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ASSESSMENT OF EXISTING AND PROSPECTIVE WORLD ECONOMIC AND FOOD TRENDS

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PREFACE

This report is part of a broad study addressed to an assessment of the world food situation undertaken at the International Institute for Applied Systems Analysis. The central objectives of the study are to:

1. evaluate the nature and dimensions of the world food situation;
2. identify the underlying factors;
3. investigate alternative courses of policy action at the national, regional, and global level that may alleviate existing and emerging food problems in years ahead;
4. develop models suitable for quantifying intra and inter-country and global food interdependencies based on strategic variables and probable policy alternatives.

Pursuing these objectives the study divides into six inter-related and integrated components:

I Assessment of Existing and Prospective World Economic and Food Trends.

II Evaluation of Physical, Economic and Institutional Factors Affecting the Food and Agriculture Economy.

III Tracing Linkages Between the World Food Economy and Energy, Water, Chemicals, Climate and Environment and Constraints Imposed by them on Food Production.

IV Definition and Measurement of Food and Nutrition Deficiencies

V Development of Sets of National and International Policy Strategies for Meeting Food and Nutrition Goals.

The Assessment of Existing and Prospective World Economic and Food Trends will be continued throughout the duration of the study in order to:

1. have up to date information on changes in
   - commodity markets
   - general economic indicators

- national and international economic policies and arrangements;

2. expand the scope of
   - commodity coverage
   - country and/or regional coverage;
3. make forecasts of
   - general economic developments
   - commodity market developments
4. take cognizance of findings arrived in other studies having relevance to IIASA's ongoing research.

SUMMARY AND CONCLUSION

Nature of the Food Problem

The food problem is global, multifaceted and persistent. Broadly conceived the food problem is a manifestation of the geographic disparity of growth between production and demand which results in surpluses in some regions and deficits in others. This disparity, which exists between regions within nations and between nations, is rooted in a complex of ecological, biological, cultural, technological, economic and political factors.

In most developed countries, food policies are concerned with reconciling the interests of producers demanding the support and stability of farm income with the interests of consumers concerned with the security and supply of reasonably priced food and the high costs of income transfers to the farm sector.

With few exceptions the food policies for developing countries are directed at meeting chronic food deficits accentuated by extreme supply and price variability. Underlying factors are the low elasticity of food supply, relatively high income elasticity of demand for food and high rates of population growth. Aggravating the problems are: severe inequalities in income distribution, inadequate infrastructural networks including storage, and institutional barriers. To an important extent the food problem is a balance of payments problem. Whereas developed countries are able to fully make up their food deficits through imports, most non-oil, developing exporting countries can only partially cover their shortages from commercial imports or foreign aid.

Thus, a search for a simplistic or single solution to the "Food Problem" is doomed to failure. This report provides a current assessment of the dimensions of the general problem as background for country modeling efforts underway in the Food and Agriculture project at IIASA.

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I. WHERE ARE WE?

A. Extent of hunger

1. About one half of the world's people (2 billion) exist on less than $200 per capita per year; as a consequence FAO studies maintain that an estimated 460 million to 1.03 billion people eat less than the number of calories needed to maintain ordinary physical activity, 40 percent of these are children.
2. No developing region has 110 percent of average per capita energy requirements, the level considered necessary to compensate for intra-regional inequalities in distribution of energy; the problem is particularly acute in the Far East and Africa, where the regional average dietary energy supply was at 93 percent of nutritional requirements in 1970-74);
3. because of large income disparities within countries, indications are that even with increase in average per capita food availability, an increasing number of people in developing countries are suffering from hunger.

B. Direction of change in per capita availability and population

1. Per capita food comsumption has increased only slightly in most developing regions and in South Asia it has actually declined during 1962-72;
2. annual increases in developing countries' per capita food production fell off, to 0.2 percent between 1971-75, suggesting a serious deterioration in the food situation of many countries;
3. significantly slowing population growth rates--0.8 percent--in developed countries whereas massive increases--about 2.5 percent per year--are continuing in the developing regions of the world.

C. International economic developments accentuate this hunger

1. persistence of slow pace in economic activity and high unemployment in market economies leads to reduced world trade including lower demand for developing countries exports;
2. the new pattern of oil prices are contributing to a redistribution of the world's wealth, a development that has important effects on the world food economy;
3. the emergence of inflation as an international phenomenon in developed market economies;
4. worsening balance of payments deficits and growing external debt burden carried by many non-oil exporting countries;
5. primary commodity--producing countries are becoming increasingly aware of their power through control of production and regulation of exports and are urging the formation of OPEC-type cartels.

THE WORLD FOOD AND GRAIN SITUATION

A. Recent trends in food production

World food production increased at an average annual rate of 2.8 percent during 1961-70 but decelerated to 2.2 percent in 1971-75. In per capita terms, the increases averaged respectively, 0.9 and 0.3 percent.

Because of different population growth rates, food production per capita during 1961-70 rose at an annual rate of 1.6 percent in the developed countries and at 0.6 percent in the developing countries. There are wide differences in performance among the various regions. Thus, during 1971-75, the growth in output per head fell by 0.2 percent in Latin America, 1.9 percent in Africa, but elsewhere per capita production rose slightly.

B. Trends in grain production

1. The principal barometer of the world food situation is the level of grain production. Grains occupy more than 70 percent of the world's harvested area and supply more than half of man's food energy when consumed directly and an important proportion of the remainder when consumed indirectly.

2. World production of grain has been increasing at about 29 million tons per year since 1960. There is a very uneven distribution of the world grain production. The USSR, the United States and Canada account for 40 percent of world grain production. In 1976-77 the United States, USSR and Canada harvested record grain crops. However, the improved world grain situation is largely confined to the above three countries and a few developing countries in Latin America, North Africa and the Middle East.

C. Recent fluctuations in production

1. The general slow-down in the rate of growth of food production during 1971-75 is one of the more disturbing facets of the world's food problem.

2. World grain reserves, as a percent of annual world grain and rice consumption, have declined from 20-21 percent in the 1960's to 10 percent in 1975-76. However, since grain production has grown faster than consumption, carryover stocks at the end of 1976-77 may reach 184 million tons representing about 14 percent of world consumption.

3. Smaller oilseed production and continued growth in global consumption point to tighter supplies of oils and meals and higher prices in 1977.

4. Despite new grain production and consumption records in 1976-77, output per capita averaged 330 kilograms or only about two kilograms above the level reported in 1973-74. Per capita consumption at 317 kilograms would be below the 324 kilograms reported in 1973-74.

Just to maintain the same per capita grain production without providing for improvements in diets, the world must increase production by 2 percent each year or add an additional 26 million tons of grain.

D. Trends in grain trade

Non-EC Western Europe, Japan, Eastern Europe and the developing countries have increased their dependence on imported grain over the 1960-61 - 1976-77 period. EC's net grain imports have shown a declining trend since 1960-61.

Net grain imports of developing countries rose from 12.1 million tons in 1960-61 to a record 33.5 million tons in 1974-75 but declined to 25.1 million in 1976-77. North Africa, Middle East and East Asia are the largest importing areas.

E. Reasons for inadequate growth

The insufficient growth of food production in the developing world is attributable to manifold reasons and factors associated with (1) limited production resources, (2) lack of

incentive prices which could motivate agricultural producers to adopt new technology; and (3) inequitable land tenure conditions. Subsistence farmers cultivate about 40 percent of the world's arable lands. Flood, erosion, salinization and encroaching deserts are all taking their toll. Moreover, arable lands are under growing pressure for alternative uses. Energy and water constraints are further hindrances to increasing food production.

F. Grounds for qualified optimisim

Overall there appear no fundamental changes in the world grain situation nor shift in the world's ability to feed its people. The tight food situation in the first half of the 1970's appears to reflect the coincidence of a number of special factors notably weather rather than a consequence of structural shifts. Political and institutional factors are more important restraints on expanding food production in developing countries than physical factors such as land, water and other production inputs.

II. WHAT CAN HAPPEN?

Near and Medium-Term Tendencies

A. Small likelihood of improvement in the hunger scene

1. Slow economic growth is in prospect for developing countries. The upturn will be affected by the strength of the economic recovery in the developed countries, balance of payments position and foreign assistance. Real growth in developing countries should approach that of the developed market economy countries, about 5 percent.

2. Continuing inflation. The basic causes of inflation are not likely to change; inflation in the remainder of the 1970's in the OECD are should slow down but still persist between 7 to 8 percent.

3. Real output in the OECD area should hover around 4.5 - 5 percent, a solid but by no means booming recovery. This moderate recovery of developed countries should limit

   (a) export earnings of developing countries; and
   (b) aid giving ability of developed countries;

4. Little prospect for substantial progress in current round of G A T T negotiations toward liberalising trade in grains, oilseeds and their products, and livestock products;

5. Need for sustained and even increased foreign aid to developing countries.

B. Grain prices

1. Record grain harvests in 1976-77 in the major producing nations augurs well for the establishment of an internationally coordinated system of national reserves to moderate fluctuations in the world price of grains and serve for humanitarian purposes.

2. Without an effective reserve program, grain prices will remain volatile and unstable stemming from the always possible capriciousness of the weather, the relative smallness of carryover stocks and the short-run inelasticity of demand.

3. Grain prices in most recent years may have been high enough to stimulate an expansion in grain production whose momentum may hinge on the future level of real grain prices.

Long-Term Trends and Prospect

There is little to suggest major changes in near and medium-term trends. Hunger will persist in many developing regions even with surpluses in developed regions.

A. General economic prospects

1. Annual real economic growth in the OECD area may be in the range of 5 - 5.5 percent. The developing world was, prior to 1974, growing at an annual rate of six percent which conforms to the objective of the Second United Nations Development Decade. Optimistically, it may be assumed that these countries will be able to regain these growth rates. On a per capita basis, the real gains may average only half the prospective total growth rate. Based on 1962-74 performances prospective annual growth rates are likely to remain below the overall average (6 percent) in Africa south of Sahara and South Asia. Growth rates for oil exporting countries are expected to average around 8 percent.

2. Inflation rates in the OECD countries in the first half of the 1980's are likely to level off at 6 - 7 percent whereas it is likely that inflation rates in the developing countries will persist at their current level of 32 percent.

B. Food and population prospects

World demand for food will be mainly determined by population growth, income growth and consumption pattern. Numerous food balance projections are possible with the use of various combinations of population growth rates, income growth per capita, dietary standards and production technology. Among these variables the highest degree of confidence can be placed on the rates of population growth in the different areas of the world for the next 10 or 15 years.

This gap could range from a low of 22.5 million tons a year to a high of 118.1 million tons by 1985. The grain deficits of 1985 could be even higher if the more recent trends prevailed. Continuation of the rate of growth of food grain production of 1.2 percent experienced since 1969, could lead to a deficit of 144 million tons according to a World Bank estimate and could even reach 200 million tons according to a study by the International Food Policy Research Institute (IFPRI).

5. Interpretational difficulties. Grain production trends of the 1970's are giving rise to conflicting interpretations that greatly changes the possible range of outcomes. For some, the grain harvests of the last two years have displaced concern over impending food deficits with enthusiasm about the re-emergence of surpluses. Others looking at the declining rate of increase in developing countries' food-grain production fear that this could mark the beginning of a long-term production trend.

6. Regional implications of deficits. The oil exporters, South Asia and East Asia are expected to account for the largest share of grain imports of developing countries, whereas North America is expected to have increasing grain surpluses. In the socialist countries, as a group, production and consumption are projected to increase in similar proportions.

Among the developing countries, members of OPEC with a population of close to 300 million are entering the stage of increased grain and/or livestock product consumption. Their vastly improved foreign exchange earnings will allow them to meet their import demand.

For the developing countries of South and East Asia and Central Africa, the outlook is the bleakest; persistent balance of payments deficits could seriously hinder the filling of this gap. This would necessitate the initiation of massive food transfers on concessional terms which seems neither feasible politically nor sustainable economically. What is more, the port facilities and distribution systems needed to handle this amount of grain may not be in place.

7. Grain price prospects. Real grain and food prices are not likely to rise significantly above 1977 levels, at least not until the mid - 1990's as global production will be sufficient to cover effective demand. Beyond that the outcome will depend on the extent to which productivity increasing technologies become available and their cost. Also, much depends on whether population growth is moderated.

8. Potential new food sources. There is hope that fabricated food will eventually make a significant contribution to world food supplies. Aquaculture offers good potential for augmenting food production and protein supplies in the longer term.

9. Climatological changes. There is a consensus of opinion among climatoligists that the climate of coming years will vary more than in the past 20 years. A continuation of the cooling trend since 1940 would (a) increase the variability in yields; (b) lower the average level of yields; and (c) be detrimental to the production of grain in the higher latitudes (above 50 degrees).

III. WHAT NEEDS TO BE DONE?

A. National policies

1. Increasing the food production capability in developing countries and narrowing the nutritional gap between the developed and the developing countries. There appears to be considerable latent capacity for increased food production throughout the developing world. This may be accomplished by way of:

(a) using more inputs and improving farming methods.

There is still a tremendous potential for increasing yields per unit of land. Average yields in the developing countries are about half or less of the levels attained by developed countries. Even for crops of major importance to these countries such as cotton, rice, sorghum, corn, wheat and groundnuts, yields are below world average levels. Even in the developed countries there is room for further increases in yields per hectare. Also, the world still has a reservoir of unexploited land that could be brought under cultivation. Yet, it should be recognized that the expansion of area under cultivation generally requires costly investments and is not likely to proceed at a faster rate than in the past notably, one percent per year;

(b) increase of investment in agriculture and related infrastructure facilities especially storage capacity, internal distribution-marketing systems, and modernizing port facilities;

(c) adoption of incentive agricultural and food policies;

(d) increased investment in public research and education.

2. No efforts to increase the world's food supply will be totally effective unless steps are taken to curb population growth on a national and global scale;

3. Institution of regional or national policies leading to a more equitable distribution of income and wealth. This could be an important means for translating nutritional needs into effective demand.

B. International policies

1. Since the food problem is global its solution will call for wide cooperation among all nations both developed and developing. The provision of stepped up development assistance, including food aid and disaster relief for averting prospective food deficits or eliminating malnutrition is required. Between 25 million to 40 million tons of grains would be needed to bring the world's 460 million undernourished people's diet to minimum nutritional requirement.

2. Reduction of balance of payments deficits and alleviation of the huge external debt burden carried by developing countries is another imperative necessity. This may be accomplished by:

(a) reduction of trade barriers by developed countries to help developing countries to expand their exports. Recent studies seem to underestimate the potential gains for developing countries stemming from trade liberalization;

(b) assurance of food aid at some minimum level for some specified time;

(c) increasing the amount of development grants and loans on concessional terms.

3. Improving world food security by the creation of a network of nationally or internationally held cereal buffer stocks;

4. A new set of international economic relationships between developing and developed countries need to be worked out, if stability in commodity markets is to be achieved.

5. Devising policies that speed up recovery in the developed market economy countries without touching-off still another inflationary spiral.

6. It is especially important to reach agreement on harmonizing production and trade policies between developed countries.

C. Research priorities

There are a number of physical, biological, political and economic constraints that inhibit the expansion of total food supply. Only new research coupled with education can help devise ways for removing some of these constraints and identifying vital interconnections in the total food system. Broadly conceived research is needed for identifying information gaps regarding:

1. the limits of the ecosystem in food production;
2. the cost and availability of energy, water and capital for meeting various food production targets;
3. national comparative advantages in food and agricultural production;
4. the potential increase in food supply resulting from the adoption of various incentive policies by developing countries;
5. the consequences of various levels of trade liberalisation on the pattern of trade and production;
6. the efficacy of alternative food security methods;
7. the nature and scope of foreign assistance needed for meeting food and development goals of developing countries.

OVERVIEW OF WORLD FOOD AND NUTRITION TRENDS

Food production trends. Food production between 1954 and 1973 declined globally (excluding the People's Republic of China) only once: 1972 production declined 1.6 percent from the previous year. However, on the average, world food production for the period 1954-1973 increased 2.8 percent annually, whereas population increased at a 2.0 percent annual rate. This combination resulted in an increase in world per capita food production of 0.8 percent (Table 1). Over these two decades, food production increased at a slightly higher annual rate in developing countries (3.0 percent) than in developed countries (2.7 percent). But because of sharply increasing population growth rates, per capita food production rose at an annual rate of only 0.4 percent in the developing countries. Thus, while some gain in world per capita food production has been realized in those two decades, a serious distributional problem between developed and developing nations remains.

What is the rate of increase in food production in the last few years? World food production during the first half of the 1970's increased by only about 2.2 percent which is below the rate of 2.8 achieved in the 1954 - 1973 period. The average annual increase in the developing countries over the same period was 2.5 percent only slightly above the 2.3 percent annual growth of population. This is well below the 4 percent food production target rate of the International Development Strategy which was reaffirmed by the World Food Conference, 1974. In the developed countries too there was a slowing in the rate of growth of food production during 1971-75, averaging 2.0 percent compared to 2.7 percent in 1954-1973. But because of lower population growth rates, food production per capita still rose at an annual rate of 1.2 percent. There are wide differences with regard to the basic food supply situation among developing countries. In the first half of the decade, food production failed to increase

in line with population growth in Africa and Latin America, and exceeded population growth by a modest margin in the Near East. The overall result was a decline in per capita food production by 1.9 percent in Africa and 0.2 percent in the Far East and 1.0 percent in the Near East.

Food consumption and nutrition trends. Food production trends can give only a rough approximation of the direction of changes in actual food consumption levels because they do not indicate changes in net, trade stocks and do not include fish.

Food experts assert that in 32 countries, up to nearly half a billion people are at present suffering from malnutrition, 40 percent of them are childern. Malnutrition has severe consequences to all strata of society, and is an important barrier to economic development in food-short countries.[1)]

Nutrition levels and quality may be appraised in terms of: average daily intake in calories; average daily intake of total protein; and average daily intake of animal protein. It must be realized that any global average daily caloric standard is a very crude measure of nutrition levels. Average calorie requirement are not uniform, and vary from region to region according to (a) stature, (b) sex, (c) activity, (d) age distribution of population, and (e) climate. Minimum caloric requirements, for example, for small-bodied people not engaged in hard physical labor in hot climates may not need to exceed 1600 calores a day.

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1) U.S. Department of Agriculture, The World Food Situation and Prospects to 1985, Foreign Agricultural Economic Report No. 98 (U.S. Department of Agriculture, Washington, D.C., 1974. United Nations, World Food Conference, Assessment of the World Food Situation (FAO, Rome, November 1974).

The 32 countries and their population in millions: India, 547.2; Bangladesh, 71.6; Pakistan, 66.8; Ethiopia, 26.1; Sudan, 16.9; Tanzania, 14.4; Sri Lanka, 13.3; Kenya, 12.5; Ghana, 9.4; Madagascar, 8.0; Cambodia, 7.6; Cameroon, 6.2; Yemen Arab Republic, 6.1; Upper Volta, 5.7; Mali, 5.4; Haiti, 5.2; Ivory Coast, 4.6; Niger, 4.3; Guinea, 4.2; Senegal, 4.2; Chad, 3.9; El Salvador, 3.9; Laos, 3.2; Somalia, 3.0; Dahomey, 2.9; Sierra Leone, 2.9; Honduras, 2.8; Cent. Afr. Rep., 1.7; Demo. Rep. of Yemen, 1.6; Mauritania, 1.3; Lesotho, 1.0; Guyana, 0.8.

Table 1: Increase in Food Production, Population, and per Capita Food Production, 1954 - 1973 and 1971 - 1975

	Increase from 1954 to 1973	Annual Rate of Increase 1954 - 1973	Annual Rate of Increase 1971 - 1975
	. . . . . percent		
FOOD PRODUCTION			
World*	69	2.8	2.2
Developed countries	65	2.7	2.0
Developing countries	75	3.0	2.5
POPULATION			
World	44	2.0	1.9
Developed countries	22	1.0	0.8
Developing countries	61	2.5	2.3
PER CAPITA FOOD PRODUCTION			
World	17	0.8	0.3
Developed countries	33	1.5	1.2
Developing countries	8	0.4	0.2

Note: Based on linear trends of indices.

*Excludes the Asian centrally planned economies, for which data are lacking.

Source: U.S. Department of Agriculture, Economic Research Service, The World Food Situation and Prospects to 1985, Foreign Agricultural Economics Report, No. 98 (December 1974), p.12; and FAO, Monthly Bulletin of Agricultural Economics and Statistics, Vol. 25, No. 5 (May 1976) p. 3.

The FAO has estimated energy requirements for the standard man and woman at respectively 3,000 and 2,440 Kcl/day (or 46 and 44.3 Kcl per kg. body weight).[1] It has set a standard of 2,284 Kcl as the minimum daily requirement for people in the developing countries. This would put 61 developing countries out of 97 (excluding the Asian centrally planned economies) into the food energy deficit category in 1970. For developing countries as a group, the average daily calorie intake per person is only about 2,210 calories compared with 3,150 in the developed countries (Table 2). The deficit is

Table 2. Average Per Capita Daily Food Supply by Region [2]

	Energy		Protein		Energy as % of requirements	
	1961	1970	1961	1970	1961	1970
	Kcals per capita		grammes per capita		percent	
Developed countries	2,960	3,150	87.0	96.4	116	123
Developing countries	2,130	2,210	55.0	56.0	93	97
of which:						
Latin America	2,410	2,530	63.7	65.0	100	105
Far East	2,050	2,080	51.3	50.7	92	94
Near East	2,200	2,500	62.3	69.3	89	102
Africa	2,120	2,160	55.7	56.3	91	93
Asian Centrally Planned Economies	2,020	2,170	54.7	60.4	86	92
WORLD	2,380	2,480	65.2	69.0	100	104

Source: United Nations World Food Conference Assessment of the World Food Situation Present and Future, E/CONF. 65/3, 1974.

1) A standard man is defined as having an age of 20-39 years and weighs 65 kg; a standard woman has an age of 20-39 years and weighs 55 kg.

2) The figures relate to food actually available for consumption (i.e. after allowance for storage and marketing losses and waste).

especially large in Asia, the Far East and Africa. In the Far East region, the dietary energy supplies average 94 percent of nutritional requirements in 1969-71 and stood at 93 percent in 1974 (Appendix Table 1). The averages, however, conceal important differences between countries in the regions, between areas within countries and between income brackets and age classes. In the Far East region in 1974 dietary energy supplies varied from a low of 87 and 89 percent of requirements in the Philippines and India to a high of 103 percent in Burma (Appendix Table 1). The gravity of the situation is illustrated by the fact that, with the exception of Burma, national average supplies were below requirements in all other countries of the region (with a total population of 940 million) in 1970-74. In Latin America, the average dietary energy supplies were 106 to 107 percent of requirements, with 10 countries (with a population of 36 million) having supplies below requirements in 1970-74.[1] The countries showing the greatest deficiencies are those located in the Andean region and the Caribbean area. Data are so far incomplete for other developing regions. Among the three African countries per capita dietary energy supplies were below nutritional requirements in Ethiopia and Kenya and were at the margin of adequacy in Ghana.

Protein is a critical factor in nutrition and recommended intake per person per day vary widely. A recommended intake of 99.3 grams per day per person is being regarded a high standard. Recent re-evaluations of protein requirements for humans have established lower minimum needs than previously thought necessary.[2] Protein and calorie malnutrition are interrelated. In an energy-deficient dietary intake, vegetal and animal proteins will be used to meet the demand for energy.

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1) FAO, Monthly Bulletin of Agricultural Economics and Statistics, Vol. 25, No. 5 (May 1976) p. 5.

2) Joint FAO/WHO Ad Hoc Expert Committee, Energy and Protein Requirements (FAO Technical Report Series No. 522, Food and Agriculture Organization of the United Nations, Rome, 1973).

Hence, a protein-adequate but calorie-deficient diet could cause protein-deficit diseases. Conversely, it is believed that protein deficiency is not likely to occur under an energy-adequate diet.[1] In normal circumstances, the consumption of more food is expected to correct any insufficiency of energy and protein.[2]

The nutritive quality of proteins is dependent on their contents of essential amino acids. Proteins from animal sources are high quality because they are composed of relatively large amounts of the essential amino acids. Even so, lack of sufficient quantity of animal proteins is not an insurmountable obstacle because vegetable proteins can easily be fortified by adding the limiting amino acids or protein concentrates.[3] This may be accomplished with the inclusion of oilseed meals, microbal protein and synthetics.

The level and quality of nutrition for major regions of the world and selected countries are shown in Appendix Tables 2-4. The importance of cereals and starchy foods in the diet of developing areas is clearly discernible. These products together with sugar cover three fourths of the calorie intake of developing countries in Africa and the Far East and more than 60 percent in Latin America. Cereals are the dietary staples in the Far Eastern countries and cover more than half of the calorie intake in North and West African countries. Wheat is the preferred cereal in North Africa and the Near East, whereas rice provides nearly half the calorie requirement in the Far East and India. Starchy foods are the chief food energy sources for the West African countries. It appears that the higher the proportion of calorie intake from cereals to total calorie intake the poorer is the calorie intake.

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1) L. Joy, "Food and Nutrition Planning", IDS Reprints 107, Institute of Development Studies, Sussex, p.1.

2) Except in areas where people subsist mainly on cassavas, plantains, yams or breadfruit foods, that are very low in protein content. Moreover, it is not possible for infants and pre-school children whose ability to consume more is limited and therefore need foods with higher protein concentration.

3) Using the amino acid composition of whole egg as the standard, whole rice contains 52 percent lysine; whole wheat, 44 percent; and whole corn, only 38 percent. See David Pimentel, et al., "Energy and Land Constraints in Food Protein Production", Science, Vol. 190 (November 21, 1975) p. 754.

Developed countries consumed an average of 94 grams of protein daily; the developing countries only averaged 56 grams (Table 2). Estimates of average protein intakes and by source also vary considerable between regions, countries and between ethnic groups and income levels. The majority of the world population obtain about 70 percent of their dietary protein from cereals, vegetables, and legumes (Appendix Tables 2-4). Most of this protein (47 percent) comes from cereal grains and about one-fifth from legumes. Fish protein supplies only about 5 percent of total protein available to man. In the Far East, animal protein (mainly milk) accounts for only 8 grams of the 56 grams protein consumed per capita per day. At the other end of the scale is the U.S. where the protein consumed per capita per day totals 96 grams, with about 66 grams of animal origin.[1)]

The composition of the diets are affected by a combination of factors including (1) stage of economic development; (2) income levels and their distribution; (3) customs; (4) availability of foreign exchange; and (5) volume of production. The relationship between these factors and food consumption standards is well documented and need no further elaboration here. Besides income, the slow rate of growth in food production, as shown earlier, are the chief causes of the poor nutritional situation.

Analytical considerations. Data on the nutrient composition of food, notably food as actually eaten, are seriously lacking. FAO determined the protein norm with the aid of laboratory experiments and the energy norm on the basis of nutrition surveys. A great deal of further work is necessary to make accurate and reliable estimates of fundamental nutritional relationships. There have been few controlled feeding experiments with human subjects; much of the information about the

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1) U.S. Department of Agriculture, National Food Situation, Economic Research Service, NSF-151, 1975 (U.S. Department of Agriculture, Washington, D.C., 1975).

effects of malnutrition has been obtained by controlled feeding of animals. Moreover, basic data on the production of food, especially in countries where food problems are severe, is not reliable. Much of the food produced by subsistence farming, for example, is not recorded in statistics. National average supplies give only estimates of average per capita availability of food and not on actual distribution of food to various groups. That is, they tend to conceal existing wide disparities between availability and consumption in relation to requirements within countries.

There are many people in developing countries whose incomes are too low to purchase even the indicated average daily food availabilities. Thus their degree of undernutrition is much worse than the national averages indicate and conversely, there are groups of affluent people in low income countries which have the means to satisfy their food needs adequately. Despite reservations about some of the data, national average supplies continue to be used because they give a first indication of the food and nutritional situation.

REVIEW OF TRENDS IN SELECTED COMMODITY MARKETS

I. WHEAT: PRODUCTION, CONSUMPTION AND TRADE TRENDS

Production trends.[1] World wheat production grew by 2.7 percent per year between 1965 and 1975 and by 1976/77 reached an estimated record of 407 million tons, 57 million tons more than total production in the previous year and some 35 million tons higher than the last high in 1973/74 (Table 3). The trend in the last two decades has been for wheat production to increase faster than rice. Between 1952 and 1956, world wheat production was only 3.5 percent greater than rice; in 1976/77 the spread was about 73 percent.

The overall increase conceals contrasting trends among regions and countries. There has been an impressive 4.9 percent growth per year in aggregate wheat production in developing countries during 1965-75. The increase was particularly marked for South Asia where production rose at 6.9 percent per year. More recently wheat production has expanded sharply in the major exporting countries as well as in the centrally planned countries. Thus Russia's wheat output in 1976/77 is now estimated at 97 million tons which is second only to 1973/74 record crop of 109.8 million tons. Among the principal developing country importers India, Brazil, Pakistan and Korea achieved sizeable production gains. (Appendix Table 6).

The increases in output in the 1960-75 period were the result of larger plantings and improved yields. Higher yields contributed most to the rise in wheat production. Yields of wheat peaked in 1976/77 at 1.76 tons per hectare compared to 1.18 in 1960/61 and 1.72 tons in 1973/74. Of significance is the wide disparity in yields among countries, with the EC being the leader with about 3.41 tons per hectare in 1976/77, followed by Canada with 2.11, and United States with 2.0. Most major producing countries are far below not only these levels but also the world average of 1.76.

The largest wheat area is in the USSR where about 59 million hectares were planted in 1976/77. The second largest area was in China with about 31 million hectares followed by the United States with a harvested area of 28.5 million, India with about 19 million and Canada with about 11 million.

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1) There are hundreds of varieties grown throughout the world but they all fall into one of two classifications--hard or soft.

Consumption trends. The post-war period was marked, particularly in developing countries, by a heavy increase in domestic utilization of wheat often at the expense of coarse grains and root crops. Consumption increased sharply in Algeria, Iraq, Turkey, India, Korea, Taiwan, the PRC and Bangladesh. During the past 12 years, per capita wheat usage has been growing more rapidly than rice although rice is still predominant in South Asia including India. In South America and Japan, where per capita consumption has initially been at comparatively low levels, an upward trend is noticeable. These trends indicate that wheat is being substituted for traditional grains such as corn in the former region and for barley in the latter country. Rice is the principal rival of wheat in certain regions of India, Pakistan, Japan, Korea, the PRC, the Near East and Southern Europe.[1)] Both wheat and rice face competition from corn in Cambodia, Indonesia, and the Philippines, and compete with beans, corn, and starchy roots in Latin America. In West Africa, millet, sorghums, and starchy roots tend to be wheat's chief competitors. North Africa is mainly a wheat consuming area. In the developed market economy countries such as the United States, Canada, the EC and Australia per capita utilization of wheat is declining. The USSR, on the other hand, is a much heavier user of wheat and per capita utilization is twice that of any other developed nation. In Brazil, the use of wheat has been increasing in the last few years.

Consumption in the developing countries has expanded as a result of increases in incomes and large volume of concessional imports in the past two decades. The income elasticity of wheat consumption averages 0.18 in Latin America, 0.74 in North Africa, Middle East, 1.0 Africa south of Sahara and 1.40 in South Asia (Appendix Table 5B). The price elasticity of demand for wheat is generally thought to lie between - 0.25 and - 0.50 in the developing countries. The corresponding order of magnitude of price responsiveness in developed countries is either - 0.1 or less than - 0.1.

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1) Habitual rice-eaters usually have a remarkably strong preference for rice over other cereals, much more so than consumers of other grains.

In 1963/64 and 1972/73 the USSR was the world's largest importer. France has consistently been a major wheat exporter. Its exports were usually larger than those of Argentina but went mainly to other EC members. Wheat plays an important role in the economy as well as export trade of the four countries.[1)]

By the end of the 1960's there were twelve countries consistently importing over one million tons, the United Kingdom, West Germany, Italy, Netherlands, India, Pakistan, South Korea, Japan, PRC, USSR, Egypt and Brazil. These twelve countries consistently accounted for about 60 percent of the world's imports during the past 25 years. These countries received about 50 to 70 percent of the U.S. exports, 70 to 90 percent of Argentina's exports over the same period.

The major factors involved in world wheat trade were (1) growth of population and income in developing countries; (2) expanding use of wheat in livestock feeding; and (3) the expansion of surplus disposal and aid programs. Also national protective measures have contributed to increased production and supply availabilities. There was a converse movement between trade and stock.

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1) The U.S. and Argentina exported about 56 and 31 percent of their wheat production, respectively in the 1970's. Wheat exports accounted for 14.2, 45.0, 5.6 and 10.5 percent of the total agricultural exports of the U.S., Canada, Australia and Argentina, respectively.

Between 20 to 30 percent of total wheat use is for feeding purposes in developed countries. All categories of animals favor wheat because of its palatibility, high energy, and protein content. It can substitute for most grains, if priced competitively.[1] Everywhere the increase in feed usage of wheat occurred when feed prices were relatively low compared with coarse grain prices. In general, lower quality wheats have become increasingly competitive in the feed grain market. The EC has been using wheat denaturing premiums in order to increase wheat feeding.[2]

Changes in feed patterns are likely to occur in 1976/77 because of the unusual price relationships. The principal shift will be from feedgrains and soybean meal to wheat because of its ample supplies and relatively low level of world prices.

Trade trends. There has been a steady increase of world trade in wheat in the post-war years reaching a record of 73 million tons in 1975/76 (Table 3). Reflecting increased availability world exports in 1976/77 are expected to fall short by 8 million tons from the previous years level. Over the past two decades four countries, the United States, Canada, Australia and Argentina, have accounted for 66 to 82 percent of the total world exports of wheat.[3] Two other countries have been and/or are major wheat exporters, the USSR and France. The USSR has not consistently been a major exporter.

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1) Having higher protein content, wheat rations need less protein supplementation than those based on corn. On a pound-for-pound basis wheat is worth approximately 105 percent of corn in most livestock feeding operations. However, the gluten content can create digestive problems and there is not complete agreement on the value of wheat as a livestock feed.

2) The denaturing premium is a subsidy granted by the EC to make wheat competitive with feedgrains and thereby facilitate surplus wheat disposal.

3) Australia varied from 5.9 to 14.9 percent, Argentina from 1.4 to 8.8 percent, Canada from 16.8 to 25.2 percent, and the U.S. from 29.4 to 46.0 percent.

Table 3: Cereals: World Supply Distribution, 1960/61, 1965/66, 1970/71, 1974/75, 1975/76 and 1976/77 Marketing Years

Year	Area Harvested Mil.ha	Yield MT/ha	Beginning Stocks[1] Mil.MT.	Production Mil.MT.	Total Exports[2] Mil.MT.	Total Consumption[3] Mil.MT.	Total Exports as % of production %	Stocks as a Percent of Total	
								Exports %	Consumption %
				WHEAT					
1960/61	204.0	1.18	77.1	240.5	43.9	238.4	18.2	175.6	32.3
1965/66	216.3	1.22	75.4	264.7	61.6	283.5	23.3	122.4	26.6
1970/71	204.9	1.54	97.1	316.2	56.3	337.7	17.8	172.5	28.7
1974/75	220.5	1.62	63.9	356.5	68.6	359.5	19.1	94.0	17.8
1975/76[4]	226.5	1.54	60.7	349.2	73.1	347.3	20.9	83.0	17.5
1976/77[5]	231.3	1.76	63.2	406.8	64.6	366.5	15.9	97.8	17.2
				COARSE GRAINS					
1960/61	336.6	1.36	91.0	456.3	26.1	447.2	5.7	348.7	20.3
1965/66	329.0	1.48	80.0	488.1	47.5	505.1	9.7	168.4	15.8
1970/71	339.7	1.68	78.6	569.5	53.4	587.1	9.4	147.2	13.4
1974/75	348.4	1.78	55.6	619.3	69.3	625.3	11.2	80.2	8.9
1975/76[4]	357.3	1.77	49.3	632.4	87.1	634.1	13.7	56.6	7.8
1976/77[5]	362.5	1.89	47.9	686.9	82.8	670.4	12.2	57.1	7.0
				TOTAL GRAIN					
1960/61	540.6	1.29	168.1	696.8	70.0	685.6	10.0	240.1	24.5
1965/66	545.3	1.38	155.4	752.8	109.1	788.6	14.5	142.4	19.7
1970/71	544.6	1.63	175.7	885.7	109.7	924.8	12.4	160.2	19.0
1974/75	569.0	1.72	119.5	975.8	137.3	984.8	14.1	87.0	12.1
1975/76[4]	583.8	1.68	110.0	981.6	160.2	981.4	16.3	68.7	11.2
1976/77[5]	593.8	1.84	111.1	1,093.7	147.4	1,036.9	13.5	75.4	10.7
				RICE[6]					
1960/61	120.2	1.94	--	157.2	6.4	157.2	4.1	--	--
1965/66	123.9	2.09	--	175.2	7.7	175.2	4.4	--	--
1970/71	131.3	2.35	17.7	208.9	7.9	208.0	3.8	224.1	8.5
1974/75	137.3	2.42	12.5	224.7	7.7	224.9	3.4	162.3	5.6
1975/76[4]	141.1	2.51	12.3	239.3	7.7	234.6	3.2	159.7	5.2
1976/77[5]	140.7	2.47	17.4	234.5	7.6	235.7	3.2	228.9	7.4
				TOTAL GRAIN AND RICE					
1960/61	660.8	1.29	168.1	854.0	76.4	842.8	8.9	220.0	19.9
1965/66	669.2	1.39	155.4	928.0	116.8	963.8	12.6	133.0	16.1
1970/71	675.9	1.62	193.4	1,094.6	117.6	1,132.8	10.7	164.5	17.1
1974/75	706.0	1.70	132.0	1,200.5	145.0	1,208.8	12.1	91.1	10.9
1975/76[4]	724.9	1.68	122.3	1,221.9	167.9	1,216.0	13.8	72.8	10.1
1976/77[5]	734.5	1.81	128.5	1,328.2	155.0	1,272.6	11.7	82.9	10.1

[1] Stocks data are based on an aggregate of differing local marketing years and should not be construed as representing world stock levels at a fixed point in time. Stocks data are not available for all countries and exclude those such as the People's Republic of China and parts of Eastern Europe; the world stock levels have been adjusted for estimated year-to-year changes in USSR grain stocks, but do not purport to include the entire absolute level of USSR stocks.

[2] Trade data are based on an aggregate of differing local marketing years and will therefore differ from July-June trade data appearing elsewhere in this report.

[3] For countries for which stocks data are not available (excluding the USSR), consumption estimates represent "apparent" consumption, i.e., they are inclusive of annual stock level adjustments.

[4] Preliminary.

[5] Projection.

[6] Yield is expressed on a rough basis; production, stocks, exports and consumption are expressed on a milled basis.

Source: U.S. Department of Agriculture, Foreign Agriculture Circular Grains, FG1-77 Washington, D.C., February 1, 1977, pp. 25-28.

II. RICE: PRODUCTION, CONSUMPTION AND TRADE TRENDS

The world's rice market is a highly differentiated one. This market differentiation is caused by wide differences in appearance, cooking quality and nutritive value of rice varieties. Although more than 7,000 varieties of rice are grown throughout the world, the main types are physically described as long, medium and short grained. Rice varieties may be further divided into high and low amylose content types.[1] People of the Indian sub-continent prefer the high amylose types, while most other Asian nations prefer the softer, stickier low amylose types. Japan only produces short grained, low amylose types, called Japonica rice. Among the major producer nations only Thailand grows all main types. Consumer preferences for long grain rice are very strong and are willing to pay premium prices if need be.

Production trends. World production of rice has increased at the rate of 2.4 percent a year during 1961-75, to an estimated record of 240 million tons (milled basis) for the production year 1975-76. World output in 1976-77 is estimated at about 234 million tons, about 5 million tons below the previous years' level (Table 3). Areas of rice have increased gradually over 1960-75 covering about 141 million hectares in 1976-77. In 1976-77, India had the largest area in rice of any country, at 38 million hectares, with the People's Republic of China (PRC) second at 35 million.[2] Yields of rice increased in 1975-76 to 2.51 tons per hectare compared to 1.94 in 1960-61. There are wide differences in rice yields among the producing countries. South Korea is the leader with about 5.94 tons per hectare in 1976-77 followed by Japan with 5.30 and United States with 5.39 [3] Countries listed with between 4 and 4.50 are the USSR, Taiwan and Colombia. India, the second largest producer, had yields in 1976-77 which averaged only 1.76 tons, and Burma, Thailand and the Philippines were all in that range. Brazil with 1.39 tons per hectare has the lowest yields among the main producer countries.

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1) Varieties with high amylose content (28-30 percent) cook dry and fluffy while those with lower amylose content (20-25 percent) have softer and stickier texture when cooked.

2) U.S. Department of Agriculture, Foreign Agriculture Circular, Grains, FG-1-77 Washington, D.C., February 1, 1977.

3) Rice is double-cropped and at times the Japanese have triple-cropping.

About 90 percent of the world output of rice is produced in Asia and bulk of the remainder in South America (3 percent), Africa (2 percent) and the United States (1.5 percent). The PRC, with about 4 million hectares less area than India, is the world's largest rice producer accounting for over one-third of total rice output. Chinese production in the past 12 years has increased by 28 percent and the rate of increase has been fairly steady. India is the second ranking producer with about one-fifth of the world's total. Other important producers are Indonesia, Japan, Bangladesh and Thailand. Brazil and the United States are the two main non-Asian rice producers.

Utilization trends. About half the world's population eat rice in some form and for a large proportion of these people rice forms 70 to 80 percent of their daily food.[1] Rice is the main staple in the Far East and Central Africa where its per capita utilization has been increasing in the post-war years. In some Asian countries such as India and the PRC, wheat usage has been growing more sharply than rice whereas in Japan the trend was toward wheat and away from rice. Rice is a major source of protein in the diets of most Asian people but it is generally lower in protein than most bread wheats.[2] Elsewhere, the disappearance of rice on a per capita basis is small and has remained steady in recent years.

World trade. World trade in rice has been increasing 1.2 percent per annum during the 1961-75 period and lost ground in importance relative to wheat and coarse grains.[3] Rice trade, however, has not fluctuated from year to year as markedly as wheat. Since the 1960's, world exports exceeded the 8 million tons mark only on two occasions, 1965 and 1971; estimates indicate total exports at 7.6 million tons in 1976-77 (Table 3).

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1) A kilogram of rice contains about 3,520 calories.

2) Protein content may vary between 4 to a maximum of 13 percent and is relatively high in lysine.

3) Rice trade in the post-war period decreased to about one-half or less of its pre-war level.

The largest rice exporters are the United States, Thailand and the PRC. With a net export balance of 1.7 million tons, the United States became, by 1970, the biggest rice exporter. Exports from the United States account for about 29 percent, Thailand 14 percent, and the PRC 12 percent of the world rice exports in 1976-77. Supplies dwindled sharply in Burma during the 1960's which, as a result, lost its traditional position as the world's leading exporter. Stimulated by high domestic support prices, rice output in Japan as well as in some EC countries has expanded faster than consumption giving rise to exportable surpluses by the end of the 1960's.[1] Since then, programs were devised in Japan to reduce production but which, so far, have not proved to be effective. At prevailing prices potential returns from rice are still higher than can be realized from any other crop. The major rice importing countries are in Asia, which normally account for about two-thirds of the world's total. Indonesia is the largest importer with an estimated 1.5 million tons in 1976-77. Other importers of importance are Iran, Sri Lanka, Bangladesh and Hong Kong. Outside of Asia, Europe and Africa account for the remainder of world imports. The EC-9 have imported 0.7 million tons of rice in 1976-77, giving preference to long grain rice.

Rice is a unique cereal in so far that its production and consumption is concentrated in one region--the Far East--has limited substitutability in production and developing countries dominate world trade. Rice policies such as the rice premium policy in Thailand, the BIMAS program in Indonesia, the rice policy of Japan and the rice export policy of the United States and Japan play important roles in the national and international rice markets. The rice premimum policy, which is an ad quantum rice export tax policy, is the most controversial economic policy in Thailand during the post-war period. The premium

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1) Japan changed from one of the leading rice importers to one of the leading rice exporters around 1969, and her share was about 7.7 percent of the world total rice import between 1966-67 and about 7.8 percent of the world total rice exports between 1970-72.

amounted to about 20 to 35 percent of the export price of rice. The argument is that the premium depressed the farm price of rice and thus decreased rice production and export.

The world rice economy is characterized by a high degree of instability in production, prices and trade. The main source of production instability is lack of irrigation and poor water management. Most of the world's rice crop is produced without irrigation and is thus subject to droughts and floods. Concurrently, there were wide swings in rice prices that had an unsettling effect both on production and trade. Another cause of instability is that the major rice exporting countries, with the exception of the United States, carry only minimal stocks. And this situation, in turn, is caused by inadequate infrastructure and lack of financing.

In times of excess supplies producers were introducing export subsidies and other aids to dispose of their surpluses. When prices were high many Asian countries, for balance of payments reasons, had to substitute wheat and other grains for rice. Rice crops and prices thus have an impact on world grain trade. Depending on the price spread between rice and cereals, China has been exporting the higher priced rice and supplemented domestic supplies with imports of cheaper cereals.

In view of the wide disparity in yields among rice producing developing countries there is need for research aimed at facilitating improved production. Apparently the gains in yield associated with the introduction of the new high yielding varieties were not as significant as originally expected. A number of problems that arose with the use of new varieties have to be solved before more substantial growth of rice production can be achieved. Besides research related to plant physiology, varietal improvement and agronomy, there is also a need for study in (1) marketing and processing problems; (2) promotion of greater use of short grain rice; and (3) introduction of better grading standards.

III. COARSE GRAINS: PRODUCTION, CONSUMPTION AND TRADE TRENDS

Production trends. The combined output of the five coarse grains increased from 456.3 million tons in 1960/61 to an estimated 686.9 million tons in 1976/77 (Table 3). World production rose at an average annual rate of 2.9 percent per annum during 1965-75. Altogether coarse grains are the most important grains representing about 52 percent of world output of all cereals, including rice, in 1976/77. Corn is by far the most important coarse grain and, together with barley, is the fastest growing crop among the group. Corn has gained in importance, constituting over half of total production compared with 42 percent in 1958/59. Apart from the United States, the fastest expansion has taken place in the developing countries, primarily in Mexico, South America (Argentina and Brazil), Africa (Kenya), and Asia (India, Indonesia and Thailand). Barley has remained the second ranking coarse grain, accounting for around 23 percent of world output. World barley production has shown the fastest rate of growth among coarse grains, because of both larger areas and higher yields. There has been a substantial diversion of land from oats and rye to barley. The USSR, France, the United Kingdom, Denmark, Australia and Canada are the world's leading barley producers. Sorghum and millet are the third ranking coarse grains but production increases were below the average for the group. The United States has dominated sorghum production and normally accounts for nearly one-half of the world's output. Argentina, Mexico and South Africa are other major producers. (Appendix Table 7).

The production of both oats and rye has shown a downward trend.[1] Oats are still more widely grown than rye. The United States, the USSR, the EC countries and Canada dominate world oats production. Rye is rapidly loosing ground, both as a food and feed grain, to wheat and barley. This is caused by the substantial reduction in the rye area and only a small improvement in yields. The USSR, the countries of Eastern

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1) Oats because there are fewer horses to be fed, and rye because less of it is used for bread in Europe.

Europe and of the EC (principally West Germany) are the major rye producers.

Consumption trends. World coarse grain usage has reached an estimated record 670 million tons in 1976/77, some 8 million above the previous peak of 1973/74. The bulk of coarse grains are fed to livestock in developed countries, whilst they are widely used as food in developing countries.

Coarse grain demand is essentially a derived demand from a broad range of end-products -- feed, food, and industrial -- serving as raw-material inputs. Among end-uses, livestock feeding is the most important. The use of cereals for livestock feeding now account for two-thirds of the total grain used in the OECD area. The use of coarse grains in livestock feeding depends on a number of factors, including variations in livestock production, availability and relative cost of substitute feeds, feeding pattern and the price of livestock products in relation to the price of coarse grains. The effect of these and other factors on the quantity of cereals used in livestock feeding varies from country to country.[1] The findings of an analysis for nine western European countries combined indicate that the elasticity of the use of cereals in relation to each of the four factors below was: prices of livestock products, + 1.01; livestock production, + 0.68; prices of cereals, - 0.45; and production of cereals, + 0.10.[2] Prices of livestock products and prices of cereals seems to have been the main factors determining the amount of cereals used.

Overall changes in the relative price of livestock feeds encourage substitution of the lower-priced for higher-priced ingredients. Thus substitution takes place between cereals, and between cereals and non-grain feedstuffs. Because of the high degree of inter-cereal substitutability, demand for any

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1) OECD, Use of Cereals in Animal Feeding. (Paris, 1971), p.70.

2) Austria, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland and the United Kingdom; Ibid, p. 73.

one of them or from any particular country depends on availability and price of all others.

There is much evidence that the decline in corn and sorghum prices relative to other grains in the Sixties has been an important demand-shifting factor in Western Europe and Japan. The sharp decline in US sorghum exports after 1967 was entirely due to a rise in sorghum prices relative to corn. Prices of low-protein wheats in recent years have become competitive with coarse grains. The increased use of wheat in livestock feeding in Western Europe, especially Britain, France and Germany as well as in Japan occurred when feed-wheat prices were relatively low compared to coarse grain prices. Wheat used for feed in the United Kingdom appears to be responsive to prices of feed-wheat and corn as well as to changes in the demand for livestock.

In view of the marked sensitivity of cereal - livestock markets to changes in prices the most effective approach for achieving some measure of balance between production and utilization is to influence prices. However, the question is whether governments will be able to take sufficiently vigorous action in this direction. The difficulties arise from striking a balance between the objectives of supporting of cereal growers, and the prevention of overproduction of livestock products.

Lowering of producer prices would, of course, pose a formidable policy problem and might not be feasible without some kind of income support measures. In developing countries the demand for coarse grains for food is affected by the availabilities and prices of other foodstuffs, principally wheat and rice. Also consumption responds to changes in income. The highest degree of responsiveness of consumption to income has been found in East Asia and Latin America with income elasticities of 1.2 and 0.59 respectively (Appendix Table 5 B).

Trade trends. World exports of coarse grains showed the fastest growth about tripling in volume over the 1960/61 - 1976/77 period (Table 3). Exports grew by 7.5 percent per annum during 1965-75. The principal exporters of coarse grains are the United States and Argentina and, to a lesser

extent, Canada. Argentina is not only by far the most important developing country exporting grain but also most dependent on exports of grains as a source of foreign exchange earnings. Other developing country coarse grain exporters are Mexico, Thailand, Brazil and Kenya.

The developed countries, notably the EC nations and Japan are the largest importers of coarse grains. The former area has accounted for about 34 percent and Japan for about 17 percent of world exports of coarse grains in recent years. The share of developing countries in world imports of coarse grains was about 16 percent.

Statistical estimates indicate that the degree of inter-grain substitution with respect to price changes in world markets is quite pronounced.

IV. TOTAL, GRAIN AND RICE: PRODUCTION, CONSUMPTION AND TRADE TRENDS

Production trends. In 1976-77, the world produced an estimated all time record grain crop (including rice) of 1.33 billion tons. (Table 3). This would be about 8.8 percent higher than the 1975-76 crop and 6.1 percent more than the previous record 1973-74 harvest. The increase in production in 1976-77 was the result of both greater area devoted to grain production and record yields. The 1976-77 estimates show that the world harvested about 735 million hectares of grain and rice. This was about 74 million hectares more than in 1960-61. Most of the increases in grain production is due to bumper crops in the U.S., USSR and Canada which more than offset production decreases in the EC and other Western European countries.

Among the developing countries, significant production increases were realized in Brazil, Argentina, the countries of North Africa and the Middle East.

World grain production rose at an average rate of 29 million tons per year over the 1960-61 - 1975-76 period.[1] It has been rising at a rate of about 3 percent annually during the past 25 years--ahead of population growth.

Consumption trends. Consumption of grains and rice in 1976-77 is estimated at 1.27 billion tons which would be about 55 million less than the estimated world output. World usage has slowed during 1974-75 - 1975-76 primarily due to the poor 1974-75 harvest in the United States and the disastrous 1975-76 harvest in the USSR as well as lagging economic recovery in the developed market economy countries. Moreover, livestock feed price ratios are still not sufficiently attractive to encourage greater feed usage. Grain feeding is expected to increase at the fastest rate in the EC due to poor forage and fodder crops and in the USSR as a result of ample domestic supplies. Also, increases in grain consumption are expected in the developing market economy countries of Africa and Asia.

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1) U.S. Department of Agriculture, World Agricultural Situation, WAS-11 (October 1976) p.17.

World grain consumption is likely to increase about 3 percent per year that would call for a 38.4 million ton increase in grain output annually.

Per capita trends. Despite marked production increases, the food supply situation of developing countries has not shown much improvement, especially when viewed in terms of changes in per capita production or consumption. Per capita grain production in developing market economies rose at an average rate of 0.29 kilograms per year over the 1960-61 - 1975-76 period.[1] This amounts to a mere 0.2 percent per year growth. Aggravating the situation is the wide fluctuation in per capita production in the developing market economies that may be as much as 8 to 10 kilograms from year to year.

Per capita grain production in developing countries as a group averaged 206 kilograms compared to 574 kilograms for developed countries (Table 4).

In 1976-77 world per capita consumption of grains was 317 kilograms (Table 4). There are, however, wide differences in per capita consumption of grains and method of utilization among countries. Thus, at present, the developed countries--one third of the world's population--consume more than half of the world's grain. Per capita consumption averaged only 215 kilograms in the developing countries contrasted with 525 kilograms for the developed nations in general. In the USSR and the US these figures were 786 and 757 kilograms per capita.

About 50-55 percent of all the grain consumed in the world during the 1965-74 period has been fed to livestock and poultry.[2] Most of the grain in the developing countries is consumed directly as human food supplemented by small quantitites of livestock products and fish. As per capita income increases, there will be a change in preference from starcy roots to grains and then from the direct consumption of grains to high quality protein, especially livestock products.

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1) The annual increase in per capita grain production averaged 0.75 kilogram over the 1960-61 - 1971-72 period. U.S. Department of Agriculture, World Agricultural Situation, WAS-11, Washington, D.C. (October 1976) p.17.

2) U.S. Department of Agriculture, Foreign Agriculture Circular, Grains, FG-24-74, Washington D.C. (November 21, 1974) p.1.

Table 4. World Grain Production, Consumption and Population 1976-77[1)]

Region and/ or Country	Total		Population	Per Capita	
	Production	Consumption		Production	Consumption
	- - million tons - -		million	- - - Kilograms - - -	
Developed countries	759.5	694.9	1,323.0	574	525
United States	250.5	162.9	215.3	1,163	757
Canada	44.8	21.9	23.1	1,855	868
EC-9	91.3	119.3	259.8	351	459
Japan	11.2	32.0	112.3	100	285
Oceania	14.9	5.8	16.5	903	344
Eastern Europe	90.6	100.3	131.0	692	766
USSR	211.4	202.1	257.0	823	786
PR China	183.3	184.5	836.8	218	219
Developing[2)] countries	556.5	579.7	2,696.0	206	215
Latin America	83.5	75.3	326.0	256	231
Brazil	28.6	27.0	110.2	261	247
Argentina	26.5	12.7	25.7	1,031	480
North Africa/ Middle East	52.3	63.1	211.7	247	298
Central Africa	22.7	25.0	20.3	112	123
East Africa	10.2	10.5	66.7	153	157
South Asia	134.0	141.8	822.0	163	173
Southeast Asia	26.3	23.0	108.2	243	215
East Asia	35.8	45.7	261.3	137	175
World	1,328.2	1,272.6	4,019.0	330	317

1) Includes wheat, milled rice, and the major and minor coarse grains.

2) Including PR China.

Source: Derived from Population Reference Bureau Inc., 1976 World Population Data Sheet, Washington, D.C.

U.S. Department of Agriculture, World Agricultural Situation, WAS-12 (December 1976) p. 18.

Export Trends. World exports of grains and rice for 1976/77 are estimated at about 155 million tons which would be about 13 million tons below the record 1975/76 level (Table 3). Of this decline wheat accounts for 8.5 million tons and coarse grain for the remainder. The decline reflects bumper crops in the USSR, Canada, Brazil and the U.S. more than offsetting poor crops and higher import requirements in both Eastern and Western Europe. Over the 1960/61 - 1976/77 period, the combined exports of grain and rice just about doubled in volume. Among them coarse grains contributed most to the increase, growing by 217 percent, and rice exports the least, with a growth rate of about 19 percent. Wheat exports increased by about 47 percent.

Grain exports from North America have doubled during the seventies, expanding from 56 million tons in fiscal year 1970 to nearly 100 million tons during fiscal 1975/76. A concerning aspect of the growth in grain exports from North America is the increase in the number of food-deficit countries. The reasons for growing dependence on grain imports vary widely. They include (1) population-induced demand; (2) growth in foreign exchange earnings, as in the OPEC countries; (3) rising affluence; and (4) poor management of agriculture.

World Grain Trade Balances. During the 1934-38 period, Western Europe was the major net importer while Latin America, the USSR, Eastern Europe, North Africa, the Middle East and even Asia were among the net exporters. Latin America then exported 9 million tons per year, while North America exported only 5.3 million tons (Table 5). With the possible exception of Latin America, all these regions mentioned as net exporters then are now net importers of substantial magnitude. Asia's grain and rice imports in recent years have risen to a high of 45 to 50 million tons. The differential rates of growth of population relative to agricultural production in the developed and developing countries has led to this shift in the pattern of world grain trade. Population growth has been less influential in Eastern Europe.

Table 5: World Net Imports (-) and Net Exports of Grain, Selected Periods, 1934-77

Country	1934-38	1948-52	1960-62	1969-71	1972-73	1973-74	1974-75	1975-76	1976-77
DEVELOPED COUNTRIES	- - - - - - - - - - - - - million metric tons -								
United States	0.5	14.0	32.8	39.8	73.6	75.0	64.9	79.6	78.6
Canada	4.8	6.0	9.7	14.8	14.8	12.7	12.6	16.4	16.4
South Africa	0.3	.0	2.1	2.5	3.1	3.7	3.5	3.3	1.8
Oceania	2.8	3.7	6.6	10.6	8.9	9.4	11.6	11.4	10.6
Western Europe	-23.8	-22.5	-25.6	-21.4	-21.0	-22.5	-19.2	-17.4	-35.9
Japan	-1.9	-2.3	5.3	-14.4	-18.5	-19.3	-18.5	-19.4	-20.1
CENTRALLY PLANNED COUNTRIES									
U.S.S.R. & Eastern Europe	4.7	2.7	0.5	-3.6	-14.2	-10.5	-8.7	-33.5	-19.6
China	-1.0	-0.4	-3.6	-3.1	-6.3	-5.7	-4.5	-1.1	-1.4
DEVELOPING COUNTRIES									
Latin America	9.0	2.1	0.8	3.2	0.6	-2.5	-3.1	-0.3	3.2
North Africa & Middle East	1.0	-0.1	-4.6	-9.2	13.7	-12.7	-15.1	-13.4	-12.5
Asia	2.4	-3.3	-5.6	-11.0	-14.8	-15.2	-16.0	-16.5	-13.1

Note: Grain includes wheat, milled rice, corn rye, barley, oats, and sorghum.

Source: Data for selected periods 1934-71 and 1972-73 are from Economic Report of the President (Washington, D.C. : U.S. Government Printing Office, 1975) p. 172. Data for 1973-77 are from U.S. Department of Agriculture, Economic Research Service, World Agricultural Situation, December, 1975-76.

North America, particularly the United States, is playing a more dominant role than ever before as the supplier for the world's grain imports. The United States now accounts for 43 percent of total wheat exports and 57 percent of the world's coarse grain exports and its total share of world exports for all grains has increased in the last few years.[1)]

Cereal projections to 1985. Numerous food/population studies of the past few years have projected growing cereal grain (grains and rice) imbalance between developed and developing countries for the 1980s (Table 6). Because of different assumptions on population, income growth rates, and technology, direct comparisons between the studies are difficult. However, there is general agreement in the reports that cereal production in 1985 will balance effective demand for cereals in various uses on a world-wide basis. Projected regional deficits of cereals in the developing countries vary from a low of 22.5 million tons to a high of 118.1 million tons. Much of this extreme variation can be explained by differences in technology changes assumed in the respective reports for the developing countries. To accommodate projected import needs (for most of the estimates shown in Table 6) there must be a substantial change in present world trade patterns.

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1) U. S. Department of Agriculture, Foreign Agricultural Service "World Grain Situation: Outlook for 1976-77", Foreign Agriculture Circular, FG26-76, Washington, D.C. (Oct. 27, 1976) pp. 21-27.

Table 6: Comparison of Cereal Projections to 1985[a]
(million metric tons)

Item	FAO Base 1969-71	FAO 1985	USDA Base 1969-71	USDA-I[f] 1985	USDA-II[g] 1985	USDA-III[h] 1985	USDA-IV[i] 1985	ISU 1985	UC 1985	IFPRI 1985-86
WORLD										
Demand	1,207	1,725	1,062.6	1,548.5	1,618.7	1,501.8	1,643.9	1,145.5	1,777.2	
Production	1,239	NS	1,081.8	1,550.4	1,620.6	1,503.6	1,645.7	1,187.3(L)[j]	1,176.6	
								1,191.7(H)[j]	-0.6	
Balance [b]	+ 32	NS	19.2	1.9	1.9	1.9	1.9	41.8(L)[j]		
DEVELOPING COUNTRIES										
Demand	590	929	446.6	691.2	726.2	678.6	743.5		954.5	
Production	585	853	443.1	632.4	648.7	626.2	721.0		917.9	
Balance	- 5	-76	-23.5	-58.8	-77.5	-52.4	-22.5		-36.6	
DEVELOPING MARKET Economies[c]										
Demand	386	629	299.7	479.4	512.6	466.7	529.1	524.7	210.2	534.2(H)[k]
										517.1(L)[k]
Production	370	544	279.2	424.7	441.0	418.7	513.3	411.0(H)[j]	206.5	451.6
								406.6(L)[j]		
Balance	-16	-85	-20.5	-54.7	-71.6	-48.0	-15.8	-113.7(H)[j]	-3.7	-82.6(H)[k]
								-118.1(L)[j]		-65.5(L)[k]
ASIAN CENTRALLY Planned countries[d]										
Demand	204	300	166.9	211.8	213.6	211.9	214.4		744.3	
Production	215	309	163.9	207.7	207.7	207.7	207.7		711.4	233.4
Balance	+11	+ 9	- 3.0	- 4.1	- 5.9	- 4.2	- 6.7		-32.9	
DEVELOPED COUNTRIES[e]										
Demand	617	796	596.0	857.3	892.5	823.2	900.4	403.4	822.7	
Production	654	NS	638.7	918.0	971.9	877.4	924.7	574.0	858.8	
Balance	+37	NS	42.7	60.7	79.4	54.2	24.3	170.6	36.1	

Note: FAO = Food and Agriculture Organization; USDA = U.S. Department of Agriculture; ISU = Iowa State University; IFPRI = International Food Policy Research Institute, UC = University of California.

a The data for FAO and USDA are not comparable because FAO carries rice as milled.

b Imbalances for USDA between demand and production in base are due to stock buildup, timing of shipments, and missing data on a number of small importers. Projected equilibrium does not allow for building or reducing stocks.

c UC developing market economies include Africa and Latin America. IFPRI includes Asia, North Africa, Middle East, Sub-Sahara, Africa and Latin America.

d UC, FAO, and IFPRI Asian centrally planned includes the People's Republic of China and other Asian centrally planned countries (North Korea, North Vietnam, etc.). UC also includes Japan.

e Includes the U.S.S.R. and Eastern Europe.

f USDA-1. Assumes economic growth temporarily slowed, but resumes strong expansion in late 1970s. Limited expansion of world trade.

g USDA-II. High world import demand situation. Larger income growth rate than USDA-I in both developing and developed countries.

h USDA-III. Low demand situation that assumes economic stagnation would continue in the late 1970s and recovery does not occur until the 1980s.

i USDA-IV. Developing countries' import needs are reduced. Have assumed that they have increased their investment in food production by increasing the inputs used.

j Projections designated (L) are made under a low variant upper bound on cropland expansion. Those designated (H) are made under a high variant bound on cropland expansion.

k Projections designated (L) are made under a low variant upper bound on income growth. Those designated (H) are made under a high variant bound on income growth.

Source: U.S. Department of Agriculture, Economic Research Service, The World Food Situation and Prospects to 1985, Foreign Agricultural Economic Report, no. 98 (December 1974), p. 35; University of California Food Task Force Report, A Hungry World: The Challenge to Agriculture (Berkeley: University of California, July 1974); and International Food Policy Research Institute, Meeting Food Needs in the developing World: The Location and Magnitude of the Task in the Next Decade, Research Report No. 1 (Washington, D.C.: International Food Policy Research Report, February 1976).

CEREAL STOCKS

Size and composition. World grain and rice stocks combined (122.3 million tons in 1975/76) were at the lowest level in over two decades. In comparison, stocks of these items as recently as 1970/71 totaled 193.4 million tons. World carry-in stock levels of these items are estimated to have risen moderately, by 6 million tons, to 128.5 million tons in 1976/77 resulting in an estimated 6 million ton excess of production over consumption. The bulk of these stocks consists of wheat, estimated at about 63 million tons. Volume-wise, rice contributed most to the 1976/77 increase in stocks. World carry-in stocks of coarse grains were estimated at 47.9 million tons, down some 3 million tons from the 1975/76 level.

World closing stock levels projected by the U.S Dept. of Agriculture for the end of the 1976/77 year for grains and rice combined are at a level of about 184 million tons, 55 million above carry-in levels. The largest gains are seen for wheat stocks which at 104 million tons would surpass past levels with the exception of 1969/70. By contrast, world coarse grain stocks for the end of 1976/77 are projected to rise moderately, by about 17 million tons, and at 64.4 million will remain at a still low level. Because of lower world production, rice stock levels at the end of 1976/77 are expected to be down some 1.2 million tons from their beginning season level.

Size of Reserves. The size of reserve stocks is influenced by the purposes they are intended to serve and the costs holders are prepared to bear. Reserves may perform two major functions; stabilize commercial markets and help meet humanitarian food needs in the event of unexpected crop failures. Market stabilization may aim at moderation of fluctuation in prices, consumption and volume of international trade. These reserves may consist of three elements: working stocks, commercial contingency reserves, and surplus stocks.

The major divisive issue that reserve programs give rise to is whether they should primarily protect the interests of consumers, producers and internationally that of the importing and exporting nation interests. Another concern is that the reserve

program brought into existence should not interfere with market forces facilitating expansion in grain production. In setting desirable global and/or national reserve targets consideration is to be given to: (1) potential variability of cereal yields and output; (2) the degree of price variability to be allowed or protection sought, and (3) the cost of carrying stocks.

Globally, if reserves are intended to cover average annual shortfalls in production, stocks of 5 percent or 66 million tons based on 1976/77 production, might be deemed desirable. The FAO, Secretariat has suggested a total carryover stock corresponding to 17-18 percent of world consumption of cereals as the desirable size of minimum "safe" level for world food security. At the 1976/77 level of consumption this "safe" carryover would amount to some 216-229 million tons for the entire world. In 1976/77 world carry-in stocks of grain and rice represented only about 10 percent of world consumption (Table 3). This would compare with a carry-in of 20 percent in 1960/61 when there were large surpluses. Reserve levels may also be related to export volumes. Grain stocks equal to one year's normal exports are regarded of being at normal "pipeline" level. In 1976/77 world grain stocks including rice were about 83 percent of that year's exports. The developed market economies hold the bulk of stocks of grain and rice, some 76.7 million tons out of a total of 128.5 million in 1976/77.

V. FATS OILSEED PRODUCTS: PRODUCTION, CONSUMPTION AND TRADE TRENDS

Production Trends. World output of fats & oils, following a temporary setback in 1975, staged a recovery in 1976 and are estimated to have reached a record of 49.4 million tons, about 2.2 million tons more than in the previous year. Global output in 1977 is anticipated to be slightly below the previous years level reflecting smaller 1976 U.S. soybean production. Over the 1965-75 period, world production of fats and oils increased by nearly 1.2 million tons annually. Vegetable oils account for about two-thirds of the combined output of this commodity group, animal fats for about 30 percent and marine oils for the remainder. Soybean oil is the dominant vegetable oil and has grown in importance over the past ten years. In 1976, soybean oil represented about 40 percent of edible vegetable oil production compared with 23 percent in 1965. Palm oils together constitute the second largest component of the vegetable oil group and recorded the fastest rate of growth among fats and oils. There has been a steady growth in palm oil output, particularly in Malaysia. Sunflower-seed oil is the second largest single vegetable oil and groundnut oil ranks third (Appendix Table 8).

Developing countries are playing a growing role in the world fats and oils economy as their output has expanded faster than in the world as a whole. By 1975 their output nearly equaled that of developed countries. The weakness of this performance is that production is concentrated in a relatively few countries, notably in Asia and Latin America. In other developing countries production has fallen behind consumption needs, necessitating import supplementation. Consumption in developing countries has increased by about 400,000 tons a year over the last decade of which an average of 150,000 tons came from imports (Appendix Table 8).

World production of oilcakes and meals (including fishmeal) in 1975 are estimated at 29.6 million tons and at a record 33.2 million tons in 1976. Between 1965 and 1975, estimated world

production of oilcakes and meals increased by about 1.1 million tons (in protein equivalent) per year. As a result of sharply reduced 1976 U.S. soybean and Canadian rapeseed crops world supplies of oilcakes and meals are now projected to fall in 1977 below last years level. In accordance with production patterns vegetable oilcakes and meals are the chief components of aggregate output whereas fish meal accounts for about 10 percent of the total.

Production of soybean meal is concentrated in the U.S. and Brazil, rapeseedmeal in Canada, and groundnut meals in India. Peru is the principal producer-- exporter of fishmeal.

Trade Trends. Paralleling trends in production is trade in these commodities. World exports of fats and oils totaled about 14.4 million tons in 1975 and have risen to an estimated 16.4 million in 1976. Over the period 1965-75 world exports increased at an average annual volume of about 450,000 tons. (Appendix Table 8). Of the 1975 export volume, soybean oil represented 3.7 million tons and palm oil 1.7 million. Between 1965 and 1975 palm oils were the fastest growing fats and oils export items followed by rapeseed and soybean oils respectively. Palm oil exports followed an uninterrupted upward course since 1967. Exports are estimated at 2.1 million tons in 1976 and forecast to reach 2.4 million tons in 1977.

World exports of oilcakes and meals were estimated at 12.6 million tons in 1975 and export availabilities are projected at 15.5 million tons in 1976 (Appendix Table 9). World exports grew at an annual average rate of about 500,000 tons over the 1965-75 period. Soybean cakes and meals were largely responsible for this growth and now contribute about 70 percent of total exports. Among other oilseed meals only rapeseed meals registered significant gains whereas cottonseed, groundnut and sunflowerseed oilcakes experienced a decline in volume over the 1965-75 period. Fish meal export showed high degree of variability but on the whole did not change significantly over the 1965-75 period.

Regional features. North America, the centrally planned countries and the Far East are the world's principal producers of fats and oils whereas in terms of exports North America and the Far East are the dominant sources. The U.S. share of world output of fats and oils has varied from one-fifth to over one-fourth of the total in recent years. It has a dominant position in the world's soybean economy. However, the U.S. share of the soybean/soybean oil market has declined from around 95 percent in 1969-70 to less than 70 percent projected for 1977. Brazil is the world's second ranking producer and exporter of soybeans and soybean products. Brazil's soybean and soybean oil exports for 1977 are projected at 1.34 million tons representing nearly 30 percent of the world total compared with 13 percent in 1975. China, which prior to 1960 produced nearly half the world's soybeans and supplied between a quarter and a third of beans and oils, entering the world market, has gradually reduced its exports.[1] In 1975 Chinese exports of 251.000 tons were only about one-fifth of those made in 1960.

The developed countries as a group are net importers of fats and oils whereas the developing countries are net exporters of these commodities. On the import side, member countries of EC, Japan and the Near East are the world's largest net importers of fats and oils. The centrally planned countries have been on the whole small net exporters of fats and oils in the 1970's.

Trade Determining Factors

World trade in oilseeds and products, animal and marine fats and oils are governed by the interaction of forces and operating in both the demand and supply side of the market. Complicating the trade picture is that oilseeds yield joint products -- meal or cakes and oil -- each influenced by separate and distinct market forces. The demand for meal, used primarily for feed, is shaped by factors operating in the feed-livestock economy, whereas that of fats and oils, used mainly for foods, is influenced by factors prevalent in the food sector. An extra dimension of demand is provided by industrial usage. The major difficulty plaguing the market is that cakes or meals and oils are not enjoying parallel growth in demand. The market for cakes and meals has grown at a significantly faster rate than fats and oils.

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1) Apparently pressures on food production led to a shift of land from soybeans to cereals.

Demand for oilseeds and cakes and meals. Factors affecting trade in oilcakes and meals correspond, by and large, with those influencing trade in oilseeds. Essentially cakes and meals can be purchased either as cakes and meals or oilseeds. The growth in demand in these items has benefited from (1) increased demand for red meat and poultry; (2) improved livestock feeding techniques; and (3) liberal import policies.

The demand for oilseeds, cakes and meals has benefited from increased prosperity and purchasing power in the developed countries, allowing people to upgrade their diets by consuming more livestock products. Soybeans have gained favor in relation to other oilseeds because they have certain distinct advantages. First, soybeans when compared with most oilseeds have a relatively high meal to oil ratio; meal content is nearly 80 percent.[1] In addition, soybeans supply a high quality protein. Soybean protein has a highly desirable amino acid balance for all classes of livestock, particularly for poultry and hogs and has a high degree of digestibility. Feed-livestock price relationships and feeding techniques--protein feeding rates per livestock units --are factors that exert a strong influence on demand. Growth in cake and meal consumption and hence in trade has been markedly affected by year-to-year shifts in the price ratio of protein cakes and meals relative to other sources such as feed grains, pulses, and grain by-products.[2] In countries where grain prices are high, relative to those of cakes and meals, some substitution of grains by these is in evidence.[3]

It was found that an average 1-percent change in the import price of U.S. corn was associated with a 1.3 percent change in the same direction in the volume of U.S. soybean

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1) By contrast, the meal content is approximately 48 percent for cotton-seed, 43 percent for peanuts, and 35 percent for sunflowerseed.

2) In the U.S. soybean meal becomes attractive pricewise as a source of energy for livestock rations when the soybean meal/corn price ratio is below 1.8:1. If this ratio is bigger soybean meal will be used only as a source of protein.

3) For example, in West Germany, the Netherlands, Sweden and Spain where the price of corn was high relative to the price of soybean meal during the 1960's, the latter replaced corn in feeds.

meal exports to the European Community.[1] An even higher degree of responsiveness is discernible in the changes in livestock prices of major importing regions. For instance, a 1 percent rise in the livestock prices was accompanied by a 2.2 percent increase in U.S. soybean exports.

There is also a high degree of substitution among protein meals themselves. Fish meal and urea were benefiting when oilseed meals were non-competitively priced. The relative price attractiveness and ample supplies of soybean meal since 1969 were important factors contributing to increased utilization and trade.

Since soybeans are not grown to any great extent in the principal consuming countries, there are only nominal restrictions on imports. Other oilseed crops that are produced domestically in the consuming importing countries, however, are usually supported at fairly high levels in relation to world prices of soybeans.

Demand for fats and oils. Analysis of world trade and use of fats and oils is difficult because not only is there a wide range in competition and source of supply, but most of the major oils are by-products. The supply of vegetable oils is essentially determined by the demand for cakes and meal and entailing rate of crushings. Only the palm is strictly an oil crop.

The demand for fats and oils varies from country to country and the extent to which demand is satisfied with any particular product depends upon (1) local tastes and cooking habits; (2) relative prices of competing oils and fats; and (3) degree of price protection afforded to local producers.

Generally supply of vegetable oils has expanded faster than consumption, reflecting disparate rates of growth between the demand for cakes and meals and oils. Current per capita consumption of food - fats and oils is generally low in developing countries, about 8 kilograms a year, because of

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1) J.L. Matthews, "Conditional Forecasts and Implications for the U.S. Soybean Economy", Fats and Oils Situation (U.S. Department of Agriculture) Supplement to July 1973 issue, p. 13.

limited consumer buying power and unfavorable balance of payments. In contrast, per capita consumption in the developed countries is already high and consumption has been expanding slowly. The low income elasticity of demand for these products and the changed eating habits, underlie the levelling off in per capita consumption of edible fats and oils.[1)]

Because of the high substitutability among fats and oils, the volume of individual fats and oils consumed has shown considerable yearly variation in response to changing price relationships. Both consumers and edible oil processors tend to change the mix of their edible oil and/or products purchases in a way that minimizes expenditures and costs. Moreover, fats and oils can be used as sources of energy in animal feeds and substitute for corn and other feed ingredients.

Prospects for Trade, Production and Consumption

World trade in fats and oils and related products will be affected by the interaction of much the same demand and supply factors as were acting in past years.

Factors governing the future level of demand will certainly be tied to the (1) timing and pace of economic recovery in the market economy countries; (2) pace of economic growth in developing countries; (3) balance of payments' positions; (4) trade policy measures; and (5) further improvements in feeding efficiency. The level of economic activity will be the single most important factor determining demand for fats and oils and livestock products and thereby for protein meals. In the feed-livestock economy, demand for protein meals will also be affected by (1) protein meal-feed grain price relationships; (2) the price and availability of synthetic proteins and urea; (3) the price and availability of vegetable protein extracts;[2)] and (4) the price of high lysine corn and wheat-rye hybrids.

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1) The income elasticity of demand in developing countries for fats and oils is .55 for developed countries .14.

2) Development of various non-oilseed protein resources could have severe repercussions on the future demand for vegetable oilseed cakes and meals.

Production of edible vegetable oils is expected to continue to expand in the decade ahead primarily stimulated by increasing outputs of soybean oil, palm oils and sunflowerseed oil. There are indications of increased production plans in Brazil and in a number of other soybean exporting as well as importing countries. Outside the U.S., Brazil has the greatest potential to continue to increase production, particularly if prices remain at a favorable level. The pace of further expansion will depend on the trend in soybean price and in corn yields. In Brazil, corn yields are still low, making soybeans a more profitable crop for Brazilian farmers. Soybeans appear to have a promising future in Argentina but most of the expansion would have to come from the diversion of land sown to other crops. Soybean production in the U.S. is expected to continue to change in relation to soybean-corn price relationships. In the same vein, cottonseed production will continue to be affected by the price for cotton fibre.

Palm oil will continue to provide an expansionary momentum to vegetable oil production. Further plantings of oil palm trees in Malaysia, Indonesia and the Ivory Coast are seen to continue during the period up to 1985. Obtained from nuts grown on trees with a long productive life, palm and palm kernel oils are low cost products.[1)] Production of industrial oils will likely continue in a declining trend displayed over the 1965-75 period whereas marine oils may hover around prevailing levels. Output of animal fats is projected to grow at about the same moderate rates as in past years.

Recent studies concluded there will be adequate world supplies of fats and oils in the mid-1980's as world production will rise more rapidly than consumption. The FAO projections suggest that developing countries as a group would, by 1980, have exportable surpluses of some 2.8 million tons which

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1) Oil palms reach bearing age at two and half years with yields increasing until they reach about 8-10 years of age. Yields average up to 4.5 tons of oil per hectare by the 8th year compared with about one ton at the age of three.

would be more than compensate for a 1.4 million ton projected deficit in developed countries.[1)]

World production of oilcakes and meals are expected to continue their overall long-term upward trend. Use of high protein cakes and meals, however, are likely to increase at a slower rate than in the 1965-75 period, resulting in a 3.4 million ton exportable surplus.[1)]

Developing countries can play a key role in providing the world's needs for vegetable oils. There is much scope for increasing vegetable oilseed production in many developing countries by expanding areas and raising yields of existing crops and through the introduction of new crops. The rapid growth of exportable supplies of palm oil is a case in point. Further increases in vegetable oil production would not only allow producing countries to increase domestic consumption and to upgrade the nutritional levels of people's diets but also provide an opportunity for meeting deficits in a large number of other developing countries. Since per caput consumption is generally low, it seems certain that over the long term consumption will increase markedly.

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1) FAO, Agricultural Commodity Projections 1970-1980. Rome, 1971, pp. 150 and 165.

CONSTRAINTS AFFECTING CROP PRODUCTION

While it is recognized that a host of factors imposed by nature and man have a profound influence on future world food production, discussion is limited here to intensive and extensive land development, climate changes, water, energy and environmental constraints.

Intensive and extensive land use. Continued increases in world production commensurate with projected demand changes--or at least consistent with trends of the past two decades--require some combination of: (1) output per unit of land be increased on many soils now used for crops; (2) additional arable soils not now used, be developed and their management systems learned.

In recent years the developed world--Europe, North America, the Soviet Union, and most of Oceania--has relied mostly on increased technology to meet expanding production needs. The developing world, particularly Latin America and Africa, has relied more heavily on developing new land area to expand output. A comparison of the relative contribution of yield and cropland area to increased production of maize shows that yield increases accounted for 45 percent of gains in Latin America and area accounted for the remaining 55 percent. All increases in the United States between 1950 and 1970 have been attributed to yield increases since area in maize production declined. The highest maize and soybean yields in the world are obtained in the USA and that of wheat yields in Europe. Oceania has the highest rice yields.

Intensive land use. In many areas, cultivated lands offer greater potential than new land development for increased short-run food production. A University of California Food Task Force study concluded that the physical and biological potentials of most of the world's land and crops far exceed present performance.[1)] Maize, for example, yielded 53.9 quintals per hectare in the United States in 1970 and showed a 49 percent yield increase during the 1960-1970 decade (Table 7). World corn yields 25.8 quintals per hectare and increased 25 percent during the

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1) University of California Food Task Force, A Hungry World, Chapter 3.

Table 7: Yield Trends by Geographic Region for four Major Crops (quintals/hectare)

Commodity	Year[a] and average annual % change	World	Europe	USSR	North America	U.S.	Oceania	Asia	Latin America	Africa
Maize	1950	15.8	12.4	13.1	24.9	24.9	18.0	8.4	10.8	7.8
	1960	20.6	20.4	17.2	35.7	35.7	22.4	10.5	11.7	9.6
	1970	25.8	33.4	26.7	53.0	53.1	29.4	18.5	13.8	12.1
	1960/50-%	30.4	64.5	31.3	43.4	43.4	24.4	25.0	8.3	23.1
	1970/60-%	25.2	63.7	55.2	48.5	48.7	31.3	76.2	17.9	26.0
Soybeans	1950	10.0	5.7	4.3	14.3	14.3	--	8.0	12.0	4.9
	1960	12.0	6.9	5.0	16.3	16.3	--	7.8	12.0	5.0
	1970	13.2	10.4	6.2	18.4	18.4	9.0	8.1	12.9	4.9
	1960/50-%	20.0	21.1	16.3	14.0	14.0	--	(2.5)	0.0	2.0
	1970/60-%	10.0	50.7	24.0	12.9	12.9	--	3.8	7.5	(2.0)
Wheat	1950	9.9	14.9	8.4	11.6	11.2	11.3	7.7	10.5	6.0
	1960	12.2	18.9	10.8	15.1	16.7	12.7	8.1	11.8	6.0
	1970	15.3	26.7	14.3	19.7	20.8	11.9	10.7	13.8	9.8
	1960/50-%	23.2	26.8	28.6	30.2	49.1	12.4	5.2	12.4	0.0
	1970/60-%	25.4	41.3	32.4	30.5	24.6	(6.3)	32.1	16.9	63.3
Rice	1950	16.3	43.0	14.5	25.6	25.6	31.1	16.3	17.0	10.4
	1960	20.8	46.1	21.0	38.4	38.2	45.1	19.9	17.8	11.8
	1970	22.4	44.0	36.0	51.0	51.0	58.2	22.9	17.1	18.5
	1960/50-%	27.6	7.2	44.8	50.0	49.2	45.0	22.1	4.7	13.5
	1970/60-%	7.7	(4.6)[b]	71.4	32.8	33.5	29.0	15.1	(3.9)	56.8

a) 1950, 1960, and 1970 are five-year averages (e.g., 1950 includes 1948-1952).

b) ( ) denotes decreases.

Source: University of California Food Task Force Report, A Hungry World: The Challenge to Agriculture. (Berkeley: University of California, July 1974).

same period. Latin America, with soils and climate not greatly different from those in the United States and with about the same land area in maize, produced 13.8 quintals per hectare in 1970 and showed a yield increase in only 18 percent for the 1960-1970 decade. Similar comparisons can be made for other crops. Although improved technology is not easily transferred, scientific methodology is transferable. If that methodology is systematically applied (and resources are available), significant yield advances are possible in most developing areas.

Extensive land development. The world still has a reservoir of unexploited land that could be brought under cultivation. About 3-4 billion hectares of the globe's 13.2 billion hectares are potentially arable.[1] World wide right now only 1.4 billion hectares are actually harvested in any given year. Between 10-15 percent of arable land is now irrigated, though sometimes not very efficiently.[2]

Buringh, et.al, argue that 10-15 percent of the 2 billion of unused potentially arable land will also be irrigated. If realized irrigated area could be expended from the present 204 million hectares to 470 million hectares.

There is a further potential for expending crop area by multiple cropping. This would raise the maximum gross-cropped area to 6.6 billion hectares[3]. This gain is offset by the increased hazard from schistosomiasis and from pests which no

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1) Estimates of the absolute limits of area and possible production per hectare in 222 zones of the world are contained in P. Buringh, H.D.J. van Heemst, and G.J. Staring, Computations of Absolute Maximum Food Production in the World. Publ. 598 Landbouwhogeschool, Wageningen, Netherlands, 1975.

2) Estimates on irrigation potentials are given in H.J. Moen and K.J. Beek, Literature Study on the Potential Irrigated Average in the World. I.L.R.I. Wageningen, 1974.

3) U.S President's Science Advisory Committee, The World Food Problem Vol. 2 (Washington, DC, US Government Printing Office, 1967) p.434.

longer die during fallow periods. Eradication of infestations such as the tsetse fly accross central Africa also offers an opportunity to about 0.7 billion hectares to agricultural lands.[1)]

At this point in time then the problem is clearly not a shortage of land. But bringing more land under cultivation usually means moving into marginal land where soil and climate conditions give a poor return and greater variablility in yields. The tropics contain over half of the potentially arable land and deserts and semiarid regions 34 percent. The potentialities of the 1.5 billion hectares of land in the wet tropics are a matter of dispute among soil experts. Some suggest that there is potential for three crops a year though soils are generally deficient in nutrients and subject to hardening. It is feared, however, that this land would rapidly erode if farmed conventionally; others argue that this danger can be prevented by appropriate farming methods. The obstacles are formidable because much of the land is inaccessible until roads are built. According to FAO estimation South America and Africa south of the Sahara together have more than half of the total potential agricultural land. Specifically, the most promising unused lands are in the Amazon River basin of northeast Brazil, the savannas of Colombia, Venezuela, Ecuador and Brazil where livestock could be raised if plant varieties are bred that would thrive in the high-acid soil. There are also some opportunities for expanding the cultivated land area in Australia, the Mekong River basin, notably Thailand, Eastern Africa, Congo River basin, Sudan and in South Africa. South Asia, the Near East and North-West Africa regions, by contrast, are approaching the limit of available land for traditional forms of crop production.

1) It would cost around $100 million per year for 20 years. See FAO, Preliminary Assessment of the World Food Situation Present and Future. E/CONF. 65/PREP/G, Rome, April 1974, p. p. 7.

The world's largest area of arid and semi-arid rangeland contains over some 7 million square kilometers of Africa and the Near East. These areas support 20 million people and some 200 million head of livestock but increasing concentration has led to a deterioration in the range ecosystem. The recent drought and its aftermath in the Sahelian Zone is part of this trend. An expert consultation under joint auspices of FAO and the UN Environmental Program (UNEP) in 1974 identified five causes of this deteriorating situation.[1)]

1) Lack of commitment or strategy for range development on the part of national governments;
2) Lack of information or understanding concerning ecological potential and constraints, often leading to unworkable settlement projects, miscalculations on livestock carrying capacity, or disruption of viable nomadic lifestyles;
3) Unbalanced development, as when new water supplies are installed without regard for other inputs;
4) Lack of adequate organization in the national government;
5) Inadequate local participation and organization at the level of the pastoral community.

A follow-up conference endorsed a proposal on Ecological Management of Arid and Semi-Arid Rangelands Program (EMASAR) for Africa and the Near and Middle East. EMASAR plans to help affected countries (a) to identify and formulate programs and projects, training, and other activities; and (b) serve as a liaison between countries seeking assistance and national and international agencies in a position to provide such assistance.

Bringing the world's potentially arable land into production would require considerable financial outlays ranging anywhere from $200 to $3,000 per hectare.[2)] Assuming that it takes 0.4 hectares of arable land to feed a person a year and the world growth of population is 80 million a years, then

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1) FAO, Notes for North America, No. 10 (May 1975), p.3.

2) New land brought under cultivation through the Aswan Dam project in Egypt has cost approximately $800 per hectare at today's prices.

the capital cost per year to develop new lands alone could range between $6.4 billion and $96 billion per year just to maintain current diets. It seems realistic to assume that unit cost of development of new lands increases as the proposition of potentially arable land diminishes. Buringh et. al., estimate that 0.9 billion hectares comes at the expensive end of their scale ($3,000).[1)]

In a hypothesized function Gallopin has shown that the unit cost of development increases exponentially with diminishing fraction of potentially arable land, up to a maximum of $6000 per hectare and a minimum of $1,163 per hectare.[2)] In view of current food prices and prospective farming technologies only a relatively small portion of the potentially cultivable land could be developed.

In addition to land clearing and other soil improvements there is need for extensive investment in transportation, marketting facilities and research. Moreover, it will be necessary to recruit qualified farmers and provide them with needed production inputs (credit, new seeds, fertilizers, and animal varieties).

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1) There are estimates that the cost of establishing one workplace in modern industry is more than $3,000.

2) G.C. Gallopin, "Latin American World Model", paper presented at the third IIASA Symposium on Global Modeling, Baden, Austria, September 22-25, 1975, p.11.

ENERGY

Energy is consumed either directly as fuel or indirectly in the manufacture of inputs used in most food and fiber production. Food production can be an energy-intensive activity depending on the production technology used and the state of processing involved. Fossil energy power through fertilizers and various machinery can reduce labor and land inputs, and vice versa. The use of fertilizers, particularly nitrogen fertilizers, produces crop outputs on 1 hectare that would require several hectares without the use of fertilizers. Irrigation is another form of energy-intensive agriculture. One hectare of irrigated land not only produces the yield of several hectares but also allows multiple cropping and the bringing of unused land into production. In a North American type irrigated agriculture about 44 percent of energy used was for irrigation and 22 percent for fertilizer production.[1] Under dryland grain production the energy used for fertilizer manufacture represented about 50 percent of the energy consumed to produce these products on the farm.[2] At the present, it requires close to 0.8 ton of oil equivalent to feed each person in the U.S.and U.K., or about three times the average per capita use of commercial fuels for all purposes in the developing countries.[3] Pimental estimates that in the United-States about 13 to 15 percent of the total per capita energy used annually (directly or indirectly) is expended for food.[4]

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1) W.J. Chancellor and J.R. Goss, "Balancing Energy and Food Production, 1975-2000", Science, Vol. 192, No. 4236, April 16, 1976, p.214.

2) Fertilizers, notably nitrogen fertilizer, are energy-intensive products. A ton of nitrogen (N) applied to the soil has an energy requirement of about 1.8 ton oil.

3) Gerald Leach, Energy and Food Production. (IPC Science and Technology Press Ltd., Surrey, England, 1976), p. 2.

4) David Pimentel, et al., "Energy and Land Constraints in Food Production". Science, Vol. 190 (November 1975) p. 758.

In view of the existing low crop yields in the developing countries there is a large potential scope for increasing food production with the use of current crop production technology. But whether it will be economically feasible for the developing world to adopt an energy intensive agriculture has now become the focus of increasing concern. Broadly stated then the issue is: will there be enough energy and at what costs for the adequate feeding of today's 4 billion people and the 6 to 7 billion expected by the year 2000 should the industrial countries maintain their present consumption rates.

While energy resources combined are estimated to be sufficient to last at present usage rates for centuries, fossil fuels, particularly natural gas and oil, are rapidly being depleted and in the next few decades are expected to near exhaustion.[1] Of the fossil fuels, natural gas is in shortest supply. The principal alternative energy sources are coal, hydro-electric power and fission reactors. In light of its abundant supply, coal will have to play a greater role as a primary source of energy and as a chemical raw material in years to come. Coal could provide a feasible alternative solution to energy supply for many developing countries. Of course, environmental and techno-economic problems associated with coal gasification and liquefaction need to be solved before coal utilization can be expanded on a significant scale.

There is a growing concensus that solar energy, wind power and geothermal energy could represent promising new energy sources, though progress in their development has been slow. Nuclear fusion, ocean energy (thermal gradient, waves, tides) and biological energy are of great potential but will not be available for some time. Whatever the long-run developments will be, the use of present energy sources is expected to

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1) Known world reserves of these energy resources are expected to be more than half depleted by the turn of the century. See M.K. Hubbert, in The Environmental and Ecological Forum 1970-71 (U.S. Atomic Energy Commission Office of Information Services, Oak Ridge, Tenn., 1972), pp. 1-50.

increase putting pressures on supplies and costs.

Research and policy choices. In view of growing energy requirements there is need for studies that explore prospects of world energy demand and supply under alternative energy strategies up to 2000. Particular attention will need to be devoted to the cost and availability of energy to major industrial sectors including food and agriculture. An important aspect of this undertaking is the analysis of environmental deterioration problems and effects on local or global climatic systems.

The broad alternatives for developed countries are:

(1) continue to increase their energy use in line with past trend pattern;
(2) reduce the present rate of energy consumption;
(3) accept a zero growth long-term energy strategy; and
(4) reduce production of animal products.

For the developing nations increased energy use will be imperative if they are to meet the basic human needs and reduce dependence on food imports. Their economic and agricultural development is linked in manyfold ways to the availability and use of energy. Energy conservation together with the development of cheap and indigenous energy resources have not only become attractive policy alternatives but also necessary for the poor countries. Conversion of biological wastes into fuels could be the most important indigenous energy source according to a recent study.[1)] Producing methane from animal manures and crop wastes by anaerobic fermentation is another area now being actively explored. Moreover, there are savings to be made by greater care in the timing of fertilizer application in relation to soil and crop types, season and rainfall.

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1) It was shown that this process could provide 366 million tons oil equivalent for the U.S. in the year 2000. This quantity would be about 60 percent of the energy output of the largest nuclear program now being proposed by the U.S. Atomic Energy Commission. See FEA, Final Task Force Report on Solar Energy. Federal Energy Administration, USGPO 4118-00012, Washington, D.C., 1974; and USAEC, Nuclear Power Growth 1974-2000. United States Atomic Energy Commission, WASH-1139(74), UC-80, Washington, D.C., 1974.

Finding ways of meeting the energy needs of developing countries presents an enormous and urgent task for the rich countries, and a task that must succeed if the level of hunger is to be reduced.

ENVIRONMENTAL QUALITY

As world population expands and as technology develops, pollution and other deleterious changes in environmental quality have increasingly severe effects on economic activities, including food production, aside from the general quality of life. Two major areas of concern about environmental quality associated with food production are:[1)]

- Effects on the environment of potentially polluting materials from agriculture, such as crop-protection chemicals, fertilizers, and solid wastes.
- Effects on agriculture of environmental degradation caused by population growth and industrialization, such as effects of urbanization on farmland, and crop damage from urban-generated air pollution.

Agricultural Residues and Wastes. Technologically advanced intensive food production -- whether in developed or developing countries -- generates wastes and residues in amounts and concentrations that threaten environmental quality. These may be either unwanted by-products of agricultural activities or substances which have served their intended purposes.

Pesticide residues. In recent years, crop-protection chemicals have become far more numerous and diverse and have been used in far larger amounts. Many are highly toxic to man and other animals. Some persist in the environment and accumulate in food chains. Specific environmental side-effects from the use of pesticides -- particularly insecticides -- include possible residues in foods, poisoning of agricultural workers, killing of nontarget organisms, and residues in soil and water. There also is danger of decreasing the effectiveness of pest control, through destruction of beneficial organisms and the development of resistance in target species.

Fertilizer residues. Environmental questions are raised by the rapidly expanding use of chemical fertilizers in developed nations, as well as the trend toward more fertilizer use, particularly nitrogen, in developing countries. Nitrates

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1) A Hungry World: The Challenge to Agriculture. (General Report.) University of California; Food Task Force, University of California, Division of Agricultural Science, Berkeley, California, 1974.

in excess of those used by the crop can appear in drainage water from some croplands, and may enter groundwater supplies.

Animal and crop wastes. Large-scale intensive production units for beef and poultry have created waste disposal problems on a new scale. Large amounts of manure concentrated on a small area are problems both because of their bulk and because of their content of nitrogen, salts, and organic matter. If the trend to intensification of animal production continues, it will cause increasingly complex waste disposal and pollution problems.

Solid wastes from crops and food processing are an environmental problem primarily in relation to cities and other population concentrations. Most of these wastes are highly degradable, so they can be recycled rapidly by biological action or burning. However, the disposal process may create problems of smoke, odors, water pollution, and pests.

Salts and siltation. Soil and water salinity is a major worldwide environmental obstacle that must be faced during the next decade or two as efforts are made to expand crop production area, increase crop yields, and conserve and recycle irrigation water.

Salts can accumulate in farmland when irrigation water has too high salt content, water is insufficient for proper leaching, and/or drainage is poor. In general, irrigation waters containing soluble salts at 500 parts per million (ppm) or less will not harm soils or crops if properly managed. Water with 1,000 to 2,000 ppm requires careful management for continued successful cropping. Water containing salts of 2,000 to 5,000 ppm is detrimental to almost all crops but with very careful management can be used to grow salt-tolerant plants on readily permeable deep soils.

Of growing importance in arid or semiarid parts of the world, are the salinity levels in "return flows" (water leaving the farmland).

A comparable problem affecting soil and water quality are erosion and siltation especially in tropical areas of the world. Soil washed into rivers and streams is lost to the original farmland and degrades the water by adding sediment, nutrients, and other contaminants.

Environmental Effects On Agriculture. Agriculture's resource base of land, water, and air may be threatened by environmental degradation, particularly in heavily-populated and industrialized areas.

Water. Densely populated areas must dispose of large volumes of liquid and solid wastes. Most constituents of typical municipal effluents are either harmless to crop production or actually beneficial. Hence, there is a promising possibility of recycling vast amounts of urban wastes through farmland. The chief problems are transport and distribution of the effluents, and removal or management of pollutants such as heavy metals and viruses.

Air. In regions where man-caused air pollution is substantial, food production suffers, although no comprehensive assessment exists of the impact of air pollutants on the growth, production and quality of crops, oxidants are responsible for much of the air pollution crop damage. If more use is made of sulfur-containing fuels, sulfur dioxide also could become a serious threat. Oxidants have been shown to significantly reduce yields of cotton, citrus, and grapes.

Land. In addition to the worldwide problem of availability of arable land, there is a specific problem of urban effects on farmland. Agricultural operations are hindered not only by actual loss of land to urbanization but by urban-generated higher tax rates and by competing land uses such as power plants.

Ecological abuses too, are having perceptible detrimental effects on the quality of arable land. Deforestation and overgrasing and increased erosion due to the loss of protective vegetation are diminishing the productivity of vast areas in Asia and Africa.

WATER

According to UN estimates, out of the total fixed stock of water on our planet, 97.3 percent is ocean water and only 2.7 percent of the total is fresh water potentially useful to mankind. Moreover, since 77.2 percent of fresh water is stored in ice-caps and glaciers unavailable for use, less than 1.0 percent of the total amount of water on the earth is available for human use in streams, lakes, swamps and in the ground. And, the geographic distribution of the limited water supply is not always advantageous for agriculture production.

Irrigable Land

Where it can be developed for arid regions, irrigation is sometimes a necessity for agriculture and in most cases offers a great opportunity to increase food production. According to the FAO, irrigated land for the world totaled 180.9 million hectares in 1965 and 203.6 million hectares in 1970. Newly irrigated land during this 5-year period averaged about 4.5 million hectares per year. Projecting this rate of development to 1985 would provide 271.1 million hectares of irrigated land. However, to maintain the present ratio of persons per hectare of irrigated land, the total would have to increase to 277.1 million hectares by 1985 - a growth rate of 4.9 million hectares per year. Attainment of such a growth rate would require substantial capital resources and trained manpower to plan and develop and implement irrigation projects. (See section on extensive land development).

Table 8 shows cultivated and irrigated land in 1970 by selected countries and major regions. The 14 % of cultivated land that is irrigated produces a very much greater percentage of food production. Japan, China, and Indonesia, all very densely populated, have large percentage of irrigated land.

Table 8: Cultivated and Irrigated Land by Country or Region -- 1970

Country or region	Cultivated land	Irrigated land	Irrigated	Persons per irrigated ha.
	million hectares		percent	number
World	1457.00	203.61	14.0	17.8
Europe	145.00	12.29	8.5	37.6
EEC-9	52.38	5.35	10.2	46.6
Eastern Europe	46.02	2.67	5.8	38.9
USSR	232.61	11.10	4.8	21.9
North America	236.09	16.18	6.9	14.0
United States	192.32	15.38	8.2	13.3
Canada	43.77	.35	0.8	60.0
Oceania	47.00	1.60	3.4	11.9
Australia & New Zealand	45.44	1.60	3.5	9.4
Asia	463.00	145.71	31.5	14.1
Japan	5.45	2.63	48.2	39.2
China	111.20	76.00	68.3	10.0
India	164.61	27.52	16.7	19.5
Indonesia	18.00	6.80	37.8	17.1
Latin America	118.92	10.41	8.8	27.2
Mexico	23.82	4.20	17.6	12.1
Brazil	29.76	.46	1.6	202.2
Africa	214.00	6.34	3.0	54.3

Predicting the ultimate potential for worldwide irrigation is subject to considerable error because comprehensive feasibility studies have not been made. Gross estimates were made by the Panel on the World Food Supply (1967) by considering the potentially arable land in areas deficient in precipitation, with the runoff from rivers in the same regions. From that analysis, the panel concluded that the ultimate irrigation

potential for India, West Pakistan, and Bangladesh is about 93 million hectares, compared to about 36.4 million hectares actually irrigated in 1966. The irrigation potential for these parts of Asia, plus Africa and South America, is 259 million hectares.

The problem of estimating the potential of irrigation development on a worldwide basis becomes still more complex when you consider also the possibility of intensifying investment in existing irrigation facilities as an alternative to using scarce capital resources to open up new irrigated land. For example, better water control and management and improved drainage offer, in many cases, dramatically higher crop yields and increased food supplies. Also, in many areas groundwater sources of water can be "mined" more cheaply and may be preferable to construction of expensive dams, or at least exploited while other supply sources are under development.

CLIMATE

Weather and climate have always been major factors in determining food supplies and are also the least controllable. Two kinds of climate changes may influence future world food production: (1) a possible long-term trend toward temperature change, either natural or caused by mankind's emissions of atmospheric pollutants, and (2) short-term climatic variations. A change in world climate would certainly affect the longer term future of food supplies. In addition, worldwide food production is becoming more sensitive to climatic change for various reasons: more intensive land use which exposes more production to local extremes; expansion of cultivation to lands of marginal productivity; genetic tailoring of crops, especially grains, to narrow climatic ranges; and large area of single-crop culture, increasing vulnerability to massive failures.

Weather cycle theories and the theory of secular deterioration in weather foresee a possible gradual warming trend that could result in the melting of polar icecaps to a drift toward a cycle of colder temperatures.[1)] The experts on weather point out that from about 1550 until the turn of this century the world's climate was rather cold. This period is referred to as the Little Ice Age. Following that cold period, was a global warming in the first part of the present century reaching optimum levels from about 1920 to about 1940 and ended in about 1950. Plant growth was favored in the non-arid regions while regular rainfall reduced some of the world's deserts.

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1) It is believed that climatic changes are affected by the amount of sunlight that reaches the surface of the earth and how much of this solar energy is reradiated back to space. The former is dependent on the transparency of the atmosphere. This, in turn, is affected by the amount of particulate matter injected into the atmosphere by volcanic activity and man-made air pollution. The particulate material in the atmosphere increases the earth's reflectivity and thereby reduces the amount of sunlight reaching the earth's surface. This condition tends to cause the earth's surface to cool and enlarge the polar whirl of air.

Working in the opposite direction is the simultaneous accumulation of carbon dioxide in the atmosphere released by the combustion of fossil fuels. Carbon dioxide molecules are reflecting heat back down towards the earth thereby contributing to the warming of the earth's surface. Reinforcing this effect is the production of heat by power production on earth. This theory holds that atmospheric accumulation of carbon dioxide gradually could suppress the cooling effect of pollution from particulate matter.

Climatic research suggests that colder temperatures seem distinctly possible.[1] Since 1940, the mean temperature of the surface of the Northern Hemisphere has declined 0.1 degree per decade, but four or five degrees for some northern locations like Iceland.

While the cause of the 1940's reversal from warming into the global cooling trend is not yet known, the effect of this trend seems to be shortening the growing season in northern and mid-latitudes where two-thirds of the world's food is grown. This global cooling trend, the University of East Anglia in England found, has already decreased the growing season by two weeks in England since 1945. In the past 30 years parts of the Atlantic too have experienced cooling temperature changes which had considerable effects upon the abundance and distribution of fish stocks. Thus the herring has disappeared from Iceland in recent years and cod populations have moved further south. Were the cooling trend to continue at a minimum, it would likely bring more extremes of climate: more cold spells, more heat waves and droughts and more floods in the Northern Hemisphere. The extremes of 1972-74, 1976 and the 1977 coldspell in the United-States are indications of the future course of climatic change. A drop of one degree in the average temperature level would completely eliminate cultivation in the northernmost third of the Canadian wheat area and 80 percent of that in Siberia causing estimated production losses in these two areas alone totaling 45 million tons.[2]
Climatologists are convinced that changes in the earth's temperature also affect the atmospheric circulation and rainfall.[3] The major wind systems, the Northern Hemisphere jet stream, the summer subtropic high pressure belt, and the intertropical front

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1) Reid Bryson, in "Hearing on U.S. and World Food Situation", Committee on Agriculture and Forestry U.S. Senate, Oct. 17-18, 1973. U.S. Govt. Printing Office, Washington, D.C. pp. 128-130.

2 E. Wright Ingraham, A Query Into the Quartor Century. Workshop report, (Baja California, Mexico, January 15-17, 1975) p. 11.

3) The cooling off process reduces the north-south temperature gradient and thereby slows the atmospheric circulation. The carbon dioxide content warms the surface and thus creates temperature differences between the ground and the upper atmosphere. This vertical temperature difference also affects the circulation pattern of the atmosphere.

have shifted perceptibly toward the equator. The associated changes in rain pattern would tend to push the subtropical deserts of North Africa and Asia southward toward the equator. Consequently, the equatorial zones would be getting wetter and the inland zones on either side of the equator getting drier. The increasingly frequent monsoon failure in the Sahelian zone of West Africa and across South Asia appears to be part of ongoing climatic changes. Droughts are seen to increase in India and other southern Asian nations. In addition, this area is likely to be exposed to disastrous floods resulting from deforestation of mountain sides, overgrazing, and overcultivation. Meteorologists show that North America, notably the semi-arid plains west of 100th meridian has been subject to recurrent severe drought years about every 20 to 22 years for the past 200 years.[1] In the U.S. such a cyclical drought pattern was traced back to the Civil War when data were first collected on rainfall. In this century, they started in 1901, 1934, and 1954 and they seem to correspond with years of low sunspot activity as the current period. Thus the next stretch of drought years is overdue and which might last five or six years. Aggravating the effects of drought is the large amount of land that previously had been taken out of cultivation now being farmed again.

A recent study has shown that solar cycles, notably sunspots, are one of several factors that may affect crop yields.[2] This is through their effect on the length of growing season, temperature, rainfall, radiation levels, atmospheric pressure, and high altitude wind speed.

1) The 100th meridian is in the area of Dodge City, Kansas and Abilene, Texas.

2) The Farm Index, July 1975, pp. 19-21.

Studies in short-term climate variability indicate relatively limited changes in weather in the last forty years. Recent evidence, as noted, suggests to some a possible return to more extreme variations. However, the evidence is mixed.

In a recent report of the U.S., Congress Budget Office on the subject of food and agricultural policy, the conclusion on weather trends was: "The evidence to answer these questions is incomplete and likely to remain so for many years. What is more certain, however, is that precipitation will continue to be highly variable from year to year and region to region."[1)]

1) U.S. Congress, Congress Budget Office, U.S. Agriculture Policy in the World Economy. (Washington, D.C.: U.S. Govt. Printing Office, 1976).

GLOBAL RESEARCH NEEDS AND PRIORITIES

The primary aims of research are to find ways for the alleviation of malnutrition and its effects and to reduce the magnitude of projected food deficits in developing countries. These tasks raise three questions:

1. what are the appropriate national and international approaches and means through which basic nutritional needs can be met;
2. what are the potentialities for increasing food production in the developing countries; and
3. what is needed to accelerate the growth of food production.

The causes of the insufficient growth of food production and its maldistribution are many and complex associated with physical, biological, institutional, cultural and economic constraints. Severe though physical limitations are, institutional obstacles and deficient infrastructure facilities are the principal bottlenecks to expanded production in most developing countries. Accordingly research efforts should seek to identify the specific factors limiting the distribution of food within countries, between countries and the growth of food production. Concurrently research has to help in the delineation of corrective policies and in the creation of institutions for the diffusion of existing technology. And finally, research has to open up new frontiers of knowledge by setting targets for the development of new technologies which are expected to enhance resource productivity. Viewed in this way there are at least four broad areas where major research investment is needed:

1. estimation of nutritional requirements for various populations under various environments and development of policies for the achievement of desired nutrition goals;
2. estimation of the limits of the ecosystem in food production, taking into account the cost and availability of resources and environmental constraints;

3. improving the efficiency of crops and livestock production;
4. development of population control programs encompassing the technological, psychological, cultural, and political aspects of birth control.

The research tasks outlined above may be pursued in national institutions or in international agricultural research centers. There is a clear primary need for the redirection and expansion of national research capabilities many times over present levels. In general, national institutes should promote the more applied type research work, especially,

(1) adaptation of crop varieties to local conditions;
(2) adaptation of crop varieties to meet local taste;
(3) development breeds of ruminants adapted to tropical climate;
(4) increasing stock-carrying capacity of range lands;
(5) discovery of how to maintain the fertility of soils in the high-rainfall tropics;
(6) exploration of cultivation practices that reduce destruction of soils to erosion, floods and salination;
(7) estimation of national comparative advantages in food and agricultural production.

In addition to stimulating agricultural research the dissemination of information is also needed if the new technologies are to be widely adopted. There is a big leg between the development and availability of technology and the time of application.

National research efforts can be augmented but not replaced by international research institutes and research by developed countries carried out in the developed countries. At present there are 10 international research institutes and two other international programs in operation or in the process of being established (Table 9). The newest member of the research network is the International Food Policy Research Institute (IFPRI). Its purpose is to undertake

Table 9: Present Structure of the International Agricultural Research Network

Center	Location	Research	Coverage	Date of initiation	Proposed budget for 1975 ($000)(7)
IRRI (International Rice Research Institute	Los Banos, Philippines	Rice under irrigation; multiple cropping systems, upland rice	Worldwide, special emphasis in Asia	1959	8,520
CIMMYT (International Center for the Improvement of Maize and Wheat)	EL Batan, Mexico	Wheat (also triticale, barley); maize	Worldwide	1964	6,834
CIAT (International Center for Tropical Agriculture	Palmira, Colombia	Beef; cassava; field beans; farming systems; swine (minor); maize and rice (regional relay stations to CIMMYT and IRRI)	Worldwide in lowland tropics, speical emphasis in Latin America	1968	5,828
IITA (International Institute of Tropical Agriculture	Ibadan, Nigeria	Farming systems; cereals (rice and maize as regional relay stations for IRRI and CIMMYT); grain legume (cowpeas, soybeans, lima beans, pigeon peas; pigeon peas); root and ruber crops (cassava, sweet potatoes, yams)	Worldwide in lowland tropics, special emphasis in Africa	1965	7,746
CIP (International Potatoe Center)	Lima, Peru	Potatoes (for both tropics and temperate regions)	Worldwide including linkages with developed countries	1972	2,403
ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)	Hyderabad, India	Sorghum; pearl millet; pigeon peas; chick-peas; farming systems; groundnuts	Worldwide, special emphasis on dry semi-arid tropics nonirrigated farming. Special relay stations in Africa under negotiation	1972	10,250
ILRAD (International Laboratory for Research on Animal Diseases)	Nairobi, Kenya	Trypanosomiasis; theileriasis (mainly east coast fever)	Africa	1974	2,170
ILCA (International Livestock Center for Africa)	Addis Ababa, Ethiopia	Livestock production systems	Major ecological regions in tropical zones of Africa	1974	1,885
IBPGR (International Board for Plant Genetic Resources)	FAO, Rome, Italy	Conservation of plant genetic material with special reference to cereals	Worldwide	1973	555
WARDA (West African Rice Development Association)	Monrovia, Liberia	Regional cooperative effort in adaptive rice research among 13 nations with IITA and IRRI support	West Africa	1971	575
ICARDA (International Center for Agricultural Research in Dry Areas)	Lebanon	Probably a center or centers for crop and mixed farming systems research, with a focus on sheep barley, wheat, and lentils	Worldwide, emphasis on the semi-arid winter rainfall zone		

Source: Nicholas Wade, "International Agricultural Research," Science 188, P. 587, May 1975.

research on selected policy problems affecting the production, consumption availability and equitable distribution of food in the world. All these institutes are supported by the Consultative Group on International Agricultural Research.[1] The International research priorities may encompass a wide range of tasks including (1) evolving new means and more efficient methods of production; (2) problems of cultivation in certain climatic regions; (3) the tapping of unused biological potential of plants and animals for obtaining higher yields and more offsprings of superior quality; (4) the possible impacts of changing climatic and weather patterns and their effects on food production; (5) development of policies which could be adopted by national governments and international agencies to promote increased food production; and (6) development of low energy production techniques for the major food crops.

Both urgency and opportunity exists for enhancing the biological limits for productivity. Here, much remains to be done. Genetic manipulations maybe used for incorporating desirable characteristics into plants such as higher yields, increased nutritive value and broad adaptive base to wide differences in moisture and temperature. With respect to "Green Revolution" crops, efforts are needed to develop new strains with better genetic resistance to disease epidemics than that possessed by existing varieties. Possibilities for improving nutritive (biological) values of grain and legumes proteins are being explored. There are good prospects for success in the creation of new industrial food and feed crops.[2]

Various initiatives are in progress for increasing the biological nitrogen fixation in plants that already have this ability (legumes) and to transfer it to cereals, notably corn and wheat, that lack it.

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1) The Group is co-sponsored by the FAO, World Bank and the United Nations Development Program (UNDP). The World Bank is Chairman of the Group. The Group has 30 members of which 21 are donors.

2) Possibilities of new crop species from crosses of wheat and barley and of barley and rye are being explored.

Extension of nitrogen fixation ability to cereals is well within the realm of possibility. Further down the road are the development of abiological or chemical nitrogen --fixing systems whereby catalyst would convert molecular nitrogen to fixed nitrogen. Biological and chemical nitrogen fixation research could contribute to improving crop yields by increasing the availability of fixed nitrogen to crops.

A new frontier of research has emerged for improving the bio-conversion of solar energy through achieving greater photosynthetic efficiency of plants so that they produce more foodstuffs and/or more protein and less starch.[1)] Another target for research is the inhibition of photorespiration. Large increases in yields should be obtainable by exploiting this knowledge. It should be possible to diminish wasteful respiratory losses without our having to increase the inputs of cultural energy. An immense task still lies ahead for advances in pest control technology, improved water and fertiliser management irrigation techniques, water desalination, and the development of new foodstuffs and feedstuffs from unutilized organic materials. A related question is the food potential of textured vegetable proteins (TVP). To what extent can we expect that these products can displace the demand for meat in the next 10, 20, 30 years and what impact will that have on the use of cropland, livestock sector, and nutritional levels of the world's diet?

The role of livestock in the world food supply situation needs reassessment. Consideration must be given to the amount of cropland devoted to the production of feed crops and potential trade offs in terms of food energy and/or protein quantity and quality that may result from the diversion of feed-producing areas into food-producing ones or vice versa. Studies on improving reproductive efficiency in large mammals need to be stepped-up.

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1) This would be achieved by increasing the efficiency of carbon dioxide fixation by conventional crops. Most food crops capture only one percent or less of the sunlight that that reaches their leaves.

The production potentials that might be realized from advances in various areas elaborated above are unestimable. According to one estimate, as much as 36 billion people could be fed 100 years from now if economical methods are found for the desalination of sea water and methods are developed which allow the maintenance of fertility of soils in the high tropics.[1)]

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Dr. H.O. Carter prepared the following sections of this report:

World Grain Trade Balances
Cereal Projects to 1985
Intensive Land Use
Environmental Quality
Water

In addition, I wish to express my appreciation for his help in the organization of this report and for his various suggestions. Dr. Kirit Parikh also made helpful comments to the organization of the Summary and Conclusion section.

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1) Walter H. Pawley, "The Year 2070", Ceres, July-August, 1971.

Appendix Table 1:

Per Caput Dietary Energy Supplies in Relation to Nutritional Requirements, Selected Developing Countries[1)]

	Average 1969-71	Average 1970-74	1971	1972	1973	1974
	. . . Percentage of Requirements . . .					
Far East	94	93	95	93	90	93
Bangladesh	88	88	85	86	87	92
Burma	101	100	101	93	100	103
India	92	91	94	93	85	89
Indonesia	91	93	91	88	96	98
Pakistan	93	93	94	94	92	93
Philippines	86	86	85	86	88	87
Latin America	106	107	106	106	107	107
Bolivia	76	77	77	79	77	77
Venezuela	97	97	97	96	97	98
Africa						
Ethiopia	93	90	93	92	89	82
Ghana	99	99	99	100	99	100
Kenya	97	95	99	93	92	91
Near East						
Turkey	112	112	114	112	112	113

1) In the Far East and Latin American, countries where available supplies were below requirements in 1969-71 or 1970-74; in Africa and the Near East, countries for which data are so far available for 1970-74.

Source: FAO, Monthly Bulletin of Agricultural Economics and Statistics, Vol. 25, No. 5 (May 1976) p. 5.

Appendix Table 2. Annual Per Capita Consumption of Selected Foods and Per Capita Daily Food Calorie Intake in Selected Countries and Regions

	Per Capita Consumption						Per Capita Calorie Intake							
	Total cereals Kg/year		Total meat Kg/year		Total whole milk Kg/year		Total food calories/day		Animal calories/day		Total protein calories/day		Animal protein calories/day	
	1970	1980T	1970	1980T	1970	1980T	1970	1980T	1970	1980T	1970	1980T	1970	1980T
World	128.3	130.1	29.1	31.9	49.3	49.5	2422	2499	410	433	66.6	69.0	21.7	23.2
Developed countries	91.9	85.3	74.3	85.8	117.1	115.9	3039	3111	1021	1097	89.5	92.8	52.7	57.5
U.S.A.	64.2	60.8	119.3	132.6	145.4	129.5	3272	3310	1343	1394	96.5	98.8	69.8	72.8
E.E.C.	91.3	84.5	67.9	81.3	110.0	113.0	3037	3139	1017	1115	90.0	94.8	51.6	58.1
Japan	130.4	119.7	15.7	24.2	37.3	49.6	2537	2680	382	471	77.7	82.3	32.8	38.9
Developing countries	133.7	137.3	12.0	13.6	27.2	31.2	2193	2317	191	218	56.4	59.5	11.4	13.0
Africa	119.9	125.4	12.6	14.1	15.7	17.0	2179	2280	125	140	58.6	61.9	9.5	10.8
Central Africa	62.8	65.8	12.1	13.7	7.3	8.0	2155	2280	108	120	45.1	47.9	10.5	11.8
Western Africa	115.8	123.9	8.9	10.1	10.7	11.4	2151	2260	86	98	57.3	61.3	7.5	8.9
Eastern Africa	136.3	140.1	16.9	19.0	21.9	24.0	2243	2339	164	183	64.5	67.5	11.3	12.7
Latin America	99.9	100.7	36.7	38.7	59.8	66.2	2524	2616	445	480	64.9	67.5	24.7	26.6
Central America	130.4	126.2	20.5	23.8	44.6	52.4	2518	2586	300	347	63.7	65.1	16.1	18.6
Mexico	134.8	128.1	21.5	25.0	42.9	50.7	2660	2698	317	367	67.1	67.4	15.9	18.3
South America	90.4	92.0	43.5	45.4	66.5	73.2	2546	2646	497	533	66.3	69.2	28.0	30.0
Near East	154.2	153.1	15.1	17.9	28.0	32.1	2376	2472	227	261	66.8	69.4	13.4	15.5
Asia and Far East	143.5	148.3	4.6	5.7	21.2	25.0	2076	2200	133	159	51.7	54.8	7.9	9.3
South Asia	140.9	148.5	2.0	2.4	28.7	33.9	2037	2192	132	154	52.4	56.2	6.7	7.9
India	135.3	143.3	1.4	1.6	20.0	22.5	1991	2145	110	125	52.0	55.7	5.7	6.5
Pakistan	158.3	165.2	4.2	5.2	65.9	80.9	2167	2337	225	275	53.3	57.7	10.6	13.1
East-Southeast Asia	149.4	147.9	10.3	12.8	4.3	5.5	2161	2217	137	169	50.0	51.9	10.4	12.4
Thailand	165.9	161.3	14.0	19.3	5.9	9.0	2329	2428	183	249	53.0	57.1	13.3	17.5
P.R.C. (China)	141.0	147.1	17.3	20.7	2.3	2.7	2063	2188	185	220	58.7	62.3	9.2	10.7
U.S.S.R.	145.9	133.1	47.4	57.2	146.6	159.4	3209	3268	766	898	94.6	96.7	41.3	47.6
Eastern Europe	135.8	122.8	58.3	69.2	120.7	131.3	3116	3132	897	998	88.8	91.5	39.9	45.6

Source: FAO, Agricultural Commodity Projections, 1970-1980, Volume II, Rome, 1971.

1 kilogram = 2.2 pounds

T = trend projections of demand--assuming constant prices and trend growth in GNP.

Appendix Table 3. FOOD SUPPLY: Calories per Caput per Day - Number

	Grand Total		Vegetable Products		Cereals		Animal Products		Oils and Fats	
	1961-65	1974	1961-65	1974	1961-65	1974	1961-65	1974	1961-65	1974
Egypt	2607	2637	2468	2483	1846	1799	139	154	168	211
Kenya	2282	2117	2046	1935	1296	1195	236	182	51	47
Argentina	3247	3408	2291	2418	1062	1009	956	990	335	403
Brazil	2420	2516	2086	2186	866	932	335	331	133	204
Bangladesh	1973	2024	1891	1948	1637	1723	82	76	65	41
India	2055	1976	1952	1867	1349	1333	103	109	116	114
Indonesia	1926	2126	1881	2074	1134	1414	45	52	87	89
Iran	1891	2368	1692	2165	1165	1507	198	204	152	253
Philippines	1915	1971	1716	1761	1224	1282	199	210	70	103
Thailand	2135	2382	1986	2209	1555	1690	150	173	36	51

Source: FAO, Monthly Bulletion of Agricultural Economics and Statistics, Vol. 25, No. 4 (April 1976), pp. 3-7.

Appendix Table 4. FOOD SUPPLY: Proteins per Caput per Day - Decigrammes

	Grand Total		Vegetable Products		Cereals		Animal Products	
	1961-65	1974	1961-65	1974	1961-65	1974	1961-65	1974
Egypt	738	707	637	605	499	481	100	102
Kenya	689	596	542	483	345	319	146	114
Argentina	1052	1071	410	402	279	264	642	669
Brazil	628	621	415	409	194	214	213	212
Bangladesh	426	442	356	378	311	339	71	64
India	521	480	469	424	314	314	52	56
Indonesia	388	438	342	383	232	280	46	56
Iran	460	557	359	437	283	365	101	121
Philippines	473	501	309	313	266	280	164	188
Thailand	433	500	341	367	276	301	92	133

Source: FAO, Monthly Bulletion of Agricultural Economics and Statistics, Vol. 25, No. 4 (April 1976), pp. 3-7.

Appendix Table 5 A: Estimated Income Elasticity of Demand for Grains for Direct Consumption

	Wheat	Rice	Cereals
Asia and Far East	.43	.30	.25
India	.50	.40	.25
North America	-.31	.19	-.25
Europe	-.31	.16	-.29
Oceania	-.10	.01	-.10

Source: United States Department of Agriculture, The World Food Situation and Prospects to 1985, Foreign Agricultural Economic Report No. 98, ERS (Washington: Government Printing Office, December 1974), p. 48.

Appendix Table 5 B: Income Elasticities of Grains Consumption by Region

	Oil Exporting Countries	North Africa Middle East	Africa South of Sahara	S.Asia	E.Asia	Latin America
Wheat	0.50	0.74	1.00	1.40	0.6	0.18
Coarse Grains	-0.43	0.10	-0.20	-1.04	1.2	0.59
Rice	0.30	0.10	0.44	0.10	0.15	0.04

Source: Marc Osterrieth and Jean Waelbroeck "Agricultural Prospects of Developing Countries", paper presented at the 4th Global Modeling Conference, September 20-23, 1976, p. 10.

Appendix Table 6: World Wheat Production

Country and Region	1960/61-62/63 Average	1969/70-71-72 Average	1973/74	1974/75	1975/76	1976/77
	-----	----- million tons -----				
Developed countries	94.05	111.82	127.63	132.27	137.98	143.55
United States	33.38	40.03	46.40	48.88	58.08	57.90
Canada	12.41	13.90	16.16	13.30	17.08	23.60
South Africa	.78	1.46	1.87	1.60	1.78	1.80
Oceania	7.75	9.34	12.24	11.56	12.20	8.75
Western Europe	38.08	46.53	50.76	56.70	48.50	50.20
EC-9	29.62	36.64	41.39	45.39	38.10	40.30
Japan	1.65	.56	.20	.23	.24	.25
Centrally planned countries	103.59	148.97	175.64	155.04	133.93	161.50
Eastern Europe	17.23	26.44	31.46	34.19	28.5	32.80
USSR	67.19	92.80	109.78	83.85	66.20	90.00
PRC	19.17	29.73	34.40	37.00	38.70	38.70
Developing countries	43.38	64.11	68.54	68.89	76.54	86.69
Argentina	5.21	5.87	6.56	5.97	8.57	10.00
North Africa and Middle East	15.65	20.46	19.57	22.20	25.08	27.90
Asia	17.81	30.83	36.23	32.75	35.62	38.43
World total	241.20	325.22	372.30	356.60	349.30	397.50

Source: U.S. Department of Agriculture, World Agricultural Situation, WAS-10, Washington, D.C. July 1976, p.18.

Appendix Table 7: World Coarse Grain Production

Country and Region	1960/61-62/63 Average	1969/70-71/72 Average	1973/74	1974/75	1975/76	1976/77
	- - - - -	- - - - - - million tons - -			- - - - - - -	
Developed countries	210.31	278.05	308.31	269.59	300.65	291.93
United States	133.00	165.59	186.59	150.46	184.08	183.50
Canada	11.36	20.50	20.41	17.44	19.78	20.90
South Africa	6.20	8.68	11.92	9.70	7.90	9.67
Oceania	2.92	5.42	4.70	5.09	6.44	5.89
Western Europe	54.49	76.88	84.40	86.61	81.50	71.70
EC-9	42.58	58.19	65.00	64.20	60.00	56.70
Japan	2.34	.74	.29	.29	.27	.28
Centrally planned countries	143.78	194.95	230.61	233.78	206.01	247.80
Eastern Europe	40.55	48.59	54.41	55.44	59.80	55.40
USSR	58.97	73.81	100.95	99.74	65.71	111.20
PRC	44.26	72.55	75.25	78.60	80.90	81.20
Developing countries	102.31	131.92	137.79	134.03	143.10	148.57
Argentina	7.93	13.32	17.94	13.79	12.40	15.80
North Africa and Middle East	14.96	17.15	15.32	18.42	18.44	19.70
Asia	33.66	39.99	42.49	39.60	34.77	44.63
World total	451.20	587.50	660.40	620.10	631.90	671.70

Source: U.S. Department of Agriculture, World Agricultural Situation, WAS-10, Washington, D.C., July 1976, p.19.

Appendix Table 8: World Production and Exports of Oils and Fats
1969-71 Average, 1972, 1973, 1974 and 1975

	1969-1971	1972	1973	1974	1975[2]		1969-1971	1972	1973	1974	1975[2]
	- -	- million tons -			- -		- -	- million tons -			- -
Production						Exports[3]					
World total[1]	42.0	45.0	44.2	48.3	47.2	World total[1]	12.3	13.8	13.8	14.0	14.4
Total edible/soap fats and oils	40.1	43.4	42.6	46.7	45.7	Total edible/soap fats and oils	11.2	12.6	12.8	13.0	13.5
Edible animal fats	8.5	9.0	8.9	8.9	9.0	Edible fats inc. margarine	1.1	1.0	1.2	1.2	1.2
Soybean oil	6.5	7.1	7.9	9.8	8.5	Soybean oil	2.7	3.1	3.3	3.9	3.7
By Region						By Region					
Developed countries	18.0	19.0	19.0	20.6	18.4	Developed countries	6.6	7.4	7.9	8.1	7.2
North America	11.4	11.8	11.8	13.1	n.a.	North America	4.7	5.5	5.5	5.8	n.a.
EC	3.5	4.0	3.8	4.0	n.a.	EC	.8	.9	1.2	1.2	n.a.
Western Europe	5.3	5.8	5.8	6.0	n.a.	Western Europe	1.3	1.2	1.8	1.7	n.a.
Developing countries	14.0	16.0	14.9	16.5	17.7	Developing countries	4.3	5.2	4.9	4.8	6.0
Latin America	3.4	3.6	3.8	4.6	n.a.	Latin America	1.1	1.2	1.1	1.2	n.a.
Far East	6.2	7.4	6.6	7.5	n.a.	Far East	1.7	2.4	2.3	2.1	n.a.
Centrally planned countries	10.0	10.4	10.3	11.2	10.0	Centrally planned countries	1.3	1.2	1.0	1.1	1.2
Eastern Europe and USSR	7.2	7.4	7.4	8.2	n.a.	Eastern Europe and USSR	1.2	1.1	.9	1.0	n.a.

[1] Including rough estimates for China.
[2] Preliminary.
[3] Including the oil equivalent of oilseeds; excluding main re-exports and exports of oils from imported oilseeds.

Source: FAO Commodity Review and Oulook 1975-1976. Rome, 1976, pp. 36-37.

Appendix Table 9: World Production and Exports of Oilcakes and Meals
1969-71 Average, 1972, 1973, 1974 and 1975

	1969-1971	1972	1973	1974	1975[3]		1969-1971	1972	1973	1974	1975[2]
	-	- million tons -			-		- -	- million tons -			- -
Production[1]						Exports[1,4]					
World total[2]	25.5	26.9	27.5	32.4	29.6	World total[2]	10.6	11.9	12.0	12.7	12.6
Vegetable oilcakes	22.1	24.1	25.0	29.5	26.9	Vegetable oilcakes	8.8	10.1	11.1	11.6	11.3
Soybean	12.9	14.1	15.5	19.4	16.8	Soybeans	5.9	7.1	8.1	9.1	8.9
Cottonseed	3.1	3.4	3.6	3.7	3.7	Cottonseed	.6	.6	.5	.4	.4
Fish meal	3.4	2.8	2.5	2.9	2.8	Fish meal	1.9	1.8	.9	1.1	1.3
By Region						By Region					
Developed countries	13.6	14.4	15.3	18.0	14.7	Developed countries	6.4	7.2	8.0	8.4	7.4
North America	11.8	12.5	13.4	15.9	n.a.	North America	5.8	6.5	7.3	7.6	n.a.
EC	.5	.5	.5	.6	n.a.	EC	.2	.2	.2	.3	n.a.
Western Europe	.9	1.0	1.1	1.2	n.a	Western Europe	.4	.5	.5	.5	n.a.
Developing countries	6.9	7.2	7.0	8.8	9.3	Developing countries	3.9	4.4	3.9	4.3	5.0
Latin America	3.1	2.9	3.3	4.7	n.a.	Latin America	2.3	2.7	2.2	2.8	n.a.
Far East	2.2	2.6	2.2	2.5	n.a.	Far East	.6	.7	.9	.8	n.a.
Centrally planned countries	5.0	5.3	5.1	5.6	5.6	Centrally planned countries	.3	.2	.1	-	.2
Eastern Europe and USSR	2.5	2.6	2.5	2.9	n.a.	Eastern Europe and USSR	.1	-	-	-	-

[1] Protein equivalent.
[2] Including rough estimates for China -- less than .1 million.
[3] Preliminary.
[4] Including the cake equivalent of oilseeds; excluding main re-exports and exports of cake from imported oilseeds.

Source: FAO, Commodity Review and Outlook 1975-76, Rome, 1976, pp.41-42.