AN OVERVIEW OF WORLD POPULATION, FOOD SUPPLY AND AGRICULTURAL TRADE

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The Problem

Man uses about 11 billion acres of land for agricultural activities. Roughly 7.2 billion acres are used for grazing and nomadic herding. It is on the remaining 3.8 billion acres, which is devoted to crop production, that the real job of feeding our population is accomplished. Coincidentally, the population of the earth is currently about 3.8 billion which means that there is but one acre of crop land available per person. How big is an acre? A football field is almost exactly an acre. A big chunk of grass if you have to mow it on a hot Saturday in August, but not very big when you think that it has to provide you with the bulk of your food and a significant part of your clothing. The population of the world is expanding at a rate of about 2 percent per year. Not so alarming you say, but translated into people that means an additional 76 million per year. If the crop land available in the world remains constant and the population grows at 2 percent each year, the land available per person is reduced by 10 percent in five years. In short, we would be playing the game of feeding ourselves on a field that is 90 yards long instead of 100. The full implication of expanding population becomes evident if you extend the projections forward two or three decades -- our football field is not only far below regulation size, it becomes too cramped for a good game.

Is there new agricultural land which can be brought into food production? Yes, but unfortunately it is not located in the population hot spots. The combined populations of Mainland China, India, Pakistan and Indonesia account for more than half of the world total. In each of these nations there is less than half an acre of crop land available per person, and little opportunity to bring new land into cultivation. They have no cushion of range land and meadows to bring under the plow as would be the case if the United States were

pressed for food grain. Today's political realities dictate that the open spaces of Australia, Brazil or Central Africa are simply not available to these crowded people.

We might then ask the question: Can't the rich nations produce food and export it to their needy brethren? In my judgment if the problem of hunger and malnourishment confronting the over-populated, low-income nations is to be solved, it will be accomplished in their own rice paddies and wheat fields. Currently, imports account for only 5.2 percent of food grain consumption in the less developed countries (LDCs). The internal transportation and distribution facilities for ship-to-mouth living are inadequate in most developing nations. Any significant increase in food imports by these nations will depress prices and dampen the incentive for increased domestic production. Developing nations have pride. Many have been striving to gain a national identity and working to shed the stigma of colonialism. They do not wish to be dependent upon an outside source for their most fundamental need -- food. Finally, as an economist, I must ask the blunt but penetrating question: Who will pay for food transfers of this magnitude? A desire to eat more is not the same as effective demand.

You might ask: Why can't these nations feed themselves? Why is their situation any different than it was for any of today's industrial nations when they were in a similar stage of economic development? These are legitimate questions and it seems to me there are two very valid answers. First, the nations which have reached a higher plateau of living had the escape valve of extra land to spread out into. Canada and the United States had a vast heartland to develop, Australia had its "Outback," and the Soviet Union is still expanding under its new lands program. Europe had the same sort of escape valve. It exported its excess population to the Americas, Australia, and

Africa. The U. S. received its waves of immigrants from England, Ireland, the Scandinavian countries, Germany, Poland, and Italy. Many of the immigrants were farmers, and used their combined talents and exchanged ideas to open new farmland by pushing westward. Their efforts not only fed the Eastern Seaboard, but provided agricultural exports which earned valuable foreign exchange. Few nations have this option today. A second fundemental difference between the 19th century when the industrial nations of today were "making it," and the struggles of present-day LDCs is that we never confronted population growth rates analogous to those now being experienced by Asia, Latin America and Africa. In many of the developing nations the population is growing twice as fast as it did in the U. S., even when our immigration was at its peak. This puts an enormous burden on the food supply, and the land which produces it.

Historical demography is impossible to substantiate, but there may have been 200 million people on earth at the time of Christ. When the Magna Carta was signed, world population was about 400 million -- twelve centuries to double. At the present time 2.6 billion people live in the developing nations, and approximately 1.2 billion in industrial countries. Demographers expect world population to climb from the present 3.8 billion to 6.8 billion by the year 2000. The population of the poor nations is expected to rise 2.7 billion in the next 27 years, while the wealthy nations will experience an increase of only 300 million.

At the prerent time in large parts of the world, populations may double by the end of the century. This may be puzzling at first, but not if we think about it for a moment. The technology of controlling deaths is acceptable, transferable, and relatively low cost. We can go into a developing nation, spray its malarial swamps with DDT, inoculate its population against communicable diseases, and improve the sanitation of drinking water. Our Judeo-Christian

ethic says that this is "good" and we pride ourself on the humanitarianism of such acts. The recipient nations want to cut infant mortality and increase life expectancy. We can and have reduced the death rate significantly in nearly all of the developing nations. When the United States and Europe were developing, there were no nations higher up the economic and technological scale that could pass along pesticides, medicine and engineering talents to lower the death rate. Our death rates moved down slowly as we developed medical technology. Today the death rate can be pulled down very sharply in one generation. The mores and social attitudes towards a similar reduction in birth rate are much slower in coming. It may take many generations. The result is an inexorable increase in population.

It seems to me we have here an interesting pair of analogies. It is relatively easy to lower the death rate and relatively simple to gain an increasing food supply if new lands are available. The same old farming techniques can be applied on more acres. Farmers do not have to run the risk of untried seed, unfamiliar fertilizers or special equipment. They can merely employ time-tested techniques on an enlarged acreage. The history of United States yield trends bears this out. Crop yields per acre did not increase during the 1800's -- our added food production came from additional farm land. The other similarity lies with the difficulty of increasing yields per acre, and lowering the birth rate. Both require tremendous attitudinal changes; in some cases the whole tapestry of life must be altered. Yes, we have increased yields per acre recently, but with the assistance of the Land Grant Colleges, the Cooperative Extension Service, Government research, and the efforts of large chemical companies and machinery manufacturers. These are not available in India or Indonesia.

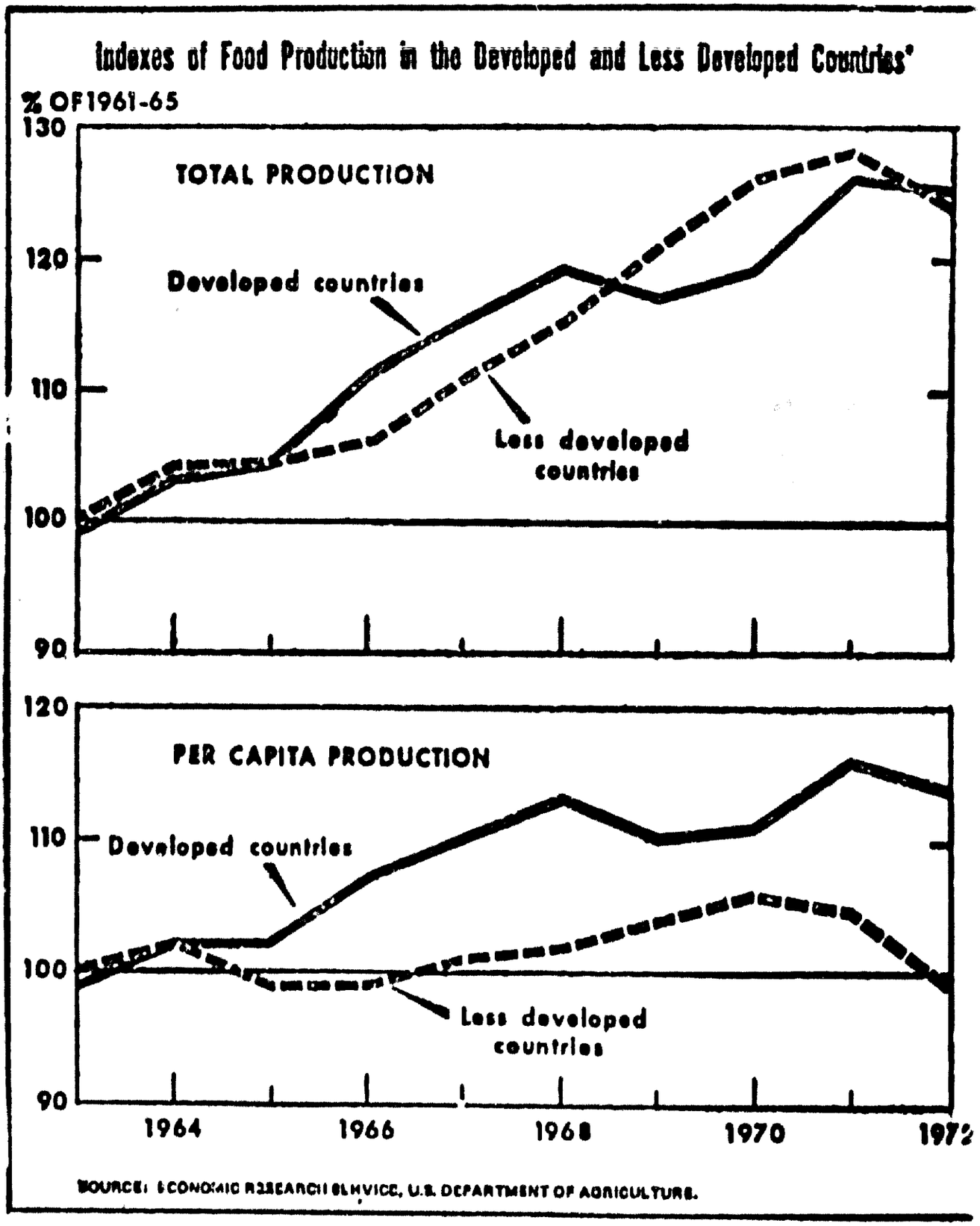
Recent Trends in Food Grain Production

The spotlight is clearly on agriculture today. With soaring domestic prices, embargos on the export of some agricultural products, and the spectrum of severe food shortages in several developing nations, food has taken center stage. Let's put aside for a moment the immediacy of the current agricultural questions, and look at the picture with a longer time horizon.

Figure 1 presents index numbers of total and per capita food production in developed and less developed countries for the period 1963 to 1972. First let's be clear what these index numbers mean. The base period is 1961-1965 and average food production in that period is set equal to 100. Production in other years is expressed as a percentage of the base, hence an index of 110 means that production in that year was ten percent above the base period. The upper part of Figure 1 shows that total food production in the developed and less developed nations has grown at about the same rate in recent years. In both groups of nations we see that 1972 production was roughly 25 percent higher than in the base period. This was a remarkable accomplishment for the low-income nations which have limited land, a shortage of adapted technology, and insufficient funds to purchase inputs such as fertilizer and agricultural chemicals.

The upward trend in output of low-income countries averaged about 2.5 percent per year over the decade. This level of achievement was never attained by the industrial nations at a similar stage of economic development. Increased food production was realized in distinctly different ways in the two groups of nations. Crop acreage in the industrial nations declined slightly over the time period, hence all the rise in production is attributable to rising yields per acre. Virtually all of the growth in agricultural output in the LDCs from the Korean War through 1967 derived from bringing new land under the plow. Since 1967 several developing nations experienced a yield take off

Figure 1.


Indexes of Food Production in the Developed and Less Developed Countries*
% OF 1961-65
130
120
110
100
90
TOTAL PRODUCTION
Developed countries
Less developed countries
120
110
100
90
PER CAPITA PRODUCTION
Developed countries
Less developed countries
1964
1966
1968
1970
1972
SOURCE: ECONOMIC RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE.

coincident with the adoption of new high yielding varieties of wheat and rice. The sharp rise in LDC food production between 1967 and 1972 is primarily attributable to the fact that approximately 50 million acres of Asian land were planted to the new seeds.

The increases in food production achieved by developing nations over the past decade were almost completely obliterated by population growth. The lower portion of Figure 1 indicates that the LDCs experienced a very modest increase in per capita food production through 1970. Per capita food production fell in 1971, and dropped abruptly in the poor crop year of 1972. Of course when all developing nations are lumped together, significant differences in the performance of sub-areas is masked. Per capita food production in Latin America has increased steadily, if modestly, over the past decade. Food production per capita in Africa has trended slowly downward. Asian food production has been erratic, probably because it is more often influenced by adverse weather than other areas. The available data does indicate the strong positive influence of the new rice and wheat seeds in Asia. We may conclude that per capita food production in the LDCs as a whole has barely kept pace with population growth. Of course these statistics represent only domestic production. Production shortfalls in the poor nations have been significantly augmented by imports. This was particularly true when massive food transfers from the United States breeched a part of the food gap brought about by the widespread drought in Asia during the mid-1960's. It is also true that this data pertains primarily to calories. In the judgment of most observers, there has been little or no improvement in the quality of diet in the LDCs. Increasing the availability of protein, vitamins, and minerals presents a very formidable problem. Upgrading the level of nutrition through increased production of livestock products, fruits, and vegetables is difficult, for these

foods require resources of land and technology which in many cases are not available.

We are certainly all aware that food production in 1972 was substantially below the record level of a year earlier. It is estimated that world grain production fell by 42 million metric tons. The main reason for the decline was an extraordinary coincidence of poor weather. The monsoon came late to India pulling her production down by nearly nine million metric tons. The Soviet wheat crop was off by 20 million metric tons as the result of heavy winter kill, and a dry hot growing season for spring sown grains. Indonesian rice production was cut by drought, while the Philippine Islands were ravaged by floods. Among the industrial nations, Australia and the United States saw food production fall as a result of bad weather. Usually when one part of the world experiences a bad growing season, climatic conditions are good elsewhere. It is probable that at no time in the past century have as many total acres been adversely affected by weather.

Hard data is not yet available, but it seems certain that 1973 will be only slightly better than 1972. This makes for a serious situation, since world grain stocks have been pulled down to bare pipeline levels in most exporting nations. (See Table 1.)

1973 wheat stocks are the lowest in two decades. They constitute only 6.5 percent of production, as compared with approximately 10-25 percent during the decade of the 1960's. U. S. stocks in the past year were pulled down by over 11 million metric tons. It will take several years to restore stocks to an adequate level of approximately 40-50 million metric tons. While these stocks are being built up, the world food grain situation will be precarious. Despite this, I think that when appraising the current food situation, many have been overly pessimistic. There was a similar wave of hand-wringing in

Table 1. WHEAT: WORLD AND UNITED STATES PRODUCTION AND STOCKS, 1950-1973

Year	World Production 1/	World Stocks 1/	World Stocks as a % of World Production	US Production 2/	US Production as a % of World Production	US Stocks 1/	US Stocks as a % of World Stocks
	Million Metric Tons			Million Metric Tons		Million Metric Tons	
1950	172.2	16.2	9.4%	27.8	16.1%	11.6	71.6%
1951	176.2	17.0	9.2%	26.9	15.3%	10.8	63.5%
1952	201.6	13.5	6.7%	35.6	17.7%	7.0	51.9%
1953	201.1	28.4	14.1%	32.0	15.9%	15.3	53.9%
1954	191.4	44.0	22.9%	26.8	14.0%	24.6	55.9%
1955	201.6	45.8	22.7%	25.5	12.6%	28.0	61.1%
1956	212.3	47.4	22.3%	27.4	12.9%	28.2	59.5%
1957	208.3	47.8	22.9%	26.0	12.5%	24.8	51.9%
1958	237.1	43.8	18.5%	39.7	16.7%	24.0	54.8%
1959	221.9	53.9	24.3%	30.5	13.7%	35.3	65.5%
1960	222.3	53.8	23.2%	36.9	16.6%	35.8	66.5%
1961	214.7	54.3	25.3%	33.6	15.6%	38.5	70.9%
1962	238.7	48.0	20.1%	29.8	12.5%	36.0	75.0%
1963	227.4	47.2	20.7%	31.3	13.8%	32.6	69.1%
1964	253.4	41.0	16.2%	35.0	13.8%	24.6	60.0%
1965	245.4	36.9	15.0%	35.9	14.6%	22.3	60.4%
1966	280.0	30.1	10.8%	35.7	12.8%	14.6	48.5%
1967	277.6	30.1	10.8%	41.5	14.9%	11.6	38.5%
1968	308.4	35.5	11.5%	42.9	13.9%	14.7	41.4%
1969	288.4	53.1	18.4%	39.8	13.8%	22.3	42.0%
1970	288.3	59.6	20.7%	37.3	12.9%	24.1	40.4%
1971	322.6	44.1	13.7%	44.1	13.7%	19.9	45.1%
1972	307.5	41.5	13.5%	42.1	13.7%	23.5	56.6%
1973 3/	343.6 4/	22.5	6.5%	47.7	13.7%	11.7	52.0%

1/ Source: Calculated from various issues of USDA, Economic Research Service, Wheat Situation. 1973 World production figure from USDA, Foreign Agricultural Service, World Agricultural Production and Trade, Statistical Report, September, 1973, p. 20. 2/ Source: Agricultural Statistics, 1972, Table 1. Figures for 1970-73 are calculated from Wheat Situation, August, 1973, Table 13. 3/ Preliminary. 4/ 1973 Soviet Wheat production may be over-stated relative to previous years due to a change in method of reporting.

the mid-1960s when production in the LDCs fell drastically. United States farmers were encouraged to gear up and "feed the world." This we did, and large quantities of grains were transferred to India, Pakistan and other needy nations. When good weather returned to East and South Asia, less of our concessional grains were desired and soon the government found itself in possession of mounting surpluses. Agricultural policies in the United States and Canada were readjusted to restrict grain acreage.

When per capita food production in the LDCs is bumping along at a level near subsistence, then any shortfall in production caused by weather or other circumstances is serious. The United States must recognize its role as residual supplier of world grain requirements, and keep its agricultural programs flexible to accommodate the ebb and flow of grain production in the LDCs and the Communist block nations.

Estimates of Future Production and Requirements of Food Grain

Economists and agriculturists have used historical data, examined current developments, and used computors to project the world food production, consumption and trade in the 1980s. Table 2 presents the most current estimates of the United States Department of Agriculture.[1/] The results provide some insights and give us some guidelines concerning the future. Several critical assumptions relating to these projections are worth noting. For the developing nations, allowance was made for the population increases cited earlier. It was assumed that per capita consumption of grains in LDCs would increase about 4.5 percent between 1969-71 and 1980. This compares with assumed increases of 7.9 percent in the developed countries and 12.5 percent in the

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1/ The author wishes to acknowledge the considerable assistance of Dr. Dana G. Dalrymple of the U.S.D.A. in the preparation of the following appraisal of world grain projections.

Table 2. WORLD PRODUCTION, CONSUMPTION AND NET TRADE OF WHEAT AND TOTAL GRAINS 1964-66 AND 1969-71 WITH PROJECTIONS FOR 1980 1/

Commodity and item	Developed Countries 2/			Central Plan Countries 3/			Developing Countries 4/			World		
	1964-1966	1969-1971	1980	1964-1966	1969-1971	1980	1964-1966	1969-1971	1980	1964-1966	1969-1971	1980
	Million metric tons											
Wheat												
Production	109.1	112.2	130.8	122.8	142.7	176.3	47.2	63.0	91.1	279.1	317.9	398.2
Consumption	78.7	87.8	96.2	136.9	147.1	181.3	66.1	82.7	120.4	281.7	317.6	397.9
Net trade 5/	32.9	29.2	34.3	-14.1	-4.4	-5.0	-17.8	-21.8	-29.3	-1.0	-3.0	0
Total Grains												
Production	346.3	403.3	495.7	350.3	401.0	499.3	248.2	301.0	406.6	944.8	1,105.3	1,401.6 6/
Consumption	328.9	374.2	450.0	364.0	408.6	504.7	263.5	317.3	441.8	956.4	1,100.1	1,396.6
Net trade	29.9	30.1	40.7	-13.7	-7.6	-5.4	-14.0	-17.8	-35.2	0.2	-1.3	0.1

1/ Wheat, coarse grains and milled rice.

2/ Includes United States, Canada, Western Europe, Japan, Australia, New Zealand and South Africa.

3/ Includes Eastern Europe, USSR and the Peoples Republic of China.

4/ Includes rest of world.

5/ Some regions do not balance because of stocks; minus indicates net imports.

6/ 1980 World production exceeds world consumption by five million metric tons. This is reflected by an accumulation of stocks in the developed nations, i.e., their production exceeds domestic consumption and exports by five million metric tons.

Communist nations. In absolute terms, per capita grain consumption in the developing nations would be only 25 percent of the level in the developed countries and one-third of the consumption of Communist block nations.

World production of all grains would increase by about 30 percent between 1969-71 and 1980. Among the grains, production increases would be greatest for wheat followed by coarse grains (corn, oats, barley and grain sorghum). The projections for 1980 indicate that the production of grain in developed nations will significantly exceed domestic needs. The difference will be exported to both Communist and low income countries. Wheat will account for the greatest part of these exports, 34.3 million metric tons out of total exports of 40.7 million metric tons. Compared to the 1969-71 level, total grain exports are expected to climb by 10.6 million metric tons. As noted earlier, the developed nations, mainly the United States, will serve as a reservoir of available grain exports. Production in the developed nations will exceed domestic requirements and exports by about five million metric tons annually. If there are no particularly poor crop years over the next decade, this will allow for a substantial rebuilding of stocks.

When projected grain consumption in the developing nations is compared with projected production, it is seen that a substantial gap of 35.2 million metric tons exists. This breech will have to be filled by imported grains, mainly wheat. If imports fill the projected 1980 deficit, they will account for 8 percent of LDC consumption. In quantity terms, LDC imports will double over the projection period. LDC imports of wheat will be particularly important, accounting for nearly one-fourth of their total wheat consumption by 1980. In dollar terms, the projected LDC grain imports represent a staggering financial burden. At expected prices, this could amount to 2.5 billion dollars yearly. It is a moot question whether poor nations will be able to expend this level of foreign exchange. In my judgment they will not, and if this magnitude of grain transfers between the "have" and "have not" nations is

realized, it will be as a result of concessional sales by the developed nations. If subsidized exports are not available, I feel that consumption of grains in the LDCs will fall significantly below the level projected.

Grain Demands in Communist Block Countries:

The largest unknown in future world grain trade is the posture taken by the Soviet Union. Until recently when poor weather lowered Soviet grain production, they tightened their belts and reduced livestock numbers rather than turning to the world market. Last year the Soviets reversed their policy. They had a substantial grain shortage, but elected to hold livestock numbers constant and imported more than 20 million metric tons of grain. The Soviet Union has a huge grain acreage, and even a reduction of two or three bushels of wheat per acre results in a very substantial drop in total tonnage produced. If the Soviets stick to their policy of increasing domestic livestock production, they may be the most dominant factor in the demand for developed country grain exports and hence the availability of grain for the LDCs. Should the demands of the Soviet Union and LDCs coincide in any single year or sequence of years, we may have a repetition of the 1972-73 situation.

Another factor importantly influencing the availability of grain imports by the free world LDCs, is the action of Mainland China. A grain shortfall in this huge nation of over 850 million people would have important implications, should they elect to increase imports. For many years, Mainland China has asserted its self-sufficiency in grains. This attitude may have changed, for China has made repeated purchases from Canada and Australia in recent years, and in 1973 United States wheat moved to China for the first time in over two decades.

A final factor bearing on the availability of future grain imports by the LDCs is the attitude and demands of the wealthy nations. Baldly put, will the

developed nations release their surplus grains? This question divides itself into two parts: First, will the developed nations give up the grain or will they elect to consume it in the form of increased livestock products? Secondly, will the developed nations be willing to subsidize grain exports to nations unable to pay commercial prices?

Grain Demands in Industrial Countries:

During the 1960s, the world food problem was perceived as a population problem. At the end of each year analysts critically compared rates of growth in food production and population to see if the situation had improved or worsened. During the 1970s, world population will continue to mount, creating a rapid increase in demand for food, but, in addition, rising affluence has emerged as a major claimant on world food resources. At the global level there are now two factors contributing to the demand for food -- population and rising income. We may divide the nations of the world into two consumption categories: those who use nearly all of their grain production directly as human food, and those who convert most of their grain into meat, eggs and dairy products. In the poor nations, annual availability of grain per person averages only about 400 pounds. Nearly all of this small amount is consumed directly to meet minimum energy requirements. In the United States, per capita grain consumption is approaching one ton per year. Only about 150 pounds of this grain is used for direct human consumption. The balance is fed to livestock and poultry. The total quantity of grain consumed directly and as livestock products, continues to rise rapidly as per capita income climbs. The impact of rising wealth on the consumption of livestock products is typified by trends in the United States. Our per capita consumption of beef climbed from 55 pounds in 1940 to 117 pounds in 1972.

Per capita poultry consumption rose from 18 to 51 pounds over the same period. Europe, Great Britain, Scandinavia, Japan and the Soviet Union have a combined population of nearly 800 million people. Future increases in the wealth of these nations will put intense pressure on the demand for grains to be converted into livestock products. We need not prolong the argument. It is possible that rising affluence in the developed nations may cause their internal demand for grains to rise more quickly than the projections indicate. If this is the case, far less grain may be available for export to nations who are struggling for mere subsistence.

Grain Transfers to Developing Countries:

The second proposition forwarded is that developing nations will be unable to pay competitive world prices for grains, and taxpayers in the wealthy nations will be unwilling to subsidize exports. This hypothesis is fortified by the observation that concessional sales to LDCs will reduce commercial exports. These are difficult questions to tackle. As to the assertion that concessional sales will not be funded, little can be said. We may make the observation that even though they are expensive, concessional sales will be worthy to the extent that they contribute to peace and reduce costly military involvement. A myriad of factors bear on the ability and willingness of LDCs to pay hard cash for grains they import. Perhaps the most important of these is the rate of growth in per capita income of the poor nations.

Some experts argue that increased technical aid and concessional food sales by the United States have been the catalyst which spurs economic development and leads to later cash food purchases. There seems to be some basis in theory and perhaps some historical evidence to support this proposition. If the LDCs import grain at concessional prices, they are able to conserve valuable foreign exchange and enhance domestic capital formation. The funds

so conserved may be used to increase domestic industrial production. This provides jobs and stimulates a rise in per capita income.

In low income countries, wage rates are closely tied to food prices. Food imported at concessional prices may dampen an upward spiral in wage rates and, hence keep low an important cost of industrial production. This allows the developing nation to be more competitive in production of labor intensive goods for both domestic use and export. If exports of labor intensive manufactured goods are increased, the developing country can use the funds to import food on a cash basis.

Rising per capita incomes in a developing nation may stimulate imports of food. The higher level of affluence may create a demand for traditional cereal grains beyond what can be produced domestically. Rising levels of income also create a demand for livestock products, fruits and vegetables. Low-income nations suffering from severe land shortages cannot afford to convert food grain acreage into the production of these "luxury" foods. As a group the developed nations have the comparative advantage in producing livestock products and the feed grains they consume. It may then be reasoned that higher levels of living in the low-income countries may create a demand for commercial sales of feedgrains and livestock products from the United States and other developed nations.

In summary the sequence is as follows: Concessional grain sales to a low-income nation can stimulate a rise in its level of living and ability to export industrial goods. The higher standard of living in turn creates a demand for foods which cannot be produced at home. The proceeds of industrial exports may be used to purchase foods from the very nations which initiated the concessional sales.

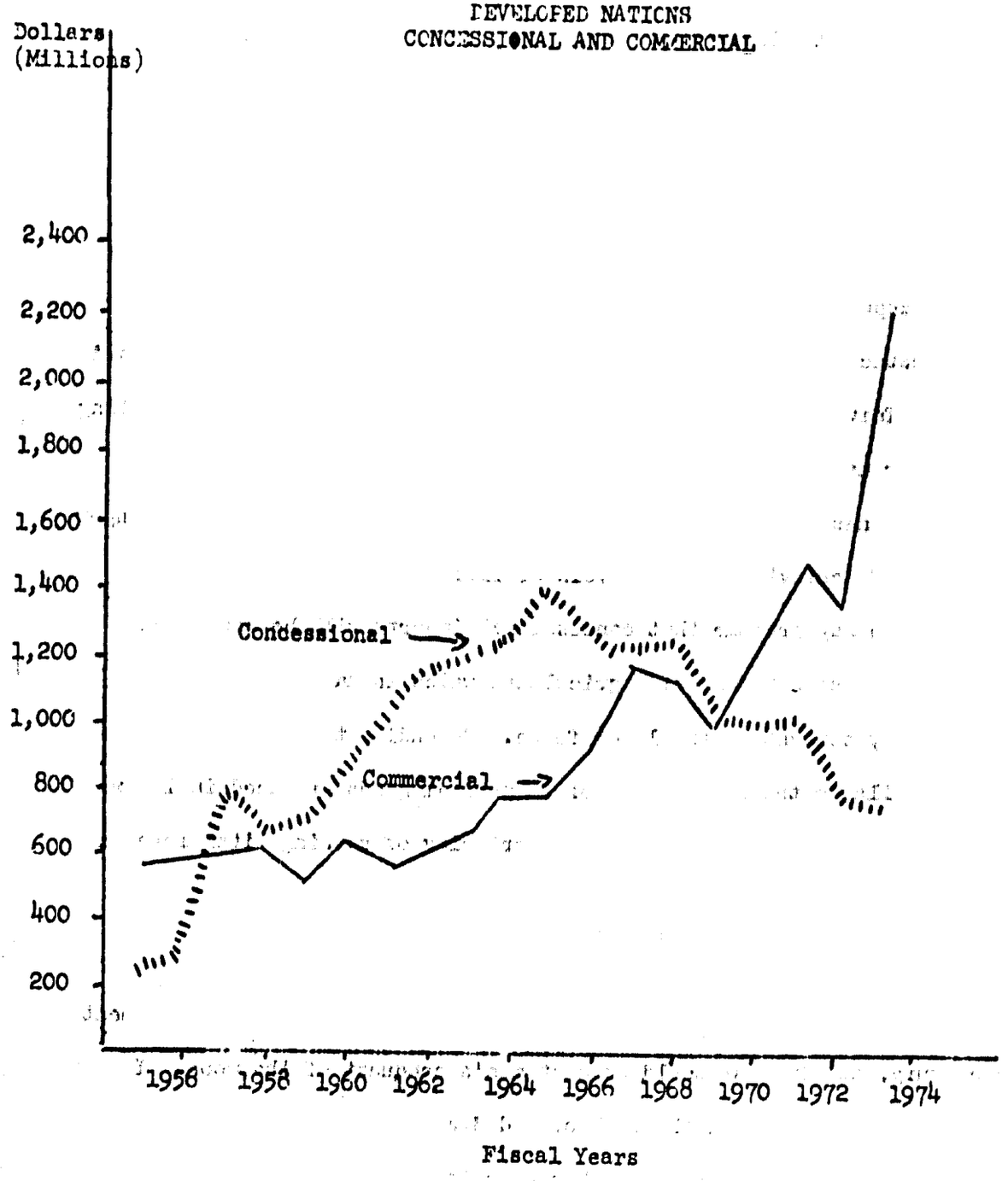
What is the evidence? Since 1965, United States concessional sales to developing nations have dropped substantially while at the same time our commercial food sales to the LDCs have increased sharply. (See Figure 2) Note particularly that between 1970 and 1973 commercial sales to LDCs more than doubled, rising from about $1 billion to over $2 billion. During the same time period, concessional sales declined by approximately $100 million. Nations which appear to have used initial import of concessional grain to stimulate domestic growth and later expand commercial imports from the United States include Taiwan, South Korea, Brazil and Nigeria. It is a very puzzling question whether nations with huge agricultural populations such as India, Pakistan and Indonesia can or should employ this strategy. The inherit danger in this method of achieving higher levels of living is two-fold. First, a developing nation may presume that concessional imports will be continued indefinitely, and neglect domestic agriculture which in many cases employs more than seventy percent of the labor force. Secondly, the wealthy nations may become hostile to the importation of industrial goods produced in low wage rate countries thereby denying them the opportunity of earning vital foreign exchange.

The Green Revolution

If I were to ask you to cite the most significant scientific advancement of this century, surely most would suggest man's conquest of the moon. I would forward as my candidate the work of a dedicated group of plant breeders and agriculturalists who spawned what has come to be known as the Green Revolution. Certainly if your criteria of importance is the number of lives affected, the Green Revolution must rank as science's greatest contribution. The new fertilizer-responsive varieties of rice, wheat and corn have touched the lives of hundreds of millions. Much has been written about the Green Revolution.

Figure 2

VALUE OF U.S. AGRICULTURAL EXPORTS TO LESS DEVELOPED NATIONS CONCESSIONAL AND COMMERCIAL



SOURCE: 1955-1971, U.S.D.A. Economic Research Service, Neg. BN 37846.
1972-73, Calculated from: FATUS, November, 1973, Table 12.

It has been forwarded as the panacea of man's problems, and has been maligned as socially and politically disruptive. Is the Green Revolution a cornucopia or a Pandora's box? No sequence of changes this far-reaching is entirely good or evil, and we do not have time to unravel much of the evidence here. I would like to discuss briefly: the nature of the Green Revolution, its successes, and some potential problems associated with its spread. New varieties of rice and wheat form the vortex of the revolution. Agriculturalists concentrated on improvements in the cereal grains because of their importance in the diet of low income people. In less developed countries approximately 60 percent of man's calories are derived from grains. For thousands of years, and hundreds of generations man has been improving rice by selecting seed from the most desirable parent plants. Hundreds of indigenous varieties were developed to meet local conditions. A typical rice variety grows rapidly to keep its head above the water of the paddy. It has long drooping leaves to shade out competing weeds, and it is relatively resistant to local pests and diseases. When fertilizer is added, particularly nitrogen, the rice plant grows taller and taller, eventually toppling from its own weight. The precious rice is lost in the mud of the paddy. This is called lodging. If a variety is moved very far from its home base, it does poorly; usually because it is sensitive to differences in day length which mark latitudinal changes. What did plant breeders have in mind as they started their quest for improved rice strains? They wanted to combine all of the good characteristics of natural varieties with wide adaptability and the capacity to respond to fertilizer. As a bonus it would be desirable if it had good cooking qualities and flavor, for not all rice cooks or tastes like "Uncle Ben's."

At the International Rice Research Institute in the Philippines, a large bank of rice varieties collected throughout the world had been assembled.

They were catalogued by characteristics, and place of origin. In 1962, an American Plant breeder, Peter Jennings drew on the bank. He placed the pollen of a tall Indonesian variety called Peta on the pistil of a short stiff strawed variety from Taiwan. This short specimen carried the unusual name of Dee-Geo Woo Gen. Jennings planted the seeds from the cross, and multiplied the seeds from the best looking plants which they produced. Hence the birth of the much heralded IR8. In 1965, IR8 was entered in field trials in several Asian countries. It consistently outyielded other varieties often by a factor of two or three.

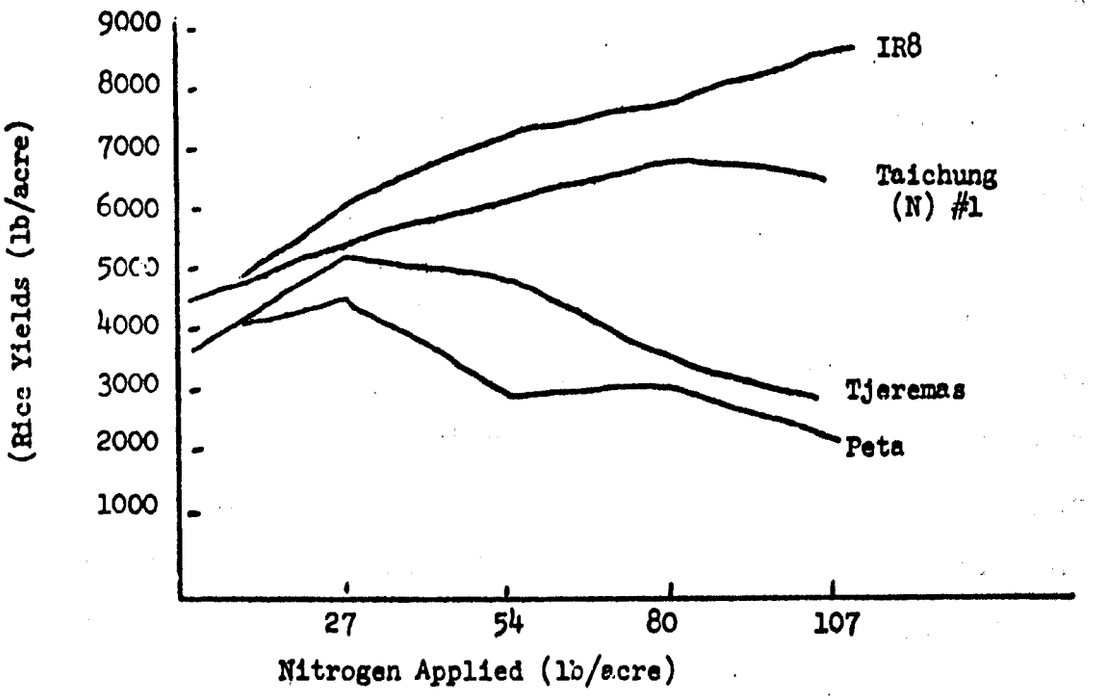
Scientists had long known that some rice varieties carried a mutant gene which resulted in a dwarf plant. IR8 assumed the short stiff strawed characteristic of Dee-Geo Woo Gen, and most of the good features of its tall parent Peta. The secret of the new variety was its ability to utilize fertilizer for added grain production.

Figure #3 illustrates the response of IR8 to various levels of nitrogen application as compared with three other rice varieties. IR8 reached a maximum yield of 8,450 lbs. per acre with 107 lbs. of nitrogen added per acre. Taichun (N) #1, a widely used variety, reached a maximum of about 6,700 lbs. of rice per acre with an application rate of 80 lbs. of nitrogen. Peta, the tall parent of IR8, reached a maximum yield of 4,500 lbs. per acre when 27 lbs. of nitrogen were added. When 107 lbs. of nitrogen is added to Peta, its yield falls to 2,320 lbs. per acre. While not illustrated in Figure #3, yield response data for several other varieties was tested in the same experiment. Maximum yields for most varieties were obtained at nitrogen levels between 27 and 55 lbs. per acre.

As a result of severe lodging, yields of tall rice varieties decline at higher levels of fertilizer application. Studies by plant physiologists have definitely shown that lodging with resultant low yields are associated with a deficiency of carbohydrates in the stem of the rice plant. Plant breeders have found in IR8 a variety with a carbohydrate-nitrogen metabolism which allows it to remain upright at high levels of fertilizer application.

It is argued that the high yields of IR8 have been obtained under systems of management which are not widely practiced in the Asian tropics. Seed beds have been carefully prepared, fertilizers have been applied, weeds have been

YIELD RESPONSE OF FOUR RICE VARIETIES
TO NITROGEN FERTILIZER
INTERNATIONAL RICE RESEARCH INSTITUTE FIELD TRIALS, 1966



controlled, and the crops have been protected from insects and pests. This is true, but what IR8 does provide is a variety which has the capacity to take advantage of these improved practices. Existing tall tropical varieties are inherently incapable of high yields even when carefully tended.

A similar story should be told about wheat. Here, the plant breeder was Dr. Norman Borlaug, who was honored with a Nobel Peace Prize for his work. The spread of the new varieties astonished agriculturalists. In 1965, less than 500 acres of experimental grain plots were planted. It is estimated that in 1972 over 52 million acres of the new varieties of wheat and rice were grown and in 1973 the total was approximately sixty million. What does this

mean in terms of increased availability of food? This is difficult to quantify. If we assume that the new varieties yield one ton per acre over the level expected from native varieties, the contribution is between fifty and sixty million tons. This is a fifteen to eighteen percent increase in the food grain production of developing nations. Of the estimated seventy-six million people added to the population annually, nearly 70 percent live in the developing nations. This means an additional fifty-three million mouths to feed where the problem is most acute. If each of these requires one pound of wheat or rice per day, then an added eleven million tons is required each year just to hold constant the level of an already inadequate diet. Assuming these very crude calculations are correct, the Green Revolution has clearly increased the per capita availability of food in third world countries. I feel confident that it has. Nineteen seventy-three is a poor year to talk about the impact of the Green Revolution. Present grain shortages are not, in my judgment, an indictment of the Green Revolution. I ask you to ponder what would the situation in India have been if the Green Revolution had not provided four million tons of storage grain against such contingencies as the present poor crop.

Problems of the Green Revolution:

The impact of the new package of food grain technology has been a mixed blessing. I would cite three difficulties or potential problems.

When there were thousands of indigenous varieties they served as a barrier to halt the advance of a disease or pest epidemic. When thousands of contiguous acres are planted to the same variety, such a buffer is lacking, and the nation is vulnerable to a potential massive crop failure. This dilemma gives plant breeders nightmares, and they are working to broaden the base of new varieties.

The Green Revolution has created social unrest, notably in India and Pakistan. The landlord class who adopted the new seeds and the costly fertilizer, and initiated improvements in irrigation, understandably felt that the gains should accrue to them. Landless laborers and tenant farmers who saw the enormous increase in yields and the attendant wealth of their more fortunate neighbors demanded a share of the windfall. The Green Revolution may have fomented intra-class feuds, and eroded traditional ways of life. This is a good example of what happens when technical change occurs so rapidly that man is unable to evolve appropriate social change.

The new varieties may also have altered political alignments and the pattern of international trade. In 1966-67 the United States exported more than ten million tons of food grains to developing nations. Much of this moved under the auspices of P.L. 480. For good or for evil, this gave us a considerable amount of influence in the third world nations. As they have become increasingly self-sufficient in food grain production our influence has waned. At the same time, the Soviet Union is turning outward for an increased quantity of agricultural products. She is purchasing sugar, tea, cotton, jute and a host of other products from the developing nations, thereby strengthening her economic influence. In World War II the Soviet Union sustained severe shortages of food. Her ports were embargoed, and the enemy had overrun the rich fertile triangle. These deprivations contributed to an intense desire to be self-sufficient in food. The Soviet Union also desired to prove to the world that collectivized agriculture could be successful. The Soviet leaders reasoned that to import food would be tantamount to admitting that collectivized farming was less than fully successful. In a herculean effort, she did become self-sufficient in nearly all foods for over two decades. It would appear that the Soviet position has changed. Confident in their military

might the Soviets reasoned that there would be little risk of entering the world food market. Also, she has demonstrated to the world that the state and collective farms were viable. These factors, in conjunction with several political events, caused her to enter the world food market. She imports sugar from Cuba, cotton from Egypt and Iran, and tea from Ceylon. More recently she has purchased wheat from Canada, Australia and Argentina. The Soviets have also apprently bent to consumer pressures, and begun to satisfy mounting consumer demands for light industrial goods and an improved diet. The Soviet Union has vast timber and mineral resources which she can profitably exchange for the industrial and agricultural output of the LDCs. As the Green Revolution proceeds, it is possible that trade and diplomatic relationships between the Soviet Union and many developing nations may solidify while, those between the United States and several LDCs may weaken. We then see another interesting and potentially important change engendered by the Green Revolution.

It is my opinion that the net impact of the Green Revolution is overwhelmingly favorable to the LDCs. It has bought an all important cushion of time in which we can tackle the central issue -- uncontrolled population growth.

Conclusions

We have explored the precarious food situation in the developing nations. Production of food per person in these poor nations has increased only slightly over the past decade, and the quality of their diet has probably not improved. It is projected that despite the Green Revolution the developing nations will have a considerable gap between domestic production and required consumption in 1980. The grain imports of developing nations will have to double over the next decade if even modest increases in consumption are to be realized. It is

most probable that they will not be able to import this magnitude of grain unless the developed nations are willing to provide it at concessional prices. Projections indicate that the grains will be available if the wealthy nations are willing to release them. Sharp year-to-year fluctuations in the production of grain within the LDCs due to weather, will make it necessary for developed nations to hold surplus grain stocks and have flexible agricultural programs.

The future food outlook in the developing nations is admittedly somber. One factor may be worthy of note: There seems to be a growing appreciation that improved farming practices can be as prestigous as steel mills. Leaders no longer view agriculture as an economic backwater. They are setting into motion programs which recognize the role which agriculture must play in achieving higher levels of living and improved diets.