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A POSSIBLE EXPANSION OF THE CGIAR:

APPROACHES FOR TAC AND THE CGIAR - PART ONE

(Agenda Item 5 (a))

Objectives of the Discussion

At TAC 47 the Committee approved the broad outline prepared by the Chairman of a paper entitled "The Possible Expansion of the CGIAR: A Draft Outline of Possible Approaches for TAC and the CGIAR". The Standing Committee for Priorities and Strategies was subsequently requested to oversee the development of Chapters II, III and IV. The attached draft was prepared by staff of the TAC and CGIAR Secretariats and will be reviewed by the Standing Committee prior to TAC 48.

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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2.1. Agriculture's Current Situation and Potential Future Directions

The state of agricultural development throughout the world remains very uneven. Most developing countries face chronic food insecurity and widespread poverty of their populations, most of which are engaged in farming. In developed countries, only a small part of the population is active in the agricultural sector of the economy, which is generally efficient and producing surplus food. Whereas in developing countries almost two thirds of the population is engaged in agriculture, food production per capita averages only 260 kg per caput compared to 780 kg in developed countries, in which less than 10% of the population gains its living from agriculture (Table 1).

Table 1 Population, Food Production and Food Availability in Developing and Developed Countries

	Population (million) 1/	% of Popul. engaged in Agriculture 2/	Food Crop Prod. (kg/caput) 3/	Food Availabil. (calories/caput/day) 2/
World	4,837	49	400	2,660
Developed Countries	1,174	10	780	3,370
Developing Countries	3,663	63	260	2,420

1/ 1985 2/ 1983/85 3/ 1982

Sources: United Nations (1986); Paulino (1986); FAO (1987)

The state of agricultural and economic development varies widely across countries and continents. Generally, a classification is made of developed market economies, centrally-planned economies, developing economies in low-income countries, and developing economies in middle-income countries. A discussion of the present situation in each of these groups follows. An overview of selected statistical indicators is presented in Table 2.

1/ As in draft outline by McCalla (AGR/TAC:IAR/88/24)

Table 2 Population Growth, Growth in Agricultural Demand, Growth in Agricultural Production, Share of Agriculture in Total Exports and in Total Imports for Different Groups of Countries, and Share of Income Spent on Food

	Pop.Growth[a] (% p.a.)	Growth Agr.[b] Demand (% p.a.)	Growth Agr.[b] Production (% p.a.)	Share Agr.[c] in Total Exports (%)	Share Agr.[c] in Total Imports (%)	Share of Income spent on Food (%)
Developed Market Economies	0.8	1.5	1.9	11	11	20-25
Centrally Planned Economies	0.8	2.3	2.0	5	16	30-40
Developing Econ.	2.0	3.5	3.2	14	14	
- Low Income	1.7	3.3	3.2	27	24	70-85
- Middle Income	2.4	3.8	3.2	17	15	55-70
World	1.7	2.5	2.5	N/A[d]	N/A[d]	N/A

[a] Between 1970-80; [b] Between 1961-85; [c] 1983/85; [d] N/A = not available

Source: FAO (1987)

2.1.1. Developed Market Economies

The group of developed-market economies includes the countries of Western Europe and North America, Japan, Australia and New Zealand. The population of these countries grows slowly; between 1970-85 an average of 0.7% p.a., while per capita incomes are the highest in the world and during 1985 averaged US$ 11,810 (World Bank, 1987).

Only a minor proportion of the population is employed in agriculture. The small-farm sector consists of either highly specialized and intensive enterprises, or of less profitable enterprises that can continue to operate only with the assistance of substantial government subsidies and protective trade measures. Consumer food prices are generally high but stable and protected from the instability of world markets. As a result, total agricultural demand grows slowly, between 1961 and 1985 by 1.5% p.a. While agricultural production grew much faster, by 1.9% p.a., this has led to a rapid expansion of agricultural exports, which during the last 25 years grew by 4.9% p.a., declining food imports and during particular periods, the existence of large stocks. Although agriculture provides with 3% only a minor share of GDP, in some countries it provides a major part of total exports. In general, developed market economies tend to be net food exporters.

2.1.2. Centrally-Planned, Developed Economies

The group of centrally planned, developed economies includes the countries of Eastern Europe, except Yugoslavia, and the USSR. As in countries with market economies, population growth is slow (0.8% p.a. between 1970 and 1985), while incomes are growing rapidly. GDP has grown annually by 4.7% between 1973-80 and by 3.8% between 1980 and 1986. The corresponding figures for market economies are 2.8 and 2.3% respectively. As a result, centrally planned economies have also experienced high growth rates of agricultural demand, on average 2.3% p.a. between 1961 and 1985, particularly for livestock products. During this period, total production grew by only 2.0% p.a., mainly because of slow gains in agricultural productivity. As a group they are net importers in terms of value of total agricultural trade. The USSR particularly has been since the early seventies a persistent net importer, mainly of cereals, sugar and butter. The other countries collectively are net exporters of fruit, vegetables and certain livestock products.

Most of the countries with centrally-planned economies maintain low and stable consumer food prices, using substantial amounts of government subsidies. In contrast to market economies, diets are still largely dependent on staples, and food still accounts for a large share of total household expenditure.

2.1.3. Developing Economies

In developing countries, population has been growing rapidly by 2.3% p.a. between 1965 and 1980, and by 2.0% p.a. between 1980 and 1985. They form a heterogeneous group of both low-income and middle-income countries. Low income countries have a GDP of less than US$ 400 per

capita and can be found mainly in sub-Saharan Africa and Asia, while middle-income countries are predominantly located in the Near East/ Northern Africa and Latin America. Population growth rates have been substantially higher in middle-income developing countries, as well as food availability per capita which during 1983/85 amounted to 2,660 calories per caput per day compared to 2,310 calories in low income countries, and even to only 2,130 calories when China is excluded from the latter group. Although incomes are low, they are gradually rising, while modest gains in productivity (particularly through a rapid increase in the use of fertilizers and the effects of the Green Revolution in Asia and Latin America) have been achieved. This process has allowed for a strong growth in demand for agricultural products, averaging between 1961 and 1985 some 3.3% p.a. in low-income developing countries and 3.8% p.a. in middle-income countries. Although agricultural production has expanded equally rapidly in most developing countries, agricultural policies usually favoured the urban consumer by keeping food prices artificially low, thereby discouraging the rural producers. As a result, imports of food have also grown rapidly, particularly in the middle-income oil exporting countries.

Although food production has increased throughout the developing world, per caput food availability was lower in 1983/85 than in 1979/81 in 37 of 94 developing countries for which data are available. Well over 500 million people remain severely undernourished, and even in middle-income developing countries large segments of the population can be categorized as poor and undernourished.

2.1.4. Implications for Future Supply and Demand Balances

Despite a sustained improvement in overall food supplies, and increased agricultural productivity, chronic food shortages and poverty remained common throughout the developing world, resulting in widespread malnutrition. This problem is still particularly acute in low-income countries, mainly in sub-Saharan Africa and South Asia.

Agricultural production in developing countries is projected to rise by 3.0% a year between 1983/85 and the year 2000, or 1.1% p.a. on a per caput basis. This per caput growth rate differs significantly across regions and is expected to amount to 1.5% in Asia, 0.5% in both the Near East/North Africa and Latin America, but to only 0.1% in sub-Saharan Africa (FAO, 1987). A significant acceleration of agricultural production in developing countries may be feasible through appropriate policy reforms that favour smallholder producers, give greater priority to agriculture in government resource allocation, and allow for structural adjustments in the economies. For the foreseeable future, however, developing countries will have continuing substantial food deficits.

In developed-market economies, the existing problems of surplus production and the resulting expansion of export markets are likely to continue. In centrally-planned economies, agricultural production is expected to improve substantially while food demand would grow slowly. This may result in a better balance of production and demand, and of self-sufficiency in the latter economies by the year 2000 (FAO, Ibid).

Trade is of significant importance to the development process in the Third World, because it allows for imports of basic food staples, and for exports of agricultural commodities. At present, developing countries have a global agricultural trade surplus, but because of the disarray in commodity markets it is declining rapidly. The import demand for the main agricultural exports of the developing countries grows at very low rates, reflecting inelastic demand and protection policies in importing countries. The net agricultural trade balance of US$ 12.7 billion in 1983/85 is expected to fall to US$ 7.8 billion by the year 2000. Trade liberalisation through international agreements or policy changes could improve the trade balance by improving market access for developing countries.

2.2. Emerging Global Trends: The Likely Scenario in 2025

2.2.1. Population Growth

According to the medium variant estimates of the United Nations (United Nations, 1986), the total population of the world is projected to grow from 4.8 billion in 1985, to 6.1 billion in 2000, to 7 billion in 2010 and to 8.2 billion in 2025. The present growth rate is about 1.7% p.a., but the slowdown in the growth of world population that started in the early seventies is projected to continue, and the annual growth rate will decline to 1.5% by 2000 and fall below 1% by 2025. While at present about three quarters of the world population lives in developing countries, this proportion will increase to 79% in 2000, to 81% in 2010, and to 83% in 2025 (Table 3). The population growth rate in developing countries is indeed between three and four times the growth rate of developed countries. Wide regional differences can be observed in the expected population growth rates for developing countries with the highest rates to be in sub-Saharan Africa, and the lowest in Asia, with Near East/North Africa and Latin America having an intermediate growth rate.

Asia's population increases will be the largest in absolute terms despite slower growth rates. The continent will contain 58% of the world's population by the year 2000, although this share will not increase further because of the effects of family planning efforts in China and India.

Africa's population is expected to expand threefold between 1985 and 2025, thereby increasing its share in the world population from 11% to almost 20%.

The population of China is projected to remain the largest in the world until 2025, but the difference with the second largest, India, is expected to be reduced. Five of six European countries included on the list of the 25 most populous countries during 1985, are projected to disappear from that list and will by 2025 be replaced by one Asian and four African countries.

Table 3 Population Size and Percentage Distribution for the World, Developed and Developing Countries and Major Areas, Medium Variant Case, 1960-2025

	World	D.C's	L.D.C's	Africa	Latin America	East Asia	South Asia
			POPULATION (MILLIONS)				
1960	3,019	945	2,074	280	217	791	877
1970	3,693	1,047	2,646	361	283	986	1,116
1985	4,837	1,174	3,663	555	405	1,250	1,568
2000	6,122	1,277	4,845	872	546	1,475	2,074
2010	6,989	1,331	5,658	1,158	642	1,589	2,394
2025	8,206	1,396	6,809	1,617	779	1,721	2,814
			DISTRIBUTION (PERCENTAGE)				
1960	100.0	30.3	68.7	9.3	7.2	26.2	29.0
1970	100.0	28.3	71.7	9.8	7.7	26.7	30.2
1985	100.0	24.2	75.8	11.5	8.4	25.8	32.4
2000	100.0	20.8	79.2	14.2	8.9	24.1	33.9
2010	100.0	19.0	81.0	16.6	9.2	22.7	34.3
2025	100.0	17.0	83.0	19.7	9.5	21.0	34.3

Source: United Nations (1986)

2.2.2. Income Growth

Income growth is a significant factor in determining food demand, both in its size and its composition. In addition to an increase in food consumption, the general trend is for diets to shift from staple grains towards more meat and other livestock products. While incomes in developing countries grew rapidly during the sixties and seventies, both in absolute terms and on a per capita basis, since the early eighties this growth has slowed down. Between 1965 and 1973 the average annual growth rate was 6.5%, from 1973-80 it was 5.4%, and between 1980-86 was 3.6% (World Bank, 1987). On a per capita basis, annual growth rates were substantially lower and for developing countries averaged 3.9% between 1965-73, 3.2% between 1973-80, and 1.5% between 1980-86. During the latter period, per capita growth rates were even negative in sub-Saharan Africa (-3.4%), oil exporting countries (-1.8%), and in middle-income countries (-0.3%). For the next ten years, the World Bank has projected an annual per capita growth rate of 2.0% in developing countries as a group. On a per capita basis, no growth but stagnation is expected for sub-Saharan Africa, while the average growth in middle-income countries has been estimated to be 2.8% p.a. These projections represent the lower variant case, which assumes an overall growth of 3.9% p.a. If industrial and developing countries would adopt a variety of medium- and long-term adjustment policies and

policy reforms, output would grow on average by 5.9% a year, or 3.9% p.a. per capita. Under this latter high-variant scenario, in sub-Saharan Africa GDP per capita would grow slightly,by 0.7% p.a.

In centrally-planned economies, the GDP growth rates until the end of the century are expected to average to 3.7% p.a. overall, and 3.0% per capita. This income growth rate is likely to result in further rapid increases in food demands and diet diversification, particularly for livestock products, exotic fruit, vegetables, oils and sugar.

Incomes in developed-market economies are expected to grow by 3.3% p.a., or 2.7% per annum. In view of the fact that incomes and consumption are already at a high level, this growth is expected to result in only minor additional demands for food. Even the trend towards diet diversification may in such economies be determined more by health considerations than by further increases in income level.

Overall, the outlook on future income growth is very uncertain, both in the short and medium run. FAO is relatively pessimistic about future economic growth until the year 2000, while IFPRI expects the decade of the nineties to be a period of renewed strong economic performance (FAO, 1987; Mellor, 1988). The outcome will be largely determined by political events, the future of oil prices, and the economic policies followed by Governments.

2.2.3. Urbanization

Urbanization is a third major factor determining food demand, particularly of its composition. Consumers will indeed make further shifts in their diets from low protein cereals to high protein cereals (such as wheat and rice) and to more dairy and meat products. It also affects the mode of food supply, which for urban areas has to be generated through market production rather than through subsistence agriculture. At present, approximately 31% of the population of developing countries live in urban areas although there are strong regional variations. In Latin America, 69% of the population is urbanized, particularly in the temperate zone countries. In sub-Saharan Africa, on average 28% lives in urban areas ranging from 20% in Eastern/ Southern Africa to 47% in North Africa. Asia is the least urbanized continent, as only 25% of the population lives in urban areas. In South Asia, this percentage amounts to only 12%. By the year 2000, about 40% of the population in developing countries will be living in towns and cities, and by the year 2025 the urban population would be 57% of the total (United Nations, 1987). The process of urbanization leads to an increased demand for food commodities with a high income elasticity, and which can easily be transported, processed or stored. Yet, for planning purposes, a distinction should be made between growth of metropolitan areas and urban growth in regional centres. Regional agricultural development can play a major role in employment generation in the latter situation.

2.2.4. Environmental Challenge and Resource Degradation

The need for a substantial increase in food production during the coming decades, will inevitably lead to increasing pressures on the

natural resource base, which in recent years has deteriorated sharply through soil erosion, degradation and depletion of the wood and water base, desertification, and general pollution of the environment.

The importance of these issues for agricultural research and develoment has been adequately illustrated in TAC's report on sustainability (TAC/CGIAR, 1988) and the report of the Brundtland Commission (World Commission on Environment and Development, 1987). The facts are clear and can be summarized from the latter report. Without conservation measures, the total area of arable land in developing countries will shrink by several hundreds of million hectares because of soil erosion. Deserts spread by more than 6 million hectares each year. Water use will double by the end of the century, and shortage of potable water is already a major constraint to almost half of the world's population. More than 50% of the irrigation systems in the world have severe problems with waterlogging and salinization, and some 10 million ha are abandoned each year. Severe warnings are being made about the environmental consequences of chemical fertilizers and pesticides, and their threat to human health, the genetic stock of the population, to survival of plant and animal species, and in general to sustainable agriculture. FAO has estimated that because of the expansion of agriculture and the need for fuelwood, every year approximately 11 million ha of tropical forests disappear. In the tropics today, ten trees are being cut for every one planted, in Africa the ratio is 29 to 1. The loss of forests will continue in an accelerated way, in turn helping to provoke a mass extinction of species, which often find their natural habitat in forests.

The implications of these environmental threats to agricultural development are dramatic. TAC has already recognized that all agricultural research must have a sustainability perspective, and will re-assess CGIAR priorities accordingly.

In developing countries, the most serious environmental destruction occurs as population pressure expands against a limited land resource base and pushes cultivation onto more fragile resources (Mellor 1988). In developed countries, environmental issues related to agriculture largely result from an intensification of farming methods, particularly the heavy applications of fertilizers and pesticides, and intensive livestock rearing.

Future strains on the natural resource base may be greater in developing than in developed countries. Sound management of natural resources, except air pollution, may indeed be easier to enforce in developed countries, where the pressures of food demand are less strong. In broad terms, the environmental problems in Asia will be largely resulting from increased irrigation and deforestation, in Near East/ North Africa from lack of arable land and desertification in sub-Saharan Africa from soil degradation through over-cultivation, and in Latin America from deforestation and increased monoculture (FAO, 1987).

2.2.5. Climatic Change

There is now broad consensus in the scientific community that the deteriorating quality of the environment may result in a climatic

change during the first half of the next century, which will have both positive and negative effects on agriculture, and could have an enormous impact on the food situation in developing countries. The nature and magnitude of this climatic change is as follows (FAO, 1988; Brown, 1988). Carbon dioxide (CO_2) and other gas concentrations in the atmosphere are increasing rapidly, leading to a greenhouse effect and a global warming of the atmosphere. If present trends continue, particularly of deforestation, global average temperatures will rise by about 0.3^{o} C per decade, i.e. by about 1^{o} C by 2020. This increase would not be uniform, and temperature changes around the Arctic could be more than two times greater than global average values. Precipitation patterns will change and there would also be greater variablity, both in rainfall and temperatures, as well as an increase in cloud cover. These factors may lead to a rise in sea level of some 30 cm by about 2010, 1 m by 2025 and as high as 1.5 m by 2050. More than 50% of the world's population and much of its food producing capacity are concentrated in coastal areas. The deteriorating soil-water-balance relationship may also adversely affect the major temperate cereal-growing areas of both hemispheres. Rising CO_2 levels also have positive effects on agricultural productivity, because of the greenhouse effect and higher temperatures. Plants also transpire less water. About 5-10% of the actual annual increase of agricultural productivity can be attributed to the fertilizing effect of rising atmospheric carbon dioxide (Goudriaan and Unsworth, 1988). It is important to note, however, that there are divergent views and schools of thought with respect to the nature and extent of this climatic change. Several scientists even expect in the long run a global cooling, rather than warming, of the atmosphere.

2.2.6. Need for Income and Employment Strategies in Agricultural Development

Strategies to improve nutrition and alleviate hunger should not only focus on improving food supplies, but also on ensuring access to food by the poor, by increasing their purchasing power. In many developing countries, people are malnourished because they are too poor to buy available food. Efforts to increase food production should, therefore, be accompanied by policies to expand employment opportunities and income generation.

The World Bank has estimated the number of absolute poor in developing countries (excluding China) to be 780 million. Half of the poor live in South Asia, mainly in India and Bangladesh. Alternative FAO projections estimate the percentage of rural population living in absolute poverty as at 65% in sub-Saharan Africa, 50% in Asia, 32% in the Near East/North Africa and 53% in Latin America. In Asia, many of the rural poor are near-landless and work as daily labourers. As pointed out by Mellor (1988), the poor are heavily concentrated in rural areas of very low-income countries, and many are in rural areas where the potential for response to improved agricultural technology is high. Two thirds of the poor are in sub-Saharan Africa and South Asia. Although the absolute number of poor in middle-income countries dropped nearly by half between 1970 and 1980, it increased by more than 50% in low-income countries during the same period. In Latin America, the number of rural poor has been increasing rapidly since 1970, and the continent also struggles with a substantial problem of urban poverty.

The alleviation of poverty in developing countries depends on a dynamic expansion in employment opportunities for the poor. It has been estimated (Sabolo, 1975) that the combined rate of unemployment and underemployment is 38% in Africa, 28% in Asia and 25% in Latin America. To be effective, an employment-oriented development strategy would require a rapid growth in food production and declining food prices. These can only occur simultaneously through cost-decreasing technological change in agriculture (Mellor, 1984). Redistribution of income without technological change may increase food prices or the cost of food imports. Increased food production without additional employment for the poor may, initially, lead to lower food prices, but these may in turn inhibit the application of the particular technological change that provided the food supplies.

High rates of employment growth, both in the rural and urban sector, can only be sustained if there is a corresponding growth in domestic food production. Indeed, employment growth increases the wage bill the bulk of which, 60 to 80%, in developing countries is spent on food. If employment would increase rapidly and food supply remain constant, food prices will rise (Mellor, 1987). Accelerated agricultural growth through production-increasing technological change in turn generates capital and creates an effective demand for goods and services that can be efficiently produced by other sectors of the economy with low capital-to-labour ratios. IFPRI research has shown that in Asia, small farmers spend 40% of income increments on locally produced non-agricultural goods and services, and about 20% on horticultural and livestock products, which are also labour-intensive to produce. It is this link between agricultural growth and labour-intensive growth that needs to be encouraged. This will require a greater attention by governments to infrastructure development, such as roads and educational facilities, services, and the supply of institutional credit. Infrastructure development may provide the link between amelioration of poverty in the short term, and a self-reliant removal of poverty in the long term (Mellor, 1988). Particular attention is also to be given to the development of appropriate livestock technology to meet rapidly growing demand with high employment creation. Fruit and vegetable production are also likely to be important sources of rural employment as incomes rise. In implementing an agriculturally-led development strategy, which increases employment and alleviates poverty, cost-reducing technological change will be the driving force. Agricultural research will necessarily need to be a key element of this strategy.

2.2.7. Changing Patterns of Trade and Adjustment Policies

Despite significant increases in food production in developing countries, there has been a very rapid growth in reliance on international trade as a source of food. Whereas developing countries (excluding China) in 1961/63 imported only 5% of their food supplies, this percentage had risen to 10% in 1983/85. The rapid increase of food imports is illustrated in Table 4. During the same period, developing countries turned from net exporters to net importers of food in terms of calories. The self-sufficiency ratio of agricultural production declined sharply in Africa and the Near East, only slightly in Latin America, and remained constant in Asia.

Table 4 Food Imports by Developing Countries
(excl. China, calories per caput per day) 1/

	61/63	69/71	79/81	83/85
All Developing Countries	190	220	400	430
Sub-Saharan Africa	130	160	290	300
Near East/North Africa	400	480	1090	1490
Asia	140	150	190	190
Latin America	270	300	690	640

1/ Calories content of gross imports of food commodities for direct food consumption and for indirect consumption (livestock feed).

Source: FAO (1987)

The rise in imports as a source of calories was particularly striking for the middle income countries of the Near East/North Africa and the Latin America region. The rapid increase of food imports in sub-Saharan Africa (between 79/81 and 84/86 with 8% p.a. for cereals and 18% p.a. for non-cereals) included large amounts of food aid which, in fact, did not raise consumption levels, but only helped to prevent drastic declines. Asia is the region least dependent upon imports for its food supply. During the first half of the 1980s, the rapid growth of food imports was halted in Latin America. This slowdown was due to lack of foreign exchange caused by rising debt service burdens and falling prices of export commodities.

Imports of cereals have been growing particularly rapidly, tripling in size in 25 years. The increase occurred particularly during the last decade, and by the mid-1980s grain imports in developing countries represented 46% of the world's total, up from 36% in the 1960s. Growth rates of cereal imports were particularly rapid for coarse grains (especially maize) reflecting their expanding use for animal feed as consumption patterns shifted toward animal products in developing countries.

The increase in per capita incomes in developing countries led to a major expansion in demand for livestock products. As a result, imports of dairy products in developing countries increased by about 11% p.a. from 74/76 to 84/86, and this increase was relatively similar across different regions. Imports of meat also rose rapidly and more than doubled. The increase in meat imports was concentrated in the Middle East/North Africa and Asia. Both these regions accounted for 80% of the increase in meat imports. The gap between domestic supply and demand of livestock products is expected to widen considerably in all developing regions by the year 2000. Nevertheless, per caput consumption levels of livestock products will remain low for the

majority of people in developing countries. The poor will continue to depend on alternative sources of protein.

International economic conditions and national trade policies have during the last 20 years become of significant importance to agricultural development in the Third World. The debt crisis, fluctuations in exchange rates, recession, and volatile oil and commodity markets have strongly affected developing countries, particularly those with a high dependence on agricultural exports. International agricultural trade is in disarray. Industrial countries have agricultural trade policies to complement domestic support policies designed to redistribute income to agriculture, to keep small farmers operating and to contribute to other domestic objectives. This has led to surplus production, the growth of exports of agricultural products, and dumping practices. Tensions among industrial countries have been mounting and trade conflicts are continuing. In many developing countries, domestic food production is discouraged because of the competition with cheap imports, particularly for dairy products and wheat. Although most economic studies are strongly in favour of measures for trade liberalization, there are many other considerations for governments of industrial countries. Free trade would indeed significantly affect the welfare of some segments of the population, even though the country as a whole may be better off.

For developing countries, the economic impact of trade liberalization would depend on their share in the world markets. They would have to adjust their domestic policies to compensate for changing import prices, but could largely gain from getting greater access to international markets. Countries with insufficient land or productive capacity to support their population are dependent on world markets for food security, and political boundaries are often not consistent with ecological boundaries (McCalla, 1988). The effects of alternative trade policies on national food supply require further investigation. At the international level, the effects of trade on national food security will largely depend on the outcome of negotiations through General Agreement on Tariffs and Trade (GATT) and United Nations Conference on Trade and Development (UNCTAD).

2.2.8. Implications for Food Demand

The demand for food and agricultural products for all food and non-food uses in the developing countries is projected to grow at 3.1% p.a. over the period 1983/85-2000 (FAO, 1987). This is lower than the 3.7% growth rate achieved between 1970 and 1985. The slowdown in the growth of total demand is caused by the lower growth rates of population and the already relatively high consumption levels in some middle income countries, such as China, and the countries of the Near East and North Africa. In sub-Saharan Africa, per capita consumption will remain low and be largely dependent upon subsistence production and low cost food imports, including food aid.

In a study made by IFPRI (Paulino, 1986), past trends in the domestic utilization of basic food staples in developing countries clearly suggest shifts in their food consumption towards more livestock products. IFPRI's projections of the total domestic use of basic

staples arising from changes in population and income show average annual growth rates of 2.1% for direct food use and 4.6% for animal feed between 1980 and 2000. By the year 2000, of the total supply of basic staples in developing countries, 62% will be consumed as food and 23% as feed, with the remainder being used for industrial purposes. The use of staples for feed is increasing rapidly. The growth in demand for livestock cereal feed until the year 2000 is projected at around 5% a year. The livestock-feedgrain linkage is likely to be a major determinant of future food deficits in developing countries. A key aspect for consideration, is whether feed will be grown on land which is suitable for the production of food crops. Such a competition for land may be detrimental for the nutritional status of the poor.

Overall, the trend towards diet diversification in favour of higher value commodities such as livestock products, oils, sugar, fruit and vegetables is expected to continue, particularly in urbanizing middle income countries. The development of per caput demand for major commodities until the year 2000 is illustrated in Table 5. In sub-Saharan Africa, improved consumption will be largely reflected in an increased consumption of cereals and starchy products.

Table 5. Per Caput Food Demand in 1983/85 and 2000 for Major Commodities - kg/head/year (calories p.c. per day)

	Cereals	Roots & Tubers	Vegetable Oil	Sugar	Meat	Milk
All Developing Countries						
1983/85	173 (1,283)	63 (163)	7 (188)	18 (174)	14 (100)	34 (70)
2000	174 (1,531)	60 (147)	9 (242)	22 (214)	18 (122)	41 (83)
Sub-Saharan Africa						
1983/85	113 (907)	192 (510)	8 (195)	9 (85)	10 (49)	27 (47)
2000	121 (1,031)	196 (515)	8 (226)	11 (108)	11 (54)	27 (47)
Near East/ North Africa						
1983/85	212 (1,708)	28 (60)	12 (306)	33 (308)	21 (101)	72 (140)
2000	204 (1,671)	28 (54)	14 (363)	37 (363)	24 (114)	77 (155)
Asia						
1983/85	159 (1,339)	30 (115)	7 (166)	19 (135)	5 (90)	34 (52)
2000	173 (1,683)	28 (78)	9 (224)	23 (173)	7 (118)	39 (64)
Latin America						
1983/85	136 (1,050)	73 (168)	9 (235)	44 (427)	37 (212)	94 (161)
2000	143 (1,173)	71 (156)	11 (277)	49 (477)	41 (237)	107 (184)

Source: FAO "Agriculture: Towards 2000" data files.

Many developing countries will face demand constraints, both in their export and commodity markets. This is for example the case in the roots/plantains sector, where yields could be expanded, but where per capita demand declines steadily with increasing incomes.

2.3. Potential Sources of Increased Food Supplies

2.3.1. Land Expansion

Agricultural production in developing countries (excl. China) currently takes place on approximately 768 million ha of land with a cropping intensity of 78%, or an annual harvested area of some 600 million ha (FAO, 1987). The total area of potentially arable land available amounts to 1,291 million ha, so only 37% of available land is being cultivated. In sub-Saharan Africa and Latin America particularly, only about a quarter of potentially arable land is being cultivated, while very few land reserves remain in Asia and the Near East/North Africa (Table 6). Although these figures suggest a substantial potential for production increases by expanding the area cultivated, it is a misleading situation. First, many of these potential land reserves are located in tropical forest areas and cultivation would have negative environmental consequences. Second, most of these reserves have soils of marginal quality or are located in areas with unreliable rainfall. Almost all land reserves would require the introduction of improved technologies before they can be cultivated on a sustainable basis. Third, the land reserves are heavily concentrated in a few countries, such as Zaire and Brazil.

Table 6 Available Land Reserves and Land Use in Developing Countries (Million ha, 1982-84)

	Land Use	Total Reserves of Potential Arable Land	Under Cultivation (%)
All Developing Countries (excl. China)	768	1,291	36
Sub-Saharan Africa	201	615	25
Latin America	195	694	22
Asia (excl. China)	280	62	82
Near East/N. Africa	92	3	97

Source: Adapted from FAO (1987)

During the last decade, the amount of additional arable land taken into cultivation has expanded by only 3.9%. This figure refers to a net expansion and takes also into account the loss of land which is withdrawn from agriculture because soils were too degraded or through urbanisation and infrastructure. Regionally, land expansion amounted to 13.2% in Latin America, 5.3% in Africa and 1% in Asia. In the short run, there is little opportunity for a major expansion of cultivated land in most developing countries.

2.3.2. Technology Improvement and Increases in Productivity

In previous sections of this chapter it has been indicated that future increases in food production will have to result largely from an intensification of production, i.e. from increased yields per unit of land. During the last three decades, increases in agricultural output have been obtained largely through substantial improvements in yields. Between 1961-70 the contribution to production increase of improved yields per ha in developing countries (excl. China) amounted to 70%, and to 80% between 1971 and 1980 (Paulino, 1986). Regionally, strong differences can be observed in mean yields and their rates of growth. During 1984/86 for example, mean yields of cereals were 2.2 t per ha in Asia, 2 t/ha in Latin America and only 1 t/ha in sub-Saharan Africa. The rate of growth of output per ha for major food crops between 1961 and 1980 amounted to 1.9% p.a. for developing countries as a group, 2.4% in Asia, 1.4% in North Africa/West Asia, 1.3% in Latin America, but only 0.1% in sub-Saharan Africa. Increases in yields can only be maintained with continuous technological change.

As TAC has observed in its Sustainability Paper (TAC/CGIAR, 1988), throughout the developing world countries face major difficulties in maintaining the rates of increases in yields. The momentum of the Green Revolution is slowing down. This highlights again the need for continued research efforts to develop improved technologies and production systems in which increased productivity can be sustained.

2.3.3. Yield and Yield Potential

(To be prepared by Dr. Plucknett)

2.3.4. Intensification of Land Use

Given the limitations of expanding the amount of cultivated land, increases in food production will have to be generated by intensification of agriculture, particularly through a more intensive use of available land. Water is the prime limiting constraint for almost 600 million ha of potentially suitable arable land, and only when this constraint is released, other technical constraints can be addressed. One major approach to achieve intensification is through irrigation. There are at present about 220 million ha of irrigated land in the world, representing about 15% of the total cultivated area. Of the 220 million ha, 158 million ha, or 72% are located in developing countries. The irrigated area is approximately 20% of the total cultivated area in developing countries. Irrigated agriculture is largely concentrated in Asia where it constitutes almost 30% of areas cultivated and it supplies about half of the region's total food production. In sub-Saharan Africa less than 3% of harvested land is irrigated and in Latin America about 12%. Yield effects of irrigation can be high. In South Asia, for example, yields per ha obtained from irrigated cereals average between 1.5 and 2.3 times as much as from unirrigated land (FAO, 1987; IIMI, 1989).

Massive investments have been made during the last three decades to develop irrigation systems in the Third World. In many developing countries, investments in irrigation constituted more than three quarters of public spending on agriculture. Yet, almost all irrigation systems are performing far below their potential. Most of the benefits of irrigation development have stemmed from the magnitude of the investment, not from the increased efficiency of the production system (IIMI, 1988).

The area irrigated and the cropping intensities achieved are usually well below what was anticipated. In addition, the high capital requirement for irrigation development causes the cost of production of irrigated crops to be substantially above that of rainfed crops. Irrigation management is very complex and wastage of water, salinization, and waterlogging are common problems. Finally, land often is not suitable for irrigation, or not sufficient irrigation water is available.

Although a large potential exists for a more effective utilization of irrigation systems and to improve their management, intensification of land use will have to focus primarily on rainfed agriculture. This can be achieved by improved technologies related to soil and water conservation, the efficient utilization of inputs, improved plant varieties, and increased cropping intensity. The development of more efficient production systems, for example, by enhancing crop-livestock interaction, may also led to increases in productivity. A major source of further productivity gains is the improved and increased use of fertilizers. During the last 25 years the growth rate of fertilizer use in developing countries has been more than 10% per annum. Although developing countries now account for almost 40% of the world's fertilizer consumption compared to 12% in 1961, its use is still very limited particularly in Asia and Latin America (Dudal, 1987).

2.3.5. Increased Efficiency in the Use of Purchased Inputs

As farming systems become more market oriented, they also become increasingly dependent upon the use of off-farm production inputs, such as mineral fertilizers, improved seeds, irrigation water, pesticides, implements and machinery, vaccines and veterinary drugs. The use of off-farm inputs varies widely across farming systems, ecological zones and geographic regions. FAO (1987) has observed the relation between the level of development and input use by studying the regional variation in the share of the value of inputs to that of gross output. For most developed countries it was valued at about 50%, while in developing countries the share of inputs averages only about 24% of the value of gross output. Wide regional differences are observed however. The share in 1982/84 amounted to 36% in Near East/North Africa, 25% in Latin America, 24% in Asia (excl. China) and to only 10% in sub-Saharan Africa.

An increased use of off-farm inputs reduces the pressure to cultivate marginal lands as well as the competition between the production of crops, livestock and forestry. Increasing the availability of off-farm inputs normally requires an improvement in national infrastructure and of extension services.

There is substantial scope for an improvement of the efficiency in the use of inputs. This can be done, for example, by using plant varieties that are more responsive to inputs, through local-specific information on optimum input levels, by using biological processes to complement chemical inputs, and/or by the use of improved management techniques. An improvement in inputs for livestock production would largely relate to the animal health and animal nutrition aspects. Substantial improvements could also be made to the efficiency of energy and power inputs.

2.3.6. Improved Post-Harvest Technologies and Food Processing

Post-harvest activities refer to the transport, storage, processing, conversion, distribution and utilization of agricultural commodities and their by-products. Losses in quality and quantity of food occur at all stages of the post-harvest process. A reduction in post-harvest losses would have a significant impact on increasing the amount (both quantity and quality) available for consumption.

The importance of food processing technologies increases with urbanization and income growth, both of which lead to a tendency for diet diversification and increasing demand for convenience foods.

2.3.7. Livestock Production

In general livestock production can increase in two ways: an expansion of livestock numbers, and higher yield per animal through improvements of management, breeds, feed utilization, or other technology. During the past two decades the dominant source of growth,

especially in ruminants, has been increases in livestock numbers and in off-take rates, while yields per animal have increased only marginally. However, during the past decade in some developing countries yields of broiler and egg production have increased through the application of intensive management systems and the commercialization of production. The productivity of swine has also increased, particularly in Asia.

During the next decade or more, the increase in livestock number will continue, although higher yields will be an increasingly important source of growth. These will have to come from more intensive management and production systems. Livestock production has to increase rapidly in order to meet the growing demand for meat, milk and eggs.

Intensive beef production, such as backyard or feedlot finishing and fattening using agricultural wastes, crop by-products and other low-cost feed resources, or pasture feeding, gain importance in many countries. It is also important to note that the use of farm machineries to replace draught animal power for crop production in irrigated areas will put heavier pressure on the need to increase beef production. However, the use of draught animals will remain a major source of farm power for rainfed subsistence agriculture. The demand for draught cattle and buffaloes for crop farming is expanding in many countries, especially where fuel prices and the maintenance cost of farm machinery are relatively high.

Small ruminants, particularly goats and sheep will gain even more importance as sources of meat and milk, particularly for smallholders of integrated farming systems. Fattening of sheep and goats utilizing farm wastes and forage crops can provide a substantial source of cash income for smallholders, especially in semi-arid and highland regions.

Meat production from pigs and poultry will remain important. In countries with intensive or commercial-scale broiler production systems, productivity will be further improved through better breeds, management, and feeding. Broiler meat usually comes a relatively cheap source of animal protein, especially where livestock feeds can be produced locally. In intensive swine and poultry production systems adoption of commercial production technologies from developed countries has often been successful in many developing countries. Egg production from chicken and ducks will also become more and more commercialized in the near future.

Due to the rapidly increasing demand for food, some other animal species will be utilized as meat producers such as rabbit, geese, deer, and others. Camels and donkey also deserve attention as important sources of draught power.

2.3.8. Policy Reforms and Structural Adjustments

Improved technology alone cannot ensure increased food production, alleviation of poverty, adequate nutrition and conservation of natural resources. The political, social and economic environment of the agricultural sector is of central importance for the adoption of improved technologies and sustained agricultural development. It is

important to note, however, that only the application of new technology can lead to an improvement of the physical productivity of resources. Policy changes cannot improve resource productivity except in so far as it helps the mobilization and application of appropriate technology.

Developing countries will have to adopt significant policy reforms and ensure structural adjustments of their economies in order to boost the performance of their agricultural sectors. In examining the world agricultural scenario, and the future demands on the global agricultural research system, these factors have to be taken into account. With regard to macro-economic policies, most governments will have to give greater priority to the agricultural sector in their development strategies. Particularly important factors are the share in public spending and investments agriculture receives, patterns of protection of the industrial sectors, exchange rate and wage policies, the level of external indebtedness and debt management, and fiscal policies. Agricultural price policies are also of primary importance in providing sufficient incentives to farmers to expand production, while keeping food prices within reach of consumers. Often developing countries have resorted to negative protection of the agricultural sector to achieve the latter objective. Developing countries would also benefit substantially from trade liberalisation and enhanced access to international markets (FAO, 1987). This will also require major policy changes in developed countries. Expanded trade will however be largely dependent on overall economic development. Changes in sectoral policies are a necessary but not sufficient precondition for an effective policy framework. As pointed out by Helen Hughes (1988), national economy-wide policies have a much wider impact.

2.3.9. Food Aid

The extent and organization of food aid has changed substantially since it was started on institutional basis in 1954 by the USA under its "Food for Peace" programme. During 1986/87 cereal food aid amounted to 7% of world trade in cereals and 11% of total imports of developing countries (World Food Programme, 1988). About 55% of this aid went to established food-aid programmes and 29% to emergency uses. In addition, about 1 million tonnes of non-cereal food aid was distributed during this period, mainly vegetable oil and dried skimmed milk. The major food-aid donors are the EEC, USA and Canada, while the major recipients are low-income, food-deficit countries of Africa and South Asia.

Food aid can be particularly useful to overcome temporary and/or unusual shortfalls in domestic food supply. It can also be useful as a means of protecting the poor from adjustments in government policies, for example in balancing the tradeoffs between continued food subsidies to consumers and improved price incentives to food producers (Mellor in Food Policy, February 1988). Food aid can have a diversity of beneficial effects if properly administrated, for example through food for work projects to develop rural infrastructure, literacy and school feeding initiatives, or selected food subsidy programmes.

It has to be recognized, however, that food aid may be detrimental to long-term socio-economic policies (Kates et. al., 1988 -

The 1988 Hunger Report). The level of food aid, other than which has been institutionalized through successive food aid conventions, has also been shown to depend on a considerable degree on the availability of surpluses in donor countries (Konandreas, 1987).

In the long run, food aid is not an alternative to agricultural growth to provide the necessary domestic production and foreign exchange to meet the increasing demand for food.

2.4. Major Challenges Facing the Global Agricultural Research System until 2025

2.4.1. Continued Rapid Population Growth 1/

The gains expected to be made in agricultural productivity in developing countries will largely be absorbed by rapid population growth. Farmers and policy makers alone will not be able to ensure food security. A large responsibility rests also on family planners (Brown, 1988). The area of particular concern is Africa where the annual growth rate will be more than 3% p.a. until the end of this century, and will decline below 2% p.a. only by 2020. The growth rate is especially high in Eastern and Southern Africa. Kenya's growth rate is at present 4.1% and the highest in the world, and Botswana, Tanzania and Zimbabwe also have growth rates of above 3.5%. Nigeria, the most populous country of Africa is growing at an average of 3.3% and will double its population approximately every 20 years.

Latin America is the second fastest growing area, and the annual growth rate of its population is expected to remain above 2% until the end of this century. South Asia is another rapidly growing major area, with an average annual growth rate of 2.2% for 1980-85, although it is expected to decline to 1.5% by the beginning of the next century.

2.4.2. Increasing Poverty and Malnutrition

Despite the projected improvements of consumption levels in developing countries, the number of malnourished is expected to rise further. The number of people with per caput calorie levels below the critical threshold value of 1.4 basic metabolic rate (BMR), or 1,520 calories is likely to rise from the present 510 million to 630 million in 2000, although their percentage of the total population would decline (FAO, 1987). In sub-Saharan Africa, their number would increase from 140 million to 200 million, and some deterioration would also occur in the low-income countries of South Asia. Improvements would be concentrated in the middle-income countries, particularly in Near East/North Africa and Latin America. A reduction of poverty will have to be achieved through domestic economic and agricultural growth.

1/ All growth rates quoted in this section are medium variant projections of the United Nations (United Nations, 1986)

2.4.3. Deterioration of the Natural Resource Base

The projected increases in population and agricultural production will inevitably add further pressure on the natural resource base already under heavy strain, particularly in fragile and marginal areas. By the year 2025, the global population will be about 70% above that of today, with 93% of the increase concentrated in developing countries. Agricultural output will have to increase by at least 40% by the year 2000, 100% by 2010, and 150% by 2025. Agricultural research will have to focus on the development of improved technologies and sustainable farming systems, the preservation of genetic resources, and the development of forest-management systems. Action is urgently needed to reverse the present trend of environmental degradation. Mellor (1988) has pointed to two approaches that could help in this process. First, to increase the agricultural capacity of the less fragile land to help relieve the pressure in the more fragile areas. Second, conduct research on more sustainable farming systems and provide infrastructure in the more fragile areas. In this way, a synergism could be found between alleviation of poverty and malnutrition through economic growth and environmental protection.

2.4.4. Future Demand and Supply Balances

Although agricultural production will continue to increase in most developing countries on a per capita basis there will be little room for an improvement of nutrition. For developing countries as a group (excl. China), average per caput food availability for direct human consumption is expected to rise from 2,360 calories per day to 2,582 calories by 2000, and 2,870 by the year 2025 (Table 7). By contrast, food intake in developed countries during 1983/85 amounted to 3,370 calories per person per day, while diets were much more diversified.

Table 7 Actual and Projected Value of Per Caput Food Availabiity in Developing Countries (Calories/Person/Day)

	1983/85	2000	2025
All Developing Countries	2,360	2,582	2,870
Sub-Saharan Africa	2,050	2,190	2,317
Near East/North Africa	2,980	3,100	3,671
Asia (excl. China)	2,380	2,610	2,805
Latin America	2,700	2,910	3,408

Source: Compiled from FAO "Agriculture: Towards 2000" data files and assuming annual per capita income growth between 2000 and 2025 of 1% in low-income countries, and 2% in other developing countries.

Some gains in overall food consumption will thus be registered, and average food consumption will improve substantially in Latin America and Near East/North Africa. In sub-Saharan Africa and Asia, and among large segments of the populations elsewhere, critical food shortages will persist during the next forty years. Low-income countries, particularly those which currently have already very low food availability per caput, are expected to make little progress. The food situation in sub-Saharan Africa and South Asia will remain simply dramatic during the next few decades. Unless major increases in agricultural production can be achieved, malnutrition and poverty will be a common attribute for the majority of people in the year 2025.

III. THE ORGANIZATION OF AGRICULTURAL RESEARCH FOR DEVELOPMENT

3.1. The Role of Agriculture in Economic Development

In previous sections of this report it has been illustrated that the imbalance between demand and supply of food, malnutrition, poverty, and deterioration of the natural resource base are critical issues facing the global agricultural research system during the next few decades. Research priorities in the past have generally focussed on the role of agriculture in food supply. Agriculture however also has many other contributions to make which must be considered in setting priorities for the future. Increases in food production will indeed be a necessary but not a sufficient condition for sustained economic and agricultural development. Poverty alleviation and a reversal of environmental degradation will require a substantial effort on a much broader front. It is therefore important to briefly review the contribitions agriculture can make to economic development:

- The dominant role of agriculture is and will continue to provide food for the rapidly expanding non-farm and urban populations, and for farming families.

- Agriculture can make a significant contribution to natural resource conservation and management through sound farming practices, proper land use planning, preservation of genetic resources, the use of adapted plant varieties, improved technologies, and the integration of agricultural and environmental policies.

- Increases in agricultural production and marketable surpluses provide strong stimuli to general economic growth. IFPRI's research has adequately illustrated the strong links between the agriculture and other sectors of the economy.

- Agriculture provides many opportunities for income generation for the rural poor.

- Agriculture is the major source of employment and income for the population of most developing countries. Agricultural growth may lead to a substantial expansion of employment, through the development of labour-intensive agricultural enterprises, such as for example for livestock and vegetable production.

- Finally, agriculture can also be a major source of foreign exchange, or a mechanism for saving foreign exchange.

Accelerated growth in agricultural production is thus not only essential to increase food production, but will also stimulate general economic growth. The significant contributions agriculture makes to economic development and to natural resource conservation and management is dependent upon appropriate policies and strong national research and extension services. As agricultural growth takes place through land expansion and intensification of production, surplus resources are transferred to other sectors of the economy. The increase in agricultural output, based on cost-reducing technological change, increases incomes and generates effective demand for a wide-range of industrial goods and services. The increase in efficiency and the

changing patterns of demand, together with an expansion of industry and service sectors, leads to a gradual decline of the proportion of population engaged in agriculture, and the size of agricultural GDP in relation to total GDP.

Because of higher income and demand elasticities, the industrial and service sectors grow much more rapidly than agriculture. In addition, rapid growth in agriculture requires accelerated growth in international trade (IFPRI, 1978). Capital intensive goods, such as fertilizer, pesticides and steel need to be imported, while labour-intensive goods and raw materials are exported. Recent studies by IFPRI have shown that rapid agricultural growth may also lead to increased food imports.

The process of agricultural growth also involves a gradual change in agrarian structure. Increasingly, subsistence farms develop a market orientation and produce food and agricultural products for urban and rural markets. Policy measures to keep food prices low will then lead to declining profitability of farming and consolidation of farms. Increasingly, small farmers are forced into specialization or increasing intensification in order to remain profitable.

In developed countries, only a minor proportion of the population is employed in agriculture. The small-farm sector consists of either highly specialized and intensive enterprises, and of less profitable enterprises that can continue to operate only with assistance of substantial government subsidies and protective trade measures.

In developing countries such a stage is far from being achieved. For the foreseeable future agriculture will remain the engine of economic growth and provide employment to the majority of the population in developing countries. Smallholder farms will continue to supply the bulk of agricultural output and will have to remain the focus of research and development efforts.

3.2. The Nature and Organization of Agricultural Research

Agricultural research can bring higher incomes to farmers and lower food costs to urban populations. To achieve this the technologies identified by the research process must be taken up and used by the small farmers who dominate the agricultural sectors of their countries. To be relevant the research must be targeted at their problems, and the resulting technologies must be perceived by them as useful. Further, these same technologies must be environmentally sound, to preserve the land, water and diversity of species for future generations, and, finally, they must respond to the need for equity in the distribution of benefits.

Although much germplasm and many resource management principles are widely useful, the diversity of agro-ecological environments and socio-economic circumstances demands that most be adapted for specific local circumstances. A further dimension of complexity is that the dynamics of demographic change and market development orchestrate the time when a technological component is appropriate for a farming system.

The organization of research must embrace these complexities. Interlocking levels of research are required, the final level reaching down to the farmer, with the whole hierarchy of levels supported by basic science, both national and international.

Results can be imported but basic science and strategic research will have their place in many of the developing economies. The results of applied research can also be imported but much of it must be done under the conditions in which successful results will be used; in the climate and on the soils which farmers have to manage. Finally, a geographically organized adaptive research network, sensitive to the social, cultural and economic circumstances in which groups of farmers operate, does two jobs: On the one hand, with help from farmers, it identifies those technical and resource problems most inhibiting their development as agenda for applied research. On the other hand, interacting with the extension services, it helps farmers choose and adapt those materials and management principles, discovered through applied research, which are relevant to their situations.

This adaptive research network starts and completes the "farmer back to farmer" circle: identifying the demands for applied research and adapting its results to the needs of the market.

3.3. Linkages between Research and Development

As the research organization does its job for farmers - the direct users of results - it must also perform for the nation and its aggregated needs. Again the circle must be complete: Research efforts should be focused on products and resources central to national priorities and should be sensitive to national limitations in their use of externally purchased inputs. At the same time policy should be formulated in the knowledge that development is heavily dependent on improving agricultural productivity by farmers absorbing new technologies.

Organizing for agricultural development needs to recognize the diversity of technological requirements and to promote strong linkages between the research process, policy formulation, budget allocation, programme planning and agricultural extension. Ideally policy and planning create a milieu for research to identify and mobilize technological opportunities appropriate both to national and to farmers' needs.

Although the government based national research and extension systems play a central role in the development and diffusion of agricultural technology, other bodies participate. Universities have strong concentrations of human resources which are often underutilized for research, usually due to budget limitations. Non-governmental organizations (NGO's) often have close and informal relationships with local communities which could be better exploited at the client end of the agricultural development process. Policy and planning should coordinate roles across contributing agencies. The overriding factor in the success of national agricultural research, and the management of the development process as a whole, is the mobilization, motivation and thereby retention, of a cadre of high quality professionals and

managers. Too little attention has been paid to commitment, the continuity of commitment, and with it the sustainability of research and development cadres and institutions. TAC (1988) has recently placed great emphasis on sustainability:

> "Sustainable agriculture should involve the successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources."

Sustainable and dynamic institutions in agriculture are one key to the sustainable management of agricultural resources.

3.4. The Special Place of International Research and Related Activities

International efforts have special advantages in a number of research areas and in several activities supporting and servicing research. Agro-ecologies do not stop at national, nor indeed continental boundaries. Plant material tolerant to acid soils are potentially useful wherever acid soils are found and the principles of managing vertisols are relevant whether the soils are located in Africa or the Indian sub-continent. Over the longer term supranational rationalization of a good deal of research is a logical goal, with significant savings for participating, partner nations. The CGIAR can perhaps be seen as a start to this international level of a global agricultural research system.

Currently weak national agricultural research systems demand more activities at the international level than eventual comparative advantage will dictate. Two types of activity are distinguished:

A. Activities with a Continuing Comparative Advantage at the International Level.

These include:

- assessing the changing research needs of global agriculture
- the collation and dissemination of scientific information
- the collection, preservation, and exchange of germplasm
- the development of germplasm for crops and animals dominant in the economic activity of many countries
- the development of resource management principles appropriate for agro-ecological circumstances widely distributed around the globe
- specialized manpower training.

The larger developing countries will eventually have capability in these areas, however the large number of small developing countries will remain unable to undertake the overhead investments in research

facilities and specialized, higher education. Several may be handled through strong outward looking national programmes and the effective networking of information. For others a continuing international effort will be justified.

B. **Activities justified over the Medium Term by the Current Lack of Capacity in the Developing Countries.**

These include:

- training at several levels of manpower required in research: managerial, scientific and technical
- assistance in institutional and manpower development
- assistance in priority setting and in research strategy and programme formulation
- bridging from the basic and strategic research of the industrial countries to meet the needs of the developing countries
- methodology development and training in its application
- technical assistance and financial aid for in-country applied and adaptive research often through bilateral programmes.

The need for international involvement in these Type B. activities will continue for many years though there is no inherent comparative advantage for these activities at an international level. The need for direct support differs from country to country and region to region. South East Asia and India are increasingly self-sufficient, at the other extreme national agricultural research systems in Africa remain particularly fragile.

3.5. Institutional Approaches to the Organization of International Agricultural Research

Science itself has long had an international dimension. Professionals have organized themselves into associations, while conferences and congresses are a recognized and valued means of information exchange. The recent evolution of information technology is enhancing interaction among scientists working in the same field wherever they are located. Multi-national companies with the world as their market place implement research which brings the benefits of innovation to populations far removed from the company country of origin. Easy communication and travel and the need to bring science to the quest for third world development has encouraged supra-national scientific entities, among which organizations for research in agriculture are well represented.

The colonial powers exploited the advantages of international research. ORSTOM still supports research for the former French overseas territories. The British experimented with commodity and regional research organizations particularly for export crops and

particularly in Africa. The East African Agricultural and Forestry Research Orgnaization for example broke up with the rest of the East African community after Kenya, Uganda and Tanzania squabbled over funding in 1977.

Both bilateral and multilateral international research initiatives have been taken by donor nations since independence. Multilateral investments are exampled by the CGIAR set up in 1971 and now including some 40 donors providing support to thirteen centres, each with independent governance. Small groupings among the same donors have set up or supported other centres outside the CGIAR. The key characteristics of the international centre concept have been:

- the global perspective of mandates and programmes which facilitates a clear focus on problems requiring an international solution;

- the international status of centres and their governance, staffing, programme design and resource support which protects their mandates and programmes from political pressures and from purely national or regional influences;

- the international mobility of staff, knowledge and materials; and

- the principle of universality, which ensures accessibility of research results to all interested parties and openness to all parties seeking collaboration.

Latterly, some multilateral initiatives have moved from the international centre concept to concentrate on networks between interested national programmes. These are reinforced from a small pool of scientists; often single professionals, but sometimes small teams, and work on closely focused research programmes identified and conducted collaboratively with a national programme. These are based in the country concerned, though usually relevant to the region as a whole.

This network model has much in common with the outreach activities of the international centres. Here single scientists or even multidisciplinary teams support several national programmes of countries in their region, often providing formal as well as counterpart training. In some cases activities are oriented by the needs of the centre; either to understand a technical problem and provide feedback to research or to promote a technical solution developed by the centre. This promotional role is less pronounced in the recent, more collaborative forms of the network model which are essentially partnerships.

Reconciling international and country priorities is delicate. The independence in governance of the international centres of excellence is a valuable and valued asset and for some centres has proved difficult to reconcile with national influence on programming. The collaborative process is still evolving. Priorities based on a global perspective can never embrace all the interests of all individual partner nations. Its solution demands a mechanism where countries of a region reach their own consensus and react to the global perspective of the international community to reach a consensus on priorities.

An outstanding characteristic of these multilateral initiatives is the collaboration between donors. It rests in stark contrast to the bilateral initiatives of the same donors where efforts at coordination and collaboration remain fragile.

Given the considerable potential for rationalization among the various actors, a coordinated global strategy for agricultural research is a key challenge for the developing countries and the donor community in the years ahead. Meeting the challenge will require three developments:

- better coordination among donors;
- increased political awareness and acceptance of the benefits of transnational collaboration in the developing countries;
- a mechanism which guarantees continuing access to results and allays worries of loss of self-sufficiency in the developing countries.

Despite recent political emphasis on self-sufficiency there has been a resurgence in regional in regional research organization. Examples include CATIE in Central America, CARDI in the Caribbean, SACCAR in Southern Africa and CORAF in West Africa. These remain fragile but deserve strong support from the member countries and, contingent on this, from the international community.

Literally hundreds of crop, animal and problem-specific networks have been organized throughout the world. PRECODEPA, a network of nine potato producing countries has been built into a body for rationalizing potato research in Central America and the Caribbean. Transnational decisions within the very specific areas addressed by these networks are less threatening to countries than groupings addressing agricultural research as a whole. They offer a less sensitive route to regional collaboration and complementary country specialization.

Though they have been fraught with political problems it is worth summarizing the advantages of regional organizations, particularly in current circumstances:

- they allow the rationalization of applied and strategic research efforts across each agro-ecology, this brings savings in the use of scarce specialized manpower and limited government revenues;
- they allow priority setting at the regional level;
- they provide a device, by shifting out of a national context, whereby donors can support recurrent expenditure;
- they can provide attractive terms and research facilities to retain scientists from the collaborating countries to work on their problems;
- they may provide an interface for better coordination in the application of donors bilateral and multilateral funds.

The search for organizational mechanisms for the interfaces between the international and national levels in the global agricultural research system can usefully maintain the distinction made in Section 3.4 between Type A and Type B activities. The grey area is in Type A activities which a wide range of organizational ariants can manage, including, at some cost, the national research systems themselves. The key issues in promoting regional organizations are likely to remain; obtaining a consensus on priorities, protecting the interests of the smaller, poorer countries and guaranteeing access to results.

3.6. Factors Changing International Research Priorities

Three sets of factors alter international research priorities: changing food demands, changes in science and its organization, and the evolution of scientific capacity in the developing countries. All three sets alter rapidly and the adjustment of international research priorities to reflect trends demands clear articulation of the dynamics of each set. This in turn demands a global perspective unique to the international community.

As this chapter has already noted reconciling changing priorities from a global overview with the political and economic priorities expressed by individual countries and by regional entities is no easy task. Despite clear evidence of the overwhelming need for assistance to Africa, countries of other regions perceive it as against their interests. Such biasing of priorities at the international level of the global system needs substantiation by widely acceptable criteria and by a process as participatory as possible.

3.6.1. Changing Food Demands

Six main forces change the pattern of world food demands:

- the growth of population
- increased awareness of dietary and health factors altering the eating habits of developed country consumers;
- increasing income levels allow the purchase of preferred foods and alter patterns in the developing countries;
- increasing urbanization in the developing countries raises the demand for convenience foods;
- increasing commitments of labour both on and off farm raises the demand for convenience foods in rural populations;
- highly researched crops compete with existing food staples in areas previously unfavourable for them.

The impact of increasing incomes and urbanization relax cultural identity, increase flexibility in consumption habits and enhance the complexity of demand changes.

3.6.2. Changes in Science and its Organization

Biotechnology represents a potential breakthrough in science destined to influence not only the results but also the process and methods of agricultural research. Its potential is not yet clear nor are the full implications for the organization of the global agricultural research system.

What is clear is that its development by both large multi-national and small specialized companies is reinforcing the shift of responsibility for research to the private sector being promoted in developed countries. Indications are that the increased emphasis in developed country policies on private sector research may jeopardize access to breakthroughs by the developing countries. The private sector has patent control over research findings to safeguard returns on its investments. In biotechnology company and scientists rights are the subject of hectic legal activity. With biotechnology the focus of very heavy investments, the private sector will certainly seek to safeguard itself, perhaps reducing opportunities for the public use of products. It is already clear that the private sector's priorities for biotechnology are the established and reliable markets in the advanced economies. The small uncertain markets in most developing countries will be of low priority.

Mechanisms for bridging the benefits of biotechnology to the developing countries have recently become an important preoccupation of the international community.

Ahead of biotechnology the microchip revolution has already changed the way science is organized. Computers have removed analytical constraints allowing more research per scientist and offering capabilities destined either to reduce the amount of field research required, or to radically sharpen its focus by preliminary modelling. The same microchips have proliferated means of information exchange with the potential to make public research findings instantly available worldwide.

Again, in general, the developing countries are at a disadvantage in mobilizing microchip technologies. Factors such as the low reliability and fluctuations in power supplies, the know how needed for maintenance, the changes needed in technical school curricula to provide this, and the dependence on imports requiring foreign exchange, suggest they might experience a slow and bumpy evolution rather than a microchip revolution.

3.6.3. The Evolution of Scientific Capacity in the Developing Countries

A final set of factors changing international research priorities is the evolution of scientific capacity in the developing countries themselves. It is the factor of paramount importance. The international community acknowledges national agricultural research systems as the foundation of a global system, serviced by the supra-national levels. The overall picture is of national agricultural research systems gaining scientific capacity. This general trend masks

stagnation and even decline in some countries and major advances in those where governments have an increased awareness of new agricultural technology as the engine of economic development.

Assessment of developing country scientific capacity is difficult. Indicators are often based on the trends in the numbers of scientists and government funds, and by the proportion of GDP allocated to research. These fail to measure the effectiveness of the research system. Pardey and Roseboom (1988) have estimated "real" expenditure per researcher in 1980 Purchasing Power Parity dollars. They show that the relative spending per scientist ratio for developed countries exhibits a steady increase from US$ 52,000 in 1960-64 to US$ 86,000 in 1980-85. Menawhile, the developing countries, on average, spent US$ 62,000 in 1960-64 - 19% more per researcher than developed countries for the same period - peaked in their support during the early 1970's at around US$ 71,000 and went into a fairly steady decline down to US$ 56,000 by the 1980-85 period.

A number of commentators have pointed out that the managerial capacity of many developing country research organizations is too low to effectively absorb funds and scientists. At the same time the upgrading of scientists by graduate work has frequently had to be done overseas and is often heavily dependent on donor funding. In the case of Africa in particular, ISNAR case studies have shown recurrent budgets dominated by salaries with very little money available or research programmes per se. This, together with late notification of what is available and highly variable amounts from year to year, has led to low morale among scientists and high rates of staff turnover. Increases in research budgets and staff numbers are misleading for many countries in Africa and for some in other regions.

There is wide variation in the size and quality of developing country research services. At one extreme limited Type A services will be demanded by advanced national research systems. At the other countries with young national systems may seek both technical assistance and funding to enhance domestic capability.

This diversity complicates the task at the international level of the global system. Efforts must be balanced between research and the development of national systems capacity. At the same time both the international and national levels must embrace changes in science and monitor the dynamics of national and global food demand in establishing their research priorities.

IV. THE CGIAR IN THE GLOBAL CONTEXT

4.1. Introduction

The CGIAR, while less than 20 years old has evolved to a prominent place on the global agricultural scene. To understand its current role and future potential we must have some understanding of its origins. The CGIAR evolved, as is well known, from early efforts by the Rockefeller and Ford Foundations, to develop appropriate technology for increasing agricultural production in developing countries. This pioneering research approach recognized that introducing poor farmers to directly transferred developed country technology would be unsuccessful. Rather the dominating premise was that applied research and technology development would have to be done in tropical environments recognizing their particular natural and human resource constraints.

This philosophy permeated the origins of the CGIAR. It involved applied and adaptive research, highly focused on commodities of importance to poor peoples' food supply, done in place by outstanding scientists with the facilities and resources necessary to achieve results. The underlying assumption was that research programmes in developing countries were underdeveloped, particularly for indigenous food crops. Thus the four dominant features of the CGIAR in its early years involved a food commodity focus; multidisciplinary teams and a plant breeding emphasis; developing country locations but with global responsibilities; and client-oriented interactions with National Agricultural Research Programmes.

Organizationally the CGIAR was unique. It was a forum where independent Centres interacted with independent donors to share perceptions of needs and to transfer resources. The group was advised by an independent Technical Advisory Committee (TAC) whose recommendations were hopefully respected but binding on no-one. There was a minimum of bureaucracy, no central clearing house for money and no formal constitution or decision-making machinery.

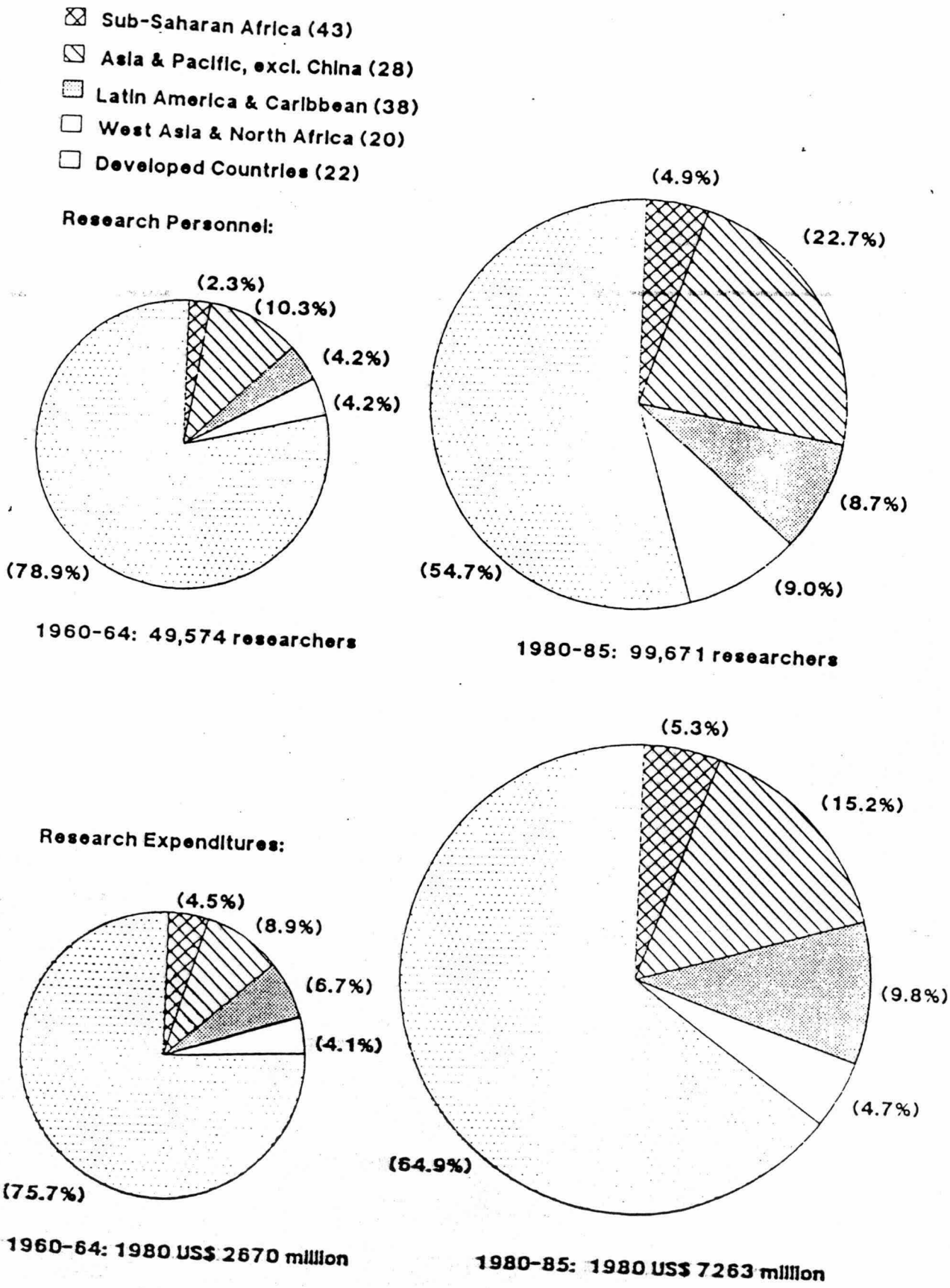
From these simple and small beginnings with four Centres, less than a dozen donors and a 20 million dollar budget the CGIAR has grown to 13 Centres, over 45 donors and a budget of more than 220 million dollars. It is now in the process of considering significant expansion.

This chapter presents a brief analysis of its past and current roles; its strategies and modes of operation; the changes in the environment in which it operates; the changes in its priorities to date and an analysis of future priorities, strategies and modes of operation as it contemplates expansion and approaches the 21st century.

4.2. National Research and the CGIAR

Despite the rapid increase in funding and the expansion of the CGIAR, it still commands only a small fraction of the resources in the global agricultural research system. The data on the global situation in Figure 1 show massive increases in the number of scientists, in the allocation of government funds and in agricultural research in every region of the globe over the twenty year period.

Figure 1 Regional Shares of Agricultural Research Personnel and "Real" Expenditures (1980 PPP US Dollars)



Source: Pardey, P.G. and Roseboom, S. (1988)

By 1980/85 the countries of Asia, Africa and Latin America were spending US$ 2.5 billion on agricultural research. This figure dwarfs the expenditure by the CGIAR Centres which represents only 7% of spending by developing country national programmes, and 2% of public spending on agricultural research world wide.

Figure 1 shows the relative growth in "real" research expenditure, measured in US dollars Purchasing Power Parity (PPP) indices, for five regional groupings from 1960/64 to 1980/85.

The developing country grouping increased its share in total world expenditure on agricultural research from 24% in 1960/64 to 35% in 1980/85. The increase varied across regions from 15% for West Asia and North Africa and 18% for Africa south of the Sahara, to 46% for Latin America and the Caribbean and 71% for Asia. Developing countries also icnreased their share of research personnel from 21% of the world total in 1960/64 to 45% in 1980/85. Here regions shared about equally in the increase. In Africa and West Asia the high increases in personnel with relatively low increases in expenditure resulted in heavily reduced expenditure per scientist; by 25% in Africa south of the Sahara and by 28% in West Asia and North Africa.

In Asia the increases were spread across nearly all countries, except Sri Lanka. In Latin America large increases in research spending in both Brazil and Mexico overshadowed reductions in five other countries. In Africa massive increases in spending in Nigeria, and significant increases in Kenya, Zimbabwe and South Africa offset declines in several others.

Table 8 shows the changes in the percentage of agricultural GDP allocated to public research over the twenty year period to 1980. Again, allocations increased in all regions and particularly dramatically in the developing countries; Latin America experienced a tripling to 1% by 1980, Africa a doubling to 1% and Asia a doubling to .5%.

Studies in the late 1970s estimated private sector spending at 20-25% of public agricultural research expenditure in the USA and up to 5% in developing regions of the world - similar to the level of CGIAR spending. Most of these studies preceded the recent policy emphasis on the greater involvement of the private sector, notably in the USA and the UK, but also latterly by multilateral and some bilateral agencies. A study of seven Asian countries published in 1985 showed private sector research spending ranging from 1% to 7% of public with the Philippines (60%) and Malaysia (24%) as high exceptions. Such high private sector spending is seen as related to a significant large scale commercial or plantation sector and the production of export commodities.

Table 8 Some Research Expenditures as Percentage of the Value of Agricultural Product

Subregion/Country Group	Agricultural Research Expenditures 1959	1970	1980
Country Group:			
Low-income developing	.15	.27	.50
Middle-income developing	.29	.57	.81
Semi-industralized	.29	.54	.73
Industrialized	.68	1.37	1.50
Planned	.33	.73	.66
Planned, excluding China	.45	.75	.73
Tropical South America	.25	.67	.98
Caribbean & Central America	.15	.22	.63
North Africa	.31	.62	.59
West Africa	.37	.61	1.19
East Africa	.19	.53	.81
Southern Africa	1.13	1.10	1.23
West Asia	.18	.37	.47
South Asia	.12	.19	.43
Southeast Asia	.10	.28	.52
East Asia	.69	2.01	2.44
China	.09	.68	.56

Sources: J.K. Boyce and R.E. Evenson, National and International Agricultural Research and Extension Programs (New York: Agricultural Development Council, 1975); and M. Ann Judd, James K. Boyce, and Robert E. Evenson, "Investing in Agricultural Supply", Discussion Paper No. 442 (New Haven, Conn.: Yale University, Economic Growth Center, 1983); and U.S. Department of Agriculture, Indices of Agricultural Production (various issues).

4.3. CGIAR Programmes and Impact

Although the CGIAR budget adds only a further 5% to the agricultural research expenditures of developing countries, the IARCs are selective in the programmes they undertake. They put an intensive and continued effort behind each programme. CGIAR impact is dictated by its skills in identifying and effectively researching those priorities important to most poor people in the developing countries. It selects programmes in which there is a strong comparative advantage for international research, which support the efforts of many national systems and which fill major gaps in the capabilities of many others.

Germplasm development offers a good example. The CGIAR aims to produce widely relevant breeding material which can be manipulated by national systems to exploit local circumstances for their farmers. At the same time, recognizing that many developing countries do not yet have the capacity to do their own breeding work, the Centres also produce finished lines, from which emerging national programmes can

select those best suited for their farmers. Paralleling this dual strategy in germplasm development is a third; the training of scientist in both selection and breeding to build up national programme capabilities.

The CGIAR recognizes that only national programmes have the potential to understand and satisfy the needs of the diverse groups of farmers in their countries. There is no long-term comparative advantage to international organizations in adaptive research, or in applied research related to local circumstances. The national systems must manage these levels which are fundamental to national efforts for development. Recognizing that only strong national programmes can mobilize the products from international agricultural research, the CGIAR Centres are committed to building national system capacity. The development of research methods for effective applied and adaptive research, advice on the research process and its institutioal organization, advice on research policy and the training of national scientists: all these are priorities in the mandates of the Centres of the CGIAR System.

This global perspective has brought successes since IRRI and CIMMYT were established in the early 1960's. The best known of these have been the results of incorporating dwarfing genes into both wheat and rice to give semi-dwarf varieties. Table 9 shows the spread of these varieties through the developing world by 1970 and then by 1983.

Table 9 Areas under Semi-Dwarf Wheat and Rice in LDC's ('000 ha)

REGION	WHEAT				RICE			
	1970		1983		1970		1983	
	Area	%	Area	%	Area	%	Area	%
China	14.7	0.1	5,126.0	17.8	26,848.0	77.3	33,265.2	95.0
India	6,480.0	39.0	18,550.0	80.1	5,588.0	14.8	22,180.0	54.1
Other dev. Asia	3,467.9	40.2	7,797.1	68.8	4,545.3	10.6	19,734.1	42.4
Sub-Sah. Africa	69.8	5.0	556.3	52.1	41.1	4.1	241.9	14.8
Latin America	794.5	10.8	8,878.0	82.5	180.2	3.0	1,831.7	27.8
Middle East & North Africa	1,144.4	5.0	7,690.3	33.8	2.1	0.3	80.7	11.0
All dev. countries	11,962.0	14.0	48,597.7	49.7	37,204.7	30.3	76,333.6	58.5

Source: Anderson, Herdt & Scobie (1988).

By 1983, some 20 years after their introduction and almost 40 years after research started, the new wheats were grown on almost 50% of the wheatlands and the new rices on 58% of the ricelands of developing countries.

These illustrious of the Centres successes, the breakthroughs in wheat and rice breeding, brought the Green Revolution to Asia. The Centres responsible, CIMMYT and IRRI, were able to build on programmes established by the Rockefeller and Ford Foundations dating from the late 1940s. This timescale is a guide to expectations for the success of the more recently established Centres. Realistically there is a twenty- to thirty-year period from set up to widespread success which is dependent on national programmes identifying Centres technologies as useful and mobilizing them with their farmers.

Although to date the impact on other crops has been less substantial, many varieties of the crops being researched by the CGIAR Centres have been released by national programmes. Table 10 summarizes the releases made by 1983.

Table 10 Number of Centre-Related Varieties Released by National Authorities in Developing Countries

Crop	Africa	Asia	Latin America	Middle East and North Africa	Total
Barley	0	2	0	8	10
Field Beans	4	2	90	0	96
Cassava	26	5	32	0	63
Chickpeas	0	1	0	2	3
Cowpeas	14	2	12	1	29
Maize	61	49	126	2	238
Pasture species	0	0	12	0	12
Pearl Millet	5	3	0	0	8
Pigeon Peas	5	2	0	0	7
Potatoes	31	16	12	2	61
Rice	31	140	129	2	302
Sorghum	8	18	5	0	31
Sweet Potatoes	6	0	0	0	6
Triticale	2	2	7	0	11
Bread Wheat	40	44	114	66	264
Durum Wheat	5	3	13	20	41

Note: Excludes varieties developed by national programmes from sources similar to those used by the Centres.

Source: Anderson, Herdt & Scobie (1988)

Centre-related maize varieties were estimated to occupy some six million hectares in developing countries by 1983.

All of the Centres producing germplasm have significant programmes in crop management research to give guidance on the exploitation of the germplasm. However much of the management of a crop is dependent on local circumstances of soil, water and biology. Considerable resources are expended on the training of national programme staff to identify crop management practices appropriate to these local circumstances.

Most of the training undertaken by the Centres supplements the formal university education process. It is organized around short courses of up to six months duration which focus mainly, but not wholly, on methods for breeding and agronomy. Sixteen thousand developing country professionals (some 27% of the 1983 total) have benefitted from the Centres' training courses between 1962 and 1983. About 2,300 were receiving training annually by 1984.

4.4. The Evolution of CGIAR Priorities

In the early years the CGIAR, established in 1971, was preoccupied with the expansion of the System. The early successes of IRRI and CIMMYT provided a momentum which the Group capitalized on. Its Technical Advisory Committee drew up the first priority statement for the Group in 1973 which suggested several new centres. The 1973 report reaffirmed poor peoples' food as the focus of the System and placed first priority on cereals, the mainstay of their diets. First priority was also placed on improving the quality of poor peoples' diets through research on food legumes and ruminant livestock. Finally, starchy foods, including roots and tubers, were recognized as a first priority, for their role as the basic staples of much of equatorial Africa and for their massive potential in terms of energy per hectare. At a secondary level of priorities the report selected oilseeds, tropical vegetables and fruits from a large group of other agricultural crops and expressed a need for careful appraisal of their economic and social importance and their market and research potential before further priorities were identified. TAC members expressed the view that forestry was perhaps of greater relevance in the context of environmental conservation than for timber production and processing. They also perceived the need for factor-oriented research best satisfied through the commodity approach. The report carried reservations on the adequacy of this "spin-off" and passed a caution to the Group that it may need to venture outside the commodity model in time.

The 1973 paper was a licence for expansion, it identified ILCA's and ILRAD's beginnings, and the consolidation of CIP. The paper named the component crops of ICARDA as priorities, as well as additional programmes for ICRISAT, and the germ of ideas for both IFPRI and ISNAR. The discussion of forestry and factor-oriented research, anticipated the current concern about agricultural sustainability.

Further priority papers in 1976, 1979 and 1986 recorded the progress in incorporating many of the TAC initiatives first listed in the 1973 paper. They also made some adjustments in the priorities

listed in 1973 and noted issues arising from the evolution and increasing complexity of the Group. The 1976 paper made first mention of the importance of increased cash incomes as a means of command over food, and the acknowledgement of increased food production as a necessary but not sufficient condition to feed the world's poor. The paper placed greater priority on the intensification of cropping, the development of improved farming systems and the need for better postharvest technology. It raises the question whether investment in cereals research had reached a ceiling in the CGIAR System. It emphasized the point made in 1973 that the tremendous potential energy per unit area realized from tubers and roots may mean a greater role for them as population grew. It reinforced the case for greater investment in agricultural research in these crops, including starchy banana.

The 1979 paper confirmed a reduction from 50% to 38% in the proportion of CGIAR resources allocated to cereals between 1974 and 1980. It also noted a tripling of funding for livestock research since 1974. A feature of the paper was a ranking of research areas in which the CGIAR System might take new initiatives. Many of these had repeatedly featured in TAC discussions and papers in previous years:

- Tropical Vegetable Research
- Water Management Research
- Plant Pest and Disease Physiology and Ecology
- Food Policy Research
- Aquaculture.

Equally important it listed areas in which action was not recommended - oilseeds, plantains, agroforestry, waterbuffalo, cotton, fertilizers, tropical soils, postharvest technology, farm mechanization, other animal diseases. While giving soils, fertilizers and agroforestry a relatively low ranking, the paper acknowledged a need for more factor-oriented research to exploit the gains from improved germplasm, and also for more effort in food policy research - a recurring theme since 1973.

Institutionally the 1979 paper highlighted the need for collaborative research networks and for collaboration between Centres when mandates overlap, particularly where two or more were operating in the same country. It stressed that the mandate of core scientists working outside the Centres in outreach should concentrate on furthering the research objectives of the Centres. It placed emphasis on two points both somewhat at odds with this "inward looking" outreach mandate. First, the need to build up national research capacity and expand country participation in global or regional research programmes. Second, the need for international Centres to build up their awareness of national and regional problems in their respective mandate areas, including environmental and socio-economic and policy constraints which may limit the impact of research. Finally the 1979 report acknowledged the relevance of the project cycle in research; the fact that programmes should wind down as well as build up, and intimated that so far there was very little sign of winding down in any Centres' programmes.

The 1986 priority paper urged reduced allocations to wheat and rice. It suggested an increased allocation to maize, sorghum and millet on the grounds that these had been underresearched in the past, were increasingly widely grown and had a dual role with the stem and leaves

useful as animal feed. In this document TAC suggested increased allocations to the starchy tubers encouraging more work on sweet potato and support by appropriate CGIAR Centres for a new international networking organization, INIBAP, working on starchy bananas.

On the protein side the 1986 paper gave priority to extra work in edible oils, encouraged increases in soya and groundnuts and offered coconut as a possible new initiative for the System. It urged some extra allocation to ruminant livestock to be focused on the improvement of nutrition which the paper identified as the key research area. Finally it recommended the rundown of work on faba beans and lentil, on the grounds of their restricted geographical importance. In addition to coconuts the paper urged the consolidation of new initiatives in tropical vegetables and aquaculture.

The 1986 paper noted the shift of emphasis from food problems in Asia, for which the CGIAR had been established to help tackle, to food problems in Africa. It posed the question of how far the Centres could and should substitute for national programmes. Efforts to link with developoed country institutions and pursue the benefits of biotechnology for the third world are currently drawing the Centres into more upstream research, away from local specific applied and adaptive research at the heart of national programmes.

The phase of early expansion worked itself out with the establishment of ICARDA in 1977, IFPRI on food policy research joined the System in 1978 and finally ISNAR, helping developing countries organize their agricultural research systems, was set up in 1980. These departures from agricultural research per se reflected an increasing recognition in the Group of two wider dimensions. First, the place of the CGIAR in a global research system, particularly its strong dependence on national programmes to reach the poorer farmers as its clients. Second, the importance of an effective policy process for identifying and mobilizing technologies relevant to farmers and to national needs.

These wider dimensions demand a CGIAR perspective sensitive to its place in the global system, rather than a view locked into the narrow, specialized focus of the individual Centres. Several contemporary issues can only be managed at this CGIAR Group level:

- the principles and mechanisms for the sharing of international responsibilities between CGIAR Centres and qualified national programmes

- the need for sustainability in agricultural production and the implications for the research process

- the need to reconcile global and national priorities through the operating process of the System and the Centres

- the coordination of multi and bilateral lending within a global research strategy

- the need to consolidate regional agricultural research and rationalize the use of scarce funds.

Over the next years these wider dimensions are likely to play an increasing role in the thinking of the Group and in the allocation of its resources.

4.5. CGIAR Modes and Operational Strategies

The CGIAR has pioneered new approaches to applied agricultural research. While they are now well recognized, it is instructive to examine some of the specific and, at times, unique features of the CGIAR institutions.

Perhaps the three keys to CGIAR success have been:

- the comparative advantage in an international perspective for important research areas
- the funding mechanism through the CGIAR allowing persistence and continuity in research efforts
- the independence of the Centres as autonomous units with an increasingly decentralized approach to their tasks.

The global research mandates of the Centres were a result of concurrent and complementary insights: The recognition that technologies are useful beyond national boundaries and the comparative advantage of international research efforts in such cases. Also the recognition of the strong influence of socio-economic circumstances on farmers' choice of technology and the need for local adaptation by local institutions. The idea of partnership was inherent in the CGIAR concept.

Centres of excellence were seen as the vehicle for exploiting international comparative advantage and were established with a unique mix of characteristics:

- Commodity focused - sometimes one, often two or more commodities. Those mandated to the regional Centres were often associated in the farming systems of the region.
- Problem oriented and multidisciplinary, including social scientists, with a critical mass of well funded and equipped scientists focused on each problem.
- Scientists located in outreach to interact with the national programmes as clients of the CGIAR System and partners in its programmes.
- Significant programmes for human capital development, to raise capabilities in national programmes to exploit the products of the Centres and take over some of their activities.

The dominance of commodities reflects an apparent bias against disciplinary or factor based institutes. The regional Centres in particular do address resource management problems which are usually researched with the Centre's mandated commodities as a vehicle.

The International Agricultural Research Centres have been independent in determining their research strategies. Each is guided by its Board of Trustees, internationally selected in their personal capacities, and is influenced by the broad priority framework laid out by the CGIAR. Recently Centres' research strategies have been formalized in official documents, these form the foundations for budget requests to the CGIAR through TAC. Some Centres have used the development of these strategy documents as an opportunity for consultation with the managers of national programmes. Several aspects of the Centres' activities have encouraged increased dialogue with the national programmes:

- The increasing presence of CGIAR Centre staff in outreach, particularly at the regional level.

- Increased awareness of the Centres' dependence on the effectiveness of national programmes.

- the Centres as important sources of training and even of materials for programme implementation in times of acute budget scarcity.

- The possibility of shared responsibilities for Centres' international activities with qualified national programmes.

Operational issues have also arisen increasing the need for dialogue:

- The belief in national programmes that the Centres' funding reduces their own receipts from donors.

- The proliferation of Centres working in a single country. The overheads at the diplomatic and policy levels for national ministries dealing with as many as ten different Centres with varying conditions and expectations.

- Inter-Centre conflicts in regions and within countries, including the duplication of efforts where mandates overlap, and where essentially the same activities are pursued to satisfy different mandates.

- Insensitive procedures which place a burden on national scientists and compromise their own research efforts. Vast quantities of breeders' material of which only a very small part is locally relevant is an example which makes national breeders feel like centre field hands.

- Country confusion due to contradictory approaches to the experimental process or to experimental methods by different Centres.

- Setting programme agenda for the region directly from Centre strategy, with nominal or no consultation at either regional or national level.

The CGIAR System and the Centres themselves have slowly begun to respond to these factors. Reaction was initially by individual Centres. However, an increasing awareness in the Group of the poor state of national programmes - much of it drawn from the work of ISNAR - together with the long-standing acknowledgement of the interdependency of the CGIAR and national programmes, has led to new emphases on inter-centre collaboration, on regional networks in which the national participants play a guiding role, and a search for other modes of operation. The idea of sharing some Centre responsibilities with qualified national programmes, and the need to safeguard the interests of other countries in the region, is also prompting a search for novel modes of operation.

Three issues are perhaps crucial to the better management of the global agricultural research system.

First, the global perspective used in priority setting for the CGIAR needs to be reconciled with the operational dependency of the Centres on successful interaction with the national systems. This dependency indicates the need for a consultative appraoch to the setting of priorities and the planning of Centre work programmes. It may be that the programmatic implications of changing global priorities should be the opening position of the Centres in regular negotiations with the national systems. Better national programme representation in the CGIAR would also contribute. Currently there is no provision for regional representatives to identify and therefore represent the interests of their constituencies.

Second, a regional mechanism to reap the benefits of rationalization by agro-ecological zone will be a powerful tool in the evolution of the global system. Three options are listed:

- Reinforce strong national programmes for a regional role, a strategy which puts the others at risk.

- Reinforce different national programmes in specialized areas of value to the region; each loses more than it gains by isolating itself.

- Set up a regional centre includes national scientists from the region as staff.

Networking across the region will be an important supplement with all three of these alternatives. There is a demand for sharing of responsibilities from qualified national programmes, some seeing it as a means of attracting international funds. There is some interest from the Centres as a means to shift priorities into the exploitation of the new biology in the face of budget limitations. Whether it can be done in a way which protects the interests of the remaining countries in the region is a major question.

Finally, the coordination of donors' bilateral and multilateral funding within a global strategy might be pursued within the Consultative Group, seeking more effective use of total donor and national resources. The building up of a regional interface dependent on national scientists and perhaps on national institutions would be one early strategy for coordinated bilateral funds.

Currently the international Centres of the System feel under siege. On the one hand they are squeezed by pressures for more consultation with national programmes in deciding their programmes, on the other hand by pressures for CGIAR-wide activities in some areas of their mandates. Both are perceived as threats to their independence, yet both have been solved in particular cases within the System while maintaining centre autonomy. These cases deserve study and replication as new modes of operation.

4.6. Changes in CGIAR Priorities since 1985

Since the last CGIAR priorities paper in 1985 several factors, a number of them touched on in the foregoing discussion, that have been recognized, are important enough to modify the current priorities.

The first of these is the explicit inclusion, as a legitimate criterion for priority setting, of the potential of technical change for income and employment generation.

A second factor which will change the balance of resource allocation in the CGIAR, is the explicit, expanded emphasis on the long-term sustainability of agricultural production. This is manifest in the inclusion of improved resource conservation as an explicit CGIAR objective and in a proposal to double resource management research.

A third and related factor is the recognition that less progress has been made in the fragile and difficult environments, particularly the rainfed drier areas. The corollary of this is that the CGIAR must remain concerned with maintaining and enhancing productivity in the more favoured areas which will have to provide the food for rapidly growing urban populations.

Of equal importance is the need to move upstream to more strategic research. There is a push upstream from the maturing of some developing country research systems. There is also a pull upstream from the rapid and exciting developments in molecular biology, and these benefits need securing for developing country farmers.

Finally there is the explicit adoption of farming systems and sustainability perspectives for formulating and implementing research programmes.

All of these new and recognized factors require a fundamental look at CGIAR future priorities.

4.7. Necessary and Desirable Changes in CGIAR Priorities, Strategies and Modes

Research is by its nature a long-term activity and as the length of the horizon expands further into the future the more one moves upstream towards strategic and basic research. This characteristic, coupled with the time required to establish or significantly change a research enterprise requires us to think about needs 10-20-30 and 40 years ahead. The planning horizons of Centres have clearly changed,

some are planning for 2010, 2025 and one even thinking about 2050. The CGIAR as an entity also ought to have long as well as medium and shorter term planning horizons.

The context for long range planning needs to be at least LDC food needs in 2025. These will be influenced by the major trends outlined in section 2.2. - population growth, income growth and urbanization. Let us recall the magnitudes. The UN median population projection for developing countries for 2025 is 6.8 billion people compared to 3.6 billion in 1988 and 60% will live in urban areas compared to about 30% now. Even with modest rates of economic growth, incomes in nominal terms will triple. The implications of these numbers are substantial. Assuming that the rate of land area expansion which prevailed over the last 2 decades continues (a very optimistic assumption), global yields of major marketed food and feed crops will need to more than double. Clearly the yield potential of these commodities will also need to increase significantly because closing current yield gaps will be insufficient even with vastly improved crop/livestock system management.

It is against this backdrop that we now need to be thinking about the future of the CGIAR. Many more variables also need to be considered including potential advances in basic biology which could increase biomass production by altering photosynthetic efficiency, improving the harvest index, improving responses to nutrients, improving resistance/tolerance to various stresses; changing capacities of research enterprises - public and private - in developing, developed and centrally-planned countries; changes in institutions and policy regimes; and possible deterioration or improvement in the global resource base. The complexity of the task is enormous, but that does not absolve us from thinking about what role an international research operation should play in that context.

The completion of such a comprehensive review will take longer than the CGIAR can wait to consider the current expansion proposal. In the interim it is necessary for TAC and the CGIAR to revise or reaffirm the statement of goals for the System adopted in 1986 and formulate explicit priorities for the next decade which takes into account changes which have occurred since the last TAC/CGIAR priority paper.

Following is the goal statement for the System, adopted in 1986:

> "Through international agricultural research and related activities, to contribute to increasing sustainable food production in developing countries in such a way that the nutritional level and general economic well-being of low income people are improved."

TAC further elaborated on the goal as follows:

> "The CGIAR supports a System devoted to agricultural research and related activities for the benefit of developing countries. Its main effort has been directed towards the elimination of food deficits, but the scope of its activities has been gradually broadened. While not a development agency, it has

> become increasingly concerned with problems of alleviating hunger and poverty, recognizing that both relate not only to total production, but also to the distribution of income. More recently, TAC, the Impact Study and the Bellagio group have all drawn attention to the importance of sustainability of production systems and to the conservation of natural resources.
>
> The System recognizes that its purpose cannot be achieved in isolation and that it is only one participant in a vast, interrelated set of activities. Through increasing collaboration and partnership, it must constantly contribute to strengthening national systems. In order to maintain its vitality, it must also collaborate with appropriate advanced institutions throughout the world. To be effective it must be selective, avoid duplication and concentrate its efforts."
>
> (p. 220, CGIAR Priorities and Future Strategies (TAC/CGIAR/FAO, 1987).

It is suggested that in the short term this goal statement, with slight modification, continue to serve as a basis for considering CGIAR priorities and that decisions for changing the System by incorporating additional entities be guided by whether such changes will contribute, significantly, to the achievements of the System's goal.

The 1986 goal statement refers to "increasing sustainable food production ..." (emphasis added). It is suggested that this goal of increasing food production be modified to incorporate the concept of achieving food self-reliance in the developing world (food self-reliance being defined as the capacity of a nation to provide a sufficient stable food supply to all of its inhabitants either from domestic production or from production of exportable goods to enable commercial imports to cover the domestic deficit). It should be clearly understood that self-reliance does not necessarily imply self-sufficiency. Rather it implies producing those things that a country is best able to do and where necessary trading them for required food. The implications of a goal of self-reliance are that the range of agricultural commodities that are potentially in a farming system is likely to be large. This does not and should not commit the CGIAR to working on all commodities but it does commit us to taking account of diverse farming systems and their capacities to produce income and employment as well as marketable agricultural commodities. The direct implication is that the CGIAR should not rule out, by prior assumption, non-basic crops which provide food directly or indirectly. Therefore the CGIAR should support research activities which contribute most effectively to improving a country's capacity for food self-reliance. There are several direct implications that would follow from this expanded priority statement.

First, given population growth and urbanization, the CGIAR should retain high priority for basic crops grown in more favoured areas (e.g. irrigated) because it is the marketable surplus grown in these areas that will help feed urban, predominantly poor populations.

Second, parallel with this goal, there should be increased attention given to indigenous, subsistence crops which feed rural

populations in less favoured areas. In stating this priority it must be clearly understood that progress in these areas will be more difficult, slower and quantitatively less in contributing to the national food supply and that these areas will not provide significant surpluses for non-farm populations. The balance between favoured and less favoured areas is critical and will be different by country, region, commodity and farming system. Nevertheless we must not abandon yield gains accomplished to date in more favoured areas. We need to sustain and enhance these yields if we are to contribute to long range food security in 2025.

The third implication of the goal of assisting countries to achieve sustainable food self-reliance is that increased attention must be paid to natural resource management. This concern with resource conservation and management is absolutely critical to a sustainable production system. The critical question for the CGIAR is what portion of this type of research does an international system have a comparative advantage in pursuing. In the extreme it can be stated that each country, each region, each district and even each farm has a unique resource base. For some it follows from this that, research on natural resource issues is so location specific that it can be only done by national programmes. But is this really true? Clearly some major resource issues transcend national boundaries. For example deforestation because of energy needs, results in flooding and subsequent water shortages, increases erosion and siltation of downstream reservoirs, increases environmental pollution and ultimately diminishes capacity to produce agricultural commodities in favoured and less favoured areas alike. River basins seldom are solely contained within national boundaries as several major basins in Asia show. Further examples of international migration of pests and diseases, wind erosion and pollution are prevalent. Surely an international research organization could contribute by (1) clearly defining the magnitude and potential future consequences of the process; (2) by contributing methodology for characterizing, analyzing and evaluating interventions in mega ecological zones. We need to know the problem and how to address it in order to support national programmes in pursuing specific research approaches; (3) collecting, evaluating and disseminating available information from the global research community that is relevant to national policy choice; (4) doing actual research on a selective basis to both develop methodology and basic information and to provide examples of how to do it; (5) providing training of various sorts; and (6) exploring appropriate institutional and management approaches.

The fourth implication is that a sustainable agricultural system involves both issues of productivity - expanding yield potential and improving management to reduce the yield gap - as well as long-term resource management. The intellectual challenge of converting a concept of, and commitment to "sustainability" into operational research programmes and for setting priorities within research programme is enormous. The CGIAR has a critical leadership role to play in this area.

The CGIAR is, as noted, but a small part of the global research system and therefore to be effective must work in partnership with all relevant research entities. The evolution of NARS has been significant

in many cases, resulting in a much more heterogenous set of partners than was perceived at the initiation of the CGIAR. Similarly rapid developments in biology have altered the desirable linkages with advanced institutes. CGIAR entities must adjust to these changes which will of necessity require movement upstream because an effective linking role requires institutes to be in touch with both sets of developments. At the same time there is need to devise or strengthen appropriate mechanisms for dealing with less well developed national programmes especially in the smaller countries. the implication of this is that simplistic notions of homogenous programmes which will be relevant to all partners must be questioned. It is therefore necessary for both the components of CGIAR and the CGIAR itself to adopt more flexible research strategies which reflect these and other changes. The implication which seems inevitable is a more decentralized approach in priority setting.

In this changing context there is a critical role for international research. International agricultural research can help (and should help) by concentrating its efforts on the poor and on sustainability. By targeting and coordinating efforts on:

(a) Assuring that production potential in more favoured environments is sustained and enhanced because it is the marketable surplus from these areas that will feed the urban and non-farm poor. Over time NARS will assume a greater role.

(b) Less-favoured environments in which population pressure is high vis-à-vis the potential productivity of the resource base, given existing knowledge and socio-economic possibilities.

(c) Generating new knowledge based on science to increase sustainable productivity and to solve biotic constraints to achieve yield potential.

(d) Providing support to crop management research (CMR).

(e) Helping remove institutional constraints for effective R&D.

(f) Helping remove policy constraints and overcoming market failures.

The global effort must be complemented by regional efforts targeted at specific constraints and problems shared by countries at the regional level. Thereby: (a) tapping regional research and institutional capabilities and capturing economies of scale in research; (b) providing for coordination of efforts of international institutions and NARS to address common researchable problems; and (c) for helping coordinate donor support.

The task before us then is to adjust CGIAR priorities and modes of approach to this constantly changing environment. This makes the process more difficult but at the same time more challenging. TAC needs to develop a revised set of priorities to reflect our current thinking on these matters as a backdrop for the current task of considering possible expansion.