase chemicals or to hire labor for weeding.

Yields are highly variable, mostly because of drought--lack of rain for as little as 10 days at critical growth stages can reduce yields severely. Blast disease also depresses yields.

Most upland rice breeding programs have progressed slowly. At most breeding stations, the breeding cycle is one generation a year--in the wet season. Even at IRRI, agronomic evaluation in the field is done only once a year, but rapid-generation advance and drought evaluation are conducted in the dry season. Many research stations have few adequate outlets for on-farm evaluation of breeding materials. Many upland rice breeders were trained for lowland rice breeding and may have inappropriate concepts and perspectives. They often transfer to higher-paying jobs and more professional recognition at irrigated stations. In short, there have been too few years of continuous, systematic work in upland production areas. There also has been an insufficient critical mass of scientists working on this ecosystem.

Objectives and content

1. To design a range of rice production practices that will help rehabilitate the uplands and transform them into sustained ecosystems.

Rehabilitation techniques will focus on improved soil fertility maintenance and soil and water conservation by using trees, shrubs, and grasses integrated with diversified cropping systems and by exploiting crop and livestock interactions. Development of acid-tolerant rice varieties and organic fertilizer technologies will require understanding the mechanisms of acid soil tolerance, the amelioration of acid soils, and the socioeconomic constraints that farmers face. Furthermore, methods and implements to control weeds more efficiently, with less labor, and rice plant types that are competitive with weeds are needed.

We are considering a man-on-the moon project to produce a perennial upland rice by 2010. It would tolerate diseases, pests, cold, and drought and have nitrogen-fixing properties, competitive ability, and adaptability to adverse soils (Fig. 9).

To guide the breeding program, a detailed study will be designed that simulates the continuous presence of rice in the upland ecosystem. This would provide data on the probable effects of insects, rats, birds, weeds, and other pests and diseases, and insights into how a perennial rice might be integrated into upland farming systems.

2. To develop techniques and technologies for reducing yield instability.

Research will be directed toward

- Integrated pest management practices to reduce variability in output due to diseases and insects.
- Crop and water resource management systems that conserve moisture for crop use and improve drought escape.
- Understanding the physiology and inheritance of traits for drought tolerance.

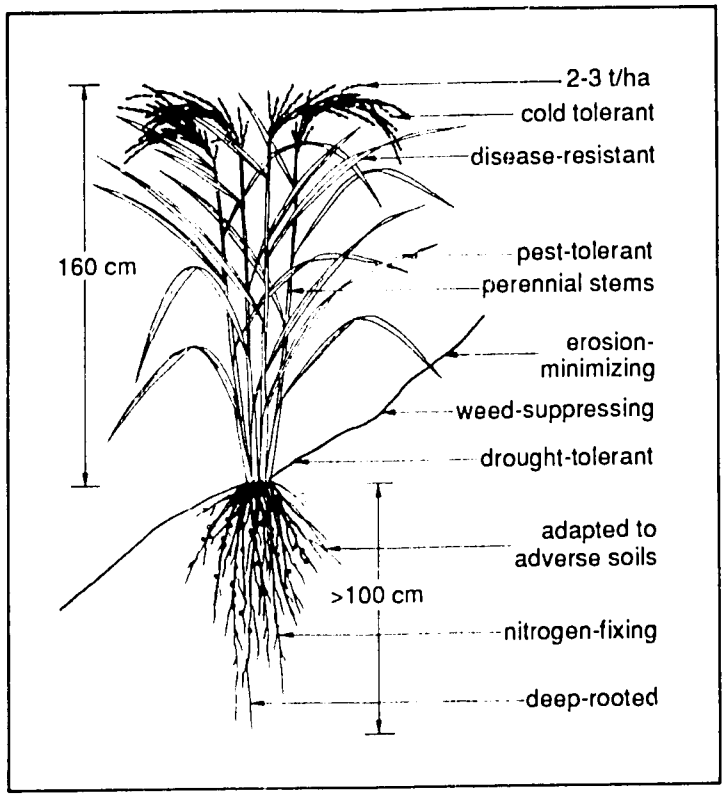

Figure 9. An ideotype for a perennial upland rice plant.

- Developing a broad gene pool of improved materials with drought tolerance, durable blast resistance, weed competitiveness, and tolerance for acid soils.
- Understanding the inheritance of blast resistance, by study of cultivars with durable resistance.
- Determining how blast interacts with drought, soils, and mineral nutrition.

Deepwater and tidal wetland rice ecosystem

Definition. Deepwater and tidal wetland areas are affected by floods from river discharge, tides, and rainfall, and may have problem soils. Deepwater areas have sustained water levels of more than 50 cm. In deepwater areas, very deep refers to water depths above 100 cm, suitable for floating rices. Tidal wetlands are directly or indirectly influenced by tides. Tidal fluctuations flood them periodically; they are usually associated with problem soils.

Background and problem identification. Deepwater rice areas cover 10 million ha and tidal wetlands cover 4 million ha. An expected rise in sea level with global warming will turn large rainfed areas of some river deltas into deepwater rice environments. The area affected by coastal salinity, a tidal wetland condition, also will increase.

Yield potential and stability are the crucial problems too deepwater and tidal wetland rice.

This group of environments has three important characteristics:

- Little choice for crops other than rice.
- Substantial room for cultivation to expand into millions of hectares of planted areas in South and Southeast Asia.
- Wide variation in flooding patterns and soil constraints.

Climatic stresses (deep water, very deep water, and drought) and soil stresses (salinity, acidity, acid-sulfate condition, and peatiness) are common. While screening methods have been developed and rice germplasm with tolerance for these stresses has been identified, the inheritance mechanisms of these traits are still unknown. The transfer of tolerance traits into a high-yielding plant type has proved feasible, and the process can be accelerated through modern breeding techniques.

There is a lack of Deepwater rice varieties response to high fertility. New combinations of modern plant types and deepwater survival mechanisms are available in concept or as prototypes, but their potential in actual deepwater situations needs to be evaluated.

There are no economic data for assessing the viability of deepwater rice before introducing it into nontraditional deepwater or tidal wetland areas. Susceptibility to stem borers, a major deepwater pest, may be overcome through crosses with wild rices. Several deepwater rices have resistance to the nematode ufra.

Almost all tidal wetlands have varying combinations of problem soils. Mineral toxicities and deficiencies are prevalent. Adapted varieties should possess tolerance for mineral toxicities and be highly efficient in using deficient minerals.

Deepwater rice breeding has been going on at IRRI for more than a decade, and tidal wetland breeding for three years. Progress has been slow, mainly for the following reasons:

- Few experiment stations represent deepwater or tidal wetland environments.
- Varietal testing takes longer than it does for irrigated rices, because only one crop can be grown yearly and because it is more difficult to fit varieties into the wide range of environmental conditions.
- National research programs devote few resources to these environments.

Objectives and content

1. To develop rice varieties capable of higher (3-4 t/ha) and more stable yields, with tolerance for floods, climate stress, and even problem soils.

Hybridization and early selection might be done at IRRI, with final varietal selection done by national programs. Strategic research done at IRRI in collaboration with advanced laboratories might include investigation of the genetics, physiology, and mechanisms of tolerance for flooding and for various problem soils.

2. To develop cropping systems that increase land use efficiency by including early-maturing rice; ratooning; and preflood, postflood, and intercrop planting.

Management amd amelioration measures for crop intensification will be formulated.

3. To improve crop and resource management practices suitable for unused deepwater and tidal areas.

We will map and delineate the extent and distribution of potential ricelands and characterize and classify deepwater and tidal wetland rice areas.

Improved management practices for crop establishment, water and land management; and alleviation of flood, drought and soil problems must be developed.

Our target for this ecosystem is to produce halophytic submergence tolerant rice.

Cross-ecosystem: applied and cross-ecosystem: strategic research

Rationale. The rationale for these two program thrusts is considered jointly before separately discussing their definitions, objectives, and content. Applied research that is applicable mainly to a single ecosystem will be administered under one of the first four program thrusts. However, there will be much applied research that is relevant to two or more ecosystems. It will be more efficient to administer this work under the cross-ecosystem: applied thrust that also includes research **intended** to be broadly applicable, even though the initial work may be focused on one ecosystem.

In a project that is applicable to only one of the four main ecosystems, the proportion of **strategic** research will be relatively minor. Projects in which the strategic research component is significant are unlikely to be ecosystem-specific. That is why we are planning a separate cross-ecosystem: strategic program thrust. Many strategic research projects will be carried out in collaboration with other advanced institutions. Keeping this work in a separate thrust will assure it of optimum resources and attention.

The challenges of the future are likely to be more complicated than those we have had to address in the past. To meet them, we need strategic research using new techniques. Strategic research should also include anticipatory research, in which we adopt a "futurist" role to safeguard gains in rice science. Strategic research will allow the **selective** transfer of knowledge and methodologies generated in advanced laboratories into IRRI's own programs. This will reduce not only cost, but also lag time for use of such knowledge by national systems.

Our comparative advantages for doing more strategic research provide the rationale for this program thrust:

- We are able to mobilize the expertise needed to solve problems, even if it is not available at IRRI.

- We have well-established links with the national rice research systems, and can act as a bridge between rapidly generated scientific knowledge worldwide and the needs of national rice programs.
- The results of IRRI's strategic research will benefit a large number of national programs.
- Lack of critical mass and research facilities often limit the depth of national program research activities.

Cross-ecosystem: applied research

Definition. This program thrust will include research on two or more ecosystems and research that generates knowledge applicable to more than one ecosystem. The program can also be considered a link between the cross-ecosystem: strategic research thrust and the four ecosystem-specific thrusts.

Objectives and content. The overall objective is to identify and address problems common to several ecosystems. Projects in this thrust should clearly reflect our comparative advantages: our network of national cooperators and our ability to mobilize resources across ecosystems. Research will provide the specific-ecosystem thrusts with relevant knowledge for incorporation into their technologies. Compared with strategic research, applied research has a shorter time frame and produces a clearer end product. This program thrust will not only produce technology that can be adapted to specific ecosystems, but also knowledge about the socioeconomic and policy context and implications of rice technologies.

Examples of cross-ecosystem: applied research are

- Impact of technical change on productivity and income distribution.
- Characterization of the major aroma principles in grain and plants of important aromatic rices.
- Development of screening methods for cooking and eating qualities of rices within the same amylose class through a better understanding of varietal differences in cooked rice rheology.
- Design of new threshing, milling, and fertilizer placement equipment for resource-poor farmers.
- Collection of wild rice germplasm.
- Genetics of virulence of rice blast disease.
- Simulation models to develop dynamic thresholds and predict pest outbreaks.

Australia succeeded in controlling rabbits and humanity is now free of smallpox. A man-on-the-moon target for IRRI could be to banish rats from the ricelands by 2010 or before...

Cross ecosystem: strategic research

Definition. Strategic research links basic and applied research. It selects, evaluates, and develops tools from concepts emerging from basic research and

uses them to solve existing problems and to meet applied research challenges. Many of IRRI's ecosystem-specific research projects will include a strategic research component to ensure full use of recent scientific innovations.

Objectives and content

To develop modern scientific tools and methods to address current and anticipated rice production problems, such as raising yield threshold, reducing biological and physical stresses that reduce yield, and increasing efficiency of conventional technologies. To make available to national programs promising technologies arising from more basic science.

Themes for strategic research

A number of themes that are linked to the problems and objectives identified for the first four ecosystem thrusts will guide the choice of strategic research activities.

- Genetic engineering applied to rice.
- Impacts of global climatic change.
- Pest dynamics and disease epidemiology.
- Plant-water relations.
- Soil-plant nutrient dynamics.
- Morphology and physiology of the rice root system.

Some examples of research within these themes are

- Transfer of the toxin-producing gene from the insect pathogen *Bacillus thuringiensis* into rice to confer insect resistance.
- Transfer of genes for disease and insect resistance from the wild relatives of rice into cultivated rice and exploitation of new genetic variability for improving yield.
- Identification of molecular markers for "tagging" genes of economic importance, such as the ability to stimulate biological nitrogen fixation and tolerance for flooding and salinity.
- Identification of major gene(s) with potential for increasing grain protein content in a way that does not adversely affect yield and grain quality.
- Apomixis in rice to develop true breeding hybrids with permanently fixed heterosis.

International Rice Research Services

This program highlights a fundamental objective of both IRRI and the CGIAR: strengthening national research capabilities.

Since its founding, IRRI has played a major role in fostering the growth of a global family of rice research institutes and scientists. Through IRRI's training programs, more than 5,000 rice scientists from 78 countries have been trained during the last 27 years. Many IRRI alumni now occupy important positions in national agricultural research and development agencies and universities.

As well as training, we have used several other approaches to strengthen national research capabilities: knowledge-sharing through publications, bibliographic services, seminars, research services, networks, the services of resident scientists, and scientist-to-scientist collaboration.

Our international rice research services during the next ten years will have five major components:

- Germplasm conservation and supply
- Information and knowledge exchange
- Rice research networks
- Training
- Technical support for regional and country programs

Training and other support services for national rice programs must continue, not only because there are still some national systems that need help, but also because

- Recent advances in rice science and technology have made it necessary to diversify IRRI's training programs into new areas of instruction.
- As an internationai institute, IRRI has certain resources that are expensive to duplicate in every country (library, germplasm center, database, high concentration of rice scientists in different disciplines).
- The objectives of raising the yield threshold in favorable rice ecosystems and of overcoming constraints in unfavorable ecosystems will require greater scientific skills and international collaboration.

General objective. To support and strengthen the rice research capacity of national systems so that they can effectively address their production problems and make increased contributions to the global rice research effort.

Germplasm conservation and supply

Rationale. A continuous supply of diverse germplasm, including wild relatives and grasses in rice-related genera, is crucial to raising yield potential, stabilizing yields, and enhancing the sustainability of biotic ecosystems.

Objectives. To conserve the world's irreplaceable rice germplasm, to provide free access worldwide for rice research and rice crop improvement.

IRRI will systematically explore, under a global scheme, unprotected germplasm in existing collections and in natural habitats and incorporate new accessions into the base germplasm collection (we have a capacity for 50,000 accessions beyond the current collection of 83,000).

Tropical Asia will be the principal responsibility of IRGC in field collection, in collaboration with national scientists in agricultural research and botanical centers. We will develop cooperative exploration and collection with other IARCs (IBPGR, IITA, CIAT, etc.) and concerned national programs in rice germplasm niches outside Asia.

We will ensure maximum security through duplicate storage in other repositories and national collections and through consolidation of conserved materials.

We will characterize and document our collections and make seeds of current and future accessions available to all rice researchers and to reestablished national collections. We will also continue technical assistance to other genebanks and expand information activities to increase public understanding of the crucial role genetic conservation plays in food security.

Information and knowledge exchange

Library. Rationale. IRRI must maintain a world-class library and documentation center to serve as the primary repository of rice and rice-related literature.

Objectives. To continue to upgrade and provide current reader services and to expand user access to rice-related knowledge and services through interlibrary loan and electronic linkages between IRRI and libraries/research centers around the world.

With the volume of rice-related knowledge increasing exponentially, and with physical space limitations, IRRI will rely more on computer technology for information storage, classification, cataloging, and search and retrieval. This will give more rapid access to more information in libraries and research centers worldwide.

Scientific publication. Rationale. Research publication is a basic part of science. Through publication, we record and disseminate knowledge.

Objective. To provide scientific publications that increase the flow of current rice research information to scientists worldwide.

We will direct knowledge toward problem-oriented program thrusts by

- Categorizing IRRI scientific publications by ecosystem-based program thrusts, analyzing the pattern to identify gaps where publication is needed, and planning publications with the scientists involved in the programs.
- Establishing (or modifying existing) newsletters to serve as efficient research awareness channels, providing information to scientists working on different problems.
- Designing publications and other materials in a manner that encourages their copublication in languages other than English by national programs and private publishers.
- Evaluating processes and strategies used for technical and public awareness communication, with respect to their contribution to our objectives.

Rice Databases

Rationale. IRRI has a responsibility to compile, conserve, and disseminate all relevant information on rice.

Objectives. To compile, continuously update, and disseminate primary and secondary data on rice production technology, marketing, consumption, policy, and on the physical and biological environments of the rice ecosystems. To establish linkages among databases at IRRI and elsewhere that are amenable to interactive data-sharing.

IRRI has a number of databases. Four examples are presented in Table 4, including our proposals for improvements in content, management, and dissemination.

In addition, IRRI will establish and update a database on rice scientists around the world and their current research and development activities. We also plan to establish an Environmental Data Service which will compile and computerize data and maps of the edaphic, biological, climatic, and human aspects of rice environments, to serve the diverse information needs of the various ecosystems.

Public awareness

Rationale. Accurate understanding of IRRI, and of rice research, among diverse audiences worldwide is necessary to assure continuing support. Public awareness programs are also essential for the creation of an information climate in which the media and the public are less prone to misinformation.

Objective. Create an accurate understanding of IRRI and its programs among donors, policymakers, and the general public in both developed and developing nations, particularly in the Philippines, IRRI's host country.

IRRI will establish a Rice News Service to disseminate news about rice research activities to the media, worldwide. This could be expanded by tapping part-time professionals in different regions to add elements of local interest to IRRI materials and, where necessary, translating them.

We will maintain a computerized list of the specific interests and purposes of different media to improve the focus of news materials.

We will also develop capability in the production and dissemination of video materials.

Rice Research Networks

Strengthening of national research capacities is facilitated by several networks that link national rice scientists with each other and with IRRI and other International and Regional Centers. The three major networks are

- International Rice Testing Program (IRTP)
- International Network on Soil Fertility and Sustainable Rice Farming (INSURF)
- Asian Rice Farming Systems Network (ARFSN)

Rationale. Through research networks, experiences and resources from across the rice-growing world can be focused on problems of varietal improvement and crop and resource management. This improves efficiency and

Table 4. Examples of IRRI Databases.

Type of database	Characteristics	Clientele	Improvements in contents	Improvements in management	Dissemination
World Rice Statistics	Rice production, consumption, trade, price, etc. data at country level	Policy makers NRRS, IRRI	Provide disaggregated data by region and production environment	Formal linkages with national statistical systems	Data made available on diskettes for easy use
IRGC	Passport data, morphoagronomic characteristics and results of evaluation of collection	Scientists IRRI, NRRS	Extend and complete evaluation, provide linkage with varietal information in library, Plant Breeding and IRTP	Incorporation of improved data management system	Interactively with NRRS and IBPGR
IRTP	Nursery trials by agroclimatic environment	Scientists NRRS, IRRI	Environmental characterization, establishing better relationships between results and location-specific factors	Incorporation results from other networks such as INSURF	Preliminary final reports highlighting results through separate newsletter
Rice literature databases	Rice literature reference	Scientists			Computer retrieval bibliographies

saves time in national rice improvement efforts, thereby accelerating the transfer of improved technology to rice farmers. Individual strengths of national systems may vary, but their combined strength is considerable.

Objectives. To encourage and support network activities in order to strengthen collaborative activities among national rice research systems (NRRS), IRRI and other IARCs, and to facilitate the exchange of technologies.

To the extent possible, particularly in the case of IRTP, network activities will also cover Africa, in collaboration with WARDA and IITA, and Latin America, in collaboration with CIAT.

We will increase network activities on adverse environments, particularly in the rainfed lowland ecosystem. Identification of varieties tolerant of adverse soils will offer opportunities to expand rice farming into idle areas. Improved cold-tolerant varieties will provide growing-season flexibility.

INSURF will promote collaborative efforts in nitrogen fertility efficiency trials, long-term fertility trials, integrated use of inorganic and organic fertilizer, and soil fertility management of upland soils.

ARFSN will collaborate with CIMMYT, IITA, and ICRISAT to promote rice - wheat and rice - corn/sorghum cropping patterns. For rice - legume cropping patterns, we will continue cooperation with IITA and ICRISAT.

Training.

We will survey the strengths and training needs of NRRS so that we can sharpen our training focus on key institutions. For each country, the appropriate balance of degree/non-degree and IRRI/in-country training will be determined jointly with IRRI's partners. A medium-term, rice-related training program will be developed.

Objective. To conduct training in applied and strategic research that will assist national systems in developing a critical mass of professionals to advance rice science and solve rice production and utilization problems.

Training will be redirected to the changing needs of national programs and to using recent advances in educational technology. Over the next decade, IRRI will

- Focus training efforts on selected national research institutions in each country, so that critical masses of scientists can be formed at strategic locations.
- Phase out short-term training courses for which several countries have the capacity to train their own people and those of other countries. These might include rice production, integrated pest management, and farming systems.
- Establish evaluation and feedback mechanisms to ensure that IRRI's training efforts continue to serve national needs and remain relevant to meet emerging problems.
- Provide short training courses on new research techniques as needed by some NRRS.

- Encourage and, where appropriate, assist universities in countries where IRRI has country or regional projects to initiate short-term courses for national rice scientists; to offer the academic coursework component of MS and Ph D degree training, with thesis research undertaken at IRRI; and to bring key university staff for advanced training at IRRI. IRRI also will increase collaborative graduate degree programs with universities in industrialized countries for more specialized training.
- Expand efforts to support national training capacity in rice research and intensify the transfer of appropriate courses to strong national institutions. This will include documentation of rice science and technology in a training format that is readily transferable and adaptable to national systems.
- Increase research efforts on training strategies and instructional resource materials to ensure that the most effective communication methods are employed. This research should examine language and cultural barriers that impede the learning process.
- Institute a training course on research management, in collaboration with ISNAR.

Technical Support for Regional and Country Programs

Rationale. This service is designed to enable IRRI to respond to the specific needs and problems of any rice-growing country. We have formal and informal relationships in both research and training with nearly all the rice-growing countries of the world. We play a complementary role by posting IRRI liaison scientists at other IARCs. Invariably, the help given by IRRI on a regional basis involves supplying germplasm and breeding materials and providing training opportunities.

In Asia, IRRI is heavily committed to providing technical support to country programs that cover a wide range of activities in research and training.

Support for Country Programs largely comes from special funding, either from a single donor or a consortium of donors. At present, IRRI provides technical support to Country Programs in Burma, Bangladesh, Indonesia, India, Kampuchea, Bhutan, Malaysia, the Philippines, China, Korea, Madagascar, and Egypt.

To remain an effective partner in strengthening national rice programs, it is essential that IRRI establish priorities in determining where to focus its limited resources. For 1990-2000, greatest attention will be given to countries with low rice yields, low levels of rice self-sufficiency, low per capita GNP, and less-developed rice research capacity. In addition, the following considerations will be applied in evaluating requests to provide technical services in support of Country Programs:

- An official request from the country concerned.
- A clear national policy to increase rice productivity;

- Potential for increases in rice productivity through location-specific research.
- Willingness to share the results of cooperation with other countries.
- Comparative advantage for IRRI to provide the level and scope of cooperation being requested.
- Potential contribution to the objectives of one or more of IRRI's research program thrusts.

IRRI will not play a major role in research infrastructure development or in the provision of research equipment. IRRI does not have a clear comparative advantage in these areas. However, where these are seen as important constraints to national rice program development, IRRI will, at the request of the national program, assist in identifying possible sources of support. Through dialogue with national program leaders and with donors and related agencies, IRRI will make every effort to ensure complementarity with other research and development activities.

Regional Projects will provide assistance in developing rice research capacity to groups of neighboring countries, some or all of which may have relatively small rice areas. For such countries, it is difficult to undertake an effective country-specific project approach without overextending IRRI's managerial and staff support capabilities. In the past decade, IRRI has maintained three regional projects under the IRTP, in East Africa, Latin America, and the Caribbean. Those concentrate on supplying germplasm to national programs. Over the next decade, we will explore the development of broader-based Regional Projects with other IARCs, recognizing that germplasm improvement alone will have limited impact on rice production and rice research capacity. Efforts along this line will depend on availability of additional financial support.

IRRI's Role in Africa

The WARDA region

There is every prospect that the quality and impact of rice research in the West African region will be substantially greater in the future. WARDA has been reorganized into a full CG center, with a clear mandate for rice research to serve the West African region. IITA will continue research on rice-based farming systems, but its rice improvement activities will be gradually incorporated into the WARDA sphere of operations.

IRRI welcomes this development and is committed to support WARDA in fulfilling its new mandate. IRRI will locate at least one scientist at WARDA's headquarters to liaise between the institutes and to participate in the scientific program of WARDA. IRRI will support WARDA's research program and will not develop independent country projects in the region covered by WARDA. We will work through and with WARDA in meeting the expressed needs of these

countries for collaboration in training and research. The IRTP-Africa Program will be undertaken as a joint activity of WARDA and IRRI.

The Non-WARDA Region

WARDA's mandate is limited to 14 West African countries, with 2.6 million ha of riceland. The remainder of the African continent has 2.4 million ha of rice area. IRRI will continue to accept responsibility to assist the non-WARDA rice-growing countries in strengthening their national rice research capabilities.

The two major rice-growing countries of Africa outside the WARDA countries are Egypt and Madagascar. Total rice area in these countries is 1.6 million ha. Our country projects to strengthen the national rice research systems in both will continue, strengthened through project funding where possible.

The rice-growing countries in East, Central, and Southern Africa (ECSA) remain. Here, the present rice area is approximately 0.8 million ha, or 16% of the total for Africa. Tanzania, Zaire, Mozambique, and Malawi have the largest rice-growing areas, predominantly in the shallow rainfed lowland ecosystem. At least another 1.0 million ha land in ECSA could be used for rice cultivation.

We have been considering four models for more involvement with the ECSA countries:

- Develop a regionally-based scientific team to cover the rice research problems of the countries as a group.
- Develop additional country programs, with a team of scientists based in respective countries or a single country, depending on the interest of prospective countries and the availability of project funding.
- Strengthen the training of rice scientists from the national programs in these countries at IRRI and at its key research sites, but without country projects that involve IRRI staff being stationed in the countries.
- Intercenter collaboration, in which several centers could share facilities, pool resources, and establish a joint program. The different program components could be grouped on the basis of ecosystems. This could result in significant economies.

All of these models have been studied. Action has been taken on models 1 and 3 and initial discussions with CIAT and IBPGR have encouraged us to further pursue model 4. An IRRI scientist has been stationed in Tanzania to coordinate the IRTP network activities in the ECSA region and to liaise with the countries on training and research. We have observed that a single scientist in this role is not adequate. Better technical and administrative support is needed.

Our proposals for this area relate to research and training.

Research. We can only recommend a program for the ECSA region if additional capital and operating funds can be made available. We would

recommend a team of at least six scientists in one country--possibly Tanzania or Malawi. The team would include:

1 agronomist - weed control, crop management within farming systems
1 plant breeder - rainfed lowland and irrigated
1 soil scientist - soil fertility
1 plant protection scientist - integrated pest management
1 agricultural engineer - labor bottlenecks
1 social scientist - farming environment analysis

The team would conduct applied and strategic research in the rainfed lowland and irrigated ecosystems. Key sites could be established in other countries. Scientists would supervise postgraduate research. The team could also provide support to the outreach programs in Madagascar and Egypt.

Training. Almost all training for the West African region will be conducted at WARDA. Trainees from non-WARDA countries will, whenever possible, be trained in the region, using national facilities or those of other international centers. Training in special fields will continue to be done at Los Baños. Key sites in ECSA countries could also conduct training.

IRRI's Role in Latin America

In Latin America and the Caribbean region, 23 countries produced 16.5 million tons of rice from 7.15 million ha in 1985, with an average yield of 2.3 t/ha. Irrigated rice accounts for 32% of the total area; upland, 62%; and rainfed lowland, 6%. Deepwater rice is grown on a negligible area, but there is considerable potential.

Major exporters in the region are Uruguay, Surinam, Argentina, and Guyana. Brazil, Cuba, and Mexico are the major importers. Per capita consumption of 35 kg milled rice annually is increasing. Rice is often cultivated by large market-oriented, highly mechanized farms.

According to a CIAT study, rice shortfalls in Latin America could reach 6.7 million tons by the year 2000.

CIAT collaborates with several countries (Brazil, Colombia, Peru, and Panama), mostly in irrigated rice. Recently, CIAT increased its focus on upland rice, particularly in the favorable spectrum of that ecosystem, and developed promising lines based on progenitors from Latin America and Africa.

The major bottlenecks for upland rice are drought, poor soils, and diseases, mainly blast. In the irrigated and rainfed lowlands, the predominant problems are salinity, iron toxicity, low temperature, diseases, and insects such as Hoja Blanca and stem borers.

IRRI's work to date

IRTP has been the major activity of IRRI in Latin America, jointly implemented by IRRI and CIAT since the mid1970s. Seven IR lines have been released in 5 countries since 1978. Many IRTP entries from IRRI and Asia perform well, mostly in irrigated conditions. Some entries show good levels of tolerance of cold, blast, and salinity.

Most CICA lines [jointly bred by CIAT and ICA (Colombia)] have lines bred at IRRI in their parentage.

We have trained 92 scientists from 15 countries in the region and scientists participate in conferences and workshops at IRRI. The Germplasm Centre and the Library store many materials from Latin America. We have two liaison scientists, one at CIAT and one in the Dominican Republic.

Future involvement

Except for some specific stresses, rice production problems and constraints are very similar to those in Africa and Asia. Since CIAT has the regional mandate and IRRI has a systemwide mandate, our role will be complementary to the activities of CIAT and will be in close collaboration with both CIAT and concerned national programs. The main features of our program will be:

- We will concentrate on the irrigated and upland ecosystems.
- For irrigated rice, we will respond to specific requests and collaborate on activities such as collection and conservation of germplasm, exchange of improved genetic materials, salinity and low temperature tolerance, ecosystem characterization, water-balance simulation, water/soil management, small farm machinery, soil microbiology, and socioeconomic analyses.
- For upland rice, we will concentrate on drought, blast tolerance, and adaptation to poor soils.
- IRTP activities will be continued and the participation of Latin America in the INSURF network will be explored.
- Copublication will receive more attention. Participation of Latin American rice scientists in workshops will be strengthened.
- CIAT and IRRI scientists will participate in internal reviews of both institutes. A planning workshop for intercenter collaboration will ensure joint planning of programs, more efficient use of facilities, exchange of research findings, and experience gained. For example, IRRI could become a service center for agricultural engineering for CIAT, and CIAT could help IRRI with screening for blast tolerance, using CIAT's facilities.

Chapter V: Implementing the strategy

Collaboration

Collaboration is important for meeting both of IRRI's general objectives: conducting relevant research and helping to develop national rice research capability. In many cases, the same activity will contribute to both objectives, reflecting our view that the permanent search for new research experiences and findings is often best done as a joint endeavor, leading to better research and to stronger research systems.

We are defining **collaboration** as working cooperatively with other institutions on specific activities that have agreed objectives, with each party contributing resources in some form.

It should be stressed that every proposal for collaboration will be tested against one fundamental question: **Is it going to improve the effectiveness with which we achieve our objectives and, ultimately, the goal?**

Rationale. The irrigated ecosystem is quite homogeneous and, to a large extent, can be simulated on a research station. More than half the rainfed lowland ecosystem and most of the upland and deepwater and tidal wetland ecosystems are unfavorable rice-growing environments of considerable heterogeneity. This means that we can only ensure research relevance and productivity by working more closely with our partners in the national systems and closer to the ecosystems themselves. The bulk of the overall activities will continue to be carried out at headquarters; in terms of program thrusts, almost all the irrigated and cross-ecosystem: applied and strategic and the more "upstream" components of the rainfed lowland, upland, and deepwater/tidal wetland ecosystems will be at the IRRI center.

The problems of the more adverse ecosystems are more difficult to solve than those of irrigated rice. We must use great care in the selection of research sites, and in deciding which program components should be done at which sites (i.e., at headquarters or elsewhere) and we must be careful to maintain the links among all sites. Long-term commitments are needed because significant breakthroughs and solutions to problems will take longer in the adverse ecosystems than in the irrigated ecosystem.

Alternative collaborative mechanisms

In our view no generic model or mechanism is inherently better than another. Our working hypothesis is that, for certain ecosystems, benefits from research conducted by IRRI will be limited unless some of the work is done on site, in collaboration with the national programs concerned. Depending on the mechanisms chosen, the relative costs to IRRI and the national programs will vary. We will therefore concentrate on weighing up the benefits and costs of alternative research programs according to the criteria laid out in Chapter III. Many of those alternatives will be defined in terms of different ways of carrying out the same research, with the benefits and costs varying according to the collaborative mechanisms assumed.

To facilitate comparative analysis of different ways of implementing research programs, the following six collaborative mechanisms have been identified. They are not mutually exclusive--indeed, many are complementary. The optimum solution for a particular case may draw upon several approaches simultaneously and/or in an evolutionary sequence, starting with something relatively modest and adding elements to it over time. The examples given are only a selection of a wider spectrum of possible mechanisms.

- **Outreach**. An internationally-recruited IRRI scientist is posted to work in and for a specific country program, including its links to neighboring countries.
- **Joint Venture**. An activity focused on a specific topic (e.g., peat rice soils) is conducted jointly, with cost-sharing, by IRRI and a collaborating country. IRRI scientists usually are not posted to the host country for long periods.
- **Visiting IRRI Scientist.** An internationally- recruited IRRI scientist is posted temporarily to another advanced institute, that has a comparative advantage of importance to IRRI, to work on a particular problem.
- **Key Site.** National scientists are recruited by IRRI to work on a site (or sites) in their own country that is (are) representative of one or more ecosystems and more than one country. The research is administered by IRRI, but IRRI scientists usually are not posted at the site, although short appointments are possible. Facilities may or may not be leased from the host country.
- **Regional Consortium.** Two or more national institutions are formally linked in an integrated program that draws upon the respective strengths of each institution and is focused on a particular problem area (e.g., Upland Rice Drought/Blast Consortium). At least one internationally-recruited IRRI scientist is posted to the lead institution. Other internationally-recruited scientists may be stationed in member institutions.
- **Network**. Several national programs are linked on a continuing basis to exchange knowledge and plan joint activities. The subject matter of the

network may be a function (rice testing) or a research topic (soil fertility). The hub, or coordinating center, of networks has to now been IRRI. This mechanism is similar to a consortium, but does not involve outposting IRRI staff and usually is at a lower cost to the national systems.

The matrix in Table 5 shows the main characteristics of each mechanism, as they relate to IRRI and to the national rice research system (NRRS).

Collaboration for research

We will collaborate with the full range of national programs and basic to adaptive research-oriented institutions.

The criteria for choice of research partners will be

- Scientific standards and relevance.
- Agreement on a common objective.
- Comparative advantage of each research institution.
- Mutual belief in IRRI's goal and guiding principles.

We are conscious of the risk that a stronger organization can dominate a weaker one, and that striving for high standards can be interpreted as arrogance.

With the increased emphasis on ecosystems, networks will have a common basis for integrating their activities and can stimulate interaction among teams of scientists working at key research sites across Asia and beyond. IRRI's experience with networks can be used as a basis for establishing regional consortia with an ecosystem focus.

The cheapest and most flexible collaborative mechanisms--Outreach, Joint Ventures, and Visiting IRRI Scientist--offer great scope for the research program thrusts. Examples of the Visiting IRRI Scientist approach include agreeing to post a soil microbiologist at the Chinese Azolla Research Center or sending a biotechnologist to a European institute to become updated on new agrobacterium transfer techniques.

In a variation to Visiting IRRI Scientist, an IRRI scientist could carry out part of a research activity at IRRI, part at an advanced institute in an industrialized country, and part in the national program of a rice-dependent country. This type of **Shuttle Research Program** could enhance international collaboration, especially if it were combined with the Joint Venture approach to give a scientist from a national program an opportunity to work in an advanced institution overseas.

In terms of Key Sites, lessons could be drawn from the existing example of the rainfed lowland rice project at Ubon, Thailand. The "arms length" relationship between IRRI headquarters and a Key Site could be considerably reduced by a relatively minor investment in modern electronic communications technology. That way, scientists could maintain a virtually continuous dialogue, if necessary. The productivity of site visits would be enormously enhanced.

In terms of **partners** for collaboration, we recognize that, in the broad sense, universities are a part of national research systems. We intend to increase the

Table 5. Main characteristics of six mechanisms for collaboration.[a]

Characteristic	Outreach	Joint venture	Visiting IRRI scientist	Key site	Regional consortium	Network
Ownership of facilities	NRRS	NRRS	NRRS	NRRS (or lease)	NRRS (or lease)	NRRS IRRI
Staff recruitment	IRRI	NRRS IRRI	IRRI	IRRI	NRRS IRRI	NRRS IRRI
Management	NRRS IRRI	NRRS IRRI	Mainly IRRI	Mainly IRRI	NRRS IRRI	Joint
Cost to IRRI	Low	Low	Low	Moderate	High	Moderate
Cost to NRRS	Low	Low	Low	Moderate	Moderate	Low
Location of IRRI staff	On site	H.Q., on site	On site	H.Q.	on site, H.Q.	H.Q.
Location of NRRS staff	On site	On site	On site	On site	On site, H.Q.	On site
Applicability of results	National	Mainly national	Inter-national	Inter-national	Inter-national	Inter-national
Mobility/ flexibility	High	High	Very high	Low	Low	High
Dependence on national system	High	High	n.r.	High	High	High
Political complexity	Low	Low	Low	Moderate	High	Low
Scope for critical mass	Lowest	Low	n.r.	Low	Moderate	Low

[a]NRRS = National Rice Research System, H.Q. = IRRI Headquarters, n.r. = not relevant.

degree of our collaboration with universities, both for research and for training. The research potential of universities is often neglected and unexploited, to the detriment of their teaching role and to national development. We will aim to form international university networks, focused on specific research problems and drawing more university staff into collaborative research--not just with IRRI, but with each other. For example, the knowledge base in rural socioeconomics could be enhanced and mobilized for the different rice ecosystems through university-based networks.

In addition to the national programs, we will develop collaborative relationships with non-national research institutions, especially the IARCs within and outside the CGIAR, as we have done effectively in the past with ICIPE and IFDC. As well as IBPGR, CIAT, IITA and WARDA, we will need to work closely with ISNAR and IFPRI on such topics as research planning and national rice policies.

Collaboration to enhance national rice research systems

Many of the mechanisms described as valuable for collaboration for research can also be used to help develop national programs. However, the benefits tend to be greater and management more simple if activities are concentrated on only one objective. Collaboration for research that also aims to enhance national systems may end up achieving neither objective very well. For example, networks in which there is too wide a range of research capability in the member institutions tend to be unproductive: the stronger institutions can become frustrated and the training effect on the small, incomplete research systems is minimal. With the Visiting IRRI Scientist approach, the Institute aims to strengthen its own capabilities in particular specialized areas.

Scientific collaboration will also be supported by **short-term visits** to national programs by IRRI headquarters staff and by special consultancies, where appropriate. National scientists will be encouraged to visit IRRI headquarters to develop and review plans for collaborative programs.

We also intend to orient our **training programs** more to serving the needs of universities. Midcareer courses, seminars, and workshops will be offered, with special emphasis on the needs of universities in rice-dependent areas. In this way, we should increase the multiplier effect of our training efforts.

The past concentration of research effort on the favorable environments has resulted in a significant accumulation of knowledge, experience, and capability at IRRI. The body of knowledge and capability specific to the unfavorable environments is less. As we shift our attention more to these environments, collaboration--especially through mechanisms such as Key Sites and Regional Consortia--will be a particularly valuable means of mutual learning, as IRRI builds up its own capabilities with respect to these environments, together with its national partners.

Managing the research program matrix

To now, IRRI's budgeting has been based mainly on discipline-oriented departments. Many feel that there has been some correlation between past achievements and the discretion and flexibility given department heads by this system. However, the new CGIAR approach to planning and budgeting and our own evaluation of IRRI's present organization have led to the decision to shift to an interdisciplinary program system. The existing departments will be regrouped into a smaller number of "divisions." Program planning, budgeting, monitoring, and evaluation (PBME) will be carried out on the basis of interdisciplinary activities that cut across divisions. For this purpose, there will be no "walls" between the units in the Research Program Matrix and those in the International Rice Research Services (Fig. 7): many projects will integrate components from both.

This system will be phased in, since for logistical, financial, administrative, and other reasons, it is not possible to introduce it overnight. Over about two years, a certain amount of evolution will occur and decisions on the finer details will be made. At this stage, we can state the commitment to change and describe a broad outline of the process.

We believe that for a matrix to work effectively, the lines of authority and the division of labor between the program thrust and division leaders must be clearly defined. Job descriptions and evaluation must correspond to the expectations of the Institute. PBME procedures and paper flow should be as light as possible, consistent with adequate financial control and accountability. The system should evolve with some flexibility and with growing understanding and sense of ownership by the staff.

The role and responsibilities of key individuals are central to explaining how the system will work. For this general introduction, we consider the program leaders and division heads.

A two-dimensional matrix is a potentially efficient mechanism to draw upon the range of disciplines needed to fulfill the objectives of each respective program. However, it does not automatically ensure effectiveness. Clearly focused objectives and good leadership are required. **Program leaders** who can motivate, monitor, and evaluate individual scientists are key to the task of creating enthusiasm, loyalty, and teamwork. Their job will be facilitated to the extent that scientists can be assigned full-time to a given program and program leaders will control a major portion of the budget allocations. This puts program leaders into supervisory line positions, responsible for program PBME functions. They will report to the Deputy Director General (DDG) for Research. The functions of a Program Leader will be:

- To initiate and coordinate the identification and formulation of new projects for the program thrust.
- To assist the DDG for Research in determining budget allocation priorities.
- To monitor and evaluate implementation of the program.

- To control disbursement of project operating budgets.
- To receive and review all project reports and to synthesize them for the DDG for Research.
- To harmonize division specific activities related to the program.
- To maintain contact with those national programs with special interests in the program thrust.

A **division head** has a dual role, as a scientific leader who promotes scientific activities to enrich the knowledge base in the disciplines of the division and as an administrator who facilitates the efficient implementation of approved projects. The functions of a Division Head will be:

- To review program budget allocations with the DDG for Research.
- To monitor scientific quality at each stage of the program PBME process.
- To evaluate the performance of scientists in the division jointly with their respective program leaders.
- To provide the capital stock required for program implementation.
- To coordinate professional, clerical, and other project support services.
- To establish and maintain links with collaborating national programs and other research institutions, with particular emphasis on those conducting more advanced research.

Procedures for retaining and enhancing disciplinary strength shall include

- Divisional funds to allow scientists to explore innovative research ideas outside approved projects.
- Divisional funds for attendance at professional meetings and for organizing seminars.
- Scientists of the same discipline continue to be housed in the same division.
- Divisional responsibility for staff recruitment and career planning.

Projects will be the basic building blocks of the program thrusts. During the first and second evolutionary years, the number of projects will be kept deliberately small, with each project quite large (say, at least $1 million over 3 years). They will be new activities derived from the strategic content of each program thrust, rather than a reformulation of existing activities. This will permit more visibly focused programs during the changeover period.

Projects will have clearly defined, measurable objectives and a finite life. There will be scope for midcourse corrections if monitoring reveals that they would be desirable.

Fiscal responsibility will be delegated to the project leaders, bringing managerial authority closer to the research and accountability closer to the user of funds.

Our perspective

We are aware that these changes cannot be implemented without careful preparation. This will involve extensive dialogue within the Institute, assisted by a

systematic module-based, in-house training program tailored to the needs of the new organizational units and the IRRI staff. Research--the first purpose of the Institute--has to go on during the changeover period. There must be enough time to ensure that this can happen and that the reorientation and adaptation process is indeed helping us enhance our contribution to the goal:

> **to improve the well-being of present and future generations of rice farmers and consumers, especially those with low incomes.**

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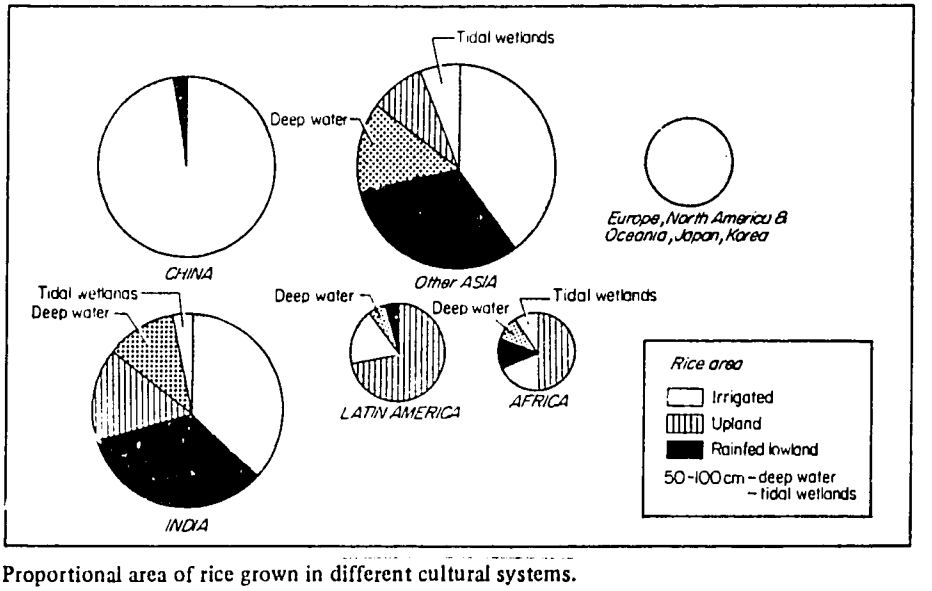
TERMINOLOGY FOR RICE GROWING ENVIRONMENTS

G. S. KHUSH

The following terminology for rice growing environments recognizes several criteria that affect rice production practices and varietal requirements. Factors considered in naming the environments are water regime (deficit, excess, or optimum), drainage (poor or good), temperature (optimum or low), soils (normal or problem), and topography (flat or undulating). The widely used method of classifying rice environments into five major categories is retained; however, each category is divided into distinct subcategories:



Proportional area of rice grown in different cultural systems.

IRRIGATED

- Irrigated, with favorable temperature
- Irrigated, low-temperature, tropical zone
- Irrigated, low-temperature, temperate zone

RAINFED LOWLAND

- Rainfed shallow, favorable
- Rainfed shallow, drought-prone
- Rainfed shallow, drought- and submergence-prone
- Rainfed shallow, submergence-prone
- Rainfed medium deep, waterlogged

DEEP WATER
- Deep water
- Very deep water

UPLAND
- Favorable upland with long growing season (LF)
- Favorable upland with short growing season (SF)
- Unfavorable upland with long growing season (LU)
- Unfavorable upland with short growing season (SU)

TIDAL WETLANDS
- Tidal wetlands with perennially fresh water
- Tidal wetlands with seasonally or perennially saline water
- Tidal wetlands with acid sulfate soils
- Tidal wetlands with peat soils

Characteristics of rice varieties needed for each subcategory are different and well defined. Production practices for subcategories may differ considerably.

IRRIGATED

About 77 million ha, 53%, of the world rice area is irrigated and has adequate water supply throughout the growing season. In much of this area, rainfall supplements irrigation water. Irrigated areas with good water control are suitable for growing of improved varieties with short stature and lend themselves to improved cultural practices. Perhaps 70 to 75% of world rice production comes from irrigated areas. Varieties with short stature, short growth duration, and multiple disease and insect resistance perform best. Irrigated areas are subdivided into three categories.

Irrigated with favorable temperature
In irrigated areas with favorable temperature, the temperature range is acceptable for normal rice growth throughout the growing period. Most irrigated areas in the tropics and subtropics fall within this category.

Irrigated, low-temperature, tropical zone
In low-temperature irrigated areas within the tropical zone, low temperatures affect crop growth at some stage. The boro crop in India and Bangladesh experiences low temperature at seedling stage. In high-elevation tropical and subtropical areas of India, Nepal, and the Philippines, low temperatures may limit plant growth at seedling stage and cause panicle sterility at maturity. Indica varieties are grown most often. Cold tolerance and blast resistance are the most important characteristics needed.

Irrigated, low-temperature, temperate zone
Rice crops in the temperate zone generally are affected by low temperatures at seedling and flowering stages. Cold-tolerant japonica varieties are grown. Varieties have been improved and selected for cold tolerance, short stature, and

hard threshability to avoid shattering losses. Japonica rices are transplanted in Japan, Korea, and northern China, but are broadcast in standing water or drilled before flooding in Europe, including the USSR, and in Australia and USA (California).

RAINFED LOWLAND

About one-fourth of the world rice area and 40% of the ricelands in South and Southeast Asia are rainfed lowland. Rainfed lowlands have a great diversity of growing conditions that vary by amount and duration of rainfall, depth of standing water, duration of standing water, flooding frequency, time of flooding, soil type, and topography. Varieties with tolerance for varying levels of excess moisture or moisture stress, varying growth duration, and plant height are needed. Management practices vary in the rainfed lowlands. Based on varietal requirements and management practices, rainfed lowland has five categories.

Rainfed shallow, favorable

Rainfall and water control are adequate in areas categorized as rainfed shallow, favorable. Short periods of moisture stress or mild submergence may occur, but are not a serious constraint. Supplementary irrigation may be available. This category comprises perhaps 12-15 million ha of ricelands in Indonesia, Malaysia, the Philippines, Vietnam, Burma, Nepal, India, and Sri Lanka. Varieties developed for irrigated fields are well adapted and widely grown, and management practices are similar to those in irrigated areas. Semidwarf cultivars with disease and insect resistance, 100-140 days growth duration, and photoperiod insensitivity are needed.

Rainfed shallow, drought-prone

Fields in rainfed shallow, drought-prone areas are bunded and growing conditions range from upland to lowland. The rainy period is 90-110 days and moisture stress may occur at any growth stage. There are 6-7 million ha of these lands in north and northeast India (eastern Uttar Pradesh, Bihar, Madhya Pradesh, Orissa, and West Bengal) and Bangladesh (aus crop), and smaller areas in central Burma and northeast Thailand. Rice is generally broadcast but may be transplanted. Soils vary from neutral to alkaline. Photoperiod-insensitive varieties with short growth duration (90-105 days), intermediate stature (120 cm), and drought tolerance at all growth stages are needed.

Rainfed shallow, drought- and submergence-prone

Rainfed shallow, drought- and submergence-prone areas have periods of heavy rainfall when submergence may result from local rains or from heavy rains that cause rivers and creeks adjacent to the riceland to overflow. The rice crop may be submerged for 10 days. There may be extended periods of no rain and the crop may suffer from moisture stress. There are about 3 million ha of these lands in northeast Thailand and 1 million ha in Laos and Kampuchea. Land is bunded and puddled and rice is transplanted. Soils have light texture and low fertility. Grain

quality strongly influences varietal acceptance. Varieties with intermediate height, drought and submergence tolerance, and 100-130 day growth duration are most adaptable. No improved varieties have been developed for this environment.

Rainfed shallow, submergence-prone

Periods of heavy rainfall when sudden floods may submerge the rice crop up to 10 days frequently occur in rainfed shallow, submergence-prone areas. Rainy period is long (5-6 months) and rice is harvested after the rainy season ends. Submergence-prone areas occur in Vietnam, southern Thailand, Burma, and Bangladesh.

Rainfed medium deep, waterlogged

Rainfed medium deep, waterlogged areas are low-lying. Water accumulates and stagnates for 2-5 months because of impeded drainage. Water depth may vary from 25 to 50 cm. Fields may or may not be bunded. Old, tall seedlings are transplanted in puddled soil. Tall, photoperiod-sensitive varieties with tolerance for stagnant water are grown. Rice crops may be submerged for several days during the life cycle, and are harvested after water recedes.

There are about 5-6 million ha of rainfed medium-deep ricelands in India, Bangladesh, Burma, Thailand, Kampuchea, and Vietnam. Photoperiod-insensitive semidwarfs with long growth duration, 110-120 cm height, and tolerance for stagnant water may perform well. In some areas, however, photoperiod sensitivity may be necessary. Submergence tolerance also might be useful in some situations, but elongation ability is unnecessary and may actually be a handicap. Therefore, long-duration semidwarfs with or without photoperiod sensitivity and with submergence and stagnant water tolerance are needed.

DEEP WATER

There are about 9 million ha of low-lying lands on the river deltas of South and Southeast Asia where deep water accumulates during rainy season. Standing water depth varies from 50 cm to more than 3 m; however, flooding occurs only during part of the growing season. Fields are unbunded. Rice is broadcast sown and grows under droughty conditions for 50-60 days before flooding. Some deep water lands are acid sulfate. Two categories are recognized for varietal improvement purposes.

Deep water

Water depth in deep water areas varies from 50 to 100 cm. There are about 6 million ha of deepwater areas in India, Bangladesh, Burma, Thailand, Kampuchea, and Vietnam. Tall varieties with elongation ability are grown in some areas; in others, tall varieties without elongation ability are planted. Improved varieties with elongation ability, semidwarf stature, photoperiod sensitivity, drought tolerance at seedling stage, and tolerance for stagnant water conditions at later growth stages are required.

Very deep water
Very deep water areas have water more than 100 cm deep. There are about 3 million ha of such areas in India, Bangladesh, Thailand, Kampuchea, and Vietnam. Tall, photoperiod-sensitive varieties with drought tolerance at seedling stage and ability to elongate 5-10 cm per day are needed.

UPLAND

Rice grown in rainfed, naturally well-drained soils with bunded or unbunded fields without surface water accumulation is called upland rice. Ricelands that are submerged for a significant part of the growing season are not suitable for upland rice. Some ricelands in West Africa that are classified as hydromorphic are truly upland, especially those areas on higher slopes where there is no water table in the root zone. However, the hydromorphic lands at lower slopes may have the water table in their root zone during a significant part of the growing season, making them more similar to rainfed lowland culture. Varieties suited to upland environments have drought avoidance through deep root systems and drought recovery ability, intermediate stature with moderate tillering and big panicles, blast resistance, and tolerance for iron deficiency and aluminum toxicity. There are four categories of upland rice environments.

Favorable upland with long growing season (LF)
In LF environments the rainy season is long and upland rice is often grown in sequence with other field crops. Growing conditions are favorable. Soils are fertile with good water retention capacity. Yields are relatively high. About 15% of Asian upland rice is in this category. India has 0.6 million ha; Bangladesh, 0.5 million ha; Indonesia, 0.3 million ha; and the Philippines, 0.2 million ha. Colombia, Panama, and Central American countries have similar upland rice areas. There is good potential to develop improved varieties and technology for these environments. Semidwarf varieties may perform well.

Favorable upland with short growing season (SF)
In SF environments the rainy period is short but the growing conditions are favorable. There are about 2.8 million ha of SF uplands in India, 0.5 million ha in Sri Lanka, and 0.2 million ha in Bangladesh. Drought is the overriding constraint because of the extremely short growing season. Varieties with short growth duration, drought avoidance, and drought stress recovery characteristics are needed.

Unfavorable upland with long growing season (LU)
In LU environments rainy season is long but soils are acidic, highly leached, or shallow and are a serious constraint to high productivity and adoption of improved varieties. About 33% of Asian upland rice is LU. It is the most important upland environment in Indonesia (0.8 million ha), Burma (0.6 million ha), Vietnam (0.4 million ha), and Laos (0.4 million ha). India has 0.8 million ha of LU category.

Varieties with adverse soils tolerance, and careful attention to soil management would be necessary to raise the productivity of these areas.

Unfavorable upland with short growing season (SU)
The SU environment is a marginal environment for upland rice. The rainy period is short and soils are infertile. Serious climate and soil constraints may preclude any significant improvements in productivity. SU areas occur in India, Brazil, and West Africa.

TIDAL WETLANDS

Tidal wetlands are near seacoasts and inland estuaries that are directly or indirectly influenced by tides. They are heterogeneous environments and are classified into four categories.

Tidal wetlands with perennially fresh water
Freshwater tidal wetlands occur near inland estuaries some distance from the coast, such as in the Barisal district of Bangladesh. There is little intrusion of saline water. Varieties with tidal submergence tolerance are needed.

Tidal wetlands with seasonally or perennially saline water
Tidal wetlands with saline water occur near seacoasts and mouths of estuaries. There is seawater intrusion either throughout the year or during the dry season. Varieties should have salinity and tidal submergence tolerance.

Tidal wetlands with acid sulfate soils
Vast areas near seacoasts and inland estuaries in Indonesia (Sumatra and Kalimantan) and smaller areas in India, Bangladesh, and Thailand have acid sulfate soils. Salt water intrusion also occurs. Most of these areas are not presently planted to rice. Varieties with acid sulfate soil, salinity, and tidal submergence tolerance are required.

Tidal wetlands with peat soils
Peat soils are found near seacoasts and estuaries in Indonesia and Vietnam and in smaller areas in other countries. Some of the areas may be used for rice production if suitable varieties and appropriate management practices are developed.

ARTICLES OF INCORPORATION

As amended 14 October 1982

The Institute is organized as an autonomous entity and the purpose of the Institute is to establish, maintain and operate an international rice research institute designed to pursue any and/or all of the following objectives:

1. To conduct research on the rice plant, on all phases of rice production, management, distribution and utilization with a view of attaining nutritive and economic advantage or benefit for the people of Asia and other major rice-growing areas of the world through improvement in quality and quantity of rice;
2. To publish and disseminate research findings and recommendations of the Institute;
3. To distribute improved plant materials to national, regional and international research centers where they might be of significant value or use in breeding or improvement programs;
4. To develop and educate promising young scientists from Asia and other major rice-growing areas of the world along lines connected with or relating to rice production, distribution, and utilization, through resident and joint training programs under the guidance of well-trained and distinguished scientists;
5. To establish, maintain, and operate an information center and library which will provide, among others, for interested scientists and scholars everywhere a

collection of the world's literature on rice;

6. To establish, maintain, and operate a rice genetics resources laboratory which will make available to scientists and institutions all over the world a global collection of rice germplasm;

7. To organize or hold periodic conferences, forums, and seminars, whether international, regional, national, or otherwise, for the purpose of discussing current problems and for developing research strategies for elevating and stabilizing rice yields under different environments.