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THE LONG RUN OUTLOOK FOR WORLD FOOD PRODUCTION

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by

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For this discussion, the long run is the outlook for 1985 and for the year 2000. My approach is to outline a generalized program for increasing food production, and offer judgments on what rates of increase could reasonably be expected from this program.

It is unrealistic to assume that maximizing agricultural production is the only or even the highest priority goal for each country. Three other goals are suggested, and the four of them would be weighted quite differently in importance by different countries. These are the four goals:

1) Efficiency -- maximizing agricultural production economically. The relevant, simple measures are calories and grams of protein, distinguishing between vegetable and animal sources of protein.

2) Equity -- managing the economy, particularly the agricultural sector, to distribute the benefits of additional production equitably among the nation's families. Three aspects of equity are important: distribution of output among consuming units; distribution of returns from agricultural production among producing units; and distribution of income between farm and nonfarm sectors. During the last decade or so, the concern expressed for income distribution

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has increased a good deal, but measurable improvements are far from proportional to the growth in expressed concern. Given that the efficiency goal is to increase the output per capita, then the equity goal would be measured in part by the variance in income. In a real world situation, maximizing agricultural employment without diminishing agricultural income per family might be an acceptable approximation to the equity goal for the agricultural sector.

3) Conservation -- using renewable agricultural resources so that their potential productivity will be available to future generations.

4) Environmental quality -- using natural resources for food production in such a way that environmental attributes entering the quality of life are not impaired unless the trade-offs between food production and environmental quality are estimated carefully and the results for a particular country clearly indicate choosing additional food production. There would be a multitude of measures for particular environmental danger points, from the degradation of particular air, water, soil and other natural resources.

For some purposes it will be useful to separate countries into developed and developing, market and centrally planned economies, and into regions or major ecological zones. This leaves us with the following as the most detailed breakdown considered.

I. Developed market economies (Western Europe, North America and Oceania).

II. Developed centrally planned economies (Eastern Europe and USSR).

III. Developing market economies.

A. Africa
B. Far East
C. Latin America
D. Near East and North Africa

IV. Developing centrally planned economies in Asia.

Classification of Alternatives

Next we need a classification framework for the alternatives for increasing agricultural production. We classify our alternatives as follows:

1. Bringing new land under agricultural use.

    a. With no direct investments in land. Infrastructural developments, especially public roads, may be necessary.

    b. With direct investment in land, such as irrigation, drainage, land clearing, and so forth.

2. Increasing the intensity of utilization of land already in agricultural use. This would include the following classes of alternatives.

    a. Transfer land used for grazing, or cultivated less intensively, into intensive crop cultivation. Again, this transfer may or may not involve direct land investments.

    b. A variant of 2a would be to transform some cultivated lands from single crop systems to multiple cropping systems. Again, direct land investment may or may not be an essential part of the transformation.

    c. The Green Revolution alternative would be to increase intensity of cultivation by using a package of practices developed from basic and adaptive research. The key element in these packages of practices is usually a more productive seed variety, but they almost always include an input package, such as fertilizer, pesticides (controls for insects, plant diseases and weeds), and often irrigation water. It is appropriate at this point to recognize the important contributions already made by the international agricultural centers in conducting the basic and much of the applied research that led to new, output-increasing technology for wheat, corn and rice. These centers will continue to be an important factor in the efforts to institutionalize technology-based increases in food production.

3. Increase the output of livestock products from ruminant animals grazing on dryland ranges. Whether the present system involves nomadic or settled herdsmen, the transformation is likely to involve improvements in forage crop production, in animal disease control, in the genetic quality of the animals, and possibly in the social organization of the human groups. Crucial would be a temporary--if not a permanent--reduction in the ratios of humans and ruminant animals to the land, in order to reduce overgrazing and let the range lands achieve their potential productivity. Animal protein from dryland ranges is important for several reasons. It is a nutritionally superior form of protein. Animal protein is in many cases almost the only valuable output that can be obtained from these particular land resources. It is a valuable product economically; a calorie of animal protein can be exchanged for more than a calorie from grain sources, a gram of animal protein can be exchanged for more than a gram of vegetable protein.

4. Forestry investments and improvements in forest management are important in their own right, because wood products are needed for construction, for exports, and for firewood (to allow animal manures to be returned to the land, rather than used for cooking fuel). Forest investments are also needed to return some cultivated lands to trees, in order to arrest erosion on sloping lands not suited for cultivation, and in order to prevent silting of streams.

It should be emphasized that these alternatives are not mutually exclusive. Quite the contrary -- they are highly interactive. For example, 1a, 1b, 2a, and 2b could be achieved with traditional practices, or they could be planned from the beginning to include Green Revolution practices. Adding controlled irrigation and the Green Revolution to a single crop rice region in the Far East might make triple cropping possible (rice, rice, and a vegetable, for example), that would multiply the net value of product per acre several fold.

Before we try to reach judgments for the different world regions on how much it is possible to increase production with these different alternatives, we need to look briefly at the prerequisites for the different alternatives, and examine the bases on which a particular country might choose the optimum mix of food production strategies.

Beginning with 1a, capital funds would be required, though not in exceptional amounts. The gestation period need not be long. The requirements for institution building might be high, although countries that have developed satisfactory institutions of the needed types would need only to reproduce them in the development area. If effective institutions of the needed type have not been developed, then the time required would be longer, and the requirements for highly trained manpower greater. The functions of the institutions that might need to be created from scratch or reproduced include information dissemination, input manufacturing and marketing, output marketing, credit for farmers and marketers, land tenure reform, adaptive research, market news, building farm-to-market roads, formal and informal eduction for farmers and their families, and so on. For institution building, the requirements for highly trained manpower are considerable, and the time requirements for forming human capital (whether for village level extension workers with six years of formal schooling plus one or more years of extension training, or for research project leaders with a Ph.D. in their specialty) would be long. These needs emphasize the importance of training institutions to create the highly trained manpower so sorely needed for the growth and development of agriculture.

Alternative 1b would have all the requirements of 1a, in addition to large (usually public) investments for planning, designing, constructing, and getting effectively into operation the project that would be the core of this alternative. In 1974, the World Food Conference proposed for 1974-85 irrigation projects totalling 23 million hectares estimated to cost U.S.$38 billion at 1974 prices; this would average $1650 per hectare or nearly $670 per acre (12, p.63). This would increase the potential irrigated area in the developing countries at an average rate of 2 million hectares per year. The gestation period for many irrigation investments--the time between initiation of the investigation of the natural resources to be developed and the time when the project is operating at full capacity--is a very long one. The highly trained manpower requirements would be very large, including needs for resource investigations, project planning and design, project execution, planning for the settlement of the completed project, settling the farm families on the project, providing for all the infrastructural requirements, and operating the project efficiently. Many skills and many people with each skill will be required. Some time could probably be saved if three important components of each project could be initiated at the same time and carried on in parallel. These are the engineering, the agricultural, and the settlement components.

Alternative 2a will require less time and capital if no direct land investments are necessary, much more of both if direct land investments are necessary. In either case, the requirements for highly trained manpower will be large, but they will be much larger if these investments are an integral part of the development project.

Alternative 2b would be similar to 2a in many ways, including the effects of direct land investments, which are more likely to be needed in the case of multiple cropping systems than in the case of 2a. Another difference is that capital requirements are likely to be greater because of the probable need for some mechanical equipment to reduce the turnaround times between crops in the multiple cropping system.

Alternative 2c is different from 1a, 1b, 2a, and 2b which are in general mutually exclusive, while 2c can be combined with 1a, 1b, 2a, or 2b as well as carried out on land already being cultivated, when the only intensification is the introduction of the Green Revolution package.

Where no direct land investments are required for 1a, 1b, 2a or 2b, then incorporation of the Green Revolution into the development project would be likely to lengthen the time to completion, although the additional capital investment would not be large. The additional skilled manpower needs would be considerable, although not as large, other things being equal, as for 2c not in combination with 1a, 2a, or 2b.

Even with direct land investments, it should be possible to incorporate Green Revolution technology into agricultural development projects without lengthening the time period to maturity, if the basic research results are already available (only adaptive research is required to work out a feasible package of productive practices). The additional capital investments to incorporate the new technology would not be great, although some increases in highly trained manpower would probably be required. What we are arguing here is that a development project that includes direct land investments should be designed to incorporate Green Revolution technology (if that is technically feasible), because the additional requirements in time, capital investment, and highly trained manpower would not be substantial.

Alternative 3 is a different genus of development projects. The informational needs for an efficient livestock agriculture consisting of grazing ruminant animals on arid or semiarid rangeland are not adequate for designing action-oriented programs. The starting point for this alternative is basic research, followed closely by adaptive research--research in forage crops, in animal diseases, in livestock breeding, and in the social science aspects of the human ecosystems in which this type of agriculture is imbedded. It is likely that the interim development program will involve removal of some people and animals from overgrazed ranges, and that the ultimate program will be built around some mixed system of crop and livestock farming with feedstuffs being stored against the unavoidable risks created by large and largely unpredictable weather variability. Neither the time, nor the capital, nor the highly trained manpower requirements can even be guessed at until the scientific studies of these ecosystems are further along.

Alternative 4 is still another genus of project. Many of the basic research findings are on hand, but resource investigations and adaptive research will be needed before useful programs can be designed for particular countries or ecologies.

Expanding Harvested Areas of Food Crops

What can we say about the magnitudes of increases in world food production that are available from the above sources? The background papers for the U N

World Food Congress provide targets for the development of new arable land in the developing countries. From 1970 to 1985, an increase from 737 to 890 million hectares is called for. The past rate of settlement of new lands was about 4-5 million hectares per annum at a cost of U.S.$1.2 billion. In the 1975-85 phase of the land development program, the annual rate is to reach 6-7 million ha. at a cost of U.S.$2 or $2.3 billion. In the second part of the 1980's land development is to reach 10 million ha. per annum. Should these goals be achieved, the total arable land in the developing countries might approach 1.05 billion hectares by the year 2000, a 1970-2000 increase of around 40 percent. The increase from 1975 to 2000 would be around 35 percent.

Table 1 shows, for four developing regions of the world, the area, the total cost and the foreign exchange costs of the following kinds of land and water projects: renovating and improving existing irrigation projects; equipping new land for irrigation; and development of new land (1, pp. 66-67). Increases of this order of magnitude -- 196 million hectares of new land, and nearly 70 million hectares of highly productive irrigated land by 1985 -- would contribute a good deal to agricultural production capacity in the developing countries, even though at a fairly high capital cost, U.S.$90 billion at 1974 prices.

Table 2 gives some detail on countries that have come to rely importantly upon irrigation to increase their food production. In the Assessment (1, p.112) the total cultivated land in the developing countries was estimated at 740 million hectares, with 93 million hectares commanded by irrigation. In Table 2, about 450 million of the 740 million cultivated hectares were represented, while the estimate of the irrigated land for the 20 developing countries shown in

Table 1. Objectives and Estimated Costs of Water and Land Development in the Developing Countries, 1974-85.

World region	Units	Renovation and improvement of existing irrigated area	Equipping new land for irrigation	Development of new land
Far East	Area in million hectares	28	15	24
	Total cost in million $	11,700	22,000	9,500
	Foreign exchange component in mil. $	3,500	11,000	500
Near East	Area in million hectares	12	3	10
	Total cost in million $	6,700	7,400	2,500
	Foreign exchange component in mil. $	2,700	5,000	250
Africa	Area in million hectares	1	1	34
	Total cost in million $	500	2,400	1,500
	Foreign exchange component in mil. $	200	2,400	570
Latin America	Area in million hectares	5	4	85
	Total cost in million $	2,100	6,200	12,800
	Foreign exchange component in mil. $	100	2,500	2,500
Total Developing Countries	Area in million hectares	46	23	153
	Total cost in million dollars	21,000	38,000	30,000
	Foreign exchange component in mil. $	6,500	20,000	3,820
	Total cost per hectare in $	457	1,652	196

Source: The World Food Problem — Proposals for National and International Action, U.N. World Food Conference, E/CONF. 65/4, Rome, 5-16 November 1974, pp. 66-67.

Table 2. Major Irrigating Countries, According to Cultivated Area, Irrigated Area and Percentage of Cultivated Area Irrigated 1/

Country	Year 2/	Cultivated Area 3/	Irrigated Area	Percentage Irrigated
		(thousand hectares)		(per cent)
PRC	1967 (1960)	110,300	75,980	68.9
India	1968	164,610	27,520	16.7
United States	1969	192,318	15,832	8.2
Pakistan	1969	19,235	12,505	65.0
USSR	1970	232,809	11,100	4.8
Indonesai	1969	18,000	6,800	37.8
Iran	1971	16,727	5,251	31.4
Mexico	1960 (1964)	23,817	4,200	17.6
Iraq	1970 (1963)	10,163	3,675	36.2
Egypt	1971	2,852	2,852	100.0
Japan	1970	5,510	2,836	51.5
Italy	1971 (1960)	12,409	2,444	19.7
Spain	1970	20,626	2,435	11.8
Thailand	1965 (1969)	11,415	1,830	16.0
Argentina	1968 (1959)	26,028	1,555	6.0
Turkey	1970 (1967)	27,378	1,549	5.7
Australia	1970 (1967)	44,610	1,476	3.3
Peru	1971	2,979	1,116	37.5
Chile	1965 (1964)	4,632	1,091	23.6
Bulgaria	1971	4,516	1,021	22.6
Rep. of Korea	1969 (1968)	2,311	759	32.8
Greece	1968 (1969)	3,631	711	19.6
Madagascar	1966	2,900	620	21.4
Rep. of Vietnam	1971	3,065	580	18.9
Taiwan	1969	867	500	57.7
Ceylon	1970	1,979	465	23.5
Albania	1967	556	227	40.8
Israel	1971	417	173	41.5
Somalia	1960	957	165	17.2
Saudi Arabia	1967	809	131	16.2
Cyprus	1968 (1967)	432	102	23.4
TOTAL		968,858	187,501	19.3
Developing countries		451,456	149,246	33.1
Developed Countries		517,402	38,225	7.4

1/ Includes individual countries reporting more than 1 million hectares irrigated, and individual countries with more than 100,000 hectares that irrigated 16% or more of cultivated area.

2/ Year refers to year for which data on cultivated area apply; year in parenthesis refers to year for irrigation data when different from year for cultivated area.

3/ Cultivated area is arable land plus land under permanent crops.

Source: FAO, *Production Yearbook*, 1972 and earlier years.

that table was almost 150 million hectares. There is no obvious way for me to account for this difference between 93 and 150 million hectares.[1/]

Expanding Yields per Hectare of Cropland Harvested

If we agree tentatively that considerable increases in harvested area can -- though not necessarily will -- be achieved in many of the developing countries by 1985, and even larger increases by the year 2000, the next question becomes, what increases in yield per hectare (or production per animal, in the case of livestock enterprises) can be achieved? Will these be large enough to make it possible for every human being to enjoy quantitative and qualitative improvements in his diet?

Table 3 shows area, yield and production data for cereal grains in 1961 and 1972 for developed, developing and centrally planned countries. Table 4 gives 1961 and 1972 yields and 1961-72 yield changes for selected countries. Table 5 shows -- for selected developed, developing, and centrally planned countries -- the compound annual growth rate in area, yield, production, consumption, population and income for the 1960-62 to 1969-71 period.

It is clear from Table 3 that average yields were higher in the developed countries in 1972 than in the developing or centrally planned economies, and that the yield gaps widened between 1961 and 1972. From Tables 4 and 5, we see that compounded annual rates of increase in production for the 1960-62 to 1969-71 period were in general larger for the developing (3.5%) and the

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1/ Multiple cropping might account for some of the discrepancy but the Indicative World Plan (7, p. 44) shows a cropping intensity of only 99 percent for the 73 (sic) million hectares shown as irrigated arable land in 1961-63 for the developing countries. The irrigated area harvested annually is identical with the "net area reported to be served by irrigation systems," or the command area; this may be in excess of what can actually be irrigated with water available in a system in any given year. It is also not clear that the irrigation data for the People's Republic of China are included in the data shown here. There is some question as to whether all the numbers shown here for irrigated area are based on the same definition.

Table 3. World Cereal Grain Area, Yield, and Production, 1961 and 1972.

Year	Region	Area (million hectares)	Yield (metric tons/ hectare)	Production (million metric tons)
1961:				
	Developed	147	2.1	314
	Developing	261	1.1	278
	Centrally Planned	256	1.3	332
	WORLD	665	1.4	924
1972:				
	Developed	146	3.1	452
	Developing	290	1.3	367
	Centrally Planned	263	1.7	456
	WORLD	698	1.8	1,275

Source: The World Food Situation and Prospects to 1985, USDA, ERS, FAE Report No. 98, Washington, D.C., March 1975, p.64.

Table 4. Cereal Grain Yields, Selected Countries, 1961 and 1972.

Country	1961	1972	1961-72 Change	1961-72 Annual Rate Compounded
	(metric tons/hectare)		(percent)	
Belgium	3.5	4.2	20	1.7
France	2.3	4.2	83	5.6
West Germany	2.5	3.8	52	3.9
Italy	2.1	2.9	38	3.0
Sweden	2.8	3.5	25	2.0
United Kingdom	3.2	4.1	28	2.2
Japan	4.2	5.5	31	2.5
United States	2.5	3.9	56	4.1
Canada	1.3	2.0	54	4.0
Africa	0.8	1.0	25	2.0
Asia	1.3	1.6	23	1.9
Bangladesh	1.6	1.5	-7	-0.6
PRC	1.4	1.8	29	2.3
India	0.9	1.1	22	1.8
Pakistan	0.9	1.3	44	3.4
Philippines	1.0	1.2	20	1.7
Indonesia	1.5	2.1	40	3.1
Korea	2.9	3.4	17	1.4

Source: The World Food Situation and Prospects to 1985, USDA, ERS, FAE Report No. 98, Washington, D.C., March 1975, p.64.

Table 5. Annual Growth Rates in Factors Affecting Grain Production and Consumption, Regions and Selected Countries, 1960-62 to 1969-71.

Region, Country	Area	Yield	Production	Consumption	Population	Income[1/]
	Compound rate of growth, 1960-62 to 1969-71					
Developed countries	-0.1	2.8	2.7	2.5	1.1	4.4
United States	-1.0	3.4	2.4	2.1	1.3	3.9
Canada	0.0	3.3	3.3	2.9	1.8	4.0
EC9	0.7	2.5	3.2	2.2	0.7	3.7
Other West Europe	0.2	3.5	3.8	3.5	0.9	5.1
South Africa	3.2	1.1	4.2	4.5	3.0	5.7
Japan	3.5	1.3	-2.2	3.3	1.1	9.8
Australia & New Zealand	3.6	0.2	3.7	3.9	2.0	4.2
Centrally planned countries	0.0	3.0	3.0	3.4	1.4	5.2
East Europe	-0.6	3.7	3.0	2.9	0.6	4.5
USSR	-0.1	3.4	3.3	4.3	1.3	6.5
China (PRC)	0.5	2.2	2.7	2.6	1.8	2.7
Developing countries	1.4	1.9	3.5	3.7	2.6	4.6
East Asia	1.6	3.1	4.8	5.6	2.4	4.3
Indonesia	1.3	2.0	3.6	3.7	2.5	2.0
Southeast Asia	1.3	2.2	3.6	5.0	2.6	3.9
South Asia	1.3	2.2	3.2	3.1	2.6	3.4
India	1.0	2.0	3.0	3.4	2.6	3.3
No. Africa/Middle East	0.6	2.4	3.1	3.9	2.7	6.2
Central Africa	3.5	-0.5	3.0	4.4	2.4	2.9
East Africa	5.0	0.5	5.6	5.7	2.5	4.1
Mexico/Central America	2.7	3.0	5.7	5.6	3.3	6.5
Venezuela	4.9	0.6	5.5	7.8	3.0	5.4
Brazil	5.0	0.0	5.0	4.3	2.9	7.0
Argentina	2.6	1.7	4.4	3.2	1.5	4.1
Other South America	0.2	1.8	2.1	3.2	2.8	3.8
World	0.4	2.6	3.1	3.3	2.0	4.6

1/ Private consumption expenditures calculated for 1960-70 in constant 1970 dollars.

Source: The World Food Situation and Prospects to 1985, USDA, ERS, FAE Report No. 98, Washington, D. C., March 1975, p. 18.

centrally planned countries (3.0%) than for the developed countries (2.7%), but the rates for yields were higher for the centrally planned (3.0%) and developed (2.8%) than for the developing countries (1.9%).

It is not easy to pinpoint yield potentials in the developing countries, but assuming the availability of capital funds, inputs, adequate technical information, and a favorable economic environment, yield potentials in developing countries would appear to be no less than in developed countries, and possibly more. Many of the developing countries have 365-day growing seasons, and are favorably endowed with land and water resources. Tables 3, 4 and 5 seem to indicate that there is room for improvement by the developing countries, and I am arguing that there is potential for improvement.

Table 6 shows, for the principal grain crops in the developing regions, the growth rates in harvested area and in yields per hectare. There is a historic tendency in all of the developing regions save North Africa to obtain additional food by bringing new land under cultivation; North African production declined during the study period. The IWP objectives for annual increases in areas harvested and yields for the principal grain crops in the five developing regions are also shown in Table 6. If these area and yield growth goals could be achieved for the whole 1975-85 period in each region, rice production increases in the five regions would range from 39 to 73 percent; wheat, 33 to 65 percent; corn, 35 to 77 percent; barley, 8 to 33 percent; and millet and sorghum, -18 to 36 percent. If these growth rates could be sustained for the whole 1975-2000 period the ranges in production increases for the five regions would be: rice, 126 to 292 percent; wheat, 104 to 250 percent; corn, 110 to 317 percent; barley, 22 to 105 percent; and millet and sorghum, -40 to 166 percent. Grain production increases of this magnitude would make large increases in per capita

Table 6. Past Growth Rates and IWP Growth Rate Objectives for Yields and Areas of Cereals, 1975-85.

Item	Africa South of Sahara		Asia		Near East		North Africa		South America	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
	(annual growth rate in per cent)									
Rice:										
Past trends 1/	1.1	1.5	1.3	1.4	3.8	2.1	-4.6	2.6	5.5	0.5
IWP objectives 2/	2.0	1.6	0.6	2.7	2.1	2.0	5.3	0.3	2.7	0.7
Wheat:										
Past trends 1/	0.5	2.5	2.5	0.8	2.3	-0.8	-0.2	0.2	-0.7	1.2
IWP objectives 2/	2.5	2.2	0.8	4.3	0.1	2.8	0.5	3.2	1.9	1.5
Corn:										
Past trends 1/	4.1	0.5	3.3	2.7	-	-	-1.1	1.0	3.9	0.8
IWP objectives 2/	2.2	1.6	2.0	3.8	-	-	0.3	4.7	1.7	1.3
Barley:										
Past trends 1/	-	-	-0.8	1.1	1.4 3/	0.2 3/	-3.6	-1.4	-1.8	-0.9
IWP objectives 2/	-	-	-0.4	2.2	0.6 3/	2.3 3/	-0.8	1.6	0.6	1.4
Millet and sorghum:										
Past trends 1/	2.4 4/	1.1 4/	0.1	0.9	-	-	-3.5	1.0	10.2	5.2
IWP objectives 2/	1.8 4/	0.9 4/	0.3	2.6	-	-	-2.2	0.2	2.2	0.9

1/ 1952-56 to 1962-66 for all crops.

2/ 1961-63 base year to 1985 (IWP objective) except for North Africa, where base year is 1964-66.

3/ Coarse grains.

4/ Including teff.

— Not available or negligible.

Source: Provisional Indicative World Plan for Agricultural Development, Vol. 1, FAO, Rome, 1970, p.80.

consumption possible. This can be seen by examining Table 7, which shows the 1962-72 growth rate in population for the developing regions, and the 1975-85 and 1975-2000 increases in population, that would result from a continuation of the 1962-72 rates. The second and third columns of Table 7, examined in conjunction with the 1975-85 and 1975-2000 increases discussed above, show that reaching the IWP goals would bring about large increases in per capita availability of cereal grains, permitting large consumption increases, and making possible the release of productive resources for improving the quality of consumers' diets. The population growth rates in Table 7 are intended to represent the maximum growth that might take place by 1985 or 2000. Lower rates of population growth would make food consumption goals easier to reach.

Factors Limiting World Food Production in the Developing Countries

The crucial question to be asked at this point, is it reasonable to expect the required increases in harvested area and yields per harvested hectare to be achieved and sustained to the year 2000 by all or nearly all the developing countries? It may be useful to approach this question by listing the principal limitations to large production increases, and discuss each in turn: 1) Natural resources; 2) Material capital; 3) Human capital; 4) Institutions; 5) Information networks; 6) Economic environment; 7) Time.

1. Natural resources. Considerations of agricultural production capacity usually commence with the quantity and quality of the land and water resources, and the climate. The natural resource endowments of the developing countries for agricultural production are not at all unfavorable in relation to those of the developing countries. As far as agriculture is concerned, the important differences are that in each of the developed countries material capital (private and public), human capital, institutions, and technical information

Table 7. Population Growth Data for the Developing Regions of the World, 1962-72 Actual, 1975-85 and 1975-2000 Projected.

Region	1962-1972, Actual Annual Rate	Percentage Change, 1975-85, at 1962-72 Rate	Percentage Change 1975-2000, at 1962-72 Rate
Africa South of Sahara	1.025	28.0	85.4
Far East	1.025	28.0	85.4
Latin America	1.029	33.1	104.4
Near East	1.028	31.8	99.4
Centrally Planned Asian Countries	1.019	20.7	60.1
Developing Countries	1.024	26.8	80.9

Source: Assessment of the World Food Situation -- Present and Future, U.N. World Food Conference, E/CONF. 65/3, Rome, 5-16 November, 1974, p. 30.

needed for an efficient agriculture in that particular country are present. What each of the developing countries needs is the particular set of requirements that best complements the natural resource endowment and cultural system. With a combination of material and human capital, institutions, technical information, and economic environment that complements the natural resource and cultural endowment well, the per-hectare value of agricultural output in many developing countries could be higher than in many of the developed countries.

What can be suggested at this point -- as a personal opinion -- is that the requirements for a highly productive agriculture in developing countries are more demanding than in many of the developed countries, because of their ecological complexity. Tropical soils are difficult to manage; variability in moisture availability is often greater, even when the annual average is higher. Multiple cropping on tropical soils with a high degree of uncertainty due to weather requires a high level of management, and places heavy demands on human resources, institutions and information systems, and the economic environment. Sophisticated information systems will probably be optimal, if they can be established and operated eocnomically.

Encouraged by our tentative finding that natural resource endowments do not constitute an insuperable barrier to agricultural development, we turn briefly to the problems of designing and putting into place the combination of material and human capital, institutions serving agriculture, information networks, and economic environment that best complements the natural resource and cultural endowments of the developing countries.

Given the services of appropriate human and material capital and effective institutions, the required resource investigations (reconnaissance, semidetailed and detailed soil surveys, e.g.) will require a good deal of time. Given the results of the resource investigations, design of natural resource development projects, programs, or policies will also require a good deal of time, even with human and material resources, and effective institutions available. Getting the projects, programs, or policies into effective operation will take even longer. We can conclude that resource investigations, of soil and water resources in particular, are badly needed in many of the developing countries, and that this is a logical starting point for the design of programs to increase agricultural production.

2. Material Capital. If we include in this category all forms of fixed and variable agricultural capital except human capital, then these also become very important. Direct land investments (irrigation, drainage, or clearing) form important capital. Once output-increasing technologies are made available, then many purchased inputs become crucial in the production process -- improved seeds, fertilizers, pesticides, field and harvest equipment, feeds, irrigation pumps, and many other items. Unavailability of crucial items can abort, delay or reduce the potential effectiveness of modern technology. The provision of purchased inputs will require a considerable volume of highly trained human resources, as well as of capital funds. Setting up an effective input marketing system is also likely to be time-consuming.

3. Human Capital. Perhaps the prime candidate to bottleneck agricultural development in developing countries is human capital, particularly the highly trained manpower needed not only to conduct adaptive research and resource investigations, but also to man the massive infrastructure required by modern agriculture, to man the vast information and farmer education networks that are needed, and to turn out the highly trained manpower that is a prerequisite to sustained agricultural development. For a market economy that relies heavily on the private sector, any estimate of public manpower needs is likely to be on the short side, because the private sector will draw off large numbers

of trained people to manage and staff agribusiness enterprises. Because these managers and staff can play important roles in agricultural development, this drawdown of trained manpower available to the public sector should be of concern to manpower planners, who need to take account of this need in setting faculty, equipment, and expenditure budgets for agricultural training institutions.

Early in the development process, the highest priority claimants on skilled manpower and budgetary resources should be resource investigations and adaptive research. Whatever mix of strategies from 1a, 1b, 2a, 2c, 2d, 3 and 4 that turns out to be optimal, resource investigations will be required before effective agricultural development programs can be designed or carried out; this is true even in the case of technology-based programs (2c).

Even when early development is focused on land and water investments, it would be well to begin work simultaneously on the adaptive research required for Green Revolution technology. There are two reasons for an early start. First, agricultural development must, in almost all cases, come eventually to rely on large yield increases for increased food production, and these depend upon adaptive research. Land and water investments should be designed from the beginning in the knowledge that technology based on high yielding varieties will be installed on project lands as soon as those technologies can be developed for the particular ecology.

The second reason for simultaneous initiation of adaptive research is the long gestation period required for Green Revolution technology; an early start may be necessary to insure its availability when needed.

In the competition for highly trained manpower early in the development process, the institutions responsible for turning out highly trained manpower should also have a high priority for highly trained manpower, equipment, and budgetary resources. It will probably turn out to be economical for any developed country with an agricultural population of more than 2 or 3 million people to have its own training institutions and carry out its own adaptive research. 2/ The reason is the large number of highly trained individuals needed in the developing countries to initiate and sustain agricultural development in the complex ecological and cultural situations found there. If adequate quality control can be established, it will be more economical and will increase relevance of the training to train them in their own country. The numbers required may be proportionately larger than in the developing countries for the following reasons:

1) Complex ecological and cultural situations.

2) The importance in the developing countries of evolving an efficient, small-scale agriculture. Establishing and maintaining an efficient small-scale agriculture will place heavy burdens upon the infrastructure, institutions, informational networks, and economic environment. The number of senior-level and field-level personnel required per million dollars of output will probably be greater in developing countries that opt for a labor-intensive, land-intensive, small-scale agriculture than in developed countries with capital-intensive, large-scale farm and infrastructural units.

3) The current level of attention in developing countries to soil and water conservation is low, and needs are dramatic. A considerable volume of trained manpower will be needed to conduct investigations and research, to design and supervise programs, and to take programs out effectively to farmers.

2/ Exceptions would be small countries that have an opportunity to send students economically to a nearby country with the same or a similar language and with well developed agricultural training and research.

4) The same arguments in 3) for soil and water conservation can be made for environmental quality.

From arguments 1), 2), 3) and 4), I conclude that, because the needs for trained manpower are great and because they will continue indefinitely into the future, each developing country but the smallest should give serious consideration to establishing training institutions with the capacity to meet quantitatively and qualitatively most of their future needs of highly trained manpower for agricultural development.

The qualitative aspects of manpower needs should be emphasized. We have discussed quantitative needs as though meeting those overwhelming demands will by itself open up a more favorable set of development alternatives to a developing country. This will be the case only if quality, measured in effectiveness and competence, is up to standard. While most needs for lower skills and some needs for intermediate skills can be met with fewer years of formal training than is usual in the U.S. or in other industrial countries, no compromise on quality is acceptable for higher levels of skills. The arguments of ecological and cultural complexity, and of the demanding nature of small-scale agriculture are as powerful for qualitative as for quantitative considerations. Developing efficient, small-scale, agricultural systems in tropical or sub-tropical ecologies may well demand higher skills from some technical agriculturists and rural social scientists than do the efficient, large-scale, agricultural systems in temperate ecologies.

One of the important reasons for each large or medium-size developing country to build its own training and research capacity is to be able to take the next steps in agricultural development after foodgrain production has been increased. If foodgrain production can be increased enough to meet domestic needs, then productive resources can be shifted from grain production to other products that will make it possible to improve consumers' diets, or to increase foreign exchange earnings. Designing and carrying out these resource adjustment programs will also be demanding in terms of human capital, institutional capability, information network, and economic environment.

The only systematic study of trained manpower requirements I could find is a part of the FAO Indicative World Plan (7, 8 and 9). The complete study is found in Volume 2 (8, pp. 421-481) of the IWP. Table 8, a summary table found on (9, p.55), gives numbers and training costs of the cumulative totals of professional and technical agricultural personnel estimated in 1969 to be required by 1975 and by 1985 in most of the countries in four developing regions. Total numbers needed were estimated to be 425,000 by 1975, over 750,000 by 1985! In discussing these needs (9, pp. 421-481), the IWP concluded that most countries face greater deficits in field personnel than in senior-level personnel. In fact, it is suggested that some developing countries may now have more senior-level personnel in 1975 than will be needed in 1975. I believe this reasoning to be fallacious, based upon using academic credentials as the criterion of competence. My observations in a few countries (5, e.g.) lead me to argue that there are not enough people of the highest caliber -- those who are capable of providing leadership for and conducting the resource investigations and adaptive research that are sine qua non of agricultural development.

The time requirements for human capital formation are so great, but so self-evident, that their implications will only be noted here.

4. Institutions. The importance of effective institutions to an efficient, small-scale agriculture can hardly be overestimated, but little advice is offered here. Building effective institutions from scratch or transforming

Table 8 Numbers of Trained Agricultural Personnel Estimated in 1969 to be Required by 1975 and 1985 and Cumulative Costs of Training.1/

	-1975-					-1985-				
	Senior		Field		Total	Senior		Field		Total
	Number	$ Million	Number	$ Million	Cost $ Million	Number	$ Million	Number	$ Million	Cost $ Million 2/
Africa S. of Sahara	10,380	154.6	51,880	228.1	382.7	27,320	403.0	115,630	505.8	908.8
Asia and Far East	47,950	163.4	239,800	167.2	330.6	85,000	292.8	421,800	293.7	586.5
S. America	5,400	32.2	27,000	47.7	79.9	12,300	72.8	60,200	105.2	178.0
Near East	7,400	98.4	36,730	73.5	171.9	7,920	105.3	39,220	78.4	183.7
Developing Countries 3/	71,130	448.6	335,410	516.5	965.1	132,540	873.9	636,850	983.1	1,857.0

1/ Costs in 1966 U.S. dollars.

2/ Estimated net total investment, exclusive of wastage and assuming constant costs.

3/ Study countries in IWP, except Central America and Northwest Africa.

Source: Provisional Indicative World Plan for Agricultural Development - Summary and Main Conclusions, FAO, Rome 1970. This table is based upon Tables A.4 - A.9 in (4, pp. 469-491).

ineffective institutions usually requires high-quality human capital and large volumes of it, large volumes of accurate information, time, and good luck.

5. Information networks. So far we have stressed the importance of the information generated by adaptive research and resource investigations; many other kinds of information, such as market news, grades and standards, etc., would be needed, and institutions would need to be established for these purposes and made functional. Equally important is to establish information dissemination channels through which relevant information can move to farmers, and individuals in the public and private units serving agriculture. Establishing these networks will require above all human capital, but also material capital, budgetary resources, and time.

. Economic environment. Much has been written about the importance of economic incentives and other aspects of the economic environment (for example, by Art Mosher in (6), especially chapters 5, 7, 8, 9 and 11). It will be difficult to make agricultural development take place efficiently without an effective marketing system for farm inputs and outputs, including transportation and production credit. Building this economic environment will require human capital, material capital, and is in itself an exercise in institution building.

The importance of having farm-gate output and input prices that provide farmers with clear cut incentives to increase output efficiently needs to by emphasized. There is no economic justification for having low farm prices for agricultural products in short supply.

. Time. Overcoming each of the six limiting factors, in addition to placing demands on scarce resources (human capital and budgetary resources), will take a good deal of time because the gestation periods for the overcoming activities are substantial. This places considerable importance on program design, because of the necessity to take full account of lead times in setting priorities for the elements in agricultural development programs.

Political will in the particular country is such an important factor in releasing the limiting factors discussed above that it needs emphasis. Public actions are completely necessary in releasing these constraints, and the absence or weakness of political will is likely to negate completely a very well conceived program of agricultural development.

In Brief, the Statistical Record

Tables 3, 5 and 9 provide information on food production gains made by developed, developing and centrally planned countries during the last two decades. Developing countries increased food production 3.1 per cent per annum from 1952 to 1962, 2.7 per cent from 1962 to 1972, grain production 3.5 per cent per annum from 1960-62 to 1969-71, and grain production 32 per cent from 1961 to 1972. The 1960-62 to 1969-71 increases of 3.5 percent was achieved by a 1.4 per cent increase in area, a 1.9 per cent increase in yield; the 1961-72 gain of 32 per cent by an 11 per cent increase in area, an 18 per cent increase in yield.

Centrally planned economies made great strides in increasing food and foodgrain production. The 1952-62 annual growth rate in food production for Eastern Europe and U.S.S.R. was 4.5 per cent, 3.2 per cent for the Asian centrally planned economies; the respective annual figures for the 1962-72 decade were 3.5 and 2.6 per cent. Annual growth rate in grain production for all centrally planned countries was 3.0 per cent from 1960-62 to 1969-71, from a 3.per cent growth rate in yield, no change in area. From 1961 to 1972, the gain of 37 percent in the centrally planned countries was made possible by a 3. per cent increase in area, a 31 percent increase in yield.

Table 9. Rate of Growth of Food Production in Relation to Population, World Regions, 1952-62 and 1962-72.

	1952-62			1962-72		
	Population	Food Production		Population	Food Production	
		Total	Per Capita		Total	Per Capita
	Percent per year 1/					
Developed Market economies 2/	1.2	2.5	1.3	1.0	2.4	1.4
Western Europe	0.8	2.9	2.1	0.8	2.2	1.4
North America	1.8	1.9	0.1	1.2	2.4	1.2
Oceania	2.2	3.1	0.9	2.0	2.7	0.7
Eastern Europe and U.S.S.R.	1.5	4.5	3.0	1.0	3.5	2.5
Total developed countries	1.3	3.1	1.8	1.0	2.7	1.7
Developing market economies 2/	2.4	3.1	0.7	2.5	2.7	0.2
Africa	2.2	2.2	--	2.5	2.7	0.2
Far East	2.3	3.1	0.8	2.5	2.7	0.2
Latin America	2.8	3.2	0.4	2.9	3.1	0.2
Near East	2.6	3.4	0.8	2.8	3.0	0.2
Asian centrally planned economies	1.8	3.2	1.4	1.9	2.6	0.7
Total developing countries	2.4	3.1	0.7	2.4	2.7	0.3
World	2.0	3.1	1.1	1.9	2.7	0.8

1/ Trend rate of growth of food production, compound interest.

2/ Including countries in other regions not specified.

Source: Assessment of the World Food Situation -- Present and Future, UN World Food Conference, E/CONF. 65/3, Rome, 5-16 November 1974, p.30.

For the 1952-62 decade, developed countries increased food production at a compounded annual rate of 2.5 per cent, 2.4 per cent for the 1962-72 decade. The annual growth rate of 2.7 per cent in grain production for 1960-62 to 1969-71 resulted from a 2.8 per cent increase in yield, 0.1 per cent decrease in area. The 44 percent increase in grain production from 1961 to 1972 was attained with a 1 per cent decrease in area, a 48 per cent increase in yield.

The record since 1972 is somewhat mixed. Table 10 shows world grain production, consumption and net exports of wheat, coarse grains, and milled rice for the 1960/61 - 1962/63 average, the 1969/70 - 1971/72 average, 1972/73, 1973/74 and 1974/75. Table 11 shows the same data categories on a per capita basis. Except for 1974/75 for all regions and except for the developed countries during the whole period, consumption per capita rose steadily in centrally planned countries, in developing countries, and in the world as a whole. These increases in per capita consumption were quite respectable, and undoubtedly represented greater calorie availability throughout most parts of the world. Except in the developed countries, the increased consumption did not come entirely out of domestic production, but was made possible in part by net imports, mostly from developing countries.

Centrally planned countries were net importers throughout the 1960-75 period, but with no particular trend. Developing countries were also large importers all through the 1960-75 period, but with a steady upward trend. Net imports accounted for 9 per cent of total grain consumption in the developing countries in 1973/74, reaching 11 percent in 1974/75. Even with good crops in 1973/74 (a worldwide grain production increase of almost 8 per cent over 1972/73), net imports by centrally planned and developing countries amounted to 47 million metric tons, or 6 per cent of their grain consumption in that marketing year.

Table 10. World Grain Production, Consumption and Net Exports, 1960/61 - 1962/63, 1969/70 - 1971/72, 1972/73 and 1974/75.[1/]

Region 2/	1960/61 - 1962/63			1969/70 - 1971/72			1972/73			1973/74			1974/75		
	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports
							(million metric tons)								
Developed															
Total	315	299	20	401	375	32	422	399	62	449	399	58	419	373	58
Wheat	94	74	21	112	88	29	117	91	46	128	87	43	133	89	48
Coarse grains	206	211	-2	273	273	1	290	293	14	305	299	12	270	270	8
Milled rice 3/	15	14	*	16	15	2	15	14	2	16	14	2	16	14	2
Centrally Planned															
Total	276	279	-3	375	391	-7	384	415	-32	438	442	-16	423	443	-13
Wheat	104	108	-4	147	158	-4	148	171	-23	172	172	-9	149	161	-7
Coarse grains	120	119	1	155	160	-3	161	170	-11	188	194	-9	192	202	-7
Milled rice 3/4/	52	52	*	73	73	*	76	74	2	78	76	2	82	80	2
Developing															
Total	212	223	-12	287	306	-19	290	321	-23	300	330	-31	295	334	-38
Wheat	43	58	-15	64	84	-22	73	97	-21	69	99	-29	68	101	-33
Coarse grains	84	80	3	109	104	6	109	111	1	112	110	2	111	113	-2
Milled rice 3/	85	85	-*	114	117	-3	107	114	-2	119	121	-4	116	121	-3
Rest of the World															
Total	5	6	-1	6	8	-2	6	8	-2	6	8	-3	6	8	-2
Wheat	*	1	-1	*	2	-2	*	2	-2	*	2	-2	*	2	-2
Coarse grains	*	*	-*	*	*	-*	*	*	-*	*	*	-*	*	*	-*
Milled rice 3/	4	5	-*	5	5	-*	5	6	-*	5	5	-*	5	6	-*
World Total															
Total	799	810		1,069	1,084		1,101	1,146		1,194	1,191		1,142	1,157	
Wheat	233	242		323	334		339	361		369	363		350	356	
Coarse grains	410	412		538	541		559	577		607	611		572	580	
Milled rice 3/	156	155		208	210		203	208		218	217		220	220	

1/ Wheat; milled rice; barley, corn, oats, rye and sorghum.

2/ I. Developed - U.S., Canada, European Community (nine countries), Austria, Finland, Greece, Iceland, Malta, Norway, Portugal, Spain, Sweden, Switzerland; Republic of South Africa, Botswana, Lesotho, Namibia, Swaziland.

II. Centrally Planned - USSR, PRC, Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia.

III Developing - Mexico, Honduras, British Honduras, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Dominican Republic, Haita, Jamaica, Trinidad and Tobago, Bahamas, Bermuda, Venezuela, Brazil, Argentina; Bolivia, Chile, Colombia, Ecuador, Guiana, Guyana, Paraguay, Peru, Surinam,Uruguay, Algeria, Bahrain, Cyprus, Iran, Iraq, Israel, Kuwait, Libya, Oman, Qatar, Saudi Arabia, United Arab Emirates, Egypt, Jordan, Lebanon, Morocco, Sudan,

Syria, Tunisia, Turkey, Yemen (Sana), Yemen (Aden); Angola, Burundi, Cameroon, Central Africa, Chad, Congo, Dahomey, Ethiopia, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Mauritius, Niger, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, Spanish Sahara, Togo, Upper Volta, Zaire, Kenya, Uganda, Tanzania, Zambia, Rhodesia, Malawi, Mozambigue; India, Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka; Thailand, Burma, Khmer, Laos, South Vietnam, Indonesia; Hong Kong, Singapore, South Korea, Taiwan, Brunei; Philippines, Malaysia.

IV Rest of the World - North Korea, North Vietnam, Mongolia, Cuba, Pacific Islands, Papua-New Guinea

3/ Production Primarily in initial calendar year combined with trade in the following year to get Consumption (disappearance) in year shown. Consumption (disappearance) estimates include the effect of stock variations

4/ Rice production series for China recently revised

* Less than 500,000 metric tons

Source World Agricultural Situation, WAS-7, USDA, ERS, June 1975, Tables 4-11

Table 11. Per Capita World Grain Production, Consumption and Net Exports, 1960/61 - 1962/63, 1969/70 - 1971/72, 1972/73, 1973/74 and 1974/75.1/

Region 2/	1960/61 - 1962/63			1969/70 - 1971/72			1972/73			1973/74			1974/75		
	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports	Production	Consumption	Net Exports
							(Kilograms)								
Developed															
Total	490	466	31	567	531	45	586	554	86	617	550	79	572	509	80
Wheat	147	116	33	158	124	40	162	126	64	176	120	60	181	122	65
Coarse grains	321	328	-3	387	386	1	403	407	19	420	411	17	368	368	11
Milled rice 3/	23	22	-0.6	22	21	3.0	21	20	2.8	21	19	2.4	23	19	3.1
Centrally Planned															
Total	280	284	-3	333	347	-6	331	358	-27	372	376	-14	354	371	-11
Wheat	105	110	-4	130	140	-3	128	147	-20	146	146	-8	125	135	-6
Coarse grains	122	121	1	138	142	-3	138	147	-9	160	165	-7	161	169	-6
Milled rice 3/	53	52	0.5	65	64	0.3	65	64	1.4	66	65	1.4	68	67	1.3
Developing															
Total	152	160	-9	165	176	-11	158	175	-12	160	176	-17	154	174	-20
Wheat	31	41	-11	37	49	-13	40	53	-12	37	53	-15	35	52	-17
Coarse grains	60	58	2	63	60	3	60	61	1	60	59	1	58	59	-1
Milled rice 3/4/	61	61	*	66	67	-1	59	62	-1	64	65	-2	60	63	-2
Rest of the World															
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wheat	6	23	-17	7	48	-41	7	49	-41	8	53	-45	8	42	-34
Coarse grains	5	8	-3	3	7	-5	3	7	-4	3	9	-6	3	9	-6
Milled rice 3/	125	131	-6	116	122	-6	117	125	-8	108	114	-6	114	120	-6
World Total															
Total	264	264	1	295	298	1	293	304	1	312	308	2	293	297	2
Wheat	79	79	1	88	90	-	90	96	-	96	94	1	90	91	2
Coarse grains	134	135	1	149	149	1	149	153	1	158	158	1	147	150	-
Milled rice 3/	51	51	0.2	57	58	-0.1	54	55	0.2	57	57	-0.2	56	57	-

1/ Wheat, milled rice, barley, corn, oats, rye and sorghum

2/ I. Developed - U.S., Canada, European Community (nine countries), Austria, Finland, Greece, Iceland, Malta, Norway, Portugal, Spain, Sweden, Switzerland, Republic of South Africa, Botswana, Lesotho, Namibia, Swaziland.

II. Centrally Planned - USSR, PRC, Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia

III Developing - Mexico, Honduras, British Honduras, Guatemala, El Salvador, Nicaragua, Costa Rica, Panama, Dominican Republic, Haita, Jamaica, Trinidad and Tobago, Bahamas, Bermuda, Venezuela, Brazil, Argentina, Bolivia, Chile, Colombia, Ecuador, Guiana, Guyana, Paraguay, Peru, Surinam, Uruguay; Algeria, Bahrain, Cyprus, Iran, Iraq, Israel, Kuwait, Libya, Oman, Qatar, Saudi Arabia, United Arab Emirates, Egypt, Jordan, Lebanon, Morocco, Sudan,

Syria, Tunisia, Turkey, Yemen (Sana), Yemen (Aden), Angola, Burundi, Cameroon, Central Africa, Chad, Congo, Dahomey, Ethiopia, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Liberia, Mali, Mauritania, Mauritius, Niger, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, Somalia, Spanish Sahara, Togo, Upper Volta, Zaire, Kenya, Uganda, Tanzania, Zambia, Rhodesia, Malawi, Mozambique, India, Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka; Thailand, Burma, Khmer, Laos, South Vietnam, Indonesia, Hong Kong, Singapore, South Korea, Taiwan, Brunei, Philippines, Malaysia.

IV Rest of the World - North Korea, North Vietnam, Mongolia, Cuba, Pacific Islands, Papua-New Guinea

3/ Production Primarily in initial calendar year combined with trade in the following year to get Consumption (disappearance) in year shown. Consumption (disappearance) estimates include the effect of stock variations

4/ Rice production series for China recently revised

* Less than 500,000 metric tons.

\- Not available

Source World Agricultural Situation, WAS-7, USDA, ERS, June 1975, Tables 4-11

Prognosis for Developing Countries

Earlier we showed that, if governments and farmers in the five developing regions could attain and maintain, during the 1975-85 and 1985-2000 periods, annual rates of increase of harvested area and yields per hectare suggested in the IWP as reasonable goals, total cereal grain output could be at least doubled by the year 2000. This would make possible a very satisfactory increase in grain consumption per capita, and would release productive resources for other food crops. If we could extend grain yield increases to other food crops, an opportunity would be created for substantial improvement in consumers' diets.

Can these results be achieved? My response is "Yes, but not by the year 2000!" Whether country strategies focus on resource-based or technology-based programs, I believe the lead times for overcoming all limiting factors are great enough that most countries will not be able to reach and maintain the annual growth rates specified in Table 6 until the decade of the 1990's. My guesstimate is that developing countries can achieve cumulative growth rates in food production that would be on the order of 75 or 80 per cent of the IWP goals.

This will leave annual production for some countries below IWP goals, particularly in the early years of the 1975-2000 period. During the 1975-85 period, maintenance of past trends might be a rather good performance in most countries. This means that developing countries will need an increased volume of grain exports from the developed countries during part of the 1975-2000 period, and even during the year 2000, when the developing countries would in general have reached or surpassed the IWP growth rates in area and yield. Increased imports would be needed for developing countries to avoid interruptions in the rate of growth of calorie consumption, and to make up for bad harvests that come along periodically.

Prognosis for Developed Countries

Can developed country exporters increase production enough to meet their own growing consumption needs, the growing import demands of their regular grain customers, and much more than double exports to developing countries? In 1971-72, developed country exporters (U.S., Canada, Australia and New Zealand, and South Africa) exported 75 million metric tons; in 1972-73, 105; and in 1973-74, 100 million. More than one-half of these exports went to other developing countries, more than one-fourth to developing countries, and nearly one-fifth to centrally planned economies. An additional 100 million metric tons of grain exports from developed countries, earmarked for developing countries would require that the developed countries approach a doubling of foodgrain production by the year 2000. Continuation of the 2.7 per cent annual growth rate in grain production would bring a 30 per cent increase for 1985 over 1975, a 95 per cent increase for the year 2000 over 1975.

In many developed countries, aggregate agricultural production moves up and down with farm prices. With high prices expected, agricultural authorities ease off on supply controls, and planted area is increased by bringing retired acres back into cultivation, as in the U.S. in 1973 and 1974; expectation of high prices induces farmers to use more variable inputs and raise yields. If they expect high prices to continue 5-10 years or more into the future, then farmers in the U.S. and other industrial countries would begin to make investments in irrigation and drainage that would add to the cultivated area. The U.S. Bureau of Reclamation would, for example, accelerate the rate of development of additional irrigated acreage.[3/] Research in the U.S., Canada, and northern Europe would be pressed to develop crop varieties with shorter growing seasons, and thus extend the boundary of crop cultivation northward. A great deal of genetic, agronomic, soils, and other technical research would be done in an effort to increase yields per acre of land harvested.

Summary

High prices for agricultural products would provide strong incentives in developed and developing countries for increases in harvested area, as well as in yield per hectare. Given: a favorable economic environment in terms of output and input prices; adequate supplies of inputs (especially fertilizer) at reasonable prices; adequate supplies of capital for economical land and water investments; adequate budgetary resources for institution building, manpower training, adaptive research and resource investigations; continued progress in developing improved agricultural technology by international agricultural centers -- given all these, food production could by the year 2000 be at a rate of growth nearly double (75-80 per cent more) than in 1975. What is more important for the future after 2000, processes of creating and disseminating new agricultural technologies and of investigating and developing underutilized land and water resources would have been institutionalized in a great many number of the developing countries. This bodes well for food production in the 25 years after the year 2000.

3/ See Martin (4) for a more complete discussion of 1985 prospects in the U.S. for increasing acreage harvested and yields per acre.

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