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WORLD FOOD BALANCES, INTERNATIONAL TRADE, AND IMPLICATIONS FOR U.S. FOOD AID

An Interim Report to the Agency for International Development Under Contract No. AID/csd 2163 With Iowa State University

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INTRODUCTION

The report contained herein is submitted under contract No. AID/csd 2163 between the Agency for International Development and Iowa State University. Contributions to this report were made by Earl O. Heady, Leo V. Mayer, Roger W. Hexem, Walter W. Haessel, and Keith D. Rogers.

The report is broken down into three parts. The first section of this report reviews projections of world demand for agricultural commodities under alternative assumptions of per capita income and population growth rates, and projections of commodity supplies under alternative assumptions of cropland restraints for 96 countries of the world. Comparisons of projected commodity demand and supplies are made to determine the negative or positive food balances which a continuation of past trends in variables will create for 1970, 1980 and 2000. The locations of deficits and surpluses are established for 1975 in a second phase of section one, and an analysis of optimal trade patterns under alternative shipping rates is made. Under a pattern wherein cereal surpluses exist, the analysis evaluates the optimal locations of cropland not required for production.

The second section of this report reviews the projects to be undertaken in India under the foreign phase of this contract. Three projects are outlined: one will project Indian food supplies and demand and evaluate the required

resources which are necessary for food self-sufficiency to be achieved during the 1970's. The role of food inshipments in generating necessary foreign exchange for importation of inputs will also be studied. A second project will study the need for buffer stocks in India. This project will estimate the statistical probabilities of fluctuations in cereal supplies in India and provide estimates of the necessary food stocks to cover different proportions of these expected fluctuations, the procurement and storage costs involved in different magnitudes of stocks, the optimal location of these stocks by regions, and the optimal source for procuring stocks including shipments under P.L. 480. The third project will focus on repayment provisions of food loans under the Food Aid Act of 1966 with an evaluation of the eventual effects on agricultural and economic development. The intent is to look at the monetary and fiscal effects of repayment provisions and of monetary balances generated under P.L. 480 and to evaluate their long-run effect on the Indian economy.

The third section of this report outlines the projects to be undertaken at Iowa State University for the domestic phase of the contract. One project will establish a theoretical framework within which the welfare effects of food shipments can be compared with other forms of developmental aid. It will evaluate the role of food aid in encouraging or discouraging economic development through its effects on the agricultural production sector, the consumption sector, the public sector,

and the industrial production sector. A second project will concentrate on the factors which stimulate or retard agricultural development in less-developed areas. A framework of institutional structures, resource restraints, objectives, and incentives will be established. Such a master framework can provide the initial foundation for agricultural planning in underdeveloped countries. Modifications reflecting conditions peculiar to individual countries will be made where necessary. The third project will undertake to establish models of development with emphasis on the area of development planning. The objective of this project is to provide an analytical framework which can be used in particular countries for evaluating the intricate set of interrelationships which influence national planning. Establishment of models to measure the magnitude of interrelationships and the impact of changes in variables can improve the decision-making process in these countries.

SECTION I: FUTURE WORLD FOOD BALANCES

To provide a basis for investigating the direction and prospects for future food aid, future food production potentials and demand requirements in the major countries of the world are analyzed. The study[1/] is directed at estimating and projecting recent trends in area, yield, and production of major food crops while using income and population trends to project major food commodity demands. Based on these projections, prospects for balancing future food production and demand are evaluated.

Objectives

The objectives of this analysis are:

1. To estimate recent time trends in crop area and yield, or production, for all major crops grown for which data is available in those countries which are significant producers of agricultural commodities.
2. To project estimated area and yield trends through the year 2000 subject to estimated upper bounds on cropland expansion, but assuming that other factors affecting recent trends in food production will continue.
3. To estimate potential demand for major food commodities through the year 2000 for certain food commodity

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1/ For a complete review of this study, see Leroy L. Blakeslee. An Analysis of Projected World Food Production and Demand in 1970, 1985 and 2000. Unpublished Ph.D. thesis. Iowa State University Library. Ames, Iowa. 1967.

aggregates in each country under three alternative sets of population projections, and three alternativ sets of future total income estimates.

4. To compute estimates of surpluses or deficits from projected levels of production and demand for each commodity class for each country and for certain aggregates of countries.
5. To analyze these future food production-demand comparisons in relation to their determinates to identify those factors which are critical in determining the outcome.

A broad geographic coverage of world agriculture is included in the study. The degree of coverage is determined primarily by data considerations. No country is included unless past trends in either area and yield, or production, for a significant share of its crops could be documented with data of minimally acceptable quality. On this basis, 96 countries are included.

While the year 2000 is the maximum time horizon to be considered, a full set of balances are estimated for the intermediate years, 1970 and 1985. Time is an important variable in the future food situation of the world. Given that production-demand comparisons may indicate serious food imbalances, it is also the aim of this study to estimate when such difficulties may arise.

There are two significant differences between this and other related studies. First, no attempt is made to evaluate

nutritional aspects of the diets which might result if projected production and demand figures are realized; estimates of future demands are determined by projected economic and demographic factors only and do not necessarily reflect improved nutritional standards, desirable as these may be. Second, it is not an aim of this study to determine future levels of production, domestic demand, and trade which would reduce excess demand to zero for every commodity, country, and time. The aim of this study is the more modest one of evaluating the consequences of a continuation of recent trends, to identify possible future disparities in food balances, determine their causes, and judge the relative magnitude of some possible adjustments which might resolve them.

Comparisons of food balances are made only for primarily agricultural products, or crops. Demand for livestock product is projected, and from these data, demand for feed use of crops is estimated. No judgement is made as to whether these livestock products would be produced domestically, or imported (or whether the demand would even be fulfilled); the derived feed demand is a component of domestic demand in any case. Food and industrial demand is estimated directly and an allowance for seed and waste is estimated, based on the sum of domestic food, feed and industrial demand. Total domestic demand is the sum of food, feed, industrial use, seed, and

waste demand, each defined as indicated above. Production is total projected domestic production. Inventory changes are assumed to be zero.

Methodology

Empirical time trends for several variables affecting agricultural production and demand are estimated by applying standard statistical tools to historical time series data. On the production side, the projections reflect an extension of recent trends in the determining variables, acreages and yields. For various reasons it was not deemed desirable to insist tenaciously on a "continued recent trend" concept in the demand projections, though the total income trends do not stray far from this standard. Least-squares estimation techniques are used throughout, but primarily as a vehicle to extract whatever information can be found in a series of discrete historical data, and to incorporate it into a single, manageable, parametric function of time.

Perhaps the single most important factor determining the selection of methodology for this analysis was the quality of available data. A growing need for complete data has brought with it expanding geographic coverage in crop production statistics in many underdeveloped countries. This is a favorable tendency, but when historical statistics on crop production reflect the changing coverage, the result can be a completely spurious time trend series. Other data collection methods also tend to make published time series data for various countries suspect.

The countries included in the analysis are listed in Table 1. It will be noted that certain entries under the "Country" heading are groups of countries. Where this is the case, all phases of the analysis have been carried out for the aggregate as specified.

Demand projections are based on population estimates published by the United Nations, and projected trends in total real income. Population and total income projections are combined to estimate future per capita income. Using per capita income and population projections, projected demand for nine groups of food commodities is estimated via a consumption function and a base period income elasticity estimate specific to the commodity class. Prices are assumed constant throughout. Future demands for non-forage livestock feeds are derived from estimated future demand for livestock products. Only agricultural commodities which are used for food or livestock feed are included in the analysis.

Population projections

Population estimates prepared by the United Nation's Department of Economics and Social Affairs form the basis for population estimates in this study.[2/] Three projected levels

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2/ The U.N. analysis contains two distinct phases. First, all available recent projections of population for individual countries were assembled and analyzed. A standard set of assumptions, or a demographic model, was developed, and individual country projections through 1980 were adjusted, where necessary, to conform to the norm. In the second phase, the U.N. model was used to estimate low, medium, and high variant projections for 24 regional totals encompassing the world.

Table 1. Aggregates of countries by region and income class

Region	Country	Income class
United States	United States	high
Canada	Canada	high
Mexico	Mexico	medium
Central America and Caribbean	British Honduras	medium
	Costa Rica	medium
	Cuba	medium
	Dominican Republic	low
	El Salvador	low
	Guatemala	low
	Haiti	low
	Honduras	low
	Jamaica	medium
	Nicaragua	low
	Panama	medium
	Trinidad and Tobago	medium
Brazil	Brazil	low
Argentina	Argentina	medium
	Uruguay	medium
Other South America	Bolivia	low
	Chile	medium
	Colombia	low
	Ecuador	low
	Paraguay	low
	Peru	low
	Venezuela	medium
Northern Europe	Austria	high
	Belgium and Luxembourg	high
	Denmark	high
	Finland	high
	France	high
	Ireland	medium
	Netherlands	high
	Norway	high
	Sweden	high
	Switzerland	high
	United Kingdom	high
	West Germany	high

Table 1 (continued)

Region	Country	Income class
Southern Europe	Greece	medium
	Italy	medium
	Portugal	medium
	Spain	medium
Eastern Europe	Bulgaria	medium
	Czechoslovakia	medium
	East Germany	high
	Hungary	medium
	Poland	medium
	Rumania	medium
	Yugoslavia	medium
U.S.S.R.	U.S.S.R.	high
North Africa	Algeria	low
	Ethiopia	low
	Libya	low
	Morocco	low
	Sudan	low
	Tunisia	low
	United Arab Republic	low
West-Central Africa	Angola	low
	Cameroun	low
	Congo (Kinshasa), Ewanda and Burundi	low
	Ghana	low
	Guinea	low
	Ivory Coast	low
	Liberia	low
	Nigeria	low
	Senegal	low
	Sierra Leone	low
	Togo	low
East Africa	Kenya	low
	Malagasy Republic	low
	Malawi, Rhodesia and Zambia	low
	Tanganyika[a/]	low
	Uganda	low

a/ Now part of Tanzania.

Table 1 (continued)

Region	Country	Income class
Republic of South Africa	Republic of South Africa	medium
West Asia	Cyprus	medium
	Iran	low
	Iraq	low
	Israel	high
	Jordan	low
	Lebanon	low
	Syria	low
	Turkey	low
India	India	low
Other South Asia	Ceylon	low
	Pakistan	low
Japan	Japan	medium
Other East Asia	Burma	low
	Cambodia	low
	China (Taiwan)	low
	Federation of Malaya	low
	Indonesia	low
	Philippines	low
	South Korea	low
	South Viet Nam	low
	Thailand	low
Oceania	Australia	high
	New Zealand	high

of population are used from the U.N. study. Low, medium, and high population estimates differ primarily with respect to fertility assumptions, and in particular, the date when

fertility is assumed to begin falling.[3] The three variants reflect differences in fertility corresponding to recently observed fluctuations. Migration is seldom significant in the projections, and in all cases, a trend to zero by 2000 is assumed. Deviations from procedures described above were made for individual countries and regions, but the general pattern described is representative.

Income projections

Total income projections are extrapolations of past trends. For all but 12 of the 96 countries studies[4], it is possible to assemble time series data on income, and to base estimates of future trends on such data. Income series are all measured in local currencies. These are not transformed into standard units since the method used to introduce income

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3/ In the high fertility countries, the most common assumption is that fertility will decline to one-half present levels over a span of 30 years. Under the low assumption, the decline begins earliest; the high variant assumption is associated with latest onset of decline (or none at all, in the case of some African high variant projections). However, estimated data of the onset for any variant varies from region to region, as does number of years separating date of the onset among the three variants.

4/ The 12 countries for which completely a priori trends are specified are the following: British Honduras, Angola, Cameroun, Ethiopia, Guinea, Ivory Coast, Liberia, Libya, Malagasy Republic, Sierra Leone, Togo, and Jordan. Trends specified for these countries reflect income growth in nearby countries judged to be similar, and in a few cases, some inferences from scattered historical data. Data required for doing most other analyses on these countries is available, and it was judged justifiable to proceed with only a crude income indicator in order to include them in the study.

into the demand projections required only that relative changes in income be specified. However, it is necessary to deflate the data series with cost of living indices.

Least-squares regression techniques are used to estimate time trends in total income.[5/] Whenever possible, two variants have been specified: (1) a low variant consisting of a function which is linear throughout the projection period, and (2) a high variant consisting of a function which is exponential throughout the projection period. Exceptions are made in a few cases.[6/] The final selection of two alternative future income growth paths is based on the appearance of the plotted observations, the statistical properties of estimated functions, known historical occurences which may have affected the data, and values projected by each function.

5/ Each country's data are first plotted against time. Of course, a variety of patterns are observed, but growth paths which are increasing at increasing rates are not uncommon. Projections based on estimated functions, $f(t)$ for which $d^2f/dt^2>0$, lie on an explosive time path; where estimates are based on short time series, projected values are very sensitive to observations away from the trend line. In view of the uncertainty about the appropriateness of individual forms, (and of course, about the future path of income itself) two alternative income growth paths are specified for each country.

6/ In a few cases, historical income observations increase at decreasing rates. For these countries, a function for which $d^2f/dt^2<0$ is used for one of the two alternative growth paths. In still other cases, the estimated functions are judged to be unduly influenced by wars, political disturbances, extraordinary economic experience, etc. during the years when the observations were generated. Here, one or both of the two income trends are specified on *a priori* grounds.

Food demand projections

In all, nine different estimates of total food demand are derived for each of the 96 countries at each of three future time periods--1970, 1985 and 2000. Three estimates assume constant per capita income with population at low, medium, and high rates. In this case, future growth in demand is proportionate to population growth alone. Three demand estimates combine a low income growth rate with the three population rates just mentioned. Finally, a high income growth rate is combined with the three population rates to complete the set of nine estimates.

The approach used to project population and income ignores the interdependence which may exist by virtue of population growth expanding the supply of productive inputs (labor), and hence, influencing output and income. But in underdeveloped countries where labor frequently is under-employed with low productivity, the linkage between population growth and total income growth would seem, at best, tenuous. Thus, in this study, total income and population are projected independently, and per capita income is computed as the ratio between the two.

Demand projections for future years are based only on population and income projections. Prices are assumed constant, and consumer preference changes are ignored. The procedure for projecting the direct demand for each commodity is carried out in two steps. Per capita demand is projected

on the basis of estimated future per capita real income; these estimates are multiplied by population estimates to arrive at a total direct demand estimate.7/

Demand projections are prepared for the following nine product classes: cereals, sugar (raw value), starchy roots, pulses, vegetables and fruits, oil crops, meat, milk, and eggs.

Estimates of area, yield, and production

Production estimates are based on an extrapolation of recent trends. Area and yield trends are used where data are available. Trends of crop acreages are extrapolated subject to a constraint on total cropland in each country. In a few cases only production data are available for

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7/ The relation between per capita income and food demand has been studied in considerable detail by FAO pursuant to their projections of world food supply and demand. Two results of the FAO study are adapted for use here: (1) a set of estimates of income elasticity of demand for various food groups in most countries of the world, and (2) a specification of consumption function forms judged appropriate for long-term demand projections in the same countries for the same food groups. The elasticity estimates were not all made for the same base year, but the dates range over the period from 1959-1962. Income changes to be accounted for are often large, and the methodology for projecting per capita demand must take into account the falling marginal propensity of consumption for individual foods. Thus, all but one of the consumption functions exhibited declining income elasticities at higher income levels.

The projection procedure assumes the following: (1) at some base period, observed per capita consumption and income values constitute a point on a consumption function, and (2) the consumption function is of a mathematical form specified on the basis of FAO's investigation. Given estimates of per capita income and consumption, and estimated income consumption functions, it is possible to estimate the consumption which the function would predict for any income level.

projection of total output. Nearly all fruit crops are projected on this basis. Such projections do not take into account possible bounds on cropland. All data used are drawn from sources published by USDA or FAO.[8/]

Least-squares techniques are used to estimate all equations. Several criteria are applied in selecting functions to represent individual time trends, but among the most important are the trends of the plotted observations and statistical properties of the fitted functions. Recent (often provisional) data, not used in fitting the regressions, are used to consider relations with the data used in the estimated functions. Extraordinary historical events, for selected countries, which are known to have affected the observed data are taken into account. Examples of such historical events are major agricultural policy changes, extreme weather, war, political disturbances, severe market disruptions, etc.

Estimates of potential cropland expansion

All projections are conditional upon their assumptions, and the most pervading assumption is a continuation of recent

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8/ FAO coverage is broader, both geographically and in terms of the number of crops. Data from individual countries are not used because the same data, with very few omissions of significant crops, can be found in FAO publications. This avoids the encumbrance of working in numerous units of measurement and languages. However, for certain countries of the world, USDA estimates are thought to be more reliable, and a priority was established whereby USDA data are used as a first choice whenever available.

trends. Obviously, the assumption that cropland expansion can continue indefinitely can be ruled out *a priori*. Projections of crop areas in most countries of Central and South America, the Near East, and Non-Communist Asia are made subject to upper bounds on cropland expansion which have been derived from estimates of William G. Harper.[9/] From these basic data, upper boundaries on cropland expansion are established for each country at two levels. The basis for establishing low and high variant upper bound differs in Latin America, the Near East, and the Far East. For Latin American countries, the low variant is computed as the sum of all cropland located within fifty miles of rail, water, or road transportation. Little of the cropland is presently planted more than once annually in Latin America, and the low variant here assumes no multiple cropping. The high variant bound includes all cropland, regardless of location, and in addition, multiple cropping is assumed possible on irrigated land where sufficient water is deemed available or on island

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9/ Estimates derived by Mr. William G. Harper under an agreement with the Center for Agricultural and Economic Development, Iowa State University of Science and Technology, Ames, Iowa.

areas having favorable soil characteristics and acceptable temperature and moisture for eight months or longer annually.10/

Crops for which area trends are estimated do not include all crops grown in the country, and hence, the sum of the area trends cannot be interpreted as the trend in total cropland. Estimates of total potential cropland are reduced to allow for minor crops not included in the analysis of area trends.

10/ For the countries of the Near East, multiple cropping is assumed possible only on presently or potentially irrigatable land. No potential crop land is identified at distances greater than fifty miles. The low variant upper bound reflects on cropland identified in upland areas, and irrigated land presently in use. Multiple cropping is increased to reflect potential increases in supplies of irrigation water and better management of existing and future flows.

Beginning with the eastern part of India and moving eastward, annual precipitation is judged adequate to permit multiple cropping on upland soils in some cases. Thus in these countries, the conceptual basis for differentiating between low and high variant land boundaries is the same as in the Near East, except for the distance criterion in the case of Indonesia. Under the high variant, multiple cropping is assumed possible on non-irrigated cropland having favorable soil characteristics and acceptable temperature and precipitation for eight months or longer annually, while under the low variant a minimum ten months favorable growing season is assumed needed. Certain portions of Indonesia's cropland are designated as more than fifty miles from transportation, and these areas are omitted from the low variant land constraint. In no other case is the location criterion operative in Asia.

A hectare of land designated as suitable for multiple croppings is treated as two hectare of cropland, whereas a hectare of cropland marked for dry fallow management is added at one-half hectare. Where land is designated as suitable for long-term crops such as coffee, sugar cane, etc., no multiple cropping is assumed in any case.

For countries for which data are not available from the Harper study, constraints on land expansion are routinely set at levels only slightly above those of 1960. Most estimated total area trends show only modest changes.[11/]

Analytic Results

The 96 nation aggregate world production-demand comparison for cereals under assumptions of three time periods, two land restrictions, three population levels, and three income levels is summarized in Table 2. For summary purposes, only the case of cereals is presented because (1) cereals, consumed directly and indirectly, form the major portion of man's diet, (2) across countries, cereal crop data is more complete and of

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11/ Aside from Finland and Norway, no European country's data show rates of total cropland expansion in excess of 0.4 percent per year in 1960. Trends for Japan and for fourteen countries in Europe are estimated to be negative in 1960, though as some individual crop areas go to zero in later years, projected total area trends often recover. Norway, with an estimated growth in total cropland of 1.6 percent in 1960, is constrained to 115 percent of 1960 crop area; Denmark, with an 0.8 percent growth in 1960, is limited to 110 percent of 1960 area. Two other European countries, Finland and USSR are permitted a ten percent increase in cropland under the land constraint on the basis of their 0.4 and 0.3 percent growth in 1960 cropland. France is allocated a ten percent increase on the basis of U.N. projections.

Australia and New Zealand present special problems because both exhibit rapid growth in total cropland, evidence suggests that substantially more expansion is possible, but neither have been singled out for detailed studies. In the case of New Zealand, estimates are available suggesting that ample undeveloped land is available to permit the expansion implied in the projections, so land constraints are set at a level which left the trend unbounded. For Australia, where the 1960 growth rate in cropland is estimated at 3.4 percent per year, a land constraint forty-five percent above the 1960 level is estimated from the data.

In all other cases, land constraints are specified at only one level.

Table 2. Projected world cereal balances for 96 nations in 1970, 1985, and 2000 (1,000 M.T.)

Land Restraint	Year	Population Income	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
	1970		76,783	68,623	58,364	92,454	82,460	71,321	54,293	45,519	35,282
Low	1985		164,731	118,814	77,726	197,847	140,854	90,460	94,269	41,821	-4,507
	2000		258,838	144,504	58,485	302,191	158,248	43,193	117,069	-22,989	-132,801
	1970		77,998	69,837	59,579	93,669	83,674	72,536	55,507	46,934	36,497
High	1985		169,146	123,229	82,141	202,262	145,269	94,685	98,684	46,236	-92
	2000		279,645	165,311	79,292	322,998	179,055	64,000	137,876	-2,182	-111,994

better quality than is that for other crops, and (3) cereals are the major group of food stuffs which move in international trade, commercial sales or concessional sales.

Of the fifty-four combinations presented in Table 2, only six result in a production minus demand deficit. All of the shortages occur under two income-population combinations. In 1985 a shortage occurs under the combination of high population with high income. This combination provides the most possible individuals to feed and each individual demands the most possible per capita consumption. In projections for 2000, there are two cases where cereal shortages occur. A shortage occurs with a medium population and high income assumption and becomes progressively greater under the high population and high income assumption. Again, the shortages only occur under the highest and next to the highest of all demand assumptions.

The assumption on land expansion has a sizable affect, decreasing the 1985 deficit from 4,507,000 metric tons to 92,000 metric tons when moving from the low to high land restriction. The effect of land is less noticed in 2000. Both income and population have a significant effect, but, even then, a high level of either occurring alone does not have serious consequence, evidenced by surplus projections for high population and low income or high income and low population. Only the interaction of these two factors at medium to high levels create a strain on the world balances for cereals.

To disaggregate the world summary for cereals, nations are grouped according to low, medium, and high income classification. Low income nations are identified as those with a per capita income below $300 per year. In the low income nations, Table 3, a cereal grain deficit is experienced at the lowest demand level, and any increase in either income or population aggravates the shortage. Medium income nations are defined as having per capita income between $300 and $800. The medium income nations also experience a cereal shortage under the most favorable demand conditions (Table 4), and an increasing shortage as the demand assumptions become less

Table 3. Projected cereal balances for low income nations in 1970, 1985, and 2000 (1,000 M.T.)[a/]

Land Rest.	Year	Pop. Inc.	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
	1970		-16,198	-18,304	-18,978	-12,270	-15,810	-16,958	-32,417	-34,865	-35,661
Low	1985		-44,055	-58,792	-69,207	-35,784	-59,956	-78,443	-95,300	-115,450	-130,306
	2000		-96,147	-130,891	-155,698	-87,798	-148,189	-199,434	-200,185	-255,761	-300,621
	1970		-14,984	-17,089	-17,764	-11,056	-14,595	-15,744	-31,202	-33,650	-34,447
High	1985		-39,651	-54,387	-64,803	-31,380	-55,552	-74,039	-90,896	-111,086	-125,902
	2000		-75,478	-110,222	-135,029	-67,129	-127,521	-178,765	-179,516	-235,092	-279,952

a/ Low income defined as less than $300 per year.

Table 4. Projected cereal balances for medium income nations in 1970, 1985 and 2000 (1,000 M.T.)[a/]

Land Rest.[b/]	Year	Pop. Inc.	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
	1970		-6,103	-7,409	-8,659	525	-942	-7,592	-10,576	-11,945	-13,244
High	1985		-5,716	-12,626	-19,546	7,478	-120	-2,320	-16,058	-23,762	-31,318
	2000		-542	-16,721	-33,976	17,021	-913	-19,851	-17,762	-36,976	-56,993

a/ Medium income defined as from $300 to $800 per year.

b/ Only one land restraint was used in medium income nations.

favorable, with one exception. The case of low population and constant income results in a surplus for all three time periods.12/

There is only one land availability class for the medium income nation group of countries. The condition of one

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12/ This raises a question of the relative level which constant per capita income represents when compared with low and high per capita income. Summarization of several country's income projections indicate that the nature of the constant income is somewhat more elusive than that of the low and high income. As a generalization, constant income represents the lowest of the three income assumptions when considering high income nations. Per capita income in these nations is expected to grow faster under the low income variant than if the income were to be projected at the current level. The necessary projections for this assumption are that total real income is growing faster than the population even when income is projected on the basis of the low growth rate variant. For the medium income nations, the population and real income are growing at approximately the same rate under the low income assumption so that a constant per capita income assumption falls at about the same position as the low income assumption. The data summary indicates that the constant income assumption is slightly below the low income assumption for the group in the aggregate. In essence this suggests a weighting of the class toward the upper side of the $300 to $800 income range.

For the low income nations, the constant assumption occurs either as the highest, the middle, and or the lowest of the three assumptions depending on the particular nation under consideration. This variance among the countries which are aggregated together makes it difficult to generalize about the relative position which the constant income assumption represents. The summarized data indicates that constant income is the lowest of the three income assumptions for this group in the aggregate, but there is considerable disparity among individual nations. To compound the analysis of the relative position which constant income represents, that position switches within countries as you project population from 1970 to 1985 and on to 2000.

In conclusion, the exact nature of the constant income assumption is difficult to establish among income groups. Only the high and low assumption can be compared directly. The constant income assumption is a meaningful assumption, and one which is often used, but it should only be compared with the other two within a given income class. One consistent ordering of the nine income-population combinations from high to low for all income groups is not possible.

cropland bound is a function of the individual countries that happens to fall in this group rather than a function of the income group itself.

Comparing the summaries for low and medium income nations, the same pattern of shortages occurs with the main difference the magnitude of shortages. For example, the deficit in the low income nations for 1985-medium population-low income-high land is approximately four and a half times the deficit for the medium income nations under the same assumptions (54,387,000 vs. 12,626,000 m.t.). Comparing the two groups for the same time, population, and land assumptions, but high income growth rate, the shortage for the low income nations is again about four and a half times that in the medium income nations. Other similar comparisons result in different ratios of shortage, but holding three of the variants constant and varying the fourth will produce shortages reflecting fairly constant ratios of deficit between the two income groups.

Examination of food balances for the high income nations defined as over $800 per capita, indicates that a surplus will prevail under all of the assumption combinations (Table 5). Surpluses decline as income and population growth rates increase, but the minimum surplus of 84,187,000 metric ton occurs under the least favorable assumptions of high income and high population. The unique characteristic of the high income group is that time works in favor of world cereal balances with surpluses being at a minimum in 1970 and

Table 5. Projected cereal balances for high income nations for 1970, 1985 and 2000 (1,000 M.T.)[a/]

Land Restraint	Year	Population Income	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
	1970		99,085	94,335	86,001	104,198	99,211	90,598	97,286	92,529	84,187
Low	1985		214,510	190,237	166,484	226,160	200,938	176,499	205,631	181,076	157,116
	2000		335,540	292,128	248,171	372,982	307,363	262,490	335,027	269,758	224,820
	1970		99,085	94,335	86,001	104,198	99,211	90,598	97,286	92,529	84,187
High	1985		214,521	190,247	106,494	226,171	200,948	176,509	205,642	181,087	157,127
	2000		335,675	292,263	248,305	373,117	307,498	262,625	335,162	269,892	224,955

a/ High income defined as over $800 per year.

increasing constantly through 2000. Fortunately this is a reversal of the trends in the low and medium income nations where the balances are at their best in 1970 and declined with time. Noted exceptions are the cases of low income-low population, constant income-low population, and constant income-medium population for the medium income nations. For both of the cases with low population, food shortages deminish with time as in the high income nations. For the medium population-constant income, the deficit declined from 1970 to 1985 and then reversed from 1985 to 2000. All other income and population combinations for the low and medium income nations exhibit a continuous decline with time.

Selected individual country summaries

Summaries of cereal balances for the United States and India were prepared to allow comparison of these two countries which provide extreme examples of surplus and deficit nations. The United States summary, Table 6, exhibits the characteristics of the high income class of nations to which it belongs. Surpluses are projected even under the least favorable demand conditions in 1970, and the surpluses grow as production and demand are projected to 1985 and 2000. The United States is classified as having a high cropland bound; therefore, comparisons are only available for one cropland bound.

India is classified in the low income group, and demonstrates some, but not all, of the characteristics of that group. With low income and low population assumptions, surpluses are positive

Table 6. Projected food balances for United States in 1970, 1985 and 2000 (1,000 M.T.)

Land Restraint[a/]	Population Year	Income	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
High	1970		84,192	81,499	77,989	85,379	82,545	78,853	83,581	80,890	77,383
	1985		168,892	156,209	147,463	171,817	158,464	149,256	165,432	152,665	143,882
	2000		276,079	242,192	229,499	280,871	245,231	231,854	267,233	232,497	219,572

a/ Only one land use class in United States.

for 1985 but small or negative for 2000. Increasing the population growth rate to the medium variant exhausts the surpluses in all except the case of constant income for the year 2000. All other surpluses occur under low population growth and low or constant income growth. In the case of India, Table 7, it is useful to examine the nature of the deficit pattern growing out of the interaction effect of income, population, and land. Under the low land, low population, and low income variant, deficits occur in 1970, disappear in 1985, but return in 2000. Increasing either income or population is sufficient to create a deficit in 1970 which gets continuously greater in 1985 and 2000. Under the high land variant, the production-demand balances improve as time elapses for three of the nine income-population combinations, low income-low population, constant income-low population, and constant income-medium population. In the other six cases under the high land variant, the deficit increases with time as it did under the low land variant. In any case the deficit does not exceed 25,000,000 metric tons until medium or high population occurs with the high income variant.

It is interesting to note that the Indian cereal deficits take on increasing values, without overlap, when the population variant is ordered from low to high within the low and high income classes. When the income-population combinations are ordered from low income-low population, low income-medium

Table 7. Projected food balances for India in 1970, 1985, and 2000 (1,000 M.T.)

Land Restraint	Year	Population Income	Low Low	Medium Low	High Low	Low Constant	Medium Constant	High Constant	Low High	Medium High	High High
	1970		-156	-1,076	-1,298	-26	-1,670	-2,073	-3,987	-5,030	-5,282
Low	1985		1,730	-2,826	-6,628	5,917	-1,625	-8,409	-8,933	-14,736	-19,718
	2000		-6,503	-15,590	-24,269	5,187	-8,235	-22,335	-24,386	-36,515	-48,647
	1970		-156	-1,076	-1,298	-26	-1,670	-2,073	-3,987	-5,030	-5,282
High	1985		1,730	-2,826	-6,628	5,917	-1,625	-8,409	-8,933	-14,736	-19,718
	2000		1,995	-7,090	-15,769	13,687	263	-13,835	-15,887	-28,015	-48,647

population, and so forth up to high income-high population, the cereal deficits are 6, 15, 24, 24, 36, and 48 million metric tons respectively in 2000. This ordering indicates that the income classification breaks the deficits into two distinct groups and then population orders the deficits within the two groups, making income level the dominant variant and population the secondary variant. The predominance of this ordering is consistent throughout the analysis with one occasional exception. In a few cases the high income-low population assumption overlaps the low income-high population assumption.

Conclusions

The basic aim of this study was to estimate time trends in production of and demand for food in the world as data would permit, and to conduct comparisons by country, geographic area, and income group for two levels of cropland variant, three time periods, three levels of population, and three levels of income. Selected cases have been summarized for cereals because of their representative nature and to demonstrate effects of the variables and their interaction.

As would be expected, progressing from the low to high land variant helps the food balance either by reducing the deficit or by increasing the surplus, depending upon the original position of the nation of group of nations under consideration. Time plays two roles in the comparisons. On the one hand time serves to identify three future reference

points for comparison. On the other, time enters the comparisons indirectly as it is used to project the estimated time trends for total population and income. Since both functions are increasing for most nations, population and income increase over time, but the relative rate at which the two advance affect the balances at various points in time. For most of the nations, the balances under the low income variant fall below the balances under the high income variant regardless of the population level. Other variants held constant, the balances decrease as expected when population varies from low to high.

The exact nature of the effects of the various variants depend upon the income class in which the country or group of countries fall. In the aggregate, surplus cereal balances exist under all assumptions when any three of the variants are held at lower levels and the other variant is allowed to go to its upper limit. In fact, surpluses persist under all combinations of variants except when high income growth rate occurs with high population growth rate until 1985, or high income growth rate occurs with medium or high population growth rate through the year 2000.

OPTIMIZING DISTRIBUTION OF FUTURE FOOD SUPPLIES AMONG DEMANDS

The study completed on future food balances suggests that the major world problem of the future will be similar to that of the past: how to place excess food production in the hands of those who have inadequate food supplies. Only if the nations of the world maintain a medium or high population growth rate after 1985 will the problem of world wide food deficits appear. Even then, this rate of population growth must be coupled with high income growth rate for total food supplies to be inadequate. However, this outcome does not imply that particular countries will not continue to have deficits in food supplies in the future. Those less developed countries with per capita incomes of less than $300 show continuous deficits over the period 1970 to 2000. For these nations to provide adequate food supplies for their population will require that imports of food be continued. But which of the surplus countries will provide the food? And at what cost? From the U.S. point of view, what effect does restrictions on shipments of government program exports in foreign flag vessels have on the competitive position of cereal exporters from the U.S.? These are but some of the questions which have had little attention in the past but are relevant to discussions on food aid, agricultural and economic development.

Study Objectives

To develop improved levels of knowledge on the optimum manner of distributing future food supplies among competing demands, a study of world trade in cereals was undertaken.[13/] The objectives of this study are:

1. To develop a model suitable for use in the analysis of world[14/] trade in cereal grains[15/] given the existing and/or potential capacity for production and predetermined import-export potential for the commodities involved.
2. To analyze for 1975 levels and patterns of inter-regional trade in cereal grains and utilization of productive capacity.
3. To analyze the significance of certain trade restrictions like (1) U.S. policy requirements that at least one half of its total export sales under government sponsored

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13/ For a complete report of the basic study, see Charles F. Framingham, An International Analysis of Projected Cereal Grain Production, Requirements and Trade and Its Implications for Importing Nations, Major Exports and the Fertilizer Industry in 1975, 1985 and 2000. Unpublished Ph.D. thesis Iowa State University Library. Ames, Iowa. 1968. The Framingham study did not include trade balances for Communist Asia. These later extensions were completed by Keith D. Rogers.

14/ Certain small countries with low population and production levels were excluded because of inadequate data.

15/ Cereals were divided into three categories: wheat and rye, rice, and other grain.

programs move in U.S. vessels, and (2) self imposed variations in world export price among different countries.

Methodology

Because of the importance which cereals play in total world food production and consumption, only cereals are considered in this study. Cereals are disaggregated, however, to allow for examination of balances for specific individual cereal crops or combinations, namely wheat and rye, rice, and other grains.

The basic study was extended to include the import requirements for Communist Asia, Mainland China, North Korea, and North Viet Nam. After examination of trends in other low income nation food balances, it was hypothesized that the production-demand balance for this group of countries would get progressively worse with time. From this point, an attempt was made to estimate the increase in food deficits which would result from an increased population and income level. Increased production capacity was assumed to be used to meet increases in food needs thus holding cereal deficits to rates experienced in recent years. Although estimates of future food shortages in Communist Asia, are inexact, the crudeness of these estimates could be justified in order to include this large block of world population and potential food deficit in the analysis.

In order for this study to be most useful, it should identify potential pressure points and do so in time for corrective measures to be initiated. It was felt that 1970 projections tended to only describe the current conditions rather than provide information which could be used in policy planning. On this basis it was considered reasonable to drop the 1970 projections or update them to 1975.

To achieve the objectives specified, a 39 region linear programming model was developed.[16/] The objective of the model was to minimize the cost of obtaining the commodities required to satisfy projected regional requirements for wheat and rye, rice, and other grain.[17/]

16/ To specify the model used, it was necessary to:
(1) divide the 97 nations studied into 39 producing-consuming regions.
(2) choose one or more ocean ports in each region for purposes of interregional analysis.
(3) specify future levels of productive capacity and domestic requirements for each of the three cereal classes, wheat and rye, rice, and other grains, in each country or region.
(4) establish interregional ocean transportation costs and intra-regional rail transportation rates for each commodity.
(5) assume that conditions of free trade exist in the international markets for cereals.

17/ The constraints in the model are:
(1) projected regional import requirements or export capacity for each of the cereal classes.
(2) minimum excess requirements for rice.
(3) projected cereal grain production capacities be fully utilized or the associated land withdrawn from production.

The following activities are defined for each region in the model:

1. An activity providing for export of each cereal grain class for each region in which an excess is projected.
2. A wheat for rice substitution activity allowing for the production and export of wheat from regions with excess capacity to regions with rice deficits remaining after satisfying minimum rice requirements and utilizing all projected world rice capacity.
3. A land retirement activity to retire land from production for regions with excess cereal capacity.

Countries and corresponding regions included in the study

Ninety-seven countries or regions are included in the study. For most purposes they are aggregated into country groups. Three different levels of aggregation are used. Countries are aggregated into geographic regions according to their association with a common ocean port selected to minimize differences in marine distance between that region and other regions. Trade area aggregates are specified in accordance with those normally used. A two-way development classification is also made. Countries with per capita income levels of $800 or less are classified as "developing" countries. Those with higher per capita income levels are classed as "developed". Because of the geographic groupings, it was necessary in a very few cases to modify this aggregation to

prevent cross classification. With only a few exceptions, this classification puts all of the low and medium income nations in the "developing" class and the high income nations in the "developed" class. Where the few exceptions do occur, the classification on the basis of development is determined by the nature of the majority of the nations in the group. The breakdown of the income classifications is given in Table 8.

For each of the 39 regions specified in Table 8, a port or ports for receipt and dispatch of cargo is specified. Due to their geographic nature, multiple ports are specified for Canada, the United States, India, and Australia. The proportions of regional excess capacity and/or demand allocated to each within a region is a function of historic export or production patterns and the distribution of regional population respectively.

Cereal grain requirements

For the purposes of this study, a "most probable set" of population and income assumptions are chosen from the nine possible combinations analyzed in the earlier study. The set selected included a medium population growth rate and low

Table 8. Countries included in the study and their group delineations.

Country	Geographic region and identification number[a]	Trade area	Development class[b]
United States	1 United States	U.S.	DD
Canada	2 Canada	Canada	DD
Mexico	3 Mexico	Latin America	DG
Cuba Dominican Republic Haiti Jamaica	4 Caribbean		
British Honduras Costa Rica El Salvador Guatemala Honduras Nicaragua Panama	5 Central America		
Trinidad and Tobago Columbia Venezuela	6 Northern South America		
Brazil	7 Brazil		
Bolivia Equador Peru	8 Western South America		
Argentina Uruguay Chile Paraguay	9 Southern South America		
Belgium and Luxemburg West Germany France Netherlands Italy	10 European Economic Community	European Economic Community	DD

a/ The region numbers indicated were used for region identification in the analysis model.

b/ DD-Developed, DG-Developing.

Table 8. (Continued)

Country	Geographic region and identification number[a]	Trade area	Development class[b]
Ireland United Kingdom	11 Ireland-United Kingdom	Other Western Europe	DD
Denmark Norway Sweden Finland	12 Scandinavia		
Spain Portugal	13 Spain-Portugal		
Austria Switzerland	14 Austria-Switzerland		
East Germany Poland Czechoslovakia	15 Northern East Europe	East Europe	DD
Yugoslavia	16 Yugoslavia		
Hungary Romania Bulgaria	17 Other East Europe		
U.S.S.R.	18 U.S.S.R.		DD
Greece Turkey	19 Greece-Turkey	Middle East	DG
United Arab Republic	20 United Arab Republic		
Iran Iraq	21 Iran-Iraq		
Israel Jordan Lebanon Syria Cyprus	22 Other Middle East		

Table 8. (Continued)

Country	Geographic region and identification number[a]	Trade area	Development class[b]
Marocco Algeria Tunisia Libya	23 Northern Africa	Africa	DG
Ghana Guinea Ivory Coast Liberia Nigeria Senegal Sierre Leone Togo	24 Western Africa		
Angola Cameroun Congo (Kinshasa, Rwanda, and Burundi)	25 West Central Africa		
Ethiopia Sudan	26 Ethiopia-Sudan		
Kenya Tanganyika Uganda Malagasy Republic Malawi, Rhodesia and Zambia	27 East Central Africa		
Republic of South Africa	28 Republic of South Africa		
Australia	29 Australia	South Africa-Oceania	DD
New Zealand	30 New Zealand		
India Ceylon	31 India	India-Pakistan	DG
Pakistan	32 Pakistan		

Table 8. (Continued)

Country	Geographic region and identification number[a]	Trade area	Development class[b]
Burma	33 Burma	Other East Asia	DG
Cambodia Thailand South Viet Nam	34 Other Far East		
South Korea	35 South Korea		
Federation of Malaya Indonesia	36 Malaya-Indonesia		
Philippines China (Taiwan)	37 Philippines-China (T)		
Japan	38 Japan	Japan	DD
China, North Korea and North Viet Nam	39 China	China	DG

income growth rate.[18/] One modification is made in this set. Where a low income projection yielded a falling per capita income for a country, the constant per capita trend is substituted. The effect of that modification is to guarantee at least maintenance of base period per capita income and consumption levels for all commodities in all countries except those with negative income elasticities and rising incomes.

Substitution of wheat for rice

In the analysis, wheat can be substituted for rice in the absence of adequate rice supplies. Actual substitutions are constrained by the following assumptions:

1. Substitution of wheat for rice is possible only after all available rice supplies are exhausted.
2. No substitution is possible in a developed country.

18/ Selection of the most probable set of population and income estimates was guided by the following considerations:

1. The FAO study from which the population data are drawn indicated that the medium population projections developed in it are the most probable ones.
2. High income nations tend to have low income elasticities of demand for staple foods such as cereals. Consequently the effect of income on their future cereal demand is small.
3. Low income nations have typically not had high income growth rates.
4. The assumption that agricultural production and income are closely correlated in developing countries has previously been used in the development of production projections for the developing countries with reasonable success. Thus deviations of income from the selected trend are partially offset by corresponding deviations in production. This tends to make the selection among income assumptions less critical.

3. Where substitution is required, rice imports available to developing importers are distributed in accordance with regional minimum rice requirements.
4. Minimum rice requirements in each developing region with rice deficites are the larger of the level of domestic production or the average maximum per capita availability for all developing region importers whose domestic production is less than 1960 per capita consumption.

Transportation costs between and within regions

Transportation cost estimates are developed for ocean transportation and inland transportation of cereals. Techniques based on available transportation research are used to estimate ocean and inland freight rates. The ocean transportation rate estimates are based primarily on research reported in Maritime Transportation of Utilized Cargo - A Comparative Analysis of Break-Bulk and Unit Load Systems.[19/] Total costs per ton are

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19/ To facilitate development of the rates, the following assumptions are made:
1. Cereals all have a cargo storage requirement of 50 cubic feet per ton.
2. The commodities moving in trade are all transported in vessels having a bale cubic capacity equivalent to 15,000 tons.
3. When full, 90 percent of the ship's bale capacity is utilized. In other words, a full load is 13,500 tons.
4. Vessel speed equals 14 knots per hour.
5. Labor costs on foreign flag vessels are 53 percent of those on U.S. flag vessels.
6. Vessels can obtain only 60 percent of a full load in ports where they discharge their grain cargo.
7. The cost of discharging a vessel plus profit for the voyage is 10 percent of vessel ownership, at sea, and port expenses.
8. Days in port for loading and discharging is 5 for cereals.
9. Only one port call is made per voyage.
10. Vessel construction costs equals $2,475,000.

estimated at $4.37 plus $0.25167 (at sea days) for cereal crops. Where one or more canal passages are required on a voyage, 23 cents per ton per passage is added which is the equivalent of one extra day. Where commodities are exported from Great Lakes ports of North America, $1.60 per ton is added to the cost for the equivalent of a seven day delay passing through the St. Lawrence Seaway.

The regional inland transportation costs are based on information contained in the Directory of World Railways.[20/] From this information country rates by commodity and regional rates weighted by country imports within regions are developed.

Analytic Results

Food balances for the three cereal classes under the medium population-low income variant are summarized in Table 9 for the 97 nation aggregate including Communist Asia. By 1975 a surplus is projected for all three classes which will hold through 1985. By the year 2000, a surplus exists of wheat and rye as well as other grains, but a deficit for rice develops. Allowing for wheat-rice substitution, the total requirements are met even in 2000.

For the developing nations a surplus of rice and other grain existed in 1960. By 1975 only a surplus of rice exists;

20/ This directory contains country data on total number of freight cars, total number of passenger cars, total expenses, and total volume of freight carried for major railways. By assuming that:
(1) expenses associated with freight movement are the same proportion of total expenses as freight cars are of total rail cars used, and
(2) that the commodities being hauled are average freight commodities, it was possible to develop per ton freight rates.

Table 9. Production minus demand requirements for cereals (1,000 M.T.)
Assumption: Land low-population medium-income low

Time	Crops	97 Nation Total	Developing Nations	Developed Nations
1960	Wheat & Rye	-2,654	-14,630	11,976
	Rice	2,039	1,812	227
	Other Grain	2,431	2,550	-119
1975	Wheat & Rye	29,880	-25,664	55,544
	Rice	3,993	116	3,877
	Other Grain	47,047	-7,186	54,233
1985	Wheat & Rye	33,049	-38,618	71,667
	Rice	306	-5,589	5,895
	Other Grain	74,824	-21,691	96,515
2000	Wheat & Rye	30,361	-66,687	97,048
	Rice	-20,386	-29,786	9,400
	Other Grain	110,239	-57,679	167,918

by 1985 a deficit occurs in all three classes and increases by 2000. For the developed nations, however, a surplus occurs in all classes in all time periods except for other grains in 1960.

World Trade Patterns

Patterns of world trade in cereals are provided under two alternative combinations. Under one set of alternatives, a common world price for cereal grains is assumed and transportation rates are varied to evaluate the effect of restrictions on the proportion of cereal cargos which must move in U.S. flag ships and the effect if all cereal cargos could move at foreign flag rates. Since the U.S. flag ship rates are approximately two times the foreign flag rates, and approximately 50 percent of U.S. program exports move under this restriction, ocean rates for the purchasing country are raised to 1.5 times the foreign flag rate. Under a second set of alternatives, individual country prices for cereals based on historical patterns are used. These prices are coupled with transportation rates with restrictions on quantities of cereals shipped in U.S. bottoms and with these restrictions removed. Shifts in quantities exported by countries with surpluses are evaluated under each set of alternatives. The quantities shipped under each alternative are presented in Table 10.

Two types of comparisons can be made from these data. One comparison is between quantities each country ships under the different pricing of commodities. With a common world price

Table 10. Quantities of cereal grains shipped from major exporting countries under alternative pricing mechanisms and alternative transportation costs in 1975 for 39 trade regions (1,000 M.T.)

Ocean Rates	Export Countries									
	U.S.	Canada	Mexico	Southern So. Am.		Yugoslavia	East Europe	USSR	Australia	Total
Set A - Common World Price										
US = FF(ALL)	32,898	5,290	554	631	2,653	1,400	1,852	450	6,511	52,239
US = 1.5FF(DG)	19,068	16,200	554	631	2,653	1,400	1,852	450	9,431	52,239
Change	-13,830	10,910	0	0	0	0	0	0	2,920	0
Set B - Individual Country Prices										
US = FF(ALL)	38,520	0	554	631	2,653	0	0	450	9,431	52,239
US = 1.5FF(DG)	37,234	1,286	554	631	2,653	0	0	450	9,431	52,239
Change	-1,286	1,286	0	0	0	0	0	0	0	0

and no differential in shipping rates, the U.S. exports 32,898,000 metric tons of cereals while with individual country pricing which allows the U.S. to lower its supply price, the U.S. exports 38,520,000 tons. The second comparison is between different shipping rates. This comparison measures world trade in cereals based on foreign flag shipment rates for all U.S. shipments, simulating the absence of any U.S. shipping restriction.

With a pricing policy of individual country prices for 1975, a differentiated shipping rate causes a shift in the trade pattern for two exporting countries compared to the undifferentiated transportation rates. U.S. exports of wheat and rye decrease by 1.286 million metric tons while the Canadian exports increase by the same amount when 50 percent of U.S. program exports must move in U.S. vessels. With the same variance of shipping requirements, but with a common world export price for the cereal grains, the U.S. ships 13.8 million fewer metric tons of cereals while Canada increases its exports by 10.9 million tons and Australia supplies the other additional 2.9 million tons.

On the importing end, under the assumption of individual country prices, the shifts in trade for the U.S. amount to a 554 thousand metric ton increase in Latin America, but a reduction of 606, 148, 913, and 173 million tons in the Middle East, Africa, China and "other nations" respectively (Table 11). The projected increase in Canadian exports result from an

Table 11. Quantities of cereals imported under alternative policies and pricing mechanisms for selected areas under least cost distribution for 39 trade regions (1,000 M.T.).

Import Areas	Export Countries: United States			Canada			Australia		
Set A - Common World Price									
	US=FF	US=1.5FF	Change	US=FF	US=1.5FF	Change	US=FF	US=1.5FF	Change
Latin America	9,966	4,969	-4,997	0	4,997	4,997	0	0	0
Middle East	4,394	0	-4,394	0	4,394	4,394	392	392	0
Africa	2,896	0	-2,896	0	3,010	3,010	487	373	-114
India-Pakistan	0	0	0	0	944	944	3,740	2,796	-944
Japan	0	4,004	4,004	4,004	0	-4,004	0	0	0
China	5,747	0	-5,747	790	790	0	0	5,747	5,747
Other	9,895	10,095	200	496	2,065	1,569	1,892	123	-1,769
Total	32,898	19,068	-13,830	5,290	16,200	10,910	6,511	9,431	2,920
Set B - Individual Country Prices									
Latin America	9,966	10,520	554	0	0	0	0	0	0
Middle East	5,232	4,626	-606	0	0	0	0	0	0
Africa	2,896	2,748	-148	0	0	0	0	0	0
India-Pakistan	0	0	0	0	0	0	0	0	0
Japan	4,004	4,004	0	0	0	0	0	0	0
China	4,053	3,140	-913	0	790	790	0	0	0
Other	12,369	12,196	-173	0	496	496	0	0	0
Total	38,520	37,234	-1,286	0	1,286	1,286	0	0	0

increase of 790 and 496 million tons respectively to China and "other countries". Under the assumption of common world prices, Latin American purchases shift from the U.S. to Canada, Middle East shipments shift from the U.S. to Canada; African shipments shift from the U.S. and Australia to Canada, Japanese shipments shift from Canada to the U.S.; Chinese shipments shift from the U.S. to Australia; Canada picks up most of the losses in other countries from Australia.

Because of the high relative U.S. rice price, no rice is exported from the U.S. in 1975 and consequently the concessional sales policy has no effect on rice shipments.

With "other grain" sales, the increased ocean rate reduces U.S. exports by 3.7 million tons with small gains going to Mexico, but the major gains being realized by Australia, i.e. 2.3 million tons under individual country prices. When a common world price is assumed, U.S. exports decrease by 3.1 million tons with major increases supplied by Southern South America. Unlike the case with wheat and rye shipments, the price assumption does not have a very large effect on other grain sales.

The value of the changes in trade patterns are summarized in Table 12 for the U.S. Under the individual country price assumption, the higher freight rate causes a reduction in 1975 cereal sales of $281.5 million dollars figuring wheat and rye, rice and other grain at $63.20, $134.70, and $57.94

Table 12. Effects of ocean transportation rates and prices on United States export shipments of grain in 1975 under least cost distribution for 39 trade regions.

Ocean Rates	Common World Prices				Individual Country Prices			
	Wheat & Rye	Rice	Other Grain		Wheat & Rye	Rice	Other Grain	
	(1,000 M.T.)			($1,000,000)	(1,000 M.T.)			($1,000,000)
US = FF	32,898	688	20,804	$3,377.2[a]	32,520	0	26,518	$3,913.0[b]
US = 1.5FF	19,068	1,180	17,662	$2,387.4	37,234	0	22,862	$3,631.5
Change	-13,830	492	-3,142	-$989.8	-1,286	0	3,656	$281.5

a/ U.S. prices are $63.20, $134.70, and $57.94 respectively for wheat and rye, rice, and other grains. Source: "World Trade in Selected Agricultural Commodities 1951-1965". U.S.D.A. 1968.

b/ U.S. prices are $64.10, $154.10, and $54.45 respectively for wheat and rye, rice and other grains.

per ton, respectively, as in the model. Under the assumption of common world prices for each commodity, the decreases in exports is $989.8 for 1975, a 29.3 percent decrease.

Location of Excess Supply Capacity with Optimized Cereal Trade

Given the set of population and income growth rates adopted and analyzed, surpluses of cereals are available on a world basis for 1975. After optimizing the distribution of surpluses among deficit countries, certain countries remain with surpluses of cereals or they remain with surplus capacity to produce surpluses of cereals. Under the present arrangement of trade, this surplus capacity is located in the "developed" countries and particularly in the United States. Much discussion has centered on whether this arrangement is necessarily efficient or useful, or whether an alternative arrangement could locate this excess capacity in more optimal regions.

One phase of this study provided a means to evaluate where excess capacity would be located under optimal trade patterns. Excess capacity in cereal production was interpreted as cropland which could be idled from production. Assuming an optimal pattern of trade in cereals, Table 13 lists areas and quantities of cropland which would be idled. Under this pattern of trade, major acreages retired are located in the U.S., Canada and Australia. Under individual country commodity prices, about 23, 22, and 4.5 million acres of cropland is

Table 13. Effects of price and transportation on world land retirement by trade area in 1975 (thousand acres)

Trade Area	Land Type	Common World Prices			Individual Country Prices		
		US=FF	US=1.5FF	Change	US=FF	US=1.5FF	Change
United States	Wheat & Rye	10,241	25,767	15,526	4,817	5,372	556
	Rice	531	585	54	1,351	1,351	0
	Other Grain	23,062	25,098	1,788	20,207	22,193	1,986
Canada	Wheat & Rye	17,665	613	17,053	24,702	23,932	771
	Rice	0	0	0	0	0	0
	Other Grain	0	0	0	0	0	0
Latin America	Wheat & Rye	0	0	0	C	0	0
	Rice	168	0	-168	1,092	1,092	0
	Other Grain	4,594	27	0	0	0	0
Other West Europe	Wheat & Rye	0	0	0	0	0	0
	Rice	0	0	0	25	25	0
	Other Grain	0	0	0	3,663	3,663	0
East Europe	Wheat & Rye	0	0	0	3,572	3,572	0
	Rice	0	0	0	0	0	0
	Other Grain	0	0	0	734	734	0
U.S.S.R.	Wheat & Rye	0	0	0	0	0	0
	Rice	0	0	0	0	0	0
	Other Grain	0	0	0	1,200	0	1,200

Table 13. (Continued)

Trade Area	Land Type	Common World Prices			Individual Country Prices		
		US=FF	US=1.5FF	Change	US=FF	US=1.5FF	Change
Middle East	Wheat & Rye	0	0	0	0	0	0
	Rye	0	0	0	425	425	0
	Other Grain	0	0	0	0	0	0
Africa	Wheat & Rye	0	0	0	0	0	0
	Rye	0	0	0	299	299	0
	Other Grain	0	0	0	0	0	0
So. Africa-Oceania	Wheat & Rye	4,940	0	-4,940	0	0	0
	Rice	62	62	0	62	62	0
	Other Grain	1,470	0	-1,470	5,101	40	-5,061
Other East Africa	Wheat & Rye	0	0	0	0	0	0
	Rice	1,163	1,163	0	0	0	0
	Other Grain	0	0	0	0	0	0
Japan	Wheat & Rye	0	0	0	0	0	0
	Rice	1,363	1,363	0	294	294	0
	Other Grain	0	0	0	0	0	0

retired for the U.S., Canada and Australia, respectively. Under a common world market price for cereals, shifts occur so that approximately 30, 15, and 5.5 million acres are located respectively in these countries in 1975. Canada shows a reduction in retirement of significant size; Australia shows a moderate decrease; the U.S. shows a 50 percent increase. With variance in the shipping rates at individual country prices for commodities, the U.S. retires approximately another 2.0 million acres. Under the common world prices, a variance in the shipping rates increases the U.S. land retirements by 16 million acres to about 46 million acres total. For the common world price situation the shipping rate requirement causes another 50 percent increase.

In summary, under the 1975 projections, the U.S. is significantly affected by changes in the world price situation or the shipping agreements under which commodities are sold. The magnitude of the effects vary with the commodity, but the higher shipping rate is most detrimental to the U.S. under the common world commodity price assumption for wheat and rye. The 40 percent decrease in cereal grain sales would be of no small importance to the future of U.S. agriculture. Increases of 50 percent in U.S. land retirements under shifts in either of the two assumptions also have considerable relevance for formulation of U.S. agricultural policy.

SECTION II: RESEARCH PROJECTS ON THE INDIAN ECONOMY

The detailed review of individual country food production and demand trends provides a basis for future analysis of food aid. The trends clearly point up the weak position of the low income countries and specifically the insecure position of India. However, these trends are based on data prior to 1964 and therefore do not take into account the introduction of recent technologies and increased use of fertilizer and other inputs. The future food supply in India depends to a very large extent, on the dedication with which the Indian government pursues its intentions to increase the supply of fertilizer, the supply of irrigation materials, and the supplies of superior seed stock along wi.h other minor production inputs, and at the same time maintains the appropriate set of price relationships between these inputs and the output of agricultural commodities to give producers adequate incentive. On this set of economic relationships and on the set of physical production response relationships within which quantities of inputs fit, will depend whether India will accomplish its much announced intention of gaining food self-sufficiency by 1971-72. At this point in time, only judgements can be rendered whether this goal will be achieved. At present these judgements do not agree on (1) quantities of food produced in the last agricultural year, (2) the response relationships of new and additional quantities of inputs,

(3) the quantities of carryover stocks necessary if food self-sufficiency is to be attained throughout a complete weather cycle, (4) the effect on the Indian economic plan if food aid is terminated or substantially reduced by the Indian government, and (5) the ultimate effect of repayment of past and present loans resulting from provision of food aid.

It is obvious that we will have to substantially expand the basis for our Indian economic intelligence before answers to the above questions can be more completely determined. The United States needs additional economic information so that it can formulate a policy on food aid of longer-term duration. From the standpoint of the United States such an improvement in information on our long-term outlook is essential if our program of food production and administration of carryover stocks is to operate with any semblance of economic optimality.

Proposed Projects in India

The foreign phase of the Iowa State University AID/Washington research project will be initiated in India with this background. Three specific projects are proposed which aim at improving the economic intelligence of the United States about Indian food supplies, providing a means for updating the food outlook in India through future use of the models or methodology developed in the studies and providing to the Indian government additional economic information on the quantities of inputs necessary if food sufficiency is to be developed, and ways and means by which stocks of food grains can be accumulated in a minimum cost manner.

Projections of supply-demand and input requirements for future food production

The initial project will focus on the broad relationships between food production and demand in India, required levels of inputs for each level of production and the prospects for food imports and exports. This project will be carried out under an agreement with the National Council of Applied Economic Research in New Delhi whereby that organization will use the basic supply-demand work which it has completed in the past to build a further analysis of the rapidly changing conditions in present-day Indian agriculture. The project will analyze these changing conditions for the period 1970-1985, drawing together the implications of new technologies for increasing supplies of food and alternative levels of population and income growth for increasing the demand for food. Sharp differentials in income elasticities for food exist in India. Which income classes receive future additions of income will substantially affect the total demand for food. Income distribution policy of the Central government will be of importance in projecting demand for food. It is also of great importance from the standpoint of governmental stability but that is outside our scope of interest at the moment. More directly involved is the effect that a shift in income distribution will have on future food demand requirements. These factors must enter calculations if projections are to meet with reality.

On the supply side, the analysis will evaluate the new technological innovations which crop breeders and others are concluding work on, and make estimates of the production effects these new inputs will provide. Further, however, the study will draw upon new surveys on fertilizer response to work up estimates of the quantities of fertilizer which will be required to optimally use the new varieties of crops now being developed. Following up fertilizer estimation, irrigation requirements for investment in equipment, investment in land development, and in overhead development of public waterways for the new varieties will also be estimated. Given these major input requirements for new varieties of food grains, the analysis will concentrate on evaluating foreign currency considerations implied in these import requirements. From these derived estimates of foreign currency needs, the project will proceed to interpret all of the above research in terms of the "food aid" needs or potentials with suggestions for new alternatives in food aid to meet changing agricultural conditions and prospects in Indian agriculture.

Repayment provisions, counterpart funds and effects on fiscal and monetary policy in India

This project will analyze the Food Aid Act of 1966. Under that act Congress initiated legislation whereby sales of food stuffs under P.L.480 for local currency will be terminated by 1971. Instead, food stuffs will be provided under contracts with long term credit to countries receiving

food aid, but this credit must be eventually repaid in dollars rather than local currency. The implications of this change are not evident at this point in time, to administraters who are charged with day to day operation of extending food aid. The change in repayment provisions was not prepared and completed because of any theoretical consideration but instead grew out of the severe strain on world food balances during the 1966-67 drought in India and the lack of obvious improvement in food production in that country. Since the changes grew out of practical considerations of food supply rather than an attempted movement toward a policy to stimulate economic development, a thorough analysis of the ultimate effects of this change in repayment provisions is needed at an early date.

Furthermore since over 60 percent of the total foreign currency generated by food sales to India between 1954 and 1968 was provided to that country's government in the form of loans, there is an immense amount of monetary resources (in excess of $2.3 billion) which will be repaid to the U.S. government over the next several years. While this is local currency and will not require any drain on foreign exchange, yet the magnitude of these funds and the large purchasing power which they represent for commodities produced in India cannot help but bring concern to those charged with monetary stability. These considerations require that long-term guidelines be developed for handling funds generated from repayment

of past loans as well as evaluating the potential effect on development of changing repayment provisions to dollars. These guidelines will be based on a thorough analysis of all factors involved in the monetary and fiscal operations of P.L. 480 and their interrelationships with goals of agricultural and general economics development.

This study will analyze repayment provisions and the monetary effects of eventual repayment of past food aid loans. It will also study and analyze the effects of the "self help" provisions which are attached to each new food loan since 1966. All told, this study is aimed at a thorough theoretical and practical analysis of the provisions of the new Food Aid Act of 1966 with comparisons of provisions under the previous act, the different impacts resulting from each type of provision and the potential for further changes to mesh food aid extension with the goals of self sufficiency in food, economic betterment for the masses of people and a stable government in India.

The consultant services of Professor A. M. Khusro of the Delhi University Economic Growth Center will be secured for the purposes of directing the analysis with the actual effort being completed by Dr. Uma K. Srivastava who has recently completed his Ph.D. thesis on "Impact of P.L. 480 on Indian Economy". Dr. Srivastava will be located at the Economics Growth Center at Delhi University. His analysis will be initiated in June 1969, and completed in 12 months.

Analysis of buffer stock requirements and minimum cost sources of procurement

This project will analyze the problem of establishing buffer stocks of foodgrains in India to protect against fluctuations in food production resulting from vagaries in weather. The analysis will focus on alternative sources of supply for food stocks after establishing projected demand-supply relationships and statistically estimated levels of stock, to protect against expected changes in food supply resulting from weather variability. Costs will be calculated for procuring and annually storing quantities necessary to cover differing proportions of the estimated fluctuations in food supply.

The study will broadly attempt to provide answers to the following questions (1) what level of stocks are necessary to provide security of food supply in India given weather probabilities by states or regions (2) what are the alternative sources of supply from which stocks could be accumulated and what is the price per unit for doing so (3) where should stocks of foodgrains be located in India given the location of the population and the regional fluctuations in weather and food supply (4) under a policy of purchasing quantities of food-grains from Indian production, where will these excess supplies be located and at what price can these supplies be purchased (5) under an alternative set of policies for purchasing stocks from the minimum cost source, what role will food shipments

under P.L. 480 fill in supplying quantities required (6) given the present sets of conditions under which food aid is given what is the present value (cost) of food for which payment is required at some future date in dollars?

These questions will be analyzed in the following manner:

(a) regional estimates of production (supply) equations will be developed.

(b) regional estimates of weather probabilities will be developed.

(c) regional estimates of demand for foodgrains will be developed with differentiation of requirements for food, seed, feed, waste and other purposes.

(d) regional estimates of quantities of stocks of foodgrains necessary to cover expected variation in food supplies will be developed taking into account the known deficit areas based on past production records.

(e) the effect of time on food demand, food production and levels of stocks necessary will be brought into the analysis.

When the above parameters have been established for a specific year or set of years these data will be formulated into a model which will analyze the alternative ways by which stocks of foodgrains can be established, the cost of procuring and storing over time, and the effects of alternative policies with regard to procurement pricing, food imports and other appropriate policy variables.

This project proposes to use the consultant services of Professor A. M. Khusro located at the Economic Growth Center at Delhi University for leadership and direction, and the actual work and effort in the study will use the services of Mr. S. K. Ray who will take a leave of absence from USAID/India for the period specified.

SECTION III: FOOD AID RESEARCH PROJECTS AT IOWA STATE UNIVERSITY

Given the longer run outlook for food production and demand, the role of food aid takes on added significance in resolving the food problem of low income and food deficit countries. These countries will require considerable long term aid of various forms if development is to adequately accelerate so that aid can turn to trade in foodstuffs, or for self sufficiency in food to be achieved. Either objective will require aid to be used in a manner consistent with principles of agricultural development, general economic development, and consumer and producer theory.

The projects at Iowa State University are designed to establish a consistent framework for all aspects of food aid in relation to goals for economic betterment in the less developed nations of the world. The range of projects is designed to provide both the theoretical principles of agricultural development and the role of which food aid can fill in this process. Further, models will be developed which relate the vast number of interrelationship within an economy to food aid or more broadly to outside aid, for countries at lower stages of development. These projects are designed as a consistent set of studies to provide the eventual guidelines for improving on the operations of foreign aid extension by the United States and other developed countries.

Welfare and investment aspects of food aid on agricultural and economic development

This study deals with theoretical and applied aspects of food aid as a foreign investment instrument. The primary objective will be to evaluate the role which food-aid plays in stimulating agricultural and economic development. One facet of the evaluation involves a formulation of a conceptual framework which will provide the organizational structure for further analysis. The second and more important facet involves analysis of P.L. 480 provisions within the conceptual framework to determine forces which can be activated through intersectoral linkages to stimulate economic development.

Although considerable effort and time has been devoted to the use and impact of food-aid, a review of the literature reveals that only a limited amount of achievement has been made in associating use of food aid with a complete set of Economic principles and theories which are involved. Primarily the literature involves analytical work which appraises effects of food aid on a specific economy as opposed to discussions of general cases. Although no set of principles has been developed with respect to use of food-aid, such a step is necessary so that basic economic principles may be developed for the specific use of food-aid. With an integrated framework, policy instruments can be specified which will effectively incorporate food-aid into a recipient economy as an economic catalyst to achieve specified objectives.

One objective stands out as basic to all food-aid contracts. That objective is the improvement of consumer welfare whether strictly for humanitarian reasons or through economic development. For this reason this analysis will concentrate on the impact of food-aid on a sectorial basis beginning with the consuming sector. Other sectors which will be studied in the analysis are agricultural producing, non-agricultural producing, and public.

Operationally, introduction of food-aid into a recipient economy begins with individual consumers. If food is provided as a grant, the consumer's income is increased and consequentl results in an increase in total consumption. Assuming that the consumer has a marginal propensity to consume food which is positive but less than unity, his preference will reflect an increase in total food demanded, but a reduction in demand for domestic food as a result of substitution of non-food products for food products. Although the food grant results in improved welfare, it is not a necessary condition. In fact, if the food is provided to the consumer at any price less than the established market price, consumer welfare will be improved as a result of the income and substitution effects

The additional income which is spent outside the agricultural sector registers an increase in demand in the non-agricultural production sector and establishes a link between the consuming and non-ag producing sectors. Of course the economic linkage does not stop here. Increased demand for

non-ag commodities facilitates increased employment in the non-ag producing sector which in turn represents increased demand which will be registered in both the agricultural and non-agricultural sectors. Although the initial impact reflected a decline in demand for domestic food, linkage from the consuming sector through the non-agricultural producing sector back through the consuming sector to the agricultural producing sector generates a permanent increase in demand for food. Alternatively this increased demand must be met with increases in domestic production, commercial imports, or food-aid. From the domestic standpoint the increased prices in the agricultural producing sector provide an incentive for increased supply. Again the increased demand facilitates increased employment, increased income, and increased demand for commodities from the non-agricultural producing sector.

Tracing the impact of food-aid on the supply side requires a look again at the transfer of food to the consumer. If transfer is insulated from the market place, the transfer will reflect a change in total supply, but no first round change in domestic supply. Under transfer arrangements insulated from the market place, the impact on supply comes indirectly through price incentives induced by increasing demand. If on the other hand food-aid transfer is not insulated, supply effects on consumer prices are introduced. If an external supply of food is introduced into an open market system, the direct effect would be a lowering of prices. Based on a

positive price elasticity of supply, domestic supply would be reduced resulting in an initial increase in consumer welfare but a decrease in domestic production. Alternatively as in the case of the demand increase, the deficit can only be net through decreased second round demand, commercial imports, or additional food-aid. The market place pricing of food has already tied the consuming and agricultural producing sectors together. Decreases in agricultural supply would result in a reversing of the chain reaction back to the non-agricultural producing sector as outlined above.

At this point it is appropriate to digress for a moment and pick up the public sector. In addition to the linkages in the private sectors, it is essential to examine the relationship of food-aid to public investment as well as monetary and fiscal policy. One way which food-aid can compliment fiscal policy is as a substitute for taxing mechanisms. If the recipient government sells the food to the consumer, the payments function as a tax by transferring revenue from private to public sector. Whether the government receives the food-aid as a grant or as a long term loan, the revenue collected represents a domestic investment fund available for developmental programming. The investment funds, like counterpart funds when received and recontracted, are available for allocation among various sectors as well as among projects or programs within sectors. They may be used as social overhead to build irrigation wells, fertilizer plants, marketing facilities, etc.

in the agricultural producing sector, or they may be used to provide raw materials or other resources for the non-agricultural producing sector. This study will relate only indirectly to the specific allocation decisions within sectors and instead, will concentrate on an evaluation of the impact of investment alternatives in various sectors.

Like fiscal policy, monetary policy can be significantly affected by the use of food-aid. Of particular importance here is the handling of counterpart funds. When held on deposit with national banks, the funds represent an asset against which loans can be made which effectively expand the money supply. In other cases certificates are deposited to the U.S. government account and the funds are invested for domestic programming. It is at this stage that the question of inflation and its relation to food-aid arises. Food-aid appears not to be inflationary as long as the counterpart funds are not used to expand the money supply or achieve similar doubling effects.

Tieing the public sector back to the private sector, food-aid represents increased income to the consumer sector whether sold to the consumer and the funds used for domestic investment indirectly or used as wages in kind directly. The increase investment leads to increased employment, increased income, and increased demand as before. At this stage supply has also been stimulated directly through increased investment whether providing resources to the agricultural or non-agricultural

producing sectors. At the same time the investment funds or counterpart funds are available for supplementing food-aid on an open market system and allowing consumer price to decline. Initially consumer welfare would be improved by the price decline, but in second round effects both producing sectors would enjoy increased demand, employment, income, etc.

One of the most important stages of the study will involve the incorporation of case studies in the conceptual framework to insure compatibility with the operational problems of food-aid contracting and use. This stage will be most useful in translating the conceptual framework and analysis into policy statements which can be used to direct future food-aid programming.

The study will exploit the following secondary objectives:

1. To establish inter-sectoral linkages in order to measure income and investment multiplier effects which will be generated from food sales and counterpart fund investments.
2. To determine what provisions make food-aid disposition supply and/or demand increasing.
3. To measure effect on consumers of providing food-aid under alternative marketing mechanisms.
4. To evaluate degree of complimentarity or competitiveness between food-aid and fiscal or monetary policy.
5. To analyze inflationary impact of food-aid or counterpart fund use.

6. To examine impact of transfer methods on distribution patterns and consumer welfare.

This core of analysis will cover the basic relationships in the use of food-aid and indicate the close linkage of the individual sectors. In the realm of consumer welfare, food aid increases income and welfare of consumers. Increased income expresses itself as increased demand in both the agricultural and non-agricultural producing sectors which in turn generates increased employment and income fur further demand increases. At the same time food-aid may be invested through Title II work projects which expand supply capacity concurrently with demand expansion. Food-aid can also serve as a means to raise revenue for public investment. These areas are important and require further analysis to provide guidelines for future developmental planning.

Factors affecting agricultural development and growth in less-developed areas

This project will conceptualize and synthesize a general theory of the growth and development of the agricultural sector in less-developed areas. Given the heterogeneity of the less-developed areas in terms of resource endowments, rates of economic and population growth and their absolute levels, and institutional structures, this general theory would need to be modified for application to particular areas. However, the model based on the general theory may be viewed as a master model with modifications of variables included and structural relations to effect more meaningful results for specific provinces or countries.

The expansion of agricultural productivity is often hypothesized as being the mainspring or a necessary concurrent realization for sustained growth of the over-all economy. Yet, the growth rates of agricultural sectors have lagged in recent years. (The differences in composition, aggregation procedures, and levels of agricultural production which complicate comparisons of country growth rates are also recognized.) For some countries, this growth rate is below the rates realized in the 1950's; for some, it hardly keeps pace with the population growth rate.

A specification of the factors, both economic and social, which influence agricultural growth and development aids national planners in developing government investment programs, agricultural policy, and other sector policies. Figure 1 reflects some of these factors together with some of the interrelationships of agriculture with other sectors of the economy. For example, the quantity, composition, and distribution of foreign assistance, including food aid, likely affect resource productivity, retail and producer prices, and individual attitudes toward the development process. The impact of these hypothesized effects on agricultural production and private investment in the agricultural sector affects the capability of this sector to meet the food and raw material requirements of an expanding economy. Further, increased agricultural productivity may be the stimulus to general economic expansion.

A survey of the literature suggests that previous attempts at identifying and evaluating the crucial factors affecting agricultural growth and development have two basic shortcomings.

1. The factor under discussion has often been segregated from its interrelationships with other factors through the implicit use of ceteris paribus assumptions. Change, associated with economic development, makes invalid the use of many of the ceteris paribus assumptions.
2. A number of concepts employed in Western economic theory have questionable application to analyzing problems in less-developed areas. Further, the impact of institutional factors and social variables is recognized, but since these areas are often considered outside the purview of economists, they are usually not given sufficient attention.

Initially, this project will be directed toward the agricultural sector, per se, i.e., its structure, activities, and performance. Thereafter, the project will evaluate, at least qualitatively, the impact of the other sectors of the economy on the pricing mechanism and resources supplied to the agricultural sector. Relatively more time and effort will be devoted to the initial work.

Four major areas will be investigated initially:

1. Structure of the agricultural sector at two stages of development, e.g., subsistence - and market-oriented stages. Subtopics included would be:
   a. Impact of resource endowment;
   b. Economic and social organization of the agricultural sector; and
   c. Government programs and public investment in the agricultural sector;
2. Objectives of agriculturalists as producers and consumers;
3. Choice indicators influencing decision-making processes; and
4. Agricultural production, supply, and consequences to the agricultural sector.

Later, the impact of economic development and sector linkages on the structure of agriculture and consequences for agricultural productivity will be examined. Throughout the study the most important and most tractable factors affecting agricultural development and growth will be discussed and related to economic theory and logic. The decision will be modified, where possible, to reflect conditions existing in the less-developed areas. The next step will be to construct hypotheses relative to the role and impact of changes in quantities and prices of these factors. To the extent possible, the literature dealing with these problem areas will be surveyed and evaluated in order to find support or nonsupport

for the specified hypotheses. When secondary data are available, these will be analyzed.

For example, two hypotheses relevant to the effect of capital formation and credit institutions on economic development might be:

1. The taxation or extraction of capital formed in the agricultural sector for expanding nonagricultural sectors has not had a detrimental effect on agricultural production and private investment in the agricultural sector.
2. Private credit institutions have not been efficient in facilitating agricultural growth and development; government agencies have been more effective.

The final stage will focus on a synthesis of individual components investigated into a construct reflecting the interactions within the agricultural sector and the qualitative impact of growth in the nonagricultural sector on economic activities in the agricultural sector.

Development planning models

The purpose of this project is to specify an over-all framework for empirical analysis of problems arising out of use of food aid in economic development. Two focal points of the analysis will be to provide guidelines for programming future food aid shipments and to outline criteria for the allocation of local currency generated by the food shipments. These two objectives will be examined in a more general framework.

Food aid may be viewed as a particular type of foreign aid. Suppose two countries require $1,000 of foreign aid, the first is granted food aid valued at $1,000 while the second country received $1,000 of foreign credit (money). This second country has the option of spending the $1,000 in any way it desires. Money can be spent on capital imports, on raw materials, or on food imports if the government considers this to be the optimal allocation of the funds. The first country, however, does not have the option of selecting its "bill of goods" to import. It has $1,000 worth of food.

Before determining the optimum level of food aid a country should receive, a more general question arises: what is the optimum level of foreign aid? This particular study will address itself to the general problem of optimum use and levels of foreign aid for development of resources in a manner consistent with monetary, efficiency, and welfare considerations of underdeveloped countries.

As in the case of food aid, the problem of the allocation of local currency generated by the sale of the food can be considered as a part of the more general question of the optimum allocation of all government expenditures. The optimal allocation of public funds, in turn, can be considered as a part of an even more general question; what is the optimum allocation pattern of all investment funds, both public and private? Answers to these more general questions would appear

to hold the key to answers for the more specific problems. It can even be argued that it is not possible to discuss the specific allocation problems until the more general questions have been answered since the optimum allocation food aid money will ultimately depend on all the investment opportunities available and the coordination of the food aid funds with other private and public investments.

In view of these considerations, this project will be addressed toward models suited for analysis of the more general questions of optimum levels of foreign aid and allocation criteria for investment funds.

The study will consist of two parts. The first part will be an examination of models which have been developed and are relevant to pressing problems in developing countries, especially models which are operational and have been applied to various situations. A model is desired which could be used, at least in principle, to examine the relationships between food aid, agricultural development, and economic growth. The model should reflect the linkages between the agricultural and nonagricultural sectors, the economic and technical nature of the agricultural sector, and the domestic structure within which the food aid must operate. The desired model should permit the examination of the consequences of the magnitudes of the food shipments and the financial terms under which food aid is provided.

The second part of the study would be an attempt to extend these models to focus on some important problem areas that have not been treated in the literature in any operational way. Some of these problem areas are discussed below.

One of the most important areas that has been largely overlooked is the interdependence among investment decisions. This can be subdivided into two parts: constant costs and pecuniary externalities and decreasing costs or technological externalities. Considering the former, the principle conclusion of static economic theory in the area of constant costs is that pecuniary externalities are not important and each investment decision can be made on its own merits independent of consideration of other investment projects. According to static theory, under such circumstances, free market forces will eventually lead to the optimum situation in the very long run. However, in the short run when dynamic considerations are taken into account, Chenery has demonstrated with a numerical example that the rate of growth of an economy will actually be lower if such investment decisions are made independently and there will be advantages to the simultaneous consideration of investments in interdependent projects.

The second part of the interdependence problem, that of technological externalities, has long been a thorn in the side of economists. In these circumstances free market forces will no longer necessarily lead to the correct decisions even in the very long run. Traditionally, economists have handled

this problem by assuming it doesn't exist through convexity assumptions or assuming the problem is unimportant. Economists don't have any good tools for making investment decisions in situations involving decreasing costs. This problem is more difficult and probably more important than the problem of pecuniary externalities. It is more difficult because considerations involving market size in relation to scale of plant become relevant, which adds a new dimension to the problem.

A second important problem area is the adoption of new technology. In most underdeveloped economies, more efficient techniques of production are available than those currently being used. There are many important and relevant questions concerning the adoption of new techniques. For example: Which of several more efficient available techniques do you adopt? How quickly should these techniques be adopted? Should more efficient techniques be adopted at all is a relevant question in many areas. For example, the productivity of labor in Indian agriculture could be raised tremendously by mechanization. However, this would probably lead to severe unemployment problems for displaced farm laborers.

There are many important regional questions in economic development. It is well known that some areas develop more rapidly than others. Why do some regions develop more quickly than others? Should leading regions be encouraged to develop and depressed regions ignored? What is the effect of trying to encourage all regions to grow at the same rate?

The method of financing economic development can raise some very important and difficult questions. If economic development is being financed by foreign aid, which must be repaid after a period of years, certain restrictions are placed on the direction of the country's development program. Repayment of the loans requires foreign exchange which can be generated only through investments in export expansion, or import substitution if an export sector already exists. Successful investment in a program to generate foreign exchange depends upon developments in international markets. There is growing concern among underdeveloped countries whose exports are primarily agricultural products. Long run indications are that the international markets for agricultural products will be soft and consequently a poor source of foreign exchange. Thus, an important question relates to the direction of economic development to assure a viable balance of payments position in the future, especially when loans have to be repaid.

An area of economic development that has been virtually ignored by economics is the distribution of gains from economic growth. It frequently happens that many people are made (relatively) "worse off" by economic growth while a relatively few gain. Why do some people benefit from growth and not others? What types of policies can be implemented to overcome some of the inequitable distributional aspects? What is the effect on the rate of growth of spreading the benefits of growth evenly over "all" segments of the population?

Not all of these problem areas are directly relevant to the specific objectives mentioned at the outset. All are believed to be important and it is at these types of problems that model extensions will be directed.