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Longrun Changes in World Food Supply and Demand

Implications for Development Assistance Policy

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ABSTRACT

A steady growth in food production in the developing countries since 1950 was accompanied by increased use of land and water resources and by the application of new technologies in agricultural production. Rapid population growth in the developing countries, growth in per capita income, relative stability of food prices--except during the 1970's--and government policies influenced world food demand. Malnutrition continues to be a problem for many vulnerable groups in the developing countries. U.S. development assistance policy should focus attention on the following: nutrition and other aspects of wellbeing in relation to U.S. security interests in developing countries, agricultural policies, development and dissemination of technology, and U.S. aid in relation to international lending programs.

Keywords: world food production, food imports, resources, technology, food demand, population, income, prices, food trade, food aid, future trends, development assistance

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SUMMARY AND CONCLUSIONS

Total world food production increased rather steadily from the early 1950's to 1982. The annual compound rate of growth in world food production was 2.6 percent per year; the developing countries increased their food production by 3 percent.

Food Production

World per capita food production also increased over the three decades. However, the rate of growth in per capita food production, in contrast to that for total food production, was lowest for the developing countries. More rapid rates of population growth in the developing countries than in the industrialized or centrally planned countries kept the per capita rate of growth in food production at about 0.6 percent per year.

Gains in food production per capita varied markedly from one developing region to another. East Asia (excluding Japan and China) experienced the most rapid increases in per capita food production. Primarily because of India's performance, South Asia demonstrated remarkable stability in food production, especially during the 1970's, despite unstable weather.

Food production per capita in Africa is actually declining. A combination of environmental, political, and economic forces are behind the serious longrun food problem in Africa. The few examples of successful food and agricultural production performance in Africa suggest that appropriate policies and investment in the agricultural sector could reverse the longrun decline in food production per capita.

Food Imports

Food imports have added to available food supplies in developing countries. The developing countries were slight net exporters of grains during the very early 1950's, but, particularly during the 1970's as a result of rapid income growth, the developing countries have become major net importers of grains.

These food imports need not be viewed as the consequence of a failure of the food production system. For many countries, food imports are both a response to real income growth and an efficient allocation of resources.

Net agricultural exports of the developing countries have also grown over the past three decades, enhancing their ability to pay for food imports. Recently, because of worldwide recession and weak demand for agricultural exports, the developing countries have become net importers of agricultural commodities. Global economic recovery and strengthened demand for primary commodities could reverse this situation in the late 1980's.

Sources of Growth in Food Supplies

The remarkable growth in food production in the developing countries has been accompanied by increased use of land and water resources and by the application of new agricultural production technologies.

Cropland expanded at the rate of 1 percent per year during the 1950's and about 0.3 percent during the 1970's. This slowing of the rate of expansion indicates that considerable improvement has occurred in land productivity as well as that the most

suitable lands are now being cultivated. Most future gains in world food production will have to come from gains in productivity. Water availability is a problem in only a few, though undoubtedly important, regions of the world.

The probability of significant climatic change over the next two decades is low. Agriculture and food production remain vulnerable, however, to shortrun weather variations. Policy, modern technology, and improved infrastructure can mitigate some of the adverse effects of weather variability.

The high energy prices of the 1970's probably had more impact on the ability of the developing countries to import food (because of a higher total import bill) than on their ability to produce food. This is because the use of energy-intensive inputs in agricultural production is relatively low in the developing countries. The lower and more stable energy prices that appear likely in the 1980's could enhance the ability of the low-income developing countries to import food and invest in agriculture and other productive sectors.

Irrigation has proven to be the most promising approach to increasing food and agricultural production, especially when used in conjunction with high-yielding varieties of grain. The expansion of irrigated area has been particularly remarkable in South Asia. The rehabilitation of existing irrigation systems is likely to be a more important source of increased production in the developing countries than the building of new systems.

The use of a package of technology that includes agricultural chemicals, irrigation, and improved varieties has also contributed to increased crop yields during the past three decades.

The Green Revolution was the result of technological breakthroughs, mainly in plant breeding; there are still gains to be realized from the further spread of high-yielding crop varieties. However, it is in the area of genetic engineering, made possible by the discovery of recombinant DNA, that will lead to crop production and yield gains. The most promising developments are likely to be in such areas as nitrogen fixation, altered photosynthetic and photorespiratory responses, and disease resistance.

Changes in Food Demand

Population, per capita income, prices, and government policies are the main determinants of the demand for food.

World population grew from 2.53 billion in 1950 to 4.6 billion in 1982, with the rate of increase falling from 1.9 percent in the 1950's to 1.77 percent in the last 5 years. Population growth rates declined most in countries with rapid rates of economic growth, such as Singapore, Taiwan, South Korea, and Costa Rica.

The rapid growth in incomes, especially in the oil-exporting countries and the middle-income developing countries,

contributed to the surge in demand for U.S. and world agricultural exports during the 1970's.

Food policies of developing countries affect demand and consumption of foods. Most developing countries seem to have followed policies of providing cheap food to urban constituencies. This has led to large food imports and improved food availability in urban areas, but rural areas have frequently suffered.

Future Trends

Over the long term, the fall in population growth rates that characterized the late 1970's in the developing countries should continue as economic development proceeds. A major source of uncertainty with respect to future population growth rates are the prospective birth rates of South Asia, Latin America, and Subsaharan Africa.

The current recession has contributed significantly to reduced demand for agricultural products and slowed economic growth in the developing countries. World economic activity began to revive in 1983, and if the world economy continues to expand in 1984 and 1985, income growth in the developing countries should accelerate. Whether or not this happens largely depends on the strength of economic recovery in the United States and other industrialized countries. A return to more rapid rates of economic growth in the developing countries is particularly important for U.S. agricultural trade.

Land and water resources will be more than adequate to support further increases in world food production during the 1980's and beyond. There are still gains to be realized from adapting existing technologies in some areas. Investment in infrastructure and in the development or adaptation of high-yielding varieties of crops, will also bring production gains. Over the longer term, dramatic new breakthroughs for both crop and animal agriculture are likely to come from advances in genetic engineering.

Longrun Changes in World Food Supply and Demand:

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INTRODUCTION

This report was prepared originally for the Commission on Security and Economic Assistance, a public commission constituted by the Secretary of State to review the goals, activities, and resource availability of U.S. foreign assistance activities--security and economic, bilateral, and multilateral--and to assess the adequacy and effectiveness of U.S. assistance programs in achieving their goals. 1/ The report provides an overview of the past and present world food situation and serves as a basis for developing commission recommendations on agricultural development assistance policy.

This report thus reviews the longrun changes in world food supply, demand, and trade since the 1950's, examines factors which will significantly influence these trends for the remainder of this century, and draws implications of those trends and prospects for development assistance policy. Particular emphasis is given to analyzing trends in food supply, demand, and trade for the developing regions of the world as they influence the need for U.S. food and economic assistance. The implications for development assistance policy are not phrased as definitive conclusions but rather are posed as questions or issues so as to enable the commission members to formulate their own conclusions and recommendations with respect to U.S. food and agricultural development assistance.

The report draws heavily on work in progress in ERS on a comprehensive assessment of the world food situation. The paper has seven major sections: Changes in World Food Supplies, 1950-82, Sources of Growth in Food Production, Food Demand, Food Trade, Food Aid, Future Trends, and Implications for Development Assistance Policy.

1/ Inquiries with respect to the work of the Commission should be addressed to: Commission on Security and Economic Assistance, 1800 K Street, N.W., Suite 921, Washington, D.C. 20006.

CHANGES IN WORLD FOOD SUPPLIES, 1950-1982

World Food Production

World food production grew at a compound rate of 2.6 percent per year from 1950 to 1982 (table 1). The most rapid increases were in the developing countries, with a growth rate of 3 percent per year, while food production in the industrialized or developed countries grew at 2.1 percent. In the centrally planned countries (USSR, Eastern Europe, and China) food production grew at a rate close to that of the developing countries.

The absolute percentage changes in total food production over the three decades under review tell a comparable story. Total food production in the developing countries increased by 87 percent from 1950 to 1982, while in the industrialized countries it grew by 63 percent.

Per Capita Food Production

Per capita food production in the world grew also over the 1950 to 1982 period (table 2). In contrast to total food production, growth in food production per capita was more rapid in the industrialized and the centrally planned countries than in the developing countries primarily because population grew more slowly in the former than in the latter. The annual compound growth rate for food production per capita in the world was 0.7 percent. For the developing countries, this meant an increase of 0.6 percent per year, while for both the industrialized and the centrally planned countries the annual rate of growth was 1.1 percent.

Regional Variations in Food Production Per Capita in the Developing Countries

Although food production per capita increased for the developing countries as a whole there was considerable country and regional variation. Among the developing regions of the world, East Asia (excluding Japan and China) experienced the most rapid increases in food production per capita--1.3 percent per year--and the largest absolute increase--41 percent. Africa, on the other hand, suffered a declining growth rate of -0.6 percent over the

Table 1--Indices of total food production, 1950-82

Region	1950	1960	1970	1980	1982	Compound rate of growth
	---- 1969-71=100 ----					Percent
Developed countries	63	82	98	119	126	2.1
Developing countries	54	74	101	133	141	3.0
Centrally planned countries	53	72	101	123	130	2.8
World	58	77	100	124	131	2.6

Source: U.S. Department of Agriculture, Economic Research Service, World Indices of Agricultural and Food Production, 1973-82, SB-697 and previous issues.

Table 2--Indices of food production per capita, 1950-82

Region	1950	1960	1970	1980	1982	Compound rate of growth
	---- 1969-71=100 ----					Percent
Developed countries	79	92	100	110	114	1.1
Developing countries	86	95	101	104	105	.6
Centrally planned countries	77	87	101	106	110	1.1
World	84	93	100	104	105	.7
East Asia	81	90	101	118	122	1.3
Africa	104	107	99	89	88	.6
South and Central America	88	89	102	113	115	.9
China	86	76	102	120	129	.8
South Asia	83	96	102	97	97	.5
Middle East	84	96	100	108	104	.5

Source: U.S. Department of Agriculture, Economic Research Service, World Indices of Agricultural and Food Production, 1973-82, SB-697 and previous issues.

three decades, reflecting an absolute decline in food production of 16 percent. (We shall return below to the serious food problems of Africa and their implications for U.S. development assistance.)

In South Asia, where most of the population of developing countries reside--some 65 percent--food production per capita increased at an annual compound rate of 0.5 percent. These gains in food production per capita in South Asia were associated with the Green Revolution--the introduction and widespread adoption of high-yielding varieties of grains in the late 1960s--and have been maintained in the face of continued rapid population growth rates. Food output in South Asia is subject to considerable weather variation, but the expansion of irrigated area in conjunction with the use of high-yielding varieties has contributed substantially to the relative stability of output. China also has made considerable gains in food production per capita. From 1950 to 1982, food production per capita grew at 0.8 percent per year. China's growth rate is only slightly higher than that for the developing countries as a whole.

In Latin America, food production per capita increased at 0.9 percent per year over the three decades with more rapid gains in South America than in the Caribbean and Central America.

The Serious Food Problems in Subsaharan Africa--What is Behind Longrun Declining Food Production Per Capita?

In Subsaharan Africa, food production per capita was 12 percent lower in 1982 than the average for 1969-71 and 18 percent lower than it was in 1959-61. In fact, growth in food production per capita in Africa has been stagnant or declining over the past two decades. Africa's slow growth in total food production relative to other developing regions and a population growth rate of around 3 percent--the most rapid in the developing world--account for Africa's declining per capita food production.

Reasons for Africa's poor food production performance fall generally into three categories: Inadequate natural resources and an unstable climate; inappropriate agricultural policies and lack of investment in areas such as transportation, research, development of new technologies, irrigation, and storage; and the consequences of civil disturbances and political instability.

While drought is a major cause of the periodic African food crises, the roots of the problem go much deeper. Most food is produced under rainfed conditions, making it subject to wide weather-related variations. Yet few countries have developed the capacity to deal internally with these fluctuations, and severe foreign exchange constraints limit the ability to import to cover shortfalls. Government officials have frequently neglected the agricultural sector, often tailoring policies toward subsidizing food for politically important urban consumers rather than stimulating increased production. In addition, agricultural price policy, marketing practices, trade policy, and foreign exchange policy have often been inconsistent, making it difficult to cope with changing conditions.

There have been few breakthroughs in food production in the region, and higher yielding crop varieties developed elsewhere are difficult to transfer to Africa. The future of new agricultural technology will depend on more effective national research, with more attention to local conditions. Yet, national research systems are generally weak and lack trained personnel and adequate funding.

These weaknesses in food production are compounded by political instability in the region which reduced food production in many countries and generated flows of refugees. These displaced people put heavy demands on the food systems of neighboring countries and the international community.

Major studies by the USDA, World Bank, FAO, and International Food Policy Research Institute are unanimous in their conclusions: Without significant changes in the productivity of African agriculture, and better policies and planning capable of providing incentives for greater productivity, there will continue to be increasingly serious food emergencies over the next decade (33, 17, 38, 7, 12, 11, 40, 6). But there are enough examples of food production successes in Africa to demonstrate that food production performance is considerably enhanced where there is adequate investment in the agricultural sector, development of infrastructure, and provision of

incentive prices to farmers. Ivory Coast, Malawi, Kenya, Cameroon, and Zimbabwe show advances in per capita food production well above the majority of African countries.

Food Imports of the Developing Countries

Not only has per capita food production grown in the developing countries but so have food imports, mainly grains. Food imports added to the food supplies available to the developing countries.

The developing countries as a group were net exporters of grain from the mid-1940's to the early 1950's. However, through almost three decades of steady and remarkable growth in incomes, their grain imports increased substantially. Population growth, discussed in more detail below, also contributed to the substantial growth in grain imports by the developing countries.

The most rapid growth in grain imports by the developing countries occurred during the 1970's. In 1970 their net grain imports were approximately 15 million metric tons. By 1979 this increased to 40 million metric tons. Net imports of grain peaked at 57 million metric tons in 1980 and declined somewhat in 1981 to 50 million metric tons. Grain imports in the 1980's reflect to some extent a reduced ability to pay for imports due to slower economic growth, low prices for commodity exports, and limited foreign exchange reserves.

Agricultural Exports of the Developing Countries

While food imports of the low-income countries were increasing, their export earnings from agricultural products were also increasing quite rapidly. Total export earnings were three and one-half times larger in 1979 than they were in 1970. Net agricultural export earnings increased fairly steadily throughout the 1970's, but in 1981 the developing countries became net importers of agricultural products for the first time since 1970.

Agricultural exports exceeded agricultural imports by an average of $10 billion each year during the 1970's. However, in 1980, agricultural export earnings exceeded agricultural imports by only $4 billion and in 1981 the developing countries had an agricultural trade deficit of $3 billion. The reduced export earnings of the 1980's are due principally to weak demand for primary products in the industrialized countries and lower prices for primary agricultural commodities, while prices for grain imports, especially from the United States, are largely unaffected by the recession because of the continuing strength of the U.S. dollar. Economic recovery in the United States and other industrialized countries should tend to increase the demand for developing country exports and thus their export earnings.

Increased food imports by a developing country are not necessarily the result of an inadequate food production system, a widely held notion during the 1970's. Food imports may be both a response to rising real incomes and an efficient use of resources. Food self-sufficiency may not be an appropriate policy for developing countries; it may be more efficient for countries to allocate resources to export production and to

import at least some portion of their food supplies. Agricultural trade between the United States and developing countries is evolving along the lines of comparative advantage with the United States exporting grains and oilseeds to the developing countries and the latter exporting tropical agricultural products to the United States.

SOURCES OF GROWTH IN FOOD PRODUCTION

The remarkable growth in food production in the developing countries since the early 1950's is attributable to both increased use of land and water resources and to the development and application of yield-increasing technologies.

Land and Soils

Availability of land is not a critical limiting factor in global food production, although pressures on land resources are important in some regions. The amount of world cropland has expanded slowly, the rate of expansion dropping gradually from 1.0 percent per year in the 1950's to 0.3 percent per year in the 1970's. The area in permanent pastures changed very little. In recent years, forested area appears to have declined considerably, showing a drop of over 3.3 percent since 1966 with the largest declines in Latin America and Subsaharan Africa (table 3).

The total potentially arable land (cropland and potential cropland now in permanent pastures) is estimated at 3 billion hectares, although only half of this is currently being cropped (3, 5). Thus, it is not the absolute quantity of arable land that limits agricultural production, but its uneven distribution and cost of development. The gradual slowing of cropland expansion reflects both a large improvement in land productivity and the fact that the best lands are already being cultivated. Remaining land is likely to be of lower quality and increasingly costly to cultivate or too far from population centers.

Loss of soil fertility from soil erosion, salinization, soil compaction, and waterlogging has been largely arrested and even reversed in developed countries, but it still affects many developing countries. The problem is most severe in North Africa, the Sahel, Ethiopia, Nepal, and Indonesia, and on the cultivated lands of the Andes Mountains. New lands being opened for cultivation in many developing countries are particularly susceptible to soil erosion and will need strong protective measures to maintain their productivity (5).

If cropland growth continues to slow as it did during the last three decades, which appears likely, the rate of expansion during the 1980's is likely to fall somewhere between 0.2 and 0.3 percent per year. On the other hand, world population will probably expand at about 1.6 percent. Increases in world food production will have to come predominantly from increased productivity (31).

Water

Water resources can support rates that equal or even exceed the rates of growth in food production that have occurred over the past three decades. There are, however, geographic regions facing some kind of water constraint, including North

Table 3--World land use

Region and land category	1966	1970	1980
	Million hectares		
World:			
Cropland	1,381	1,414	1,452
Permanent pastures	3,122	3,126	3,117
Forests and woodlands	4,236	4,211	4,093
Other land	4,336	4,324	4,413
Total land area	13,075	13,075	13,075
United States:			
Cropland	176	190	191
Permanent pastures	258	244	237
Forests and woodlands	294	292	284
Other land	184	186	200
Total land area	912	912	912
Other developed countries: 1/			
Cropland	176	175	176
Permanent pastures	550	555	555
Forests and woodlands	576	580	556
Other land	791	783	806
Total land area	2,093	2,093	2,093
Eastern Europe and USSR:			
Cropland	284	287	286
Permanent pastures	395	396	395
Forests and woodlands	957	958	959
Other land	716	711	713
Total land area	2,352	2,352	2,352
Latin America:			
Cropland	143	151	194
Permanent pastures	516	528	546
Forests and woodlands	1,084	1,066	1,020
Other land	300	298	310
Total land area	2,043	2,043	2,043
North Africa and Middle East:			
Cropland	82	84	87
Permanent pastures	233	234	231
Forests and woodlands	56	56	57
Other land	796	805	831
Total land area	1,190	1,190	1,190

See footnotes at end of table.

Continued

Table 3--World land use--Continued

Region and land category	1966	1970	1980
	Million hectares		
Subsaharan Africa: 2/			
Cropland	140	146	156
Permanent pastures	723	722	720
Forests and woodlands	733	719	685
Other land	796	805	831
Total land area	2,392	2,392	2,392
China:			
Cropland	104	102	99
Permanent pastures	220	220	220
Forests and woodlands	106	109	116
Other land	500	499	495
Total land area	930	930	930
Other Asia: 3/			
Cropland	278	283	293
Permanent pastures	233	231	215
Forests and woodlands	429	430	415
Other land	235	231	252
Total land area	1,175	1,175	1,175

1/ Canada, Western Europe, Australia, and New Zealand.
2/ Includes South Africa.
3/ Includes Japan.

Source: (10).

Africa, the Sahel, the Middle East, and parts of India and China. These constraints can be partly overcome by the application of modern irrigation technology, including improved water management, and by more economic pricing of water supplies as against heavy subsidization of water delivered for irrigation.

Even in areas where water is abundantly available, there are problems with the efficiency of water use, especially where water is provided free of charge or where it is heavily subsidized. In addition to the waste which these inefficiencies entail, overuse of water also contributes to reduced yields through waterlogging, buildup of salinity, and erosion. Improved management and market-oriented user fees can ameliorate these problems as well (13, 36).

Weather and Climate

Recent literature highlights the increased interannual variability of crop production during the last decade compared to the 1950's and 1960's resulting from more variable

weather. Modern agricultural technology, irrigation for example, can dampen some of the adverse effects of weather problems.

Concerns have also been raised about the possibility of long-term climatic changes and their impact on food production. Such long-term changes could affect world food supply by altering temperature, precipitation, and the length of growing seasons. Not only yields but the kinds of crops that can be grown could be affected.

Scientific thinking about climatic change has developed along two contradictory lines. Some researchers have predicted a buildup of carbon dioxide in the earth's atmosphere--"the greenhouse effect"--as a result of the burning of fossil fuels and the clearing of forests, that would lead to a subtle warming of the earth, even to the extent of melting the polar ice cap and flooding the coastal lowlands (26). Others, relying on the study of long-term climatic trends, see the earth entering a global cooling stage, with shorter growing seasons and less rainfall, that would make it harder to grow food for an expanding world population (15).

These issues were addressed in a report commissioned by the U.S. Government (21). The study points to a low probability of significant climate change in the next two decades. It also indicates that impacts on agriculture would be minimal because crops are less sensitive to changes in temperature than to changes in rainfall. The most likely climate change (with an ascribed 30-percent probability) was a slight global warming that would have practically no effect on the principal crops on which human nutrition depends.

Energy

Agricultural production activities use between 3 and 6 percent of all commercial energy consumed, depending upon the country examined and its degree of industrialization. 2/ Although the amount of energy used is relatively small, it is critical to the sector because of its impact on the cost of production through input pricing and the development of production technology. About 80 percent of this energy is oil based, the rest being equally divided between natural gas and electricity. Oil and gas provide motor fuels for running machinery and space heating and are raw materials for fertilizer and pesticide manufacturing.

Fossil fuels play a much smaller role in agricultural production in the developing countries. The most serious impact on the developing countries of oil price increases has been on their ability to finance imports of food and other essentials rather than through an impact on production.

2/ The food sector as a whole including production, transportation, processing, and marketing accounts for 16 to 22 percent of all commercial energy use, depending upon the country and definition of the food sector.

The Arab oil embargo of 1973, the oil shortages of 1978, and the two large increases in petroleum prices in 1974 and 1979, forced up the real price of crude oil by nearly 400 percent and that of natural gas by over 300 percent. Since then, the combination of economic recession in industrial countries, improved efficiency in energy use, and an increased use of oil substitutes has reduced the rate of increase in energy demand from over 5 percent per year in the 1960's to less than 1 percent in the 1980's and has stabilized prices.

During the crisis years, fuel alcohol from biomass--including sugarcane, corn, and sweet sorghum--received considerable attention as an alternative energy source. Few petroleum deficit countries, however, have a sufficient cropland base to be able to take this route. Brazil has made the most intensive effort, reserving some 4 million hectares of land planted to sugarcane (6.5 percent of its cropland) to produce alcohol to replace 45 percent of its gasoline consumption. Moreover, the rapidly evolving technology for producing fuel alcohol (methanol) from coal appears fundamentally more efficient than large-scale fuel production from biomass. In the foreseeable future, cropland will be more valuable for food and fiber production than for liquid fuel production (36).

The energy outlook in the 1980's seems to be for ample energy supplies, including oil supplies. Oil prices, although they have come down some from their peak in 1981, will remain high and could begin a slow increase in real terms as soon as economic recovery in the industrial countries spreads, spurring an increase in energy demand.

Irrigation

In the last two decades, while total cropland area increased by 9 percent, irrigated land increased by 42 percent. In 1980, nearly 15 percent of the world's cultivated area was irrigated (table 4). This area, however, produced over 40 percent of the world's food supply. In the developing countries, irrigated land accounts for 20 percent of the cultivated area but produces two-thirds of their food (10, 19). These shares are expected to grow since most improvements in agricultural technology currently being introduced or developed in national and international agricultural research centers include irrigated land.

China has the highest proportion of irrigated land to total cultivated land, 46 percent, followed by the rest of Asia with 25 percent, and North Africa and the Middle East with 21 percent. Densely populated Asia could not have made the gains it has made in food production without irrigation. Half of the newly irrigated area in the last two decades, 30 million hectares, was developed in Asia. The smallest share of irrigated to total cultivated area occurs in Subsaharan Africa, a region generally characterized by generally low yields and slow advances in land productivity.

Irrigation is still considered the most promising approach to increasing agricultural production. FAO estimates that 53

Table 4--Total and irrigated cropland

Region	Cropland		Irrigated area		Irrigated area as percentage of cropland	
	1961-65	1980	1961-65	1980	1961-65	1980
	Million hectares				Percent	
World	1,334	1,452	149	212	11	15
United States	180	191	15	21	8	11
Other developed countries 1/	173	173	9	12	5	11
Eastern Europe and USSR	284	286	11	22	4	8
Latin America	116	167	8	14	7	8
North Africa and Middle East	81	87	14	18	17	21
Subsaharan Africa 2/	126	156	3	5	2	3
China	104	99	39	46	37	46
Other Asia 3/	270	293	50	74	19	25

1/ Canada, Western Europe, and Oceania. Excludes Japan and South Africa.
2/ Includes South Africa.
3/ Includes Japan.

Source: (10).

million hectares of new land could be irrigated in the next decade, and that about the same amount of irrigated land could be improved to provide higher yields (7). However, the estimated cost of this effort is about $100 billion, a heavy burden for developing countries to carry alone. Because of the costs, attention is shifting from the general concern with building new irrigation systems to the need for improving performance of existing systems.

Fertilizer and Other Chemicals

Agricultural chemicals--fertilizers, herbicides, and insecticides 3/--together with irrigation and improved seed varieties constitute the package of technology that provided the rapid increase in crop yields during the past three decades. During the 1930's, grain yields in the developed and developing countries averaged 1.14 and 1.15 tons per hectare, respectively. By 1970, yields in developed countries grew to 3.2 tons, and by 1980, to 3.5 tons. During the same period, yields in developing countries increased to only 1.5 and 1.8 tons, respectively. However, since 1970 yields for most crops grew faster in the developing countries (table 5) (16).

3/ In this group of chemicals, fertilizers are by far the most important, representing 96.4 percent of the total volume.

Table 5--World grain yields 1/

Region	1961-65	1969-71	1980
	Kilograms/hectare		
World	1,460	1,806	2,149
United States	2,736	3,458	3,774
Other developed countries	2,017	2,525	3,194
Eastern Europe and USSR	1,173	1,652	1,801
Latin America	1,331	1,481	1,790
North Africa and Middle East	1,075	1,165	1,408
Subsaharan Africa	849	925	969
China	1,538	2,083	2,923
Other Asia	1,130	1,334	1,649

1/ Includes wheat, rice, barley, maize, oats, millet, and sorghum.

Source: (10, 1976 and 1981).

Despite recent gains, the developing countries are far from realizing their food production potential. Subsaharan Africa is at the bottom of the scale with grain yields of less than 1 ton per hectare and fertilizer applications of only 9.7 kgs per hectare in 1980. The next lowest region, North Africa and the Middle East, uses 32.7 kgs of fertilizer per hectare to reach grain yields of 1.4 tons (table 6). There appears to be little question that most developing countries as well as Eastern Europe and the Soviet Union will have to rely on increased use of fertilizers to improve crop yields. Except for China, these countries are far from attaining crop yields comparable to those in the developed countries.

During the past two decades, fertilizer supplies and prices remained rather steady, except in the case of urea and phosphate rock and their compounds during the 1972-75 period. At that time, soaring world grain prices, fears of longrun world food scarcity, and rapidly rising feedstock costs pushed fertilizer prices to record levels. In the case of phosphate rock, an attempt to cartelize supplies contributed to the trends. After returning to their longterm trend level in real terms, fertilizer prices increased to some extent through 1981, and then began to decline as grain production in the United States and some other developed countries was cut because of weak world demand.

Fertilizer supplies in the 1980's are expected to be adequate and their use will probably increase between 3.0 and 3.8 percent annually, as compared to 8.2 percent in the 1960's and

Table 6--Consumption of fertilizers 1/ per hectare of cropland 2/

Region	1961-65	1969-71	1980
	Kilograms/hectare		
World	27.9	48.5	79.9
United States	45.6	80.0	111.6
Other developed countries	43.8	103.5	132.3
Eastern Europe and USSR	27.7	63.5	105.0
Latin America	11.2	19.6	46.0
North Africa and Middle East	6.2	13.5	32.7
Subsaharan Africa	1.8	4.7	9.7
China	12.2	41.8	154.6
Other Asia	5.7	14.6	37.6

1/ N, P_2O_5, and K_2O.
2/ Arable land and land in permanent crops in FAO land classification.

Source: (10, 1978 and 1981).

5.1 percent growth in the 1970's. 4/ This reflects a slower growth in agricultural production as well as improved efficiency in fertilizer use. Nitrogen and potash demand may fall slightly below the average growth level in the 1980's, while phosphate use may exceed it.

Biological Technology

The adoption of high-yielding grain varieties has given a major boost to the growth in food production, particularly in developing countries, since the mid-1960's. This technological development originated in Mexico in the late 1940's with the development of improved dwarf wheat varieties. High-yielding hybrid corn had earlier been developed and adopted in the United States. By the mid-1960's, high-yielding wheat and rice varieties were introduced and adopted widely in Asia and Latin America.

In the late 1970's, two-thirds of the wheat area and one-third of the rice area in Asia were sown to high-yielding varieties, accounting for the rapid increase in food production in the region. The proportion of high-yielding wheat varieties to total wheat area was 22 percent in Africa, 41 percent in Latin America, and 17 percent in the Middle East (24).

The Green Revolution was concentrated in relatively few areas within countries, and was not very successful in Africa or the Middle East. Reasons for failure to achieve the full potential

4/ Authors' projections and (9) for historical rates.

of these new varieties are insufficient fertilizer application and inadequate irrigation facilities, poor management techniques, and, in some cases, government policies which reduced production incentives by holding down prices of agricultural products. Historically, in the United States and Mexico a lag of 10 to 20 years is expected between the introduction and widespread adoption of new grain varieties. If this is so, the full impact of the adoption of high-yielding grain varieties in developing countries during the 1960's should be realized in the 1980's. Meanwhile, further and more fundamental advances in biotechnology can promote additional advances in agricultural productivity.

New developments in biotechnology center not on plant breeding but on genetic engineering and are based upon the manipulation of deoxyribonucleic acid (DNA), the basic genetic material which governs the growth of living organisms and transmits characteristics to their offspring. Techniques for recombining DNA and splicing genes have been developed. Cells are induced to take up pieces of DNA in processes like cell transformation and protoplast fusion. These new techniques are reinforced by parallel advances in cloning and tissue culture which allow plant breeders working closely with molecular biologists to develop more rapidly new, more economical plants (35).

Tissue culturing in plants and superovulation in livestock expand the possibilities for experimentation and stock multiplication and substantially shorten the time needed to conduct experiments with tree crops and large animals. Genetic research on animal cells has been aided by the heavy investment in cancer and other human diseases research. However, knowledge of plant cells has not progressed as far (36). The current bioengineering revolution is more likely to accelerate the output of livestock, or even tree crops, than of field crops in the next decade.

Over the last 20 years, there has been a considerable investment in field crop research directed to advancing in the developing countries. Researchers do not anticipate very large near-term gains in crop yields based on conventional field crop research. The new genetic engineering research is not expected to result in large crop production gains until after 1990 when such advances as nitrogen fixation, altered photosynthetic and photorespiratory response, and increased disease resistance are expected to have been achieved.

Livestock gains from genetic research are anticipated soon. Genetic engineering has already produced the first completely safe foot-and-mouth disease vaccine. Scientists are working on other vaccines. Countries that now import livestock products, because of rising demand for them, will likely seek ways to increase local production through advances in livestock reproduction and health. This is particularly true of poultry production and modern hog production. Other new livestock production techniques, including superovulation and sexed semen, promise to greatly increase livestock productivity.

A number of factors peculiar to individual regions will likely dominate innovations in the livestock sector and produce variable results among regions. In Africa, for example, expansion of livestock grazing is inhibited by diseases, principally theileriosis and trypanosomiasis. In this region, the economic returns from development of drugs for treatment of such diseases would be very high. The development of vaccines using recombinant DNA technology has great promise in near-term applications.

Regional and Commodity Variations in Yields

Yields for the principal food and feed commodities--grains, soybeans, rapeseed, and milk--have increased by about 50 percent since 1960. In the grains group, yield gains range from 33 percent for wheat and rice to 60 percent for corn. Yield gains in cotton, tomatoes, and beef have also been important, on the order of 20-40 percent. The increases in yields for roots and tubers, coffee, sugarcane, and peanuts have been only 10-20 percent. Except for potatoes, the crops in this group are tropical. The only important food commodity group where global yields have remained constant during the period are pulses, but even in this case some countries have shown impressive advances (10).

Both the level and rate of increase in yields, however, were unevenly distributed among regions (table 5). Yields are invariably high in the developed regions and much lower in the developing regions, except in China. Overall, grain yields range from 3,774 kg/ha in the United States to 969 kg/ha in Subsaharan Africa. Grain yields in China in 1980 were 2,923 kg/ha, and growing at an annual rate of 3.0 percent. At this rate, Chinese grain yields should catch up with those in Western Europe in the next 5 years or so.

Investment in Physical and Institutional Infrastructure and Human Resources

The rapid growth in world agricultural production in the past few decades, based on changes in technology, could not have been achieved without a large and sustained investment in modern infrastructure--roads and bridges, storage facilities, communication systems, market services, rural electrification, research organizations, and education facilities--to support the agricultural sector.

The developed countries already have in place a good supporting infrastructure so that they can easily implement changes required for continued productivity growth in agriculture. In Eastern Europe and the Soviet Union, infrastructure is somewhat less developed, but can be considered adequate. In developing countries, however, physical infrastructure is at various levels of development, from a relatively well-developed system in India to the lack of essential infrastructure elements, such as roads, bridges, and vehicles, in much of Subsaharan Africa.

There is little comparable statistical information on rural infrastructure in the world. FAO has estimated the investment need in 90 developing countries, growing from about $18 billion in 1980 to over $27 billion in 1990 for storage, marketing, processing and transport facilities (7). Of the latter sum, 11

percent is in Africa, 46 percent in Asia, 10 percent in the Middle East, and 33 percent in Latin America. Reaching $27 billion would require the investment to grow at a rate of 4.2 percent annually. This rate is unlikely to be achieved in many developing countries, and particularly in Africa, where half of it would represent a foreign exchange component. Hence, improvement in infrastructure in many developing countries will have to rely on development assistance.

No less important than physical infrastructure are institutional infrastructure and human resources. Schools, research stations, effective extension services, marketing and credit agencies, agricultural scientists and technicians, developed since the second half of the 19th century in the United States, Japan, and Western Europe, made the rapid productivity growth in agriculture possible during the past few decades.

Since 1960, in particular, there was rapid growth in the expenditure for agricultural research, a large part of it dealing with the problems of increasing farm production in low-income countries. Much of the research investment in the past decade has been for the international agricultural research centers and research organizations in Latin America, Africa, and Asia (18).

Agricultural Policies

In spite of many official pronouncements favoring higher agricultural production, policies around the world did not strongly promote increased production during the postwar period. The European Community (EC) and Japan are exceptions to this generalization. If one divides the world's major producing regions into three groups--the developed economies, the centrally planned countries, and the developing countries--the following picture emerges.

The wealthier countries have sought to raise and stabilize farm income. Their programs have generally restricted production (through area limitations in the United States and Australia) or provided limited subsidies (rail transportation in Canada). The EC's Common Agricultural Policy (CAP), however, has vigorously stimulated production with high support prices, notably for rice.

The centrally planned countries have targeted higher production. While low initial yield levels and some increases in area harvested (Soviet Union) have allowed significant growth rates of agricultural production, problems in resource allocation and incentives have prevented greater gains in productivity. The Cultural Revolution in China is an extreme example of the adverse impact of ideology on productivity. Recent policy shifts in China have sought to capitalize on private incentives.

The policies of the developing countries have taken many forms, but they have generally sought to promote food consumption more strongly than food production (32). Many countries have subsidized food consumption, and many have tried to support industrial development by taxing agriculture, often before

agriculture was sufficiently productive and commercialized to bear this burden. Many developing countries now accord high priority to self-sufficiency, which they see as consistent with food security and with industrialization supported by a productive agricultural sector. Although in general producers' incentives have improved, many countries' programs still do little to stimulate production, either because they are administratively ineffective or because support levels are too low. Adoption of high-yielding technology has also been limited by low levels of investment in roads, irrigation, and agricultural research.

Policies change slowly because the economic and political interests they are designed to serve do not change quickly, especially in mature economies. Policies are often linked to basic philosophies or ideologies, which also change very slowly. Thus changes are most likely to occur when they are unavoidable--for budgetary reasons, to satisfy the requirements of those granting assistance (for example, the International Monetary Fund), and because the results of existing programs are politically unacceptable. Policies might also change in reaction to a sudden advance in technology.

Perhaps the least change in policies is likely to occur in the developed countries. The farm sector is already receiving substantial assistance in several regions. Indeed, the cost of producer subsidies is a major issue in the EC, where a gradual reduction in the scope or level of subsidies will be necessary unless additional resources are allocated to agriculture by the national governments.

The centrally planned economies are currently combatting poor performance in agriculture with more emphasis on personal incentives. This is not an entirely new development, and a historical perspective suggests that success in the short run may lead to a return to ideological purity in the longer run. Thus, policy is likely to remain somewhat unstable in these regions as experimentation and adjustments take their course.

The developing countries should experience the most significant shifts in policies, if only because their situation is most urgent. Stronger producer incentives and more consistent policies can be expected. On the other hand, budgets and foreign exchange will be ever-present constraints on policymakers' ability to induce higher production through price mechanisms and the provision of infrastructure.

Because policies in developing countries in large part have not strongly promoted agricultural production, there is a potential for increased production which would result from more favorable policies. The changes in policies which are likely, however, will not, ceteris paribus, significantly alter the recent trend of world agricultural production. In combination with changes in other factors such as technology and infrastructure, however, they could have a noticeable impact.

Production in the developed countries is likely to remain unhampered by adverse policies and thus technically efficient and, with the exception of the EC and Japan, market-responsive. In the centrally planned countries, weather and policy variability will keep production unstable around an increasing trend. Stronger growth in production is possible in the developing countries as a result of policy changes, but this also depends on general advances in the world economy. Vigorous economic growth in the world would keep demand for agricultural products strong and permit substantial investment in the agricultural development of the poorer countries.

FOOD DEMAND

Total world food consumption increased rapidly during the 1960's and 1970's. Total grain consumption grew from roughly 860 million metric tons in 1960 to 1,479 million tons in 1981, or at an annual rate of 2.7 percent. A more rapid change occurred for meat and poultry consumption, with the developing countries and the centrally planned regions showing especially rapid increases. Altogether, world meat consumption grew approximately at a 3-percent rate since the early 1960's, while poultry consumption increased at a 5- to 6-percent rate.

The rapid population increases in the developing nations, however, meant that the per capita consumption of meat and poultry has remained almost unchanged for these regions for the period (table 7). Compared with the developed countries or even the European centrally planned economies, the per capita consumption of these products in the developing countries remains at very low levels. As per capita incomes continue to increase, there is reason to believe that significant increases in the per capita consumption of meat and poultry will occur in the developing regions.

Table 7--Per capita meat and poultry consumption for selected regions

Region	Red meat 1960	Red meat 1970	Poultry meat 1970	Red meat 1980	Poultry meat 1980
	Kilograms per person				
United States	79.4	88.0	22.2	82.0	27.8
Other developed countries	32.9	44.9	9.1	51.6	13.5
Eastern Europe & USSR	27.6	38.7	5.2	56.1	10.0
China	--	--	1.9	12.0	2.8
Latin America	25.5	26.4	3.8	27.2	8.0
Subsaharan Africa	--	9.5	1.3	8.9	2.0
North Africa & Middle East	--	6.6	.8	6.0	1.6
Asia	--	3.5	.6	3.8	.8
World	--	--	4.0	22.4	5.6

Sources: FAO Food Balance sheets (1982) and USDA official statistics.

Grain, however, remains the primary component of diets throughout the world. In recent years, grain has provided approximately 50 percent of world per capita caloric intake, and a similar percentage of protein intake. Moreover, another 13 percent of per capita calories and 30 percent of per capita protein came from the consumption of animal products, some of which were produced by feeding grain to animals.

Per capita grain consumption throughout the 1960's and 1970's has undergone significant changes from region to region (table 8). While the current figure for the United States (791 kg) is only slightly higher than the corresponding figure for 1960 (769 kg), per capita grain consumption in Eastern Europe and the USSR has climbed steadily throughout most of the past two decades, and actually exceeded the comparable figure for the United States in 1980. In the developing regions, modest but steady gains were made by China, Latin America, and the Middle East. The serious dietary problems that exist in many of the countries of Asia and Subsaharan Africa are reflected in the continuing low levels of per capita grain consumption in these regions.

For most of the world, sugar is the third most important source of calories in the diet. Although sugar consumption is generally low in most developing countries, it provides many more calories than meat and poultry. On a worldwide basis, per capita sugar utilization increased slowly over the 1960-81 period from 14.9 to 18 kilograms (table 9). The only region showing a decline was the United States, with consumption falling from 48 kg to 39.6 kg, a decline which may be attributable to increased health and nutrition concerns and to

Table 8--Per capita grain consumption for selected regions and world 1/

Region	1960	1970	1980
	Kilograms per person		
United States	769	803	749
Other developed countries	358	418	447
Eastern Europe and USSR	545	698	828
China	159	210	254
Latin America	194	223	263
Subsaharan Africa	136	151	143
North Africa & Middle East	272	293	346
Asia	166	179	181
World	274	311	329

1/ Consumption totals include grain fed to livestock.

Source: Official USDA statistics.

Table 9--Per capita sugar consumption for selected regions

Region	1960	1970	1980
	Kilograms per person		
United States	48.0	49.0	41.9
Other developed countries	30.9	36.7	36.2
Eastern Europe & USSR	28.1	40.5	45.8
China	1.3	2.7	3.8
Latin America	29.3	34.9	40.4
Subsaharan Africa	2.3	3.2	3.3
North Africa & Middle East	10.5	12.3	18.4
Asia	4.5	6.5	8.5
World	14.9	17.7	18.6

Source: Official USDA statistics.

increased per capita consumption of high-fructose sweeteners. Elsewhere a slow but steady increase was the rule. Per capita consumption remained low in China, Africa, and in Asia. Increases should be expected in these regions.

Population Growth

World population has grown from 2.5 billion in 1950 to 4.6 billion in 1982, with the rate of increase falling only slightly from 1.9 percent per year (in the 1950's and early 1960's) to 1.77 percent per year for the 1977-82 period.

Current population growth rates are roughly 1.1 percent for the United States and only 0.6 percent for the other developed countries. Eastern Europe and the Soviet Union have also had a very low rate of population increase, averaging 0.8 percent in recent years. For the developing world, the rates vary greatly across regions. They range from a low of 1.4 percent for China to 2.3 percent for both Latin America and Asia (excluding Japan and China), to 2.9 and 3.1 percent for the Middle East and Subsaharan Africa, respectively. Within regions population growth rates vary greatly from country to country. For example, in Kenya the population is currently growing at 4 percent per year, close to the theoretical maximum.

In a number of countries (Chile, Sri Lanka, and Malaysia are examples), the crude birth rate fell steadily throughout the 1970's. These countries seem to be proceeding through a demographic revolution similar to the one that the developed countries moved through in the nineteenth and early twentieth centuries, but at an even faster pace.

Whether population continues to grow at the historical rates is a question that will only be answered by time. Population

growth rates tend to change very slowly for the majority of countries. In the developing countries, if the birth rate dropped to replacement levels immediately, their populations would continue to increase for the next 50 to 70 years, as large numbers of young individuals move into their years of fertility.

Birth rates declined significantly in some developing countries. This occurred in countries that made substantial economic progress (Singapore, Taiwan, South Korea, and Costa Rica are good examples), but also in countries where there was a mobilization of the countries' economic, social, and political resources in family planning programs (China and Indonesia). A key accompaniment of a reduction in the crude birth rate was the dissemination of modern contraceptive methods to women of childbearing ages.

Finally, even where reductions in birth and overall population rates occurred, it does not assure that the reductions will remain permanent. For example, in the 1970's, birth rates in Mauritius, Jamaica, Trinidad, and Tobago actually increased, after having earlier fallen. Moreover, the population growth for Africa as a whole actually accelerated in the 1970's and early 1980's. Overall, however, it remains true that a decline in birth and population rates has occurred when economic growth progressed and was expected to do so in the future.

Effects of Income Growth and Income Distribution on Agricultural Demand

Income growth and income distribution are particularly important determinants of the demand for food. Where incomes are less than some minimum level, although needs exist demand is not fully realized. Where incomes are adequate, and this is true even for groups in the poorest developing countries, the demand for food is effective and hunger is not a major problem.

As incomes increase from a low level--either for individuals or for countries as a whole--per capita agricultural demand grows. Structural shifts in food demand also occur, such as a gradual shift from cereals to selected animal products.

The relative importance that rising incomes play in changing food demand varies among countries. In the developed countries, even though population growth rates have been low, it is the growth of population that has contributed the most to the increase in overall agricultural demand. In these countries the income elasticity of demand for food in the aggregate is close to zero; the major effect of income increases on food demand has been to cause the substitution of more preferred foods for those less preferred.

Increased incomes have had the largest effect on overall food demand in the developing countries. For developing countries as a whole, until the mid-1960's, income growth tended to be low. Thus, despite a relatively high income elasticity of food demand (somewhere between 0.5 and 1), increases in overall demand tended to come from increases in population rather than from income growth.

During the late 1960's and especially in the 1970's, income growth accelerated in a number of developing countries. There were major increases in real income for the oil-exporting developing countries. A number of other countries, referred to collectively as middle-income countries, also sustained relatively high growth rates throughout most of the 1970's. They include such nations as Brazil, Taiwan, South Korea, Malaysia, Thailand, the Philippines, Singapore, Hong Kong, and Turkey which collectively have a population of approximately 300 million. The middle-income countries together with the oil-exporting developing countries--a total of 20--have more than 700 million people, and experienced an average growth rate of 4 percent or better through most of the 1970's.

Income growth in the developing countries contributed greatly to the surge in the demand for U.S. and world agricultural exports in the 1970's. Food demand for the developing countries grew much more rapidly than their capacity to produce food, thus necessitating an increase in imports. The importance of these middle-income developing countries in world agricultural demand--and consequently to world and U.S. agricultural exports--is attested to by the changes that occurred in world grain trade. Between 1970 and 1980, their share of total world grain imports rose from 26 to 36 percent, while the total quantity of grain traded climbed from 109 million to 228 million tons. Over the same period, the share going to developed countries declined from 49 to 29 percent. In fact, even in those developing countries with the highest growth rates for staple food production over the 1961-77 period, imports of food staples increased (2).

In addition to the absolute level of income, the income distribution of a country is an important factor in determining the level of food demand. Where incomes within a country are very unequally distributed, a large percentage of the population may be unable to purchase sufficient food to meet minimum nutritional needs. If incomes are distributed more equally, total agricultural demand will increase.

The relationship between income growth and the resulting pattern of income distribution is also significant. The historical data reveal some tendency for incomes within a developing country to become more unequal in the early stages of development, as population shifts from the traditional agricultural sector to the higher income nonagricultural sector (4). Nevertheless, the relationship between growth and equity is anything but fixed. Some countries (Taiwan, Yugoslavia, South Korea, and Costa Rica) have grown rapidly without increasing income disparity, while others such as Brazil and Mexico have grown rapidly while experiencing a greater imbalance in income distribution. Even in these latter countries, the reduction has tended to be in relative terms, with the per capita incomes of the poorest growing at perhaps 1 percent compared with an overall average of 3 or 4 percent.

Prices: Real Price Changes

Prices play a major role in the production, distribution, and trade of agricultural commodities. When they are high, they stimulate production and discourage consumption; when they are low, they have the opposite effect. In the short run, their net effect is to ration the existing supply, including the quantities imported into a country. Over the longer run, market prices provide signals to agricultural producers, telling them to produce more or less.

Food prices, in real terms, were generally stable or declining gradually during the 1950's and 1960's, but became more unstable during the 1970's. From 1972 to 1974, the price of wheat increased from $60 to $200 per ton, while the price of rice went from $130 to $500 per ton. The inference drawn by many at that time was that the world was entering a new stage. The conventional wisdom was that a world food crisis was upon us, and many envisioned even worse conditions to follow.

By 1976, however, grain prices, in real terms, retreated to below their pre-1972 levels. Since then, fluctuations have continued, with prices rising nominally from 1977 to 1981, before again falling. Other agricultural prices exhibited similar instability in the 1970's, with real prices of both sugar and beef hitting peaks in 1974 before falling significantly. Since then, sugar prices have continued to be unstable, climbing sharply in 1980, only to fall again in 1981.

At present a consensus may be forming around the notion expressed by the World Bank that "prices of cereals and most agricultural commodities ... are not expected to be much above present levels until well into the 1990's" (39). During the early 1970's, many people also forecast little change in agricultural prices but at a time when prices were very high.

Policies and Institutions Affecting and Likely to Affect Demand

In addition to domestic policies that directly set agricultural prices, countries employ numerous other policies that directly or indirectly affect the demand for agricultural products. In developing countries almost all of these policies are aimed at providing cheap food supplies for urban residents.

Typically these are policies which involve the sale of basic food staples in state stores at low prices. One effect of such programs is to enhance the incomes of the poor. They also affect agricultural producers, depending on the methods used by the state to acquire the staple foods. Various options are possible here. The commodities may be bought by the government at market prices; at prices that are held artificially low by government dictate, or using a compulsory procurement system, under which a fixed or specified amount of a producer's goods are acquired at either market or established procurement prices.

Marketing controls may also be established in an effort to protect consumers from price increases during years of domestic or world shortages. Such controls, together with laws restricting or forbidding speculative activities, often have more consequences than planned. For in addition to preventing

price fluctuations and speculation, they often have the effect of discouraging needed investment in storage facilities by private traders. The end result for some countries is even greater year-to-year fluctuations in domestic prices and supplies.

Overall, government policies affecting demand in the developing countries range from the benevolent to the absolutely pernicious. On the positive side there are examples such as Sri Lanka and China. Sri Lanka under a pre-1979 program established a subsidized ration program which worked well in distributing food to the needy, but which was inefficient in forcing some farmers to supply food below cost. The system was significantly improved in 1979 with a new coupon system under which food was acquired from farmers at prices equal to the full cost of production. The overall effect of these distribution programs was that Sri Lanka, a nation with one of the lowest per capita incomes, now has a relatively small problem with undernutrition and an infant mortality rate that is actually lower than that of some developed countries.

China, through a number of policy instruments, instituted programs to ensure that all individuals receive a basic ration. The program is principally organized around collectives, which have the first level of responsibility for the welfare of individual members, including their basic ration. The collectives either sell grain to the National Food Ministry or pay taxes based on their production. For those provinces which have a grain deficit, the National Food Ministry becomes the source of supply, using the grain collected from the collectives. China's system lacks much of the flexibility of market based systems, but it has, at the same time, put an end to large-scale famines.

Malnutrition and Its Extent

A Presidential Commission concluded in 1981 that "the true hunger problem of our time is chronic undernutrition--the problem of millions of men, women and children who do not get enough to eat" (25).

Estimates of the numbers of malnourished vary substantially. In 1976 the World Bank estimated that from 800 to more than 1 billion people were undernourished. FAO, on the other hand, in 1977 put the number at 455 million. More recently Thomas Poleman of Cornell University derived a maximum of 309 million "vulnerable people at risk" of malnutrition in the developing countries. The reasons for these varied estimates are several. They include different methodologies for estimating the numbers affected by malnutrition, underreporting of food production in the developing countries, and using simple averages of food consumed and caloric needs while ignoring individual variation in nutritional requirements within a population.

The validity of some malnutrition estimates disappears when other statistics are consulted. For instance, a recent reexamination of hunger in Bangladesh, Indonesia, and Sri Lanka

using survey data concluded that the food deficits in these countries were seriously overestimated. 5/

Nevertheless, substantial undernutrition exists in certain regions, sometimes extending beyond mere malnutrition to actual famine. Subsaharan Africa and South Asia stand out here. Famines, however, are a complicated phenomena. Although the physical short supply of food is most commonly identified as the hallmark of famine, there is reason to believe that other factors are much more important. Recent studies (27) indicate that the most recent major famines (for example, the Great Bengal Famine of 1943, or the more recent famines in Bangladesh and Ethiopia) were not brought about by a sudden decline in the physical availability of food, but by sudden increases in food prices or by sudden contractions of real incomes.

Finally, the ramifications of serious malnutrition and, especially, famine extend beyond a simple increase in the death rate of a country. For the survivors, there may be permanent physical and mental damage. Political casualties, such as the fall of Haile Selassie's government in Ethiopia after 47 years in power, resulted in part from unrest caused by a drought-induced famine that killed an estimated 200,000 people (28).

FOOD TRADE

The unequal pattern of food supply and demand among countries and regions, the rapid growth of incomes worldwide, and the expansion of populations in developing countries have made agricultural trade increasingly important. During 1950-80 agricultural trade grew at the impressive rate of 5 percent per year.

In the case of grains, the most important food trade item, world shipments increased 3.2 percent per year in the 1960's and 7.2 percent annually in the 1970's. The dramatic increase during the latter period was caused by the sudden surge in import demand by the Soviet Union and Eastern Europe. The increased demand was a consequence of both domestic production shortfalls and the adoption of policies favoring increased consumption of livestock products. It was also due to an increase in the demand for food aid by the drought-stricken countries of the Sahel region in Africa and to crop failures in some Asian countries.

Even more dramatic were the increases in the volume of trade during the past 20 years for soybeans and for oilcake and meal which increased 14 percent and 9 percent, respectively, per

5/ The FAO estimates overstate food deficits by 147 percent in Bangladesh, 46 percent in Indonesia, and 653 percent in Sri Lanka. Similarly, the degree of undernutrition is overestimated by 129 percent in Bangladesh and 20 percent in Indonesia. Although it is difficult to generalize from these three countries to the world, adjusting previous estimates of undernutrition and food needs by some percentage based on the estimates from household survey data would give significant reduction in the level and incidence of world hunger (14).

year. Both increases reflected a strong demand for livestock feeding livestock in response to rising incomes and standards of living.

Trading patterns have also undergone great changes. Before World War II, Western Europe was the only significant importer of agricultural products, with 20 percent of their imports coming from North America. South America was the largest exporter, followed by North America, Eastern Europe, Oceania, and Asia. By 1950, North America had become the chief exporter, supplying 85 percent of the world's net grain exports. By the mid-1970's, the former exporting regions of Latin America, Eastern Europe, Africa, and Asia had become large importers. Today, six countries--the United States, Canada, Argentina, Australia, South Africa, and Thailand--supply over 99 percent of world net grain (table 10).

The net grain exports from North America grew from 22 million metric tons in 1950 to 136 million tons in 1981, in Oceania from 3 to 13 million tons, and in South Africa from 0 to 4 million tons. The biggest grain deficit, translated into net imports, occurred in Asia where imports grew from 6 to 65 million tons, and in Africa, where they expanded from a negligible quantity to 24 million tons. Eastern Europe and the Soviet Union were able to meet their grain requirements until the early 1970's, but by 1981 their combined grain imports jumped to 53 million tons. Western Europe's imports of grains remained remarkably steady until about 1970, and then began to decrease rather rapidly,

Table 10--Changing pattern of world net grain trade

Region	1934-38	1948-52	1960	1970	1980	1981
			Million metric tons			
North America 1/	5	22	36	54	133	136
Central & South America	9	2	2	4	-15	-4
Western Europe	-24	-22	-25	-22	-11	-4
Eastern Europe	5	0	-7	-6	-14	-12
USSR	1	2	6	4	-29	-41
Africa 2/	1	0	-2	-5	-21	-24
South Africa	0	0	1	1	3	4
Asia	2	-6	-13	-37	-64	-65
Oceania 3/	3	3	4	8	19	13

1/ United States and Canada.
2/ Excludes South Africa.
3/ Australia and New Zealand.

Source: Food and Agriculture Organization of the United Nations, Trade Yearbook, several issues.

partly because of the impact of the EC's Common Agricultural Policy.

North America will continue to dominate world grain exports, with Australia and, to a lesser extent, South Africa, Argentina, and Thailand playing lesser roles. As for grain imports, two-thirds of the volume will be absorbed by developing countries and one-third by the Soviet Union and Eastern Europe. However, if the balance-of-payments outlook for the developing countries fails to improve, the demand for food aid in the developing countries is likely to remain strong or increase.

The last point becomes particularly apparent from the examination of the statistics for total agricultural trade. While reliable data for such trade in the developed regions is available back to the 1930's, that for the developing countries extends back only a little more than a decade. They show that the generally positive balance of agricultural trade for the developing countries of $32.9 billion 1969-71 (in 1980 constant prices) dwindled to less than $3 billion in 1979-81 (table 11). (The developing countries actually experienced a net agricultural trade deficit in 1981.) Latin America and Oceania continue to maintain their positions as net exporters of agricultural products, maintaining the same levels in value terms as a decade ago. In contrast, net agricultural exports from North America expanded during the 1970's at a rate of nearly 25 percent per year. Of the other principal regions, net agricultural imports of Western Europe remain rather steady at a high level, while those of the Soviet Union and Eastern Europe continue to expand at an annual rate of over 10 percent. Asia, the Soviet Union, Eastern Europe, and Africa are likely to continue to be expanding markets for agricultural products.

FOOD AID

The gap between food needs and food production in a given country may be filled by imports from those countries that have surpluses. With the ability to pay for such imports limited by the availability of foreign exchange or credit, food aid has been a necessity to bridge much of the gap.

The U.S. experience in providing food aid is one that extends back through most of the 20th century. Over the 1914-24 period the United States donated 34 million metric tons of food, valued at $5.2 billion, to 23 countries.

The more recent post-World War II experience has centered around the P.L. 480 program. The program began in 1954 and at the outset was principally aimed at providing a means for disposal of surplus farm commodities. The emphasis of the program has shifted over the years to encompass many other objectives.

In terms of the overall U.S. food aid commitment, the P.L. 480 program serves as the U.S. commitment to meet its obligation as a signatory to the Food Aid Convention of the International Wheat Agreement. The other major source of U.S. food aid is channelled through the World Food Program, which is jointly sponsored by the United Nations and FAO. Recent (in 1981 and

Table 11--Agricultural trade by regions in nominal and constant dollars

Region and trade position	Nominal dollars			Constant dollars 1/		
	1969-71	1974-76	1979-81	1969-71	1974-76	1979-81
	Billion Dollars					
North America: 2/						
Exports	8.9	27.2	66.9	31.8	46.1	66.9
Imports	7.9	14.1	34.2	28.2	23.9	34.2
Net trade	1.0	13.1	32.7	3.6	22.2	32.7
Latin America: 3/						
Exports	7.4	17.0	34.3	26.4	28.8	34.3
Imports	1.8	6.2	15.5	6.4	10.5	15.5
Net trade	5.6	10.8	18.3	20.0	18.3	18.8
Western Europe:						
Exports	17.4	39.8	106.6	62.1	67.5	106.6
Imports	28.0	63.1	142.1	100.0	106.9	142.1
Net trade	-10.6	-23.3	-35.5	-37.9	-39.4	-35.5
Eastern Europe: 4/						
Exports	1.9	4.2	7.9	6.8	7.1	7.9
Imports	2.8	6.9	12.0	10.0	11.7	12.0
Net trade	-.9	-2.7	-4.1	-3.2	-4.6	-4.1
USSR:						
Exports	1.6	2.4	5.6	5.7	4.1	5.6
Imports	2.3	8.0	18.4	8.2	13.6	18.4
Net trade	-.7	-5.6	-12.8	-2.5	-9.5	-12.8
Africa: 5/						
Exports	5.2	8.1	12.5	18.6	13.7	12.5
Imports	1.9	6.6	15.3	6.8	11.2	15.3
Net trade	3.3	1.5	-2.8	11.8	2.5	-2.8
South Africa:						
Exports	.6	1.4	2.5	2.1	2.4	2.5
Imports	.3	.5	.9	1.1	.8	.9
Net trade	.3	.9	1.6	1.0	1.6	1.6
Japan:						
Exports	.4	.3	.9	1.5	.5	.9
Imports	4.0	11.1	17.6	15.4	19.8	17.6
Net trade	-3.6	-10.8	-16.7	-13.9	-19.3	-16.7
China:						
Exports	1.0	2.5	3.3	3.8	4.5	3.3
Imports	.8	2.7	7.3	3.1	4.8	7.3
Net trade	.2	-.2	-4.0	.7	-.3	-4.0

See footnotes at end of table.

--Continued

Table 11--Agricultural trade by regions in nominal and constant dollars--Continued

Region and trade position	Nominal dollars			Constant dollars 1/		
	1969-71	1974-76	1979-81	1969-71	1974-76	1979-81
	Billion Dollars					
Asia: 6/						
Exports	5.6	13.8	38.0	19.7	21.8	35.0
Imports	5.6	16.0	51.2	18.6	25.9	51.2
Net trade	0	-.3	-13.2	1.1	-4.1	-16.2
Oceania:						
Exports	3.4	7.3	13.7	12.1	12.4	13.7
Imports	.5	1.1	2.8	1.8	1.9	2.8
Net trade	2.9	6.2	10.9	10.3	10.5	10.9
Developed regions:						
Exports	30.7	76.0	199.6	111.2	128.9	190.6
Imports	40.7	89.9	197.6	147.5	153.3	197.6
Net trade	-10.0	-13.9	2.0	-36.3	-24.4	7.0
Eastern Europe & USSR:						
Exports	3.5	6.6	13.5	12.5	11.2	13.5
Imports	5.1	14.9	30.4	18.2	25.3	30.4
Net trade	-1.6	-8.3	-16.9	-5.7	-14.1	-16.9
Developing regions: 7/						
Exports	18.2	38.1	84.8	64.7	64.3	84.8
Imports	9.3	28.8	82.0	31.8	47.6	82.0
Net trade	8.9	9.3	2.8	32.9	16.7	2.8

1/ Deflated by the International Monetary Fund's Index of World Export Unit Values.
2/ The United States and Canada.
3/ Central and South America and Caribbean Islands.
4/ Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania.
5/ Excludes South Africa.
6/ Includes the Middle East, but excludes China and Japan.
7/ Excludes China.

Source: Food and Agriculture Organization of the United Nations, Trade Yearbook and International Monetary Fund, International Financial Statistics, various issues.

1982) U.S. pledges have been $220 million per year, with this aid broken down into $165 million for commodities, $50 million for ocean transport, and $5 million for administrative costs. Actual expenditures have been less than commitments recently.

To place U.S. food aid in perspective, total official development assistance (ODA) from the OECD 6/ countries increased from $5.7 billion in 1975 to $9.3 billion in 1980, with the largest part moving to the low-income countries of Africa and the Middle East. In real terms, however, this meant that development assistance increased only from $5.7 billion to $6 billion (both measured in 1975 dollars). Moreover, the food aid component of the total aid package remained about constant in nominal dollar terms.

Table 12 gives a summary of the volume of food aid contributions, broken down by both principal commodities and donor countries. In volume terms, U.S. food aid of grains has declined for six years. In absolute amounts, however, U.S. food aid still represents more than half of the world total of food aid.

The outlook for the near future--given no unforeseen major policy changes in the developed countries--is that food aid budgets will remain near the 1977/78 levels. Thus the actual amount of food shipped under these programs is likely to be heavily dependent on market prices.

On the other side, as seen by the countries requiring food aid, the need for it in 1983/84 will continue to be at moderate to severe levels. The World Food Aid Needs and Availabilities, 1983 (ERS, 1983) reports that merely to maintain consumption at 1979-82 average levels, cereal food aid needs for low-income countries are forecast at just over 12 million tons. This represents a 5 percent increase over the 1982/83 levels.

Calculating food aid needs on the basis of a minimally prescribed level gives a much higher food aid need of nearly 33 million tons. Thus the actual amount of cereal food aid likely to be shipped from developed countries in 1983/84 (table 12) is not likely to reach the figure necessary to maintain levels of consumption at the 1979-82 averages, much less bring them up to the minimally prescribed levels.

FUTURE TRENDS

Population

The fall in the population growth rates that occurred in the late 1970's should continue as economic development proceeds in the developing world. This would result in a world population of 5.27 billion people by 1990, an increase of 830 million since 1980. There is a remarkable certainty about future world and regional population projections--especially those which project only to 1990--because of the length of time usually necessary for major changes in population growth rates to work themselves out (table 13).

For the developed countries and the centrally planned countries, both birth rates and the rates of overall population increase are not expected to change in a major way. Birth rates however remain significantly above replacement rates in virtually every country of the developing world. While birth rates for most of these countries will probably decline over the next decade, it

6/ Organisation for Economic Co-operation and Development.

Table 12--Volume of food aid contributions, principal commodities

Commodity/country	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	Estimated allocations 1/ 1982/83 2/	Estimated allocations 1/ 1983/84 2/
				1,000 metric tons					
Grains	7,121	10,893	3/10,887	3/10,817	3/9,197	9,338	8,780	8,847	8,915
Argentina	0	15	32	30	38	67	20	47	45
Australia	261	230	252	329	315	370	485	450	450
Canada	1,034	1,176	884	735	730	600	600	764	675
European Community 4/	928	1,131	1,394	1,159	1,205	1,263	1,449	1,650	1,650
Finland	25	33	47	9	19	29	20	20	20
Japan	33	46	135	352	688	893	494	400	450
Norway	10	10	10	10	11	40	39	40	40
Sweden	47	122	104	104	98	94	119	80	100
Switzerland	36	33	32	32	32	16	22	43	35
United States	4,637	7,940	7,663	7,552	5,649	5,631	5,087	5,000	5,050
Other	199	157	354	505	412	324	445	353	400
Vegetable oils									
United States	217	176	366	157	230	265	267	NA	NA
Other	103	63	53	80	26	62	NA	NA	NA
Milk and products	172	204	249	251	301	334	NA	NA	NA
United States	26	55	67	64	58	85	75	NA	NA
Other	146	149	182	187	243	249	NA	NA	NA

NA = Not available.

1/ Figures relate to allocations for the budgetary period of each country.
2/ Projections based on historical patterns and current food aid policies.
3/ In addition, according to unofficial reports, the USSR provided several Asian countries with 200,000 tons each in 1977/78 and 1979/80 and 400,000 tons each in 1978/79, as emergency aid.
4/ Aid from individual EC countries as well as from the entire commission of the European Community.

Source: U.S. Department of Agriculture, World Food Aid Needs and Availabilities, 1983.

Table 13--Regional and world population

Region	1960	1970	1980	1990
		Million		
United States	181	205	228	250
Other developed countries	451	498	537	569
Eastern Europe & USSR	331	368	400	431
China	647	814	977	1,114
Latin America	216	284	363	450
Subsaharan Africa	204	265	351	476
North Africa & Middle East	134	174	231	301
Asia	853	1,078	1,354	1,680
World	3,017	3,687	4,440	5,271

Source: U.S. Bureau of the Census and USDA unpublished estimates.

is by no means a certainty. In fact, the major source of uncertainty for projections of the population growth for the developing regions and the world lie in the birth rates of the developing regions, especially the birth rates of Latin America, South Asia, and Subsaharan Africa. Whether some of the initial family planning successes in selected countries of the first two of these regions can be repeated in the developing countries is a major uncertainty.

Income

The current global recession, with accompanying reduced or even negative rates of income growth, has contributed greatly to a reduced demand for agricultural products. With world economic activity improving in 1983, and with the projected upturn in 1984, the current weak world demand for food should strengthen.

However, while a recovery is underway--in the United States and in many other countries--it is still unclear how strong that recovery will be. Because of the changes that occurred in world agricultural trade in the 1960's and 1970's, a return to strong economic growth in the developing countries is probably necessary for a resumption in steady growth in U.S. export demand for agricultural products. The growth rates shown in table 14 for the 1980's reflect recent changes--generally unfavorable--in such factors as external debt. For example, the expected growth rate for Mexico for the 1980's was estimated only a few months ago to be 6.5 percent. With medium-term growth prospects for other developed countries mixed, and with little change expected for the centrally planned countries, the developing countries will retain their importance as a major source of future export demand for U.S. farm products.

Table 14--Real GNP growth in the developing world

Country/Region	1982	Estimated 1983	Likely 1980's
		Percent	
Latin America:			
Mexico	-0.7	-2.5	4.5
Central America & Caribbean	2.0	3.0	4.0
Brazil	0	-5.0	5.6
Argentina	-5.7	0	4.0
Other Latin America	2.0	1.0	4.5
Africa & Middle East:			
Subsaharan Africa	2.0	2.0	2.1
North Africa & Middle East—			
High income	1.5	2.0	4.0
Low income	5.6	6.2	7.0
Asia:			
India	4.0	4.0	4.0
Other South Asia	4.9	4.3	4.3
Indonesia	5.0	5.5	6.5
South East Asia	6.5	6.5	6.5
East Asia	7.5	5.0	7.5
Other Asia	3.0	3.0	3.0

Source: USDA unpublished estimates.

Resource Availability and Technology

Agricultural resource availability is a regional problem rather than a global one, although expansion of cropland area has slowed. Still almost as much suitable land remains to be exploited as is now being used. Although land is a critical factor of production, it is not the only one. In the longer run it is the availability of land, in conjunction with factors such as water, irrigation, infrastructure, fertilizer, and improved crop and animal varieties that will determine food production.

In the shorter run, however, the shortage of agricultural land and water in some regions will constrain production increases. For instance, given the present population, per capita income and the state of technology, the Sahel region of Africa, North Africa, a part of the Middle East, Mongolia, parts of China, parts of South Asia, and the Caribbean Islands cannot increase production as fast as their natural population increases.

While natural resources are adequate in Latin America, Subsaharan Africa, and some countries of the Far East, the necessary infrastructure and technology are presently

insufficient for a more rapid increase in food production. Also, many developing countries pursue policies that provide cheap food to the urban consumer at the expense of farmers. Such policies in many countries of Africa force farmers out of commercial agriculture into subsistence agriculture, thus depressing food production.

Increased world food production, and specifically food production in developing countries, depends on technological progress. The large gaps that exist among crop yields in countries with different levels of input-intensive technology, as well as the gaps between yields under experimental and farm conditions in most countries, indicate that existing technology and scientific knowledge offer a great potential for further increases in crop productivity. Technological progress, however requires investment in agricultural research on a continuing basis since no one development by itself is sufficient to make a significant contribution to expanding food production. The supply of food at the end of this century depends, to a very large extent, on the investments in research that will be made in the next few years (18).

IMPLICATIONS FOR U.S. DEVELOPMENT ASSISTANCE

In the short run, many developing countries will continue to be unable to maintain current levels of per capita food consumption from domestic production and commercial imports, creating a continuing need for concessional food aid. Over the long term, both maintaining food consumption in developing countries at existing per capita levels or increasing it to nutritionally adequate levels will require substantial increases in agricultural production by the developing countries themselves. Subsaharan Africa and South Asia face the most difficulties in increasing food production. A balance will need to be struck in each country between the appropriate level of self-sufficiency in food production and the realities of comparative advantage. Some countries will find it easier to produce their own food because of a favorable agricultural resource endowment, while others will likely lean towards the production of nonagricultural commodities to gain the means for financing food imports. This review of the world food situation suggests certain things about the requirements for achieving higher levels of food consumption in the developing countries:

1. Physical resource availability (with the exception of a few countries) is sufficient to bring about such increases.

2. The development, adaptation, and adoption of appropriate technologies will be the critical factor in achieving increased food production.

3. The adoption of appropriate agricultural policies, particularly price policies, that provide incentives to farmers is crucial to increasing food production.

4. Most of the investment needed to achieve increased production will have to be generated within the developing countries themselves. This implies the need for sustained

economic growth within these countries to generate the necessary savings and investment.

5. Many of the most critical elements in increasing agricultural production will need to be imported from the developed world. The bulk of such imports can only be financed by the export earnings of the developing countries themselves. This implies access to world markets for the exports of developing countries, including agricultural products, because of the high proportion of overall economic activity that agriculture represents in most developing countries.

6. The developing countries are unlikely to be able to finance all of the imports needed to support both their general economic and agricultural development efforts from their own resources. Foreign economic assistance can play a role in meeting the needs for key inputs.

7. Merely increasing agricultural production in the developing countries is not sufficient in itself to bring about widespread improvement in nutrition in the developing countries. The absence of sufficient income to pay for an adequate diet is the major source of hunger. Thus, economic growth and more widely distributed income are essential to bringing about more adequate diets. In many developing countries, because of the large size of rural populations, expanded agricultural production can make a major contribution to growth of income.

These considerations raise certain issues with respect to U.S. foreign assistance policy:

1. Does improved nutrition in developing countries contribute to U.S. security and, if so, what is the appropriate level of U.S. assistance to developing country agriculture, both in absolute levels and as a proportion of total U.S. economic assistance?

2. The importance of developing countries' agricultural policies in providing incentives to their farmers raises this question: To what extent should U.S. economic assistance to agriculture should be made contingent upon the adoption of agricultural policies that provide appropriate incentive to farmers?

3. U.S. economic assistance policy will become increasingly concerned with technological priorities. Thus, consideration will need to be given to the relative importance that should be attached to the support in developing countries of agricultural research, the development of systems for disseminating technology to the farm level and agricultural education, including both onfarm technical needs and training of agricultural scientists and technicians.

4. The need to adapt technologies to the requirements of specific geographic regions suggests that attention will need to be given to the role of international research institutions and the level of U.S. support for them. The requirements of transferring technology raises the question of how to best maintain and draw upon available agricultural expertise in the developed countries such as that possessed by the USDA-Land Grant institutions.

5. The increasing importance of international lending institutions in the field of agriculture in recent years raises the question of how to coordinate their efforts with U.S. economic assistance policy.

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