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Food Grain Reserves in Developing Countries

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FOOD GRAIN RESERVES IN DEVELOPING COUNTRIES

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FOOD GRAIN RESERVES IN DEVELOPING COUNTRIES

Summary

This Special Report No. 6 by the Food and Feed Grain Institute at Kansas State University is presented in two parts. Part I includes an overall analysis of factors related to LDC food grain reserves and presents suggestions for AID policy to support building and maintaining such reserves. Part II presents guidelines for assessing the economic feasibility of LDC reserves using Bangladesh as a case example.

Assistance programs by the Agency for International Development to help LDCs establish their own food grain reserves can serve humanitarian, stability and development objectives. The establishment of needed LDC reserves also can serve market and price stability objectives of American agriculture. Reserves in LDCs can supplement world and U.S. reserves, increasing worldwide food security in years of lower than average food supplies from current production around the world (pages 4-10).

Conditions for Maximum Net Benefit from LDC Reserves

- Optimum levels of reserve stocks in each LDC, reflecting year-to-year production variations and price elasticities on a country-by-country basis (pages 11-16, Tables 3, 5 and 6, Figure 2).
- Most efficient sources of grain for building reserves in each country, reflecting grain storability, storage costs, market position and inventory financing costs (pages 16-17).
- Proper storage facilities for the most appropriate technology in each country, reflecting the proper type, size, location and design of facilities to maximize benefits and minimize costs of the reserves (pages 17-23, Tables 7 and 8).

- Development of the human skills for effective management of long-term storage under the appropriate technology for each country (pages 23-24).
- Effective food reserve and storage management policies in each country, and concrete guidelines for the implementation of these policies (pages 24-26).
- Appropriate pre-determined policies covering the conditions for both build-up and draw down of reserves (pages 26-29, Tables 3, 5 and 6 and accompanying discussion).
- Effective interfacing of the food reserve program with producer price support programs and consumer price control programs in each LDC (pages 29-30, Table 2 and accompanying discussion).

AID Program Recommendations to Support LDC Food Reserves

- Broadening U.S. PL 480 policy from immediate consumption needs to long-term supply requirements. This will support the build-up of reserves in LDCs, and help stabilize export markets for U.S. grains (pages 31-34).
- Coordinating PL 480 commodity assistance with capital and technical assistance. All three types of assistance are needed to support effective food reserve programs in LDCs (pages 34-35).
- Developing guidelines for assisting LDCs build viable reserve programs. Because conditions vary in each LDC, the guidelines should provide the basis for tailoring the most effective reserve in each country. Ideally, the guidelines would be reduced to manuals comparable to those guiding feasibility analysis for capital assistance projects (pages 35-37).

- Applying uniform standards for judging effectiveness of LDC food reserve programs. Such standards are necessary because of active public pressures and the tendency to over-react to individual indicators regarding the operation of the reserve. The individual indicators need to be interpreted in the context of overall goals to be served by the food reserve program (pages 37-38).
- Relating proposed LDC programs to possible future international system of food grain reserves, so that the two types of reserve can be operated to complement one another in achieving increased stability in supplies and prices of food grains around the world (pages 38-39).
- Relating proposed programs to domestic U.S. agricultural policies for food production and distribution. If this is done effectively, PL 480 programs can be shifted from the realm of surplus disposal to predictable export demand for U.S. production. U.S. producers can plan cropping patterns and crop inputs accordingly, thereby reducing "feast or famine" situations (pages 39-40).

Determining Needed Size of LDC Reserve

- The pattern of annual deviations from the trend in total food grain supplies (net production plus imports) is the crucial element in determining the size of LDC reserves to bring reasonable stability (pages 11-17).
- The price elasticity of demand determines the year-to-year variation in total supply quantity which can be accepted without serious consequences to low income consumers and small farmer producers (pages 13-14).

- The needed maximum size of the LDC reserve is affected by the support available to the reserve. In the Bangladesh example, the maximum is reduced from 800,000 metric tons to about 750,000 mt if supported by import adjustments, and from 800,000 mt to about 650,000 mt if supported by an international reserve (Tables 3, 5 and 6).

Determining Additions to and Withdrawals from Reserve

- The LDC reserve is drawn upon in years of excessive shortfalls in total supply quantities and added to in years of excessive over-supply of food grain. Quantity triggers are used in the Bangladesh example (Table 3, Figure 2).
- The targeted volume of withdrawal from or addition to the LDC reserve in a given year is pre-determined by the stability goal and the extent of the current deviation in total supply quantity (Table 3, Figure 2).
- The ability of the LDC reserve to meet the stability goal in a given year is conditioned by the maximum and minimum limits on the reserve, the closing reserve inventory the previous year and the size of the shortfall or excess in that year. The ability of the LDC reserve to meet the goal is enhanced by support from import adjustments or an international reserve (Tables 3, 5 and 6).

Measuring Benefits from LDC Reserve

- The magnitude of benefits associated with a given level of stability protection by the LDC reserve depends upon the seriousness of the consequences of the instability avoided (after transfer payments between consumers and producers in the LDC are washed out). In LDCs where the agricultural and consuming sectors are heavily dependent on food grains, the potential benefits from an LDC reserve are likely to be relatively large (pages 11-16).

- To the knowledge of the authors, the needed economic impact studies to measure consequences of unstable food grain supplies have not been made for Bangladesh or other developing countries. It has been necessary to make assumptions regarding the findings of such studies in Bangladesh (Table 2).
- Given the consequences of unstable food grain supplies in a country, the historical benefits that would have been generated under a LDC reserve program can be determined for the years when the reserve would have come into play from the degree of additional stability achieved and the magnitude of the consequences avoided (Tables 2, 3 and 4).
- The measurement of anticipated future benefits of a LDC reserve needs to be based on statistical probabilities, since the future time distribution of shortfalls and excesses in the total supply quantity of food grains will not duplicate that experienced historically, except by accident. The probability approach is needed because modern economic feasibility analysis is sensitive to the time distribution of expected benefits and costs (pages 78-79).

Measuring Costs of LDC Reserve

- Major categories of costs associated with LDC grain reserve program include (1) storage facility investment costs, (2) grain inventory carrying costs, (3) storage operating costs including costs of shrinkage and quality deterioration, and (4) administrative costs for the program. A number of inter-related factors affect the amount of cost that will be incurred under each category (pages 16-23, Tables 7 and 8).

- Specific feasibility studies are needed to develop estimates of costs in each category under appropriate conditions for the LDC. The "ball park" estimates for the Bangladesh example illustrate the methods of developing cost estimates for a specific LDC reserve (pages 63-69, Tables 7 and 8).
- If the LDC reserve is to be supported by import adjustments or by an international reserve, the additional costs for such support must be estimated. If import adjustments are made by altering the volume of purchases (or sales) in international markets, the costs of the purchase premiums (or sales discounts) can be estimated. Estimates also can be made of the per metric ton costs of transactions with an international reserve (pages 69-70).

Measuring Economic Feasibility

- Discounted cash flow analysis of the kind normally employed to measure the feasibility of capital development projects can be used to measure the feasibility of LDC reserves. If the projected cost and benefit flows are properly developed, normal direct rate of return analysis is appropriate. The Kansas State University format provides the (1) direct arrival rate of return on total capital investment, (2) the benefit/cost ratios at alternative amortization rates, and (3) the net present values at alternative amortization rates in a single computer run (Tables 9, 10, and 11).
- The direct annual rate of return on total capital investment (DRR) is independent of the interest rate on storage facilities and grain inventories in the reserve and may be compared with the opportunity cost of capital appropriate for each LDC (pages 71-79, Tables 9, 10, and 11).

- The benefit/cost ratios are fully discounted to equivalent present values of both benefit schedules and cost schedules to insure that B/C ratios for various alternatives will always rank the alternatives in the same order as the direct rate of return (pages 71-79, Tables 9, 10, and 11).
- The net present values also are fully discounted at six alternative amortization rates and will rank alternatives in the same order as the corresponding direct rates/return (pages 71-79, Tables 9, 10, and 11).

Preliminary Findings for Bangladesh

- Under the assumptions made, a LDC reserve would have been feasible for Bangladesh over the period 1960-1961 through 1976-1977. The direct rate of return is 32 percent per year. At an opportunity cost of capital of 20 percent, the benefit/cost ratio is 2 to 1 and the net present value $141 million (Table 9).
- The feasibility of the LDC reserve is enhanced if supported by a program of import adjustments to offset year-to-year variations in domestic production. The direct rate of return is increased to almost 36 percent and the net present value (at 20 percent amortization) to about $187 million (Table 10).
- The feasibility of the LDC reserve for Bangladesh from 1961 to 1977 is enhanced still further if supported by an international reserve program. In this case, the direct rate of return is increased to about 38 percent and the net present value (at 20 percent amortization) to about $198 million (Table 11).

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PART I

FOOD GRAIN RESERVES IN DEVELOPING COUNTRIES

SUGGESTIONS FOR AID POLICY

Introduction

There has been a great deal of discussion and a number of impressive analyses of food grain reserves in recent years, but so far very little has been done about it. Difficulties have been encountered by the World Food Council and other organizations in finding acceptable guidelines for a world grain reserve program. The United States, Canada, and other exporting countries are anxious to avoid the problems of burdensome surpluses encountered in the 1950's and 1960's. Following good harvests around the world, many of the developing countries are anxious to build reasonable LDC reserves, but are in need of effective guidelines and additional development assistance in order to do so effectively. Donor agencies such as the FAO and other United Nations agencies, World Bank, Inter-American Development Bank and Asian Development Bank are conscious of this need, but have not developed precise programs for meeting it. The U.S. Agency for International Development, by combining capital and technical assistance with commodity assistance under Public Law 480 programs, has the base of experience needed for leadership in developing and implementing programs to help LDCs build effective grain reserves. The Agency has taken steps in this direction under Title III of PL 480 but has not developed policies and guidelines for an integrated total approach for helping to build sound food grain reserve programs in the developing countries. Part I represents a "think piece" on how this might be done.

Need for LDC Reserves

The developing countries were made acutely conscious of the need for reserve stocks of grain by the food grain crisis of 1974, and by the repercussions caused by highly volatile world grain prices as an aftermath to the crisis. They are anxious to avoid the danger of mass starvation with only a few days of food on hand prior to the new harvest. They are anxious to avoid the potentials for serious consumer rebellion to sky-rocketing prices in times of serious shortages. They are anxious to avoid over-adjustments in agricultural resource use caused by food grain prices which are temporarily very high, and the dangers of mass bankruptcy of farmers caused by food grain prices which are temporarily very low. In short, the developing countries are anxious to develop reasonable levels of reserve stocks of food grains for protection to their producers and to their economies as a whole. This need is particularly crucial in the absence of major reserve stocks of grain in the exporting countries of the world.

Opportunities Created by Current Conditions

The relatively good world harvests of grain the past three years, have provided many of the developing countries with the opportunity now to build their own reserve stocks to resonable levels. Helping them to take advantage of this opportunity will ease the pressures on the creation of a World Food Reserve Program and buy the needed time to work out the policy, management and logistic problems involved. Helping to build reasonable LDC reserves will reduce the burden upon the United States of carrying grain reserves large enough to stabilize world supplies and maintain reasonable prices in world markets (and therefore

domestic prices) of wheat, rice and other food grains to the U.S. farmer.[1/] From the standpoint of self-interest for the economic health of the U.S. producers and the U.S. grain industry as well as the altruistic standpoint of helping the developing world feed itself, the timing is right for the United States to take the leadership in a major step forward in helping interested LDCs build reasonable food grain reserves.

Objectives of Part I

The general objective of Part I is to present suggested guidelines for AID in programs to help LDCs develop reasonable food grain reserve programs. Specific objectives include the following:

1. Discussion of humanitarian and development objectives to be served by LDC grain reserves.
2. Indication of the factors affecting the benefits and costs of grain reserve programs in the developing countries, including:
   a. determining optimum levels of reserve stocks.
   b. sources of grain for LDC reserve stocks and methods of financing such stocks.
   c. grain storage facilities, including ownership and financing of the facilities.
   d. technology and level of human skill applied.
   e. storage management policies and practices.
   f. stock acquisition and release policies.
   g. consistency in reserve stock policies and programs.
3. Recommendations for AID policies and programs to support LDC reserve programs.
   a. broadening U.S. PL 480 policy from immediate consumption needs to long-term supply requirements.

[1/] See page for further elaboration of this point.

b. coordinating commodity assistance with capital and technical assistance programs.

c. development and application of LDC reserve stock guidelines.

d. application of uniform standards for evaluating LDC reserve programs.

e. relation of proposed program to U.S. agricultural policies for food grains.

Objectives of Food Grain Reserves in LDCs

The objective of added supply and price stability served by reasonable levels of reserve stocks of food grains in the LDCs is recognized and accepted. The humanitarian objective of averting mass starvation in times of crises is seldom challenged. The development objectives served by sound food grain reserve programs may not be so widely recognized and accepted as the stability and humanitarian objectives, but are no less important.

1. Stability Objective

Given the highly inelastic price elasticity of demand for the staple food grains in developing countries, and the resulting wide fluctuations in prices with relatively small changes in supplies, the utility of reserve stocks to temper the extremes in price fluctuations is clear. In times of serious shortfalls in domestic production or international supplies, reserve stocks can be drawn upon to prevent the extremely high prices which would result otherwise. In times of surplus production or abundant world supplies, market withdrawals to build up reserve stocks will prevent prices from falling to disasterously low levels. This tempering effect on extreme price fluctuations at both ends of the scale

reduces uncertainties and maintains order in the market place to the advantage of consumers, producers and the food grains industry in the LDCs.

The alternative to reasonable stability in domestic food grain prices in the developing countries - that of alternately extremely high and extremely low prices - usually is unacceptable. Extremely high prices in times of shortage penalize low-income consumers most seriously because of the high percentage of total income spent for food by this group. Windfall profits, which may accrue to producers from the high prices, frequently cause over pricing of agricultural inputs and over adjustments in the production sector. For countries where the staple food grains represent a dominant product in the economy, grain prices which are unduly high, even for relatively short periods, tend to fuel the fires of inflation beyond the capacity of the government to control it. Countries which attempt to maintain grain price controls are hard pressed to enforce the controlled prices during extreme shortages, and may encounter excessive enforcement costs as well as serious negative impacts on producers and the entire grains industry in attempts to do so. Thus the alternative to reasonable grain reserves in the LDCs, which can be drawn upon to temper price pressures during times of grain shortages, is not attractive.

Likewise, the ability to withdraw market supplies for building reserves in times of excess production is superior to the alternative of seriously depressed prices, or of direct government subsidy to protect producer prices. The tempering effect against abnormally low prices becomes increasingly important as LDCs succeed in approaching goals of self-sufficiency in food grain production. Under these conditions, market withdrawals are required to prevent prices from falling to levels which may cause mass

bankruptcy among producers, especially among small farmers. Direct price or income subsidies may be used as an alternative method for producer protection but the costs of doing so can be excessive to the developing countries. If deficit financing is used to support the cost of the subsidy, then the inflationary effects cause serious secondary problems to producers, to consumers and to industry alike. Thus as a price floor as well as a price ceiling, the stability objective of reasonable grain reserves is difficult for the developing country to achieve by alternative means.

2. Humanitarian Objective

The humanitarian objective of adequate food supplies within the price reach of low-income consumers, while providing reasonable income to the small farmers in the developing nations, provides strong support for grain reserve programs. Sensitive people and sensitive governments around the world are anxious to help avoid mass human starvation, or even mass family bankruptcy to pay the food prices necessary to keep family members from starving. Likewise, sensitive people and sensitive governments want to avoid mass bankruptcy among small farmer families caused by disasterously low prices. Even though average grain supplies and prices are adequate and reasonable, year-to-year fluctuations in production in the absence of a food grain reserve program can bring about both kinds of disasterous effects in many developing countries of the world.

3. Development Objective

Excessive year-to-year instability in food grain supplies and prices can wreck havoc with progress toward development goals in the LDCs. Stated positively, a sound food grain reserve program can do much to support development programs, not only in the food and agricultural sector, but in other sectors of the LDCs as well.

a. Reduction of Producer Uncertainty

The impact of food reserves upon programs for increased domestic production of food grains is direct and substantial. Small farmers in the LDCs must hedge against uncertainty in order to feed their families and meet family expenses. Development programs which promise to raise materially average net farm incomes will not be adopted by such farmers if the risk of low prices in any one year might bankrupt them. This is doubly true of programs which substantially increase the cash farm input such as seed, fertilizer, chemicals, irrigation costs, tools and machines or hired labor. The fear of low prices in one year out of five, or lack of confidence in the government's ability to deliver on announced support prices, can prevent adoption on proven development programs which double or triple average annual net farm incomes. This is not changed by the farmer's expectations of offsetting windfall profits through abnormally high prices one year in five. Such profits and higher average annual incomes are little motivation if he cannot survive the feared adverse year. A food grain reserve program, which gives farmers confidence that prices will not fall below reasonable levels, will do much to stimulate adoption through the reduction of price and income uncertainty to producers.

b. Reduction of Industry Uncertainty

Programs for the rationalization and development of food grain industries and other agribusiness endeavors are affected indirectly by uncertainty facing farmers. The adoption of such programs depends upon confidence by the agribusiness investor that production increases will be achieved on a predictable schedule. Grain reserve programs, which give them confidence that farmers will adopt technology and expand production, will provide support to the off-farm agribusiness development programs.

c. Reduction of Consumer Uncertainty

Development programs designed to improve health and nutrition depend upon expectations of reasonable stability in prices of staple food grains. The uncertainty that supplies may be short and prices high will deter both households and food processing industries from adopting programs which would be jeopardized by this risk. Food reserve programs, which reduce the uncertainty of short supply and high prices, will support nutrition programs involving more effective use of the food grains.

d. Reduction of Inflationary Pressures

In a more general way, expectations of reasonable stability in the prices of major staple food grains through LDC reserve stocks which can be drawn upon in times of short supply will support a wide range of development programs through increased control on inflation. When real or anticipated increases in prices of the major staple foods rob workers and investors of any gains in monetary income, inflationary pressures mount and progress toward development goals is jeopardized. Counter programs to subsidize the food grain price to low-income households may drive the inflation still farther, especially if deficit financing is used to pay for the subsidy. These problems can be avoided if the food grain reserve in the LDC is adequate to maintain reasonable prices in times of short falls in domestic production or high world prices for imported grains.

Relationship of LDC Reserves to World Reserves

The probabilities of grain production short falls over large areas of the world at the same time are less than for production shortfalls in a given country. This is a strong supporting argument for world or regional food grain reserves because the needed level of reserve stocks and the associated costs are substantially less than for country-by-country reserves. However, without complementary LDC reserves, major

difficulties are encountered in developing mutually acceptable plans for reserves which are built up, financed, managed and drawn upon in time of need by several nations jointly. Even if these difficulties can be resolved, the administrative costs of managing and handling such reserves are likely to be prohibitive. This is true because the response capability would have to be rapid, the intelligence information on harvest potentials, pipeline stocks, etc. would have to be precise, and the additions and withdrawals from the centralized stocks would have to be relatively frequent.

On the other hand, if world or regional reserves are used to complement or backstop reasonable levels of food grain reserves in the developing countries, the costs of handling and administering the world or regional reserves could be realistic and practical. Furthermore, LDCs are more likely to accept jointly-owned and managed world or regional reserves if they are encouraged and assisted in developing solely-controlled LDC reserves to serve as front line insurance, with the world or regional reserves serving as supporting insurance to be drawn upon in relatively infrequent cases of major disaster or extreme production short falls.

Experience in handling and managing effective LDC reserve programs can prove to be of vital educational value for handling and managing world or regional reserves. As a practical matter, it may be necessary to gain real experience with food grain reserves in many of the LDCs before a mutually acceptable plan can be developed for a world-wide reserve program, or even for regional reserve programs. Certainly lessons gained from the experience in individual LDCs can improve the likelihood of success for major world-wide or regional reserve programs.

Relationship of LDC Reserve to U.S. Reserves

Reasonable food grain reserves in the developing countries of the world can do much to reduce the need for excessively large carryover stocks in the United States, Canada and other major grain exporting nations. As a stabilizing influence on world prices, the needed magnitude of the combined total levels of reserves in all nations of the world is approximately equal, whether most of the reserve is located in the U.S., or whether most of it is divided among the developing countries of the world.[2/] In fact, the dampening effect on price extremes in world markets may be greater when the reserves can be made available more easily when and where they are needed. In any case, food grain reserves in other parts of the world will help protect U.S. producers and U.S. consumers from the ill effects of extreme year-to-year fluctuations in grain prices.

Factors Affecting Benefits and Costs of LDC Reserves

There are a number of key factors which affect the magnitude of the benefits and the costs of food grain reserves in a given developing country. An obvious factor is the proper sizing of the reserve so that it is large enough to provide the key benefits, but small enough to prevent excessive storage and handling costs. Another is the sources of the grain used to build the reserve and the methods of financing those stocks. A third factor is the type of facilities used for storing the reserve, together with the pattern of ownership and financing for the facilities. A fourth key factor is the level of technology and technical skill applied in the storage operation. A fifth factor relates to the grain storage management policies

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[2/] Assuming information about the stock levels is equally well distributed in the two cases.

and practices, and a sixth to the stock acquisition and release policies employed. The final important factor determining the magnitude of benefits and costs relates to the degree of coordination between the LDC grain reserve program and the total food program of the country.

Taken together, these factors have such massive impacts on both the benefits and the costs of grain reserve programs as to render average benefits and average costs relatively meaningless. In contrast, focus upon these key factors in the design and planning of reserve stock programs, and in the operation and management of the programs, can help insure maximum benefits and minimum costs to each developing country from its own food grain reserve program.

1. Determining Optimum Levels of Reserve Stocks

The optimum level of year-end carryover stocks for a specific country depends directly upon the probability of serious shortfalls or gluts in available grain supplies in the ensuing years. The greater the probability of large year-to-year variations in supply, the greater the number of days of supply of the grain for the nation's consumers needed in the food reserve.

a. Measurement of Reserve Stocks

At this point, let us clarify the definition and measurement of LDC reserve stocks. Such stocks represent crop year-end carryover just prior to the major new crop harvest. They should be measured at the end of the crop year for the specific grain and country in question. Most countries are characterized by seasonal harvesting patterns, so that total stocks following harvest are considerably larger than the level of reserve stocks maintained. This is true because total stocks include the seasonal inventories needed to feed the nation's consumers through the remainder of the crop year as well as the year-end stocks included in the LDC grain reserve.

The size of the peak seasonal inventory in a country depends upon the number and patterns of harvests, but often will be several times larger than the reserve stock needed. In an extreme case such as the United States, with a single annual bread wheat harvest within two months, the peak seasonal inventory must include about ten months' wheat supply. If the optimum year-end carryover in the food grain reserve were two months' supply, the peak seasonal inventory would be five times the size of the grain reserve. Total stocks (peak seasonal inventory plus grain reserve) following harvest would be twelve months' supply, or six times the size of the grain reserve alone.

The common unit of measure of grain stocks is metric tons. Target size of grain reserve is based on consumption requirements in the LDC and the extent to which variations occur in available supplies generated from current production and imports in most developing countries. Population and income effects are at work causing constant change in total annual consumption requirements. Therefore, the number of tons of food grain needed in a food reserve program is changing also. Supply needed in the reserve can be calculated country by country, with continuous updating to reflect trends in population and per capita consumption of food grain. It is more meaningful to measure grain stocks in terms of consumption requirements than in metric tons. This can be done in percentage terms or in number of days food supply, then converted to metric tons each year.

b. Variations in Cereal Grain Supply

The uncontrolled year-to-year variability in grain production in a country is a function of such factors as rainfall patterns, damaging storms, flooding, major pest infestations and availability of fertilizers, pesticides and other key inputs. Normal imports vary from year to year based on availability of grain in the international market, market price, size

of in-country exchange balances and decisions of donor agencies. Year-to-year variations in production and in imports together make up annual variation in available supply of cereal grains. The greater the variation, the larger the reserve needed to protect the nation's producers and consumers. Supply deviation from trend in cereal grain requirements, and therefore its influence on the optimum level of reserve stocks, is easily calculated from historical time series production and import data for the country (see Part II). After adjustments for the influence of new irrigation projects and other developments affecting production variability, future variability can be projected for a country with a relatively high degree of confidence. This, coupled with assumptions concerning level of imports, can be used to estimate the size and frequency of variations in total cereal grain supply for a country.

c. Price Elasticity of Demand

Given the projected level of annual variation in available grain supply, the effects of this variation on domestic grain prices is determined by another key coefficient, the price elasticity of demand for the grain. Price elasticity is measured by statistical demand analysis of price and quantity consumption data for the country's markets. The magnitude of this coefficient drastically affects the price impacts of variations in quantity, so that averages are relatively meaningless. The coefficient should be determined empirically for each major food grain in each country. Furthermore, it should be determined specifically for the upper and lower ranges of variability in production which can be tempered by a food grain reserve program. An example will indicate the importance of such determination. If the price elasticity over the range of variation of concern is -0.4, then a 10 percent variation in supply will cause a 25 percent variation in price. However, if the coefficient is -0.1, then the

10 percent change in supply will cause a 100 percent change in price. The 25 percent change in price of a major staple food might be tolerated, while a 100 percent change in the price could be disasterous. Yet these examples are well within the range of magnitude one might expect for food grains from one developing country to another.

Clearly, the more price inelastic the demand (the smaller the absolute value of the coefficient) in a country, the greater the benefit from a given level of grain reserves in that country. Although a bit oversimplified, one can say that the magnitude of need for a reserve is determined by variation in available supply and that the size of the grain reserve needed is determined by the price elasticity of demand. Both parameters can be determined empirically for each major food grain on a country-by-country basis.

d. Food Grain Substitution

Two other major factors need to be considered in determining the optimum level of grain reserves in a given LDC. One is the production pattern for the different food grains, and the degree of substitution of these different food grains in consumption patterns. In Korea, for example, the seasonal harvest patterns for rice and barley are counter-cyclic, barley being a winter crop and rice a summer crop. The coefficients of variation for each of the crops separately may be quite different from that for the two crops combined. Over the range which the two grains are substitutes in consumption, the coefficient of variation in production for the two crops combined should be used in sizing the food reserve. This is true even though, for reasons of cost or management factors, only one of the grains may be stored in the food reserve. The same sort of situation exists between rice and corn in the Philippines,

Indonesia, and Latin America countries and between wheat and rice in such countries as India and Pakistan. This same logic can be extended beyond the food grains to include such semi-perishable staple foods as cassava, coco-yams and potatoes. By converting the food value of these crops to grain equivalent and computing a multiple-crop coefficient of variation in production, the optimum level of food grain reserves can be computed to hedge against production shortfalls or gluts for the food crops combined.

e. Import Substitution

The other major factor to be considered when sizing reserve stocks in LDCs which have not reached self-sufficiency in food grain production is that of imports as a substitute for reserve stocks to stabilize against serious production short falls. To the extent that dependable continuous sources of grain imports are available to such countries at prices within their reach, the volume of imports can be varied up and down in the same way that grain reserves would be drawn upon or added to within the country. However, since 1974 when carryover grain stocks in the major exporting countries became virtually exhausted and several exporting countries temporarily halted exports (e.g., Thailand on rice,USA on soybeans), the LDCs are reluctant to rely too much upon adjustments in the volume of imports as substitutes for in-country reserves. Furthermore, leaders in the LDCs recognize the potential for saving crucial foreign exchange by building up reserves from imports during periods of ample world supply and low world prices rather than importing during times of tight world supplies and high world prices. These kinds of factors must be taken into account by importing LDCs in determining the optimum level of food grain reserves to meet the unique conditions in each country. The potentials for import substition for the Bangladesh example are examined in Part II.

2. Determining Sources of Grain for Building Reserve

The sources of grain used to build reserve stocks in the LDCs will affect both the benefits and the costs of LDC food grain reserve programs. Each LDC needs the flexibility to choose the mix of sources and types of grain for the reserves which best suits its needs. In some cases it will be most efficient to build stocks from imports under Public Law 480 or other concessional sales programs. In other cases it will be more efficient to build them from domestic production; in still others the best source may be commercial imports.

a. Storability of Grain

In some LDCs the quality of grain harvested domestically is not suitable for long-term storage. The costs of drying and conditioning such grain for storage and for added quality maintenance efforts while in storage, may offset all other factors and dictate that reserves be built up from imported grains.

b. Storage Costs

In other cases, domestic grains may be storable but at higher cost than imported grain. This case may result from the quality of the domestic grain, or it may relate to the type of grain. As an example of the latter, rice eating countries which import substantial quantities of wheat (e.g. Philippines, Korea, Indonesia) may find it more efficient to maintain the large portion of their grain reserve in the form of wheat rather than rice.

c. Market Position

The optimum source of grain for the reserves in some countries will be related to the market position of the needed reserves. If the major reserves are needed in the capital city or other major metropolitan areas,

and if the demand in such areas is served largely by imported grain, then the reserves will need to be built from imports. It would be uneconomic to ship domestic grain to these urban areas for the reserves and ship the imported grain to the outlying areas to replace the domestic supplies. On the other hand, if the major reserves are needed in the outlying areas, then they should be built up from domestic production, rather than shipping the imported grain out to these points.

d. Financing Cost

If the source and cost of financing the inventories in the grain reserve are tied to the source of grain, then the financing cost will be a major factor in determining the source of the grain. Inventory financing is the largest single cost item in the total cost of a grain reserve program. Using $100 per metric ton as the value of the grain in storage, a financing charge of 20 percent per year (typically paid by private industry in the LDCs) means an annual inventory financing charge of $20 per metric ton. However, if the same inventory in the reserve is financed under an international development loan at 3 percent, then the inventory financing charge is only $3. If for any reason low cost financing were available to the LDC, for concessional or other imported grain only, then the LDC could not afford to build its grain reserves from grains other than that source.

3. Selecting Storage Facilities for Reserve Stocks

There are a number of factors to be considered in determining the optimum storage facilities for grain reserves in the developing countries. The selection of facilities affects the benefits of the reserve by helping to determine the amount of grain that will be lost to shrinkage and

quality deterioration. The selection affects both the fixed and the variable operating costs of the storage reserves. The selection of facilities may affect the cost of financing the storage facilities.

a. Type of Facilities

The amount of grain lost to shrinkage and quality deterioration will be affected by the type, location and design of the storage facilities. Under some conditions such losses will be less for storage in bags than for storage in bulk, but in other cases the reverse will be true. Factors such as the level of security, temperature and humidity conditions, the level of technology and training in grain storage management, the size of the facilities and the degree of protection against rodents and other pests under the two methods of storage will determine the best method in a particular case. The type of construction material may affect the shrinkage and deterioration that will be incurred. In the case of bulk storage, flat structures versus vertical structures may have some effect. However, if the facilities are properly designed and properly operated to suit the construction material and flat or vertical storage under the local conditions in the country, these factors should have little impact on the shrinkage and deterioration incurred.

b. Location of Facilities

The location of facilities for long-term storage can affect materially the amount of shrinkage and deterioration. Hot humid locations, such as those often found at the ports in tropical climates, add to these losses. Locations a few kilometers inland at higher elevations may avoid such problems. Locations where security is difficult, where electricity or other power is not dependable, or where the risk of typhoon, earthquake or

flooding is great all should be avoided in order to minimize losses from shrinkage and deterioration. Furthermore, the location should be chosen to minimize total storage costs by making it convenient and economical to rotate the reserve stocks as new grain flows through the marketing system.

c. Design of Facilities

The design of specific storage facilities, regardless of the type, can materially affect the amount of shrinkage and quality deterioration that will be incurred in the reserve stocks under long-term storage. The roof and walls must be watertight to protect against rain and seepage of moisture. There should be good surface drainage from the structure to prevent intrusion of surface water. In most climates, built-in aeration equipment is a must for long-term storage. Automatic or manual temperature reading equipment is needed to detect "hot spots." The design should facilitate regular inspection of the grain and the safe use of fumigants as needed. The structure should restrict the entry of rodents, birds and other pests, and facilitate good housekeeping to eliminate possible harbors for stored grain insects. Convenient systems for handling the grain into and out of storage are less important for long-term storage than for storage used for fast-turning inventories, but the design should facilitate movement of pockets of hot or deteriorating grain before contamination spreads to the rest of the stored grain.

d. Facilities to Maximize Benefits from Reserves

If the design, location and type of storage structure for the grain reserves are carefully selected to fit the local conditions in each country, then the benefits of the reserves will not be reduced through excessive shrinkage and quality deterioration in the stored grain.

Normal shrinkage and some deterioration must be expected, even under the best of conditions for long-term storage. However, with proper facilities and management, shrinkage should not exceed 2 percent per year, and the pockets of fully deteriorated grain in a year of storage should not exceed 1 percent of the grain mass.

e. Facilities to Minimize Total Storage Costs

The selection of facilities will affect the fixed and variable operating costs for the storage of grain reserves. Facilities designed for handling and merchandising grain, such as the vertical type of terminal elevator or port elevator, normally are relatively expensive for long-term storage. They are designed for rapid turnover and convenience in blending and manipulating the grain, so that the costs of elevating the grain and moving it through the elevator with belt, chain or auger conveyors are not prohibitive per ton of grain handled so long as the annual turnover exceeds 10 or 15 times per year. However, the per ton costs for long-term storage are likely to be prohibitive in such facilities. Long-term storage at major grain elevators usually is maintained in large, flat structures or annexes which can be served by the main elevator, keeping down the fixed and variable costs per ton of the grain stored on a long-term basis. In other cases, the long-term storage is maintained in separate flat structures designed for that purpose.

f. Public Versus Private Storage

In countries where the grain marketing system operates on a bulk co-mingle basis as in the United States, it may be cheaper to have the reserves stored on a custom basis under warehouse receipt by private industry rather than to store it in government-owned facilities. Under

this system, the licensed warehouseman guarantees to deliver the quantity and quality of grain called for on the warehouse receipt, so that government incurs no shrinkage nor quality deterioration. The warehouseman can do this because he co-mingles the stored grain with his own, constantly replenishing the stored grain with fresh stocks. When called upon to deliver the warehoused grain, he delivers the quantity and quality called for, but not the same kernels of grain originally placed in storage. He usually makes money by blending on various grade factors, upgrading his merchandised grain without downgrading the warehoused grain; prevailing public grain warehousing charges usually reflect this opportunity by alert grain merchandisers and elevator managers.

g. Supporting Policies in LDCs

The capital cost for the facilities used to store the reserve stocks, and the financing charge on this capital cost, directly affect the total cost of storing the reserve. Aside from selection of the appropriate type, location and design of facilities for long-term storage so as to keep down the capital cost, appropriate government policies can be used to further reduce the costs. For example, the waiver of import duties and national and local taxes on the facilities will reduce both the capital cost and the annual fixed cost. Policies to waive such duties and taxes may be in the public interest in the LDCs, even though some of the storage facilities are privately owned. Savings in the total capital cost affect not only the annual depreciation cost, but also interest costs, insurance costs and other fixed costs, so that the impact on the total annual cost of maintaining the reserve will be significant.

Likewise, effective government policies to insure relatively full utilization of the storage capacity needed for the reserve will help minimize the total annual cost of carrying the reserve. If the facilities are fully utilized, the fixed costs normally account for at least one-half the total annual storage cost per ton. If the facilities are under-utilized, the fixed cost is spread over a small volume, and the total cost per ton of grain stored is increased sharply. For example, if total annual storage costs in a specific case were $20 per metric ton with full utilization of facilities, the total cost would jump to approximately $30 per metric ton if the facilities were only 50 percent utilized. This example is based on the assumption of $10/mt fixed cost and $10/mt variable cost. When the fixed cost is spread over only one-half the ton-months of storage, this fixed component of total storage cost becomes $20/mt. By the same token, if facilities were only 10 percent utilized, the fixed cost component would jump to $100 per ton, and the total cost to $110 per ton. The example illustrates the importance of public policies to insure effective utilization of storage facilities for the food grain reserve.

h. Financing of Facilities

The annual interest payments for the loans used to finance the storage facilities directly affect the annual fixed cost, and therefore the total annual cost of storing the food grain reserve. If development loans at relatively low interest rates are used to finance the facilities, this component of cost will be relatively low. If commercial credit at interest rates typical in the LDCs is used to finance the facilities, then this component of the cost will be relatively high. There is much to be gained by working out programs for using international development

loan funds to finance needed storage facilities for the grain reserve in LDCs, even though a part or all of such facilities may be owned by private industry in the LDC.

4. Selecting Levels of Technology and Human Skill

The levels of technology and human skill applied to the storage of grain reserves affect the amount of shrinkage and deterioration in the stored grain and the magnitude of benefit which can be expected. Likewise, the levels of technology and human skill affect the total cost of maintaining the reserve. Trade-offs between the benefits and costs must be considered in selecting the appropriate levels of technology and human skill for each specific LDC. Highly advanced technology and human skill in long-term grain storage (such as that used by Japan in the 1960's to store brown rice under the sea for several years), would be economically unsound in most LDCs. The costs for such technology, and for importation of the human skill (or for massive training programs in foreign countries to develop it), usually would far exceed the benefits through reduced quality deterioration and shrinkage. At today's cost for energy, technology involving refrigeration and controlled environment, irradiation, etc. cannot be justified for grain storage in LDCs. Even automated temperature and humidity detection devices and similar technology are impractical under conditions in many LDCs.

On the other hand, the levels of technology and human skill in grain storage prevailing for short-term storage in most LDCs are not adequate for efficient long-term storage. Even if prevailing levels are optimum for two or three months' storage, they are likely to result in excessive losses from quality deterioration and shrinkage if applied to long-term storage for food grain reserves. The need is to discover the appropriate intermediate levels of technology and human skill for specific conditions

in each LDC. In most cases, the LDCs need guidance and assistance from donor agencies in discovering the optimum levels and for acquiring these optimum levels of technology and human skill for long-term grain storage.

5. Developing Management Policies and Guidelines

Packages of effective storage management policies and practices must be developed in each LDC if internal grain reserve programs are to be feasible. The food reserve policies must be interfaced with producer incentive policies, price support policies, consumer price control policies, foreign trade policies, economic development policies and other policies related to activities impacted by the food reserve program. Operating guidelines for the food reserve program must be interfaced with the operating guidelines for internal programs related to grain production, processing, marketing, distribution and utilization for consumption.

a. LDC Food Reserve Policies

Management policies need to cover the overall LDC food reserve program as well as storage policies for the reserve. Needed food reserve policies include:

1. Specific purposes to be served by the reserve
2. Size and development of the reserve by type of grain.
3. Conditions under which the reserve is added to, maintained and drawn upon.
4. Type, location, capacity and ownership of storage facilities to be used.

b. Storage Management Policies

Storage management policies for the LDC food grain reserve need to cover a range of specific subjects, including:

1. Organizational infrastructure for effective supervision and management of the program.

2. Commitment to a management information system to provide the quantitative information for effective managerial control.
3. Methods of acquiring, paying for and financing acquisition of stocks.
4. Methods of distributing and collecting grain reserves.
5. Methods of operation and control of the reserve.
6. Methods of protecting the stored grain from losses due to storms and flooding, theft, insects and molds, rodents, birds and other hazards.

c. Guidelines for Storage Management

Likewise, operational guidelines and storage management handbooks must be developed for conditions in each LDC to insure execution of the storage management policies for the food reserve. Subjects normally covered in the guidelines and handbooks include the following:

1. Overall operating procedures for the acquisition, deployment, maintenance and disbursement of reserve stocks.
2. Handbooks for national grain inspectors to use in the supervision of grain warehousemen and the stored grain reserves.
3. Handbooks for inspectors and grain warehousemen covering the standards of quality for safe long-term storage, and the procedures used to measure the quality of the incoming grain as per these standards.
4. Handbooks covering the logistics of acquiring, deploying, maintaining and dispersing the grain reserves, including the documents, authorizations, procedures and responsibilities for each of these functions.

5. If a grain warehouse receipt is used, the full documentation and handbooks for the operation of the warehouse receipt system and the supervision of public grain warehousemen.
6. Technical handbooks covering warehouse loading, sanitation, fumigation and other technical aspects of grain warehousing and storage under the level of technology and human skill adopted for the country.
7. Guidelines detailing the operation of pre-service, in-service and refresher training programs to be used for developing and maintaining the necessary human skills for the operation of the reserve program.
8. Handbooks covering the management information system (MIS) to be used for the overall control of the reserve program.

These guidelines and handbooks need to be continually reviewed, revised and up-dated as the LDC reserve program moves forward. Obsolute and out-dated guidelines may be more damaging than inadequate guidelines in the first place, because they may convey erroneous information as well as lead to unnecessary confusion and uncertainty in the operation of the food grain reserve program.

6. Establishing Stock Acquisition and Release Policies

Clear pre-determined and well-understood policies governing the acquisition and release of LDC reserve stocks are essential if the full benefits of the reserve program are to be achieved. As discussed above, both grain producers and food consumers in the country must understand and have confidence in such policies if the desired effects of reduced uncertainty in supplies and prices are to be achieved. The food reserve program is likely to be self-defeating if sound acquisition and release policies are not followed rigorously.

a. Alternatives

The basic alternatives on which to base acquisition and release policies are (1) market price triggers, (2) available supply triggers, or (3) some combination of these two. Under the option of market price triggers, stocks are withdrawn from the market and added to the reserve stocks whenever market prices fall to pre-determined minimum levels; stocks are released from the reserve and added to available market supplies whenever market prices reach pre-determined price ceilings. The stock reserve is rigged directly to market prices and used to temper extreme price movements at both ends of the scale.

Under the option of available quantities of grain in the market place as the trigger, supplies are withdrawn from the market and added to the reserve whenever total available market supplies reach pre-determined maximum levels and withdrawn from the reserve when market supplies reach pre-determined minimums. The stock reserve is rigged directly to available supplies and used to level the extreme peaks and valleys in the available supplies from year to year. This option is used in the Bangladesh case example in Part II.

The two types of triggers work in much the same fashion, because quantities and prices are directly connected through the demand function for the grain in the LDC. Students and authors on the subject are not agreed as to which type of trigger is most effective. Each LDC needs to work out the best plan for conditions in that country.

b. The Case for Price Triggers

Countries which have active markets and price indicators for the food grains, and which do not rigorously enforce price floors and price ceilings by other means, may find price triggers advantageous. Prices, anticipated prices and the uncertainties growing from price expectations

affect the allocation of resources by producers and consumers. Producers, who have confidence that prices of major food grains will be held within pre-determined ranges, are able to adopt profitable new production technology more quickly. Consumers, who have confidence that market prices of major staple foods will be held within pre-determined ranges, are able to allocate household income more rationally. Under these conditions, both producers and consumers are likely to react more favorably to a food reserve geared to price triggers than to one geared to quantity triggers.

c. The Case for Quantity Triggers

However, if domestic prices for the food grains in a LDC are effectively controlled by other means and bear little relationship to world market prices, then price triggers for the food reserve are relatively meaningless. Quantity triggers are more suitable in such cases. The quantity triggers usually need to be stated in terms of number of days supply for national consumption rather than in terms of definite quantities, such as metric tons. In years of above average production when current stocks exceed the maximum number of days of consumption, purchases for the reserve are signalled. In years of production shortfalls when current stocks drop below the minimum number of days of consumption, sales from the food reserve are signalled. If these things are done and production-market-consumption intelligence is adequate for the country, then quantity triggers can be quite effective in some LDCs.

One objection of the price trigger option is that it may not be adequate to flag needs for releases from the reserve in times of localized emergency. If so, quantity triggers can be used to supplement the price trigger option used as the basic mechanism for signalling acquisitions to and releases from the food grain reserve in a country.

d. Seasonal Timing of Triggers

Both price triggers and quantity triggers are affected by seasonal harvest patterns unique to each country. Prices will be lowest (or downward price pressures greatest) and available market supplies largest following the time of peak harvest. This ordinarily will be the period of major acquisitions to reserve stocks under either mechanism used to trigger the acquisitions. In contrast, prices will be highest (or upward price pressures greatest) and market supplies the smallest at the end of the crop season just prior to the next harvest. This latter period ordinarily will be the period of major release from reserve stocks, no matter which mechanism is used to trigger the release.

7. Maintaining Consistency in Reserve Stock Programs

It is all too easy to erode the benefits and magnify the costs of food reserve programs in the LDCs through the lack of consistency in the operation of such programs. Yet strong political, economic and social pressures will develop in every LDC to manipulate established food reserve programs to serve goals other than those for which food reserves are suited. Producers faced with excess production and high input costs may demand that the pre-determined size of the reserve be doubled in order to make it function as a surplus disposal program. Importers and consumers faced with unanticipated rises in world market prices may demand that reserves be used to relieve market pressures even though the pre-determined triggers have not been met. Market agencies may demand that releases be made in order to increase the volumes of flow into the market and maintain effective utilization of the facilities, even when the pre-determined trigger indicates no such need. Once those responsible for the management of the food reserve

start yielding to pressures of this sort, the consistency of result from the program is lost. Soon after, producers and consumers lose confidence in the reserve program as a means of tempering the effects of real shortages or gluts on the market, and the value of the reserve program is partially destroyed.

If planners in the LDCs and in the donor agencies appreciate the need for consistency in food reserve programs and the kinds of pressures which will develop to cause loss of consistency in the operation of the programs, steps can be taken at the planning stage for the food reserve to build protection against such problems. Certain consistencies in the basic policies and operating guidelines can be made pre-conditions for the joint participation by the host country and the donor agency. In the case of AID, consistencies in the supply of PL 480 grains might also be built in as pre-condition to the joint participation by AID and the host government in a given LDC.

AID Program Recommendations to Support LDC Reserves

The U.S. Agency for International Development has a unique opportunity to help the developing countries of the world build sound food grain reserve programs. Food For Peace programs under Public Law 480 can be combined with AID technical and capital assistance programs to assist these countries to acquire the needed grain stocks as well as the human skills and financing required for successful food grain reserve programs. Other donor agencies can help support such programs but are not in a position to provide directly the stocks of grain needed to build reserves in the LDCs.

The United States needs to take the leadership in developing sound policies and programs to achieve food grain reserves in the developing countries. Most of these countries are recipients of grain and other foods under PL 480 programs. Most of them are engaged in major activities designed to increase domestic food production with support from AID and other donor agencies. Many are recipients of capital assistance to help develop improved grain storage facilities. In part, the United States' leadership is being exercised through active support of international agencies such as the World Food Council, but the programs of such agencies involve complex issues and take time to develop. The need for the USA to spearhead the development can be accomplished best through presently authorized programs of the U.S. Agency for International Development. It is upon this basic premise that the following AID program recommendations to support LDC grain reserves are offered.

1. Broadening U.S. PL 480 Policy from Immediate Consumption Needs to Long-Term Supply Requirements

Historically, administration of PL 480 programs has focused on immediate consumption needs in the developing countries. This still persists under present Food For Peace programs with current Title III instructions to AID Missions from AID/Washington. The adherence to this policy in the administration of PL 480 programs has resulted in long-term world grain supplies being maintained in the United States at U.S. taxpayers' expense. If this policy is not modified, it appears that the large U.S. reserves of wheat, rice, corn and other grains characteristic of the 1950's and 1960's could be repeated in the late 1970's and 1980's. Large surplus stocks in the U.S. and Canada would make any joint efforts in world marketing by the two countries relatively ineffective.

a. Changes to Meet Needs in LDCs

From the viewpoint of the LDCs, the present PL 480 policy provides little incentive or help to them in building LDC food grain reserves. The leadership in most of these countries recognizes the need to have their own food grain reserves under the exclusive management of the LDC. However, under existing PL 480 policy, the creation of such reserves may jeopardize the country's chances for PL 480 shipments in the future. Certainly under PL 480 administrative policy, the LDC cannot count on priority claim to PL 480 supplies for replenishing reserve stocks after they have been drawn down to meet a future urgent need in the country. Unless it has such a commitment, the LDC depending on PL 480 shipments to meet critical consumption needs from time to time, has little incentive to build a sound food reserve program which depends in part upon priority commitment for future PL 480 shipments to replenish depleted reserve stocks.

b. Changes to Meet Needs in the United States

The need of the LDCs is identical to that of the U.S. taxpayer, producer and consumer - a broadening of U.S. PL 480 administrative policy from focus on immediate consumption needs to focus on long-term supply requirements in the LDCs. Such a change in focus would recognize the building of sound LDC food reserves as an important use for current PL 480 shipments, whether the shipments are used to place into the storage reserve of the LDC or to supply current consumption as a substitute for domestic production placed into the storage reserve. Furthermore, a shift to focus on long-term supply requirements would assign priority for future PL 480 shipments to replacement of food grain reserves which are drawn

down to meet legitimate needs in the LDC. This priority would need to go beyond assured first claim on available PL 480 supplies as unilaterally determined by the United States. The LDCs would need assurance that AID could back commitments to rebuild agreed levels of reserve stock in the LDC, even though the grain in question is not considered to be in surplus supply in the USA at that time. The United States would need to commit to Food For Peace officials in AID a minimum supply of food grain for LDC reserve stock replenishment regardless of current supply-demand balances in the USA.

This sort of shift in administrative policy to PL 480 shipments with focus on long-term supply requirements can add to year-to-year production and price stability in the USA as well as in the recipient LDCs. Supplies from U.S. production, which are committed to LDC food reserve replenishment, represent a predictable long-term demand to the U.S. grain producer and can be expected to influence U.S. market prices accordingly. Together with long-term projections of commercial demand for the grain in domestic markets and international markets, the long-term supplies committed to LDC reserve replenishment will give producers a basis for intelligent planting decisions. To the extent that this is accomplished, drastic year-to-year fluctuations in U.S. production and prices will be dampened.

c. The Need for Accurate Projections

The commitment of PL 480 administrative policy to long-term supply requirements will require accurate projections of production and consumption trends in the participating LDCs as well as assurance that the LDC food grain reserves will be administered soundly. These requirements are identical to those of the LDC if it is to be able to design and plan an effective food reserve program. The requirements can best be met by coordinating

AID technical assistance in the participating LDCs with PL 480 programs to insure accurate projections and effective planning for the level of food reserves needed in each participating LDC.

2. Coordinating PL 480 Commodity Assistance with Capital and Technical Assistance

The set of interrelated factors affecting the magnitude of both benefits and costs for food reserves in the developing countries (see pages 11-29) places emphasis on the need for combining commodity assistance with capital and technical assistance in this field. Few developing countries have had significant experience with long-term grain storage and many are lacking in adequate facilities for this purpose. Commodity assistance based upon long-term supply requirements is not likely to be effective unless combined with substantial inputs of capital and technical assistance to help the LDCs plan and develop sound, long-term grain storage programs. Theprovisions of Title III represent a start toward combining the three types of assistance into a coordinated total program, but expanded efforts in this direction will be needed to support development of sound LDC food reserve program.

The needs of most LDCs for assistance in building sound food reserve programs encompass the three components -- commodity assistance, technical assistance and capital assistance -- in a unified total program directed toward a single set of goals and targets. The needed redirection of the commodity assistance is outlined in the section above. The needed technical assistance requires a food systems-wide approach, incorporating food policy, production incentives, effective marketing and distribution and consumption utilization by the masses. The technical assistance

should provide help in selecting and putting into place appropriate technology for local conditions in the LDC; it should provide help in developing and applying the needed human skills for efficient management and operation of the country's food reserve program. The capital assistance should provide the financing for the appropriate grain storage facilities as well as the grain inventories in the LDC food reserve program. If the three types of assistance can be combined into an effective unified program, then the food reserve program will have the necessary support for reaching targeted goals, and investment in commodity assistance, in technical assistance and in capital assistance will be productive and rewarding. If any of the three elements in the total assistance program to the LDC is inadequate, then progress toward overall goals is likely to be restricted, and returns to the other forms of assistance are likely to be disappointing.

3. Developing Guidelines for Assisting LDCs Build Viable Reserve Programs

If effective overall support is to be given to recipient countries in building sound LDC food reserve programs, AID has the responsibility (and the opportunity) to develop and apply guidelines to help insure that the reserve programs will be successful. As pointed out under "Factors Affecting Benefits and Costs of Reserves in the LDCs", conditions vary from country to country so that standardized formulas for sizing reserves, identifying conditions for adding to and drawing on reserves, and management of the reserves are infeasible if not impossible. Nonetheless, uniform guidelines can be developed for application to specific conditions in each country. These guidelines can be used to help the LDCs make sound decisions regarding food reserve programs under the conditions unique to each country. They can be applied through effective

technical assistance and enforced through covenants and conditions for receiving the capital and commodity assistance portions of the total assistance program.

a. Reducing the Guidelines to Manuals

In order to be as effective as possible, the AID guidelines to recipient countries should cover all of the major factors affecting benefits and costs of food reserve programs outlined above (pages 11-29). Ideally, they should be reduced to manuals comparable to those covering technical and economic feasibility analyses for major capital assistance projects. Manuals of this kind could be developed in a relatively short period of time by a task force of experts representing the various disciplines involved.

b. Purposes of the Guidelines

The major purposes of guidelines for assisting LDCs build viable food reserves, and of the manuals to present such guidelines, include the following:

1. Present an unqualified statement of commitment by the United States through AID to support LDCs in building sound internal food grain reserve programs.
2. Provide the LDCs with the benefit of technical knowledge gained around the world regarding long-term grain storage.
3. Help the LDCs avoid making costly mistakes in sizing reserves, setting acquisition and withdrawal policies, selecting appropriate facilities and technology, determining storage management policies, and establishing appropriate interfacing with domestic price support and price control programs.

4. Provide uniform standards to help insure equitable allocation of commodity, capital and technical resources among worthy developing nations of the world.
5. Make explicit the criteria to be applied in evaluating alternative proposals for assistance in building LDC food grain reserves.

4. Applying Uniform Standards for Judging Effectiveness of Food Reserve Programs

In addition to guidelines and manuals for helping LDCs plan effective food reserve programs, AID needs to develop uniform standards for judging the effectiveness of food reserves under varying conditions from one LDC to another. Without such standards, the tendency is to over-rely on individual factors (deterioration in storage, deployment of withdrawals, facility construction costs, etc.) out of context particularly when such factors represent isolated extremes. Publics, in both the recipient country and in the USA, have a vested interest in the management of food reserves and tend to over-react to reports of extremes on individual factors. In some cases, public pressure may build to the point that officials in the LDC as well as U.S. AID officials may be forced to take unwise action. This can be avoided if uniform standards for judging the effectiveness of food reserves are developed in advance, so that evaluation can be made in the context of overall goals to be served by the food reserve program.

The standards of evaluation should parallel the guidelines for assisting LDCs plan and implement sound food reserve programs. They should reflect the various factors affecting benefits and costs of reserve programs in individual LDCs, with flexibility for tailoring to specific conditions in each LDC. They should be oriented to long-term supplies for tempering extreme year-to-year fluctuations in grain production and

prices. The focus should be on the complete evaluation system and the relationships among the various key indicators used in the system not upon the individual indicators as such. Such a system will permit meaningful evaluation of the food grain reserve program in each country and minimize the impact of widespread publicity regarding performance on some individual indicators in the evaluation system.

5. Relating Proposed Programs to Possible Future International System of Food Grain Reserves

The recommended AID program to assist LDCs develop needed in-country food grain reserves can help pave the way for general acceptance of internationally owned and controlled food grain reserves. Developing countries which have been assisted to develop their own solely-controlled reserves are likely to accept international reserves as a means of back stopping the LDC reserves. International reserves which can be drawn upon to replenish LDC reserves following extreme draw downs will reduce the size of the LDC reserve which each country must carry. The two types of reserves complement one another in that the LDC reserves represent the first line of defense against a future food crisis while the international reserves represent a second line of defense in case of a major food crisis. The LDC reserves reduce the frequency with which the international reserves need to be drawn upon, and therefore, reduce the total costs of operating the international reserve. The existence of the LDC reserves reduces the needed size of international reserves and vice versa.

The recommended AID program to assist LDCs acquire their own reserves also should pave the way for acceptance of international reserves by the United States and other major food exporting nations of the world. The fact that the needed size of international reserves is reduced makes them more acceptable to U.S. producer groups. The fact that they need to be drawn upon much less frequently makes them more acceptable to producers, consumers and trade interests alike. Also the fact that the LDCs are willing to assume the responsibilities and costs of the LDC reserves makes U.S. interests more sympathetic to their cause regarding international reserves.

In summary, successful food reserve programs in the LDCs can pave the way for the development of international reserves to backstop the LDC reserves. Once the two types of reserves are in successful operation, they will act to complement one another to make the total food reserve program more efficient than otherwise would be the case. This is demonstrated for the Bangladesh example in Part II.

6. Relating Proposed Program to Domestic U.S. Agricultural Policies for Food Production and Distribution

The proposed program has major consequences regarding domestic U.S. agricultural production and distribution. The shift of PL 480 programs to the concept of long-term supply requirements in the participating LDCs moves these programs out of the realm of surplus disposal activities and into the realm of genuine food assistance programs. As such, the commodity contributions to the LDC food reserve becomes a part of the predictable demand for U.S. food grains. The stabilizing effects of the LDC reserves on world prices will dampen the "feast or famine" situation in world markets facing U.S. producers and consumers of wheat, rice and other food grains.

As the proposed program moves into operation, the United States, Canada and other major exporting countries no longer will have to shoulder the entire burden of carrying food reserves sufficient to feed the hungry world in times of serious future production short falls. The reserves maintained in the U.S. can be held to reasonable levels and need not function as a "drug on the market" to forever hold U.S. producer prices to submarginal levels.

This major shift in emphasis for PL 480 programs, and the resulting consequences upon U.S. citizens, needs to be reflected in domestic policies for food production and distribution. A new concept of supply planning for U.S. food grains is involved. It includes the identification and projection of total markets for these grains and then planning production and marketing to serve these markets efficiently. The total markets that can be identified include domestic markets, commercial export markets, bilateral sales and trades, and the requirements for contributions to the LDC reserve stocks (and eventually for those to international reserves). Unusually large sales to Russia or to China in years of major production short falls in those countries should be made from separate reserve stocks maintained in the U.S.A. (assuming these countries are unwilling to maintain their own in-country reserves against such contingencies). Such sales should not be made at the expense of the predictable market demands listed above. The United States needs to be able to make a commitment to support reserve stocks in the LDCs and to establish domestic food grain policies so that this commitment can be kept. If these things are done, benefits will occur to producers, consumers, trade interests and taxpayers in the United States as well as to these same groups in the LDCs.

PART II

GUIDELINES FOR ASSESSING FEASIBILITY OF FOOD GRAIN RESERVES

THE BANGLADESH EXAMPLE

Introduction

Each LDC is unique in its need for reserve stocks and in the best means of providing food reserves. Great differences exist from country-to-country in annual variation in supply, degree of dependence on cereal grains as a food source, cereal production conditions, storage environment for cereals and ability to develop reserve stocks from domestic sources. Thorough investigation of conditions bearing on reserve stock policy is necessary in each country to determine appropriate policy.

Part II illustrates how guidelines might be applied to determine the level of LDC reserve stocks, together with acquisition and disposal policies under Bangladesh conditions. The example shows when acquisitions and releases of grain from reserve stocks would occur had a reserve policy been in operation for the past 17 years. Costs and benefits of a reserve stock program of the size generated from historical supply and demand conditions are illustrated under three alternatives:

1. LDC reserve only.
2. LDC reserve supported by import adjustments.
3. LDC reserve supported by international reserve.

The example is meant to be illustrative only. Conclusions and recommendations for food grain reserves in Bangladesh must wait until empirical studies can be made to measure specific benefits and costs of a reserve program.

Country Conditions

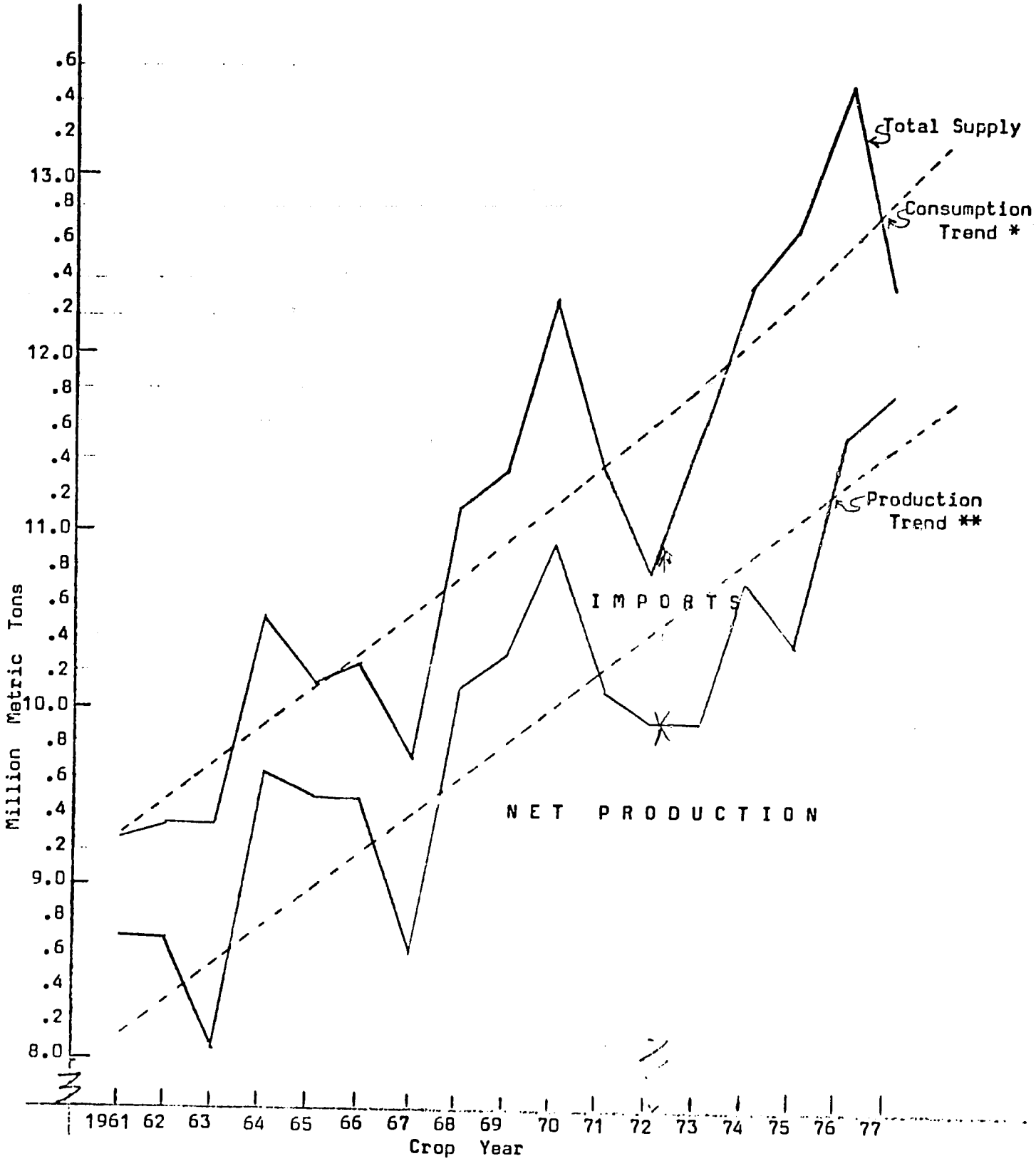
Bangladesh is an LDC in which food intake is very dominantly cereals; food production is largely rice but includes smaller quantities of wheat; domestic production fails to meet minimum nutrition requirements even in years of highest production; and food in fairly large quantities is distributed to the poor, to the military and to public employees. The country is a regular importer of food grains, through donor programs and through purchase in the international market. Food grain prices vary sharply depending upon current supply conditions. Seasonal price movements are pronounced in spite of multiple harvests. Year-to-year price variations tend to be severe as well as unpredictable.

Per capita cereal grain consumption in Bangladesh is about 15.5 ounces per day and has not changed significantly over the past decade. Population is estimated to be increasing at an annual rate of 2 percent per year. Famine conditions have occurred with relative frequency in the past. The National Government places high priority on food security for purposes of (1) avoiding human misery and political unrest growing out of food shortages, (2) reducing the instability in domestic prices to avoid the adverse effects on consumers of high food prices as well as the adverse effects on producers of low grain prices, and (3) reducing unpredictable drains on foreign exchange arising from large annual variation in cereal grain import needs.

Grain Supply/Requirement Balances

The Bangladesh food security problem is pictured graphically in Figure 1. Domestic production of food grains has increased significantly over the past 17 years, from less than 9 million metric tons in 1961-62 to about 11.5 million metric tons in 1976-77. Still the country's food requirement continues to outrun production, exceeding it by a substantial margin every year

FIG. 1. BANGLADESH FOOD GRAIN SUPPLY/REQUIREMENT BALANCE, 1961-1977



Source: Table 1

* Based on per capita consumption of 15.5 oz/day

** Net of seed requirements and on-farm losses

over the 17-year period pictured by the chart. Food grain imports must be used to make up the balance to bring total supply up to total food requirement. This has been accomplished pretty well over the last 17 years, as the chart shows, total food grain supply has averaged very closely to the food requirement trend line. The trouble is that even when imports are taken into account there hasn't been a single "average" year when total supply is in balance with the food requirement. The supply is either above or below the requirement, often by a substantial margin. The citizens and leaders of Bangladesh have reason to be concerned about the year-to-year inbalance in food grain supplies and about the highly unstable prices which have resulted.

Reference to Figure 1 raises the obvious question of why hasn't Bangladesh adjusted food grain imports from year-to-year to offset variations in net production. The reason is that variations in production cannot be predicted in advance. The country must depend upon imports every year to avoid mass starvation and must arrange for the imports long before total domestic production for the year is known. World grain prices have been volatile and in some years, additional imports would have been virtually impossible as will be noted from Figure 1. Historical variations in imports have had a stabilizing influence on total supplies in most years, 1972 and 1976 being the major exceptions. However, the variations in imports have not been sufficient to bring the needed stability in total food grain supplies, so that serious surpluses and shortfalls have persisted in an unpredictable manner.

Remember too, that the chart views the problem after the fact. The poor consumers and grain producers in the country have to face the problem of not knowing what will happen next. They are presently at the 1978 point trying to guess what may happen in 1979 and 1980. Will food supply fall short of requirements, and prices go out of sight, or perhaps worse, bring mass starvation? Will food supply temporarily outrun requirements causing depressed prices and perhaps bankruptcy to the country's small farmers? A LDC food grain reserve could help alleviate many of these problems and the stresses they cause.

Figure 1 illustrates the potential for a food grain reserve in Bangladesh. Reserves could have been built up in years of over supply such as in 1964, 1969, 1970, 1974, 1975 and 1976. They could have been drawn upon in years of deficit such as in 1967, 1972, 1973 and 1977. At least viewed after the fact, grain reserves could have had a significant dampening effect upon the year-to-year imbalances in food supplies and requirements which have occurred over the past 17 years.

The historical conditions of food grain supplies and requirements are shown more precisely in Table 1. Many donor agencies and research organizations have been interested in Bangladesh, and substantial research efforts have been devoted to the development of the data shown in the table. The authors believe that they are reasonably reliable - perhaps more reliable than could be assembled for many of the LDCs around the world. The production statistics for rice and wheat were provided by The Foreign Demand and Competition Division, Economic Research Service, U.S. Department of Agriculture. Net production available for food is taken at 90 percent of total production to allow for seed usage and losses. This is believed to be reasonable for conditions in Bangladesh. The import statistics include

TABLE 1. SUMMARY OF FOOD GRAIN SUPPLY/REQUIREMENT BALANCE

FOR BANGLADESH, 1960-61 to 1976-77

(1000 Metric Tons)

	Production			Available Supply				
Year	Rice 1/ (1)	Wheat 1/ (2)	Total (3)	Net Production (4)	Imports 1/ (5)	Total Supply (6)	Food Requirement 3/ (7)	Deviation (8)
1960-61	9672	29	9701	8731	590	9321	9337	- 16
1961-62	9618	33	9651	8686	690	9376	9530	-154
1962-63	8870	40	8910	8019	1330	9349	9722	-373
1963-64	10624	45	10669	9602	930	10532	9915	+617
1964-65	10503	35	10538	9484	630	10114	10108	+ 6
1965-66	10501	35	10536	9482	790	10272	10317	- 45
1966-67	9575	36	9611	8650	890	9540	10526	-986
1967-68	11175	59	11230	10107	1010	11117	10735	+382
1968-69	11344	59	11403	10263	1070	11333	10959	+374
1969-70	12005	93	12098	10888	1355 2/	12243	11168	+1075
1970-71	11144	105	11249	10124	1259	11383	11410	- 27
1971-72	9912	112	10024	9022	1752	10774	11635	-861
1972-73	9930	90	10020	9018	2567	11585	11860	-275
1973-74	11721	109	11830	10647	1691	12338	12100	+238
1974-75	11359	115	11474	10327	2324	12651	12358	+293
1975-76	12525	215	12740	11466	2046	13512	12599	+913
1976-77	12700	273	12973	11676	678	12354	12856	-502

Sources: 1/ Production data (columns 1 and 2) and import data (column 5) were provided by Foreign Demand and Competition Division, Economic Research Service, U.S. Department of Agriculture.

2/ High imports in 1969-70 immediately preceding the war were adjusted by the authors downward to the average of calendar year imports in 1969 and 1970 as reported in Trade Yearbook, Vol. 28, (1974) FAO, Rome.

3/ Cereal requirement based on population growth from 58.1 million in 1960 to 80 million in 1976 and per capita consumption of 15.5 ounces per day.

transfers from West Pakistan to East Pakistan prior to Bangladesh independence. Import data were provided also by the Foreign Demand and Competition Division, Economic Research Service, U.S. Department of Agriculture. The total food grain requirement is obtained by applying the constant daily intake of 15.5 ounces per capita to the total population, using an annual population growth rate of 2 percent. These rates may not be precise for projecting into the future, but they describe conditions over the past 17 years quite accurately. The deviations shown in Column 8 of Table 1 are obtained by subtracting the total available supply from the corresponding food grain requirements of 15.5 ounces per capita per day.

Determining Reserve Levels To Meet Food Security Objectives

Criteria, in addition to the figures shown in Table 1, are needed to determine the optimum level of grain reserves to meet food security objectives for Bangladesh. A very substantial reserve would have been required to fully stabilize total supply to the food requirement trend line (Figure 1 and Table 1). For example, if one starts in 1967-68 with the assumption that beginning inventories have been drawn down to zero, the reserve still would have reached 1,831,000 metric tons by the end of 1969-1970 (382,000 + 374,000 + 1,075,000). A LDC reserve of 2,112,000 metric tons would have been required to stabilize supplies to the food requirement over the entire 17-year period shown in Table 1. Usually, complete stability is not a feasible goal because of the size of the reserve required to reach it. The costs of such a reserve program would be very high, and the benefits probably would not be enough to make the reserve feasible. Normally, food

reserves give diminishing marginal benefits. A small reserve that tempers the extreme highs and lows in food grain supplies and prices brings great benefits. Beyond this, additional reserve stocks bring additional benefits but not in the same ratio as is true for the first small reserve. The larger the reserve becomes, the smaller the incremental benefit forthcoming.

In contrast, storage costs increase almost in direct proportion to the size of the reserve to be maintained. There can be certain economies of scale in grain storage operations, but in the usual range for LDC reserve programs, storage costs can be viewed as a direct function of the size of the reserve and the storage capacity required to carry it.

Measuring the Benefits from Improved Stability

How much instability in food grain supplies and prices can be tolerated in Bangladesh? How serious are the negative impacts from extreme variations, and how great are the benefits to be derived by removing the extremes? These are empirical questions which need to be answered by economic impact studies in Bangladesh. We know that benefits to masses of consumers by controlling severe shortages such as those in 1967 and 1972 (Figure 1) are relatively great. We know that benefits to the developing agricultural sector from controlling burdensome and price-depressing surpluses such as those in 1970 and 1976 are relatively great. However, to the knowledge of the authors, neither type benefit has been measured for Bangladesh.

Let us suppose for the sake of illustration that the benefits can be measured by measuring the adverse affects of extreme variations in food grain prices. Let us suppose further that economic impact studies have shown that

wide year-to-year fluctuations in grain supplies and in annual average grain prices are severely damaging to the agricultural sector, to consuming households and to the rate of economic development for the country as a whole.[1/] This means that the benefits from food reserves to temper price fluctuations within this range are great, and that they are shared generally across the producing, consuming and distributive sectors of the country. Let us suppose also that the country's producer price support and consumer price control programs are effective in supporting low income segments of the population under conditions leading to market prices within ± 15 percent of normal, but are ineffective and cost prohibitive under conditions leading to market prices outside this range.

Under these assumptions, the aggregate annual impacts of extremes in annual average food grain prices in Bangladesh might be of the nature and order of magnitude illustrated in Table 2. The impacts shown in the table are based on current consumption levels of about 13.325 million metric tons of food grains, so that each 5 percent change in annual average real prices around the $150 per mt. base means about $100 million change in value of cereal grain consumed annually {($150 x 13.325 million) x .05 = $100 million}. If it were not for the adverse effects of extreme variations in food supplies and prices, the price changes would cause transfer payments in the Bangladesh economy only. If this were the case, the figures in Column 3 of Table 2 would be identical to those in Column 5, and those in Column 6 would be zero. However, under the situation represented by Table 2, the schedule of adverse impacts in Column 2 reflects additional adverse effects upon consuming families (especially those of low incomes) as real food prices rise above

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[1/] Grain prices and price variations in this context are understood to be in real terms, after adjustments for inflation through time.

TABLE 2. ASSUMED IMPACTS OF EXTREME VARIATIONS IN ANNUAL AVERAGE FOOD GRAIN PRICES IN BANGLADESH ($1 MILLION).

Direction and Extent of Price Variation	Costs through Adverse Impacts		Benefits through Associated Favorable Impacts		Net Costs after Transfer Payments (3-5)
	Prime Incidence	Amount[1]	Prime Incidence	Amount[2]	Amount
(1)	(2)	(3)	(4)	(5)	(6)
+ 5%	Consumers & taxpayers	115	Producers	100	15
+10%	Consumers & taxpayers	220	Producers	200	20
+15%	Consumers & taxpayers	325	Producers	300	25
+20%	Consuming families	500	Producers	400	100
+25%	Consuming families	700	Resource owners	500	200
+30%	Consuming families	900	Resource owners	600	300
+40%	Consuming families	1300	Resource owners	800	500
+50%	Consuming families	1700	Resource owners	1000	700
+65%	Consuming families	2300	Resource owners	1300	1000
-65%	Farm families	2100	Consumers	1300	800
-50%	Farm families	1500	Consumers	1000	500
-40%	Farm families	1100	Consumers	800	300
-30%	Farm families	800	Consumers	600	200
-25%	Farm families	600	Consumers	500	100
-20%	Farm families	475	Consumers	400	75
-15%	Farmers & taxpayers	325	Consumers	300	25
-10%	Farmers & taxpayers	220	Consumers	200	20
- 5%	Farmers & taxpayers	115	Consumers	100	15

[1] Transfer payments as indicated in footnote (b) plus additional costs to the Bangladesh economy. Additional costs up to ±15% variation taken as the net costs of operating the domestic price support and price central program. Additional costs greater than ±15% variation derived from extreme hardships to low income consumers (plus deviations) and extreme hardships to small farmers (minus deviations). See Part I.

[2] 13.325 million m.t. x $150/mt = about $2 billion; $2 billion x percent shown in Column 1 equal figures in Column 5.

their ability to pay; similar additional adverse effects upon farm families are reflected as crop prices fall below levels needed to cover production costs. This phenomena gives rise to the net costs after transfer payments shown in Column 6 of Table 2.

The list of those bearing the prime incidence of the costs and benefits shown in Columns 2 and 4 indicates the groups impacted most severely. Thus, a rise of 50 percent in food prices will impact consuming families directly and severely. Such an extreme deviation may also have adverse affects on small producers (by causing uneconomic resource allocations), on the market system and on the general public through inflation, but the prime incidence is expected to fall upon consumers. The favorable impacts of such a deviation are expected to accrue primarily to agriculture resource owners rather than to active farm producers because the high annual average prices will be capitalized into resource costs.

The schedule of net adverse impacts reflects the assumption that price support and control policies can be made effective in protecting low income consumers and small low-income producers within the ±15 percent range without a food reserve program but not beyond this range. Thus, to read the net benefit of a reserve program which reduces the price extreme in a particular year from +30 percent to +15 percent one substracts from the net costs of $300 million (Column 6, +30 percent), that which is not affected by the reserve of $25 million (Column 6, +15 percent), for a net benefit of $275 million.

Relating the Benefits to Reserve Levels

In order to relate the benefits measured in terms of reductions in extreme price variations to year-end food grain reserve levels, empirical studies are needed to measure the relationship between changes in supply quantities and associated changes in prices for Bangladesh. This relationship is expressed as the price elasticity of demand and is measured as the percentage change in quantity associated with a given percentage change in price, $(\frac{\%\Delta Q}{\%\Delta P})$, assuming other factors constant.

Past studies show the price elasticity of demand for food grains in the LDCs to be less than 1.0 in absolute value indicating that relatively small percentage changes in quantity are associated with relatively large percentage changes in price. The sign for the coefficients is negative, reflecting the usual increase in prices associated with a decrease in quantity, and vice versa.[2/] This means that in percentage terms the needed levels of grain reserves for stabilizing market quantities are smaller than the corresponding levels of stability targeted for market prices of the food grains. The actual reserve levels needed in Bangladesh depends directly on the magnitude of the price elasticity of demand for the grain in that country.[3/]

[2/] Direct price elasticities of demand for rice with respect to changes in price of rice are estimated as follows:
(Source: World Demand Prospects for Grain in 1980, U.S. Department of Agriculture, Economic Research Service, Foreign Agricultural Economic Report No. 75, December, 1971).

Central America & Mexico	-0.5	West Africa	-0.4
Argentina	-0.3	North Africa	-0.5
East South America	-0.3	West Asia	-0.3
West South America	-0.3	South Asia	-0.3
East Africa	-0.3	South East Asia	-0.1
		East Asia & Pacific Islands	-0.3

[3/] Price change is related to change in total supply of cereals even though substantial portions of total supply do not enter commercial market channels. Changes in the available supply affect both quantity supplied and quantity demanded through commercial channels and hence are important in price level determination although large quantities are consumed where grown.

Reliable empirical studies are needed to quantify the relevant price elasticity. Short range (seasonal) price elasticities need to be separated from that appropriate for year-to-year variations in quantities and prices. Impacts of variation in available quantities of alternative foods need to be isolated and separated from the direct price elasticity coefficient for the grain under study. We will assume that such studies have been made for Bangladesh, and that they show the price elasticity of demand for rice to be -0.2. This means that targeted maximum variation in the supply quantity of food grain associated with the goal of ±15 percent variation in market prices is ±3 percent.

If we use $150.00 per metric ton as base annual average grain price and 13 million metric tons as the base supply quantity for consumers, then we have the following maximum and minimum targets for our case LDC:

	Price	Available Supply (million mt)
Base with normal production	$150.00 (100%)	13.0 (100%)
Target with production shortfalls	$172.50 (115%)	12.6 (97%)
Target with excess production	$127.50 (85%)	13.4 (103%)

In order to contain year-to-year variations within this targeted range, withdrawals will be needed from the food reserve in years when production shortfalls cause total supply quantities to be less than 12.6 million mt. Additions to the reserve will be needed in years when excess production causes total supply quantity to exceed 13.4 million mt. The quantity figures in terms of metric tons will increase through time as the LDC population and total consumption grow. They will remain a constant ±3 percent of the increasing tonnage base.

Reference to Figure 1, Column 8 of Table 1 indicates that total food grain supplies have varied from food requirements by more than 3 percent in 9 of the 17 years. Shortfalls in excess of this target occurred in crop years 1963, 1967, 1972 and 1977. Surpluses in excess of the target occurred in 1964, 1968, 1969, 1970 and 1976. Had an LDC food grain reserve program been in operation, much of this excessive variation could have been overcome.

LDC Reserve for Targeted Maximum 3 Percent Variation in Consumption and Historical Imports

The historical data for Bangladesh in Table 1 and assumed goal of no more than 3 percent variation in the quantity of food grain available for consumption provide the basis for testing the operation of a LDC grain reserve for Bangladesh had it been in existence since 1960-61. This is done in Table 3. The deviations in Column 1 are transferred directly from Table 1. The allowable deviation in supplies is computed at 3 percent of the "minimum supply target", i.e. the food requirements for each year from Column 7, Table 1. No change in reserve stocks takes place in years when the deviation in current quantity of food grain from production plus imports is within the allowable deviation. In years when a shortfall occurs, the reserve is drawn upon to bring the quantity available to the allowable deviation. In years when an excess occurs, the amount in excess of the allowable deviation is added to the reserve. The maximum storage capacity for the reserve is taken at 800,000 mt. The year-end reserve stock is not allowed to drop below 100,000 mt (the amount taken as necessary for disaster relief). Imports are taken at historical levels as shown in Table 1.

TABLE 3. COMPUTED LDC RESERVE OPERATION IN BANGLADESH, 1960-61 to 1976-77 (1000 metric tons)

Year	Deviation From Minimum Supply Target[1/]	Allowable Deviation[2/]	Change in Reserve Stocks	Year-End Balance[3/]	Residual Deviation
	(1)	(2)	(3)	(4)	(5)
1960-61	- 16	280	-	373	
1961-62	-154	286	-	373	
1962-63	-373	292	- 81	292	
1963-64	+617	297	320	612	
1964-65	+ 6	303	-	612	
1965-66	- 45	310	-	612	
1966-67	-986	316	-512	100	-158
1967-68	382	322	60	160	
1968-69	374	329	45	205	
1969-70	1075	335	595	800	+145
1970-71	- 27	342	-	800	
1971-72	-861	349	-512	288	
1972-73	-275	356	-	288	
1973-74	+238	363	-	288	
1974-75	+293	370	-	288	
1975-76	+913	378	512	800	+ 23
1976-77	-502	386	-116	684	

1/ From Table 1, Column 8.

2/ Three percent of minimum supply target (Food Requirement from Column 7, Table 1).

3/ Starting reserve balance in 1960-61 is taken at 4 percent of minimum supply target (Food Requirement from Column 7, Table 1). Average year-end stock is 445,000 mt; standard deviation, 228,000 mt; coefficient of variation is 57.3 percent.

The operation of the LDC reserve in Bangladesh since 1960-61, under the conditions postulated, is shown in Columns 3 and 4 of Table 3. The change in the year-end balance in the reserve is shown in Column 3. These figures are obtained by subtracting from those in Column 1 the absolute values of those in Column 2 for those years when the allowable deviation is exceeded. Starting in 1960-61, with a year-end balance of 373,000 mt (4 percent of the food requirement for that year), the changes in Column 3 are reflected to provide the annual year-end balances shown in Column 4. In 3 of the 17 years, the restrictions on the year-end balance of the reserve are effective. In 1966-67, the minimum balance of 100,000 mt comes into play and the LDC reserve falls short of meeting the target by 158,000 mt. In 1969-70, the storage capacity for the reserve is reached and the reserve fails to absorb 145,000 mt of the surplus. Likewise, in 1975-76, the 800,000 mt capacity is reached and 23,000 mt of the surplus cannot be absorbed.

The benefits that would have been derived from the LDC reserve in Bangladesh over the period of 1960-61 through 1976-77 can be calculated from the figures in Table 2 and those in Table 3. The results are shown in Table 4. In the 8 years out of the 17 when the reserve was not drawn upon nor added to, the benefits are zero. In the years when it was used, the benefits from the LDC reserve range up to $384.2 million in 1971-72 when an additional 4.4 percent stability in food grain supplies was achieved. On the basis of the figures in Table 2, this additional stability produces a benefit of $440 million at the 1977 consumption level, or the equivalent of $384.2 million at the consumption level in which the additional stability was achieved.

TABLE 4. COMPUTED BENEFITS FROM LDC RESERVE IN BANGLADESH, 1960-61 to 1976-77

Year	Increased Supply Stability (percent)[1/]	Annual Benefit ($ million) 1977 Level[2/]	For Year of Benefit[3/]
	(1)	(2)	(3)
1960-61	0	0	0
1961-62	0	0	0
1962-63	-0.83	62.25	45.42
1963-64	+3.23	198.00	147.33
1964-65	0	0	0
1965-66	0	0	0
1966-67	-4.86	486.00	383.91
1967-68	+0.56	28.00	22.56
1968-69	+0.41	20.50	16.86
1969-70	+5.33	308.00	258.14
1970-71	0	0	0
1971-72	-4.40	440.00	384.20
1972-73	0	0	0
1973-74	0	0	0
1974-75	0	0	0
1975-76	+4.07	229.00	216.52
1976-77	-0.90	67.50	65.12

1/ Columns 3, Table 3 divided by Column 7, Table 1.

2/ Column 1, Table 4 times 5 (price elasticity is 0.2) applied to Column 6, Table 2. For example in 1962-63, 0.83% x 5 = 4.15%; {4.15% ÷ (20% - 15%)} x (100 - 25) = 62.25.

3/ Column 2, Table 4 times Column 7, Table 1 ÷ 13,325 (The 1977 level food requirement (in 1000 mt units) used in the construction of Table 2).

Substantial additional benefits could have been derived had the LDC reserve been able to meet the targets in the years when it failed to do so. The additional potential benefits forgone in the years when the reserve could not meet targets are:

Year	1977 Level	Historical Level
1966-67	$150 million	$118.49 million
1969-70	$130 million	$108.96 million
1975-76	$ 9 million	$ 8.51 million

LDC Reserve with Import Adjustments

Let us now assume that LDC reserve balances (as well as need for reserves) can be adjusted through varying imports. Let us adopt the rule that whenever the year-end reserve balance is above or below targeted reserves by 20 percent or more, import targets will be adjusted by the amount required to return the reserve to targeted volume; however, to be realistic, we will assume that supply conditions cannot be known in time to make the full adjustment the current year, so that one-half the needed adjustment is made the current year and the other half is made the subsequent year. In this example the 800,000 mt storage capacity restriction is retained but the 100,000 mt minimum year-end balance is relaxed since import adjustments can be used for disaster needs. Assuming that imports would have otherwise remained as represented historically, import adjustments for reserve balances are indicated in Table 5. The import adjustments are given in pairs of numbers (Column 3); the first is the indicated adjustment for the previous year and the second is the indicated adjustment for the current year. The two are combined to determine the reserve balance after the

TABLE 5. EFFECT OF IMPORT ADJUSTMENTS ON YEAR-END RESERVE BALANCES, BANGLADESH 1960-61 to 1976-77 (1000 metric tons)

Year	Year-End Reserve Balance (Table 3)	Targeted Reserve Balance[1/] (2)	Import Adjustments[2/] (3) Previous Year	Import Adjustments[2/] (3) Current Year	Reserve Balance With Adjustment[3/] (4)	Residual Deviation (5)
1960-61	373	373	0	0	373	
1961-62	373	381	0	0	373	
1962-63	292	389	0	+ 49	341	
1963-64	612	397	+ 52	-132	581	
1964-65	612	404	-129	0	452	
1965-66	612	413	0	0	452	-7
1966-67	100	421	0	+211	0	
1967-68	160	429	+214	+ 78	413	
1968-69	205	438	+ 82	- 51	489	
1969-70	800	446	- 47	-319	718	
1970-71	800	456	-314	0	404	
1971-72	288	465	0	+287	179	
1972-73	288	474	+291	0	470	
1973-74	288	484	0	0	470	
1974-75	288	494	0	0	470	
1975-76	800	504	0	-239	743	
1976-77	684	514	-234	0	393	

1/ Established at 4 percent of annual consumption requirements from Column 7, Table 1.

2/ Adjustments to bring year-end reserve balances to targeted reserve balance, applied whenever discrepancy is 20% or more; one half the indicated adjustment made the current year and one-half made the subsequent year. For example in 1963-64:

Previous year: 397 - 292 = 105; 105 ÷ 2 = +52.5
Current year : 612 + 49 - 397 = 264; 264 ÷ 2 = -132

3/ Reserve balance the previous year plus changes in reserve stocks from Column 3, Table 3 plus total import adjustments from Column 3, above.

Average annual year-end reserve balance is 431,000 mt; standard deviation is 168,000 mt and coefficient of variation is 40 percent.

adjustment. Following the indicated rule, import adjustments were necessary in 12 of the 17 years. The total adjustments become relatively large in 1969-70 (-366,000 mt), 1970-71 (-314,000 mt), 1971-72 (+287,000 mt) and 1972-73 (+291,000 mt).

Even though it seems sensible to adjust imports to supplement additions to and withdrawals from the reserve, and would appear from Figure 1 to be an effective course of action, it does not always work out so well. By the time the need is known so that adjustments can be made, the shortages or surpluses may be upon the country. In two years (1963-64 and 1968-69), the lag in the adjustment causes need for a counter adjustment the subsequent year. Still the import adjustments provide increased stability in supply quantities compared to the LDC reserve without import adjustments, and do so at lower average inventory levels, and therefore, at reduced storage cost. The added benefits calculated in the same manner as those in Table 4 are as follows:

Year	Added Benefits for Year
1966-67	$113.13 million
1969-70	$108.96 million
1975-76	$ 8.51 million

LDC Reserve Supported by International Reserve

The figures in Table 6 portray the case in which an international reserve operates to support the LDC reserve in Bangladesh since 1960-61. The international reserve functions as a re-insurance plan to back-stop the insurance provided by the LDC reserve. Transactions are made with the international reserve only when and to the extent that annual excess

TABLE 6. EFFECT OF INTERNATIONAL RESERVE ON YEAR-END RESERVE BALANCES, BANGLADESH 1960-61 to 1976-77[1/]

(1000 metric tons)

Year	Year-End Reserve Balance (Table 3)	Targeted Reserves	Excess Deviation In Supply[2/]	Transactions with International Reserve[3/]	Year-End Reserve Balance[4/]	Residual Deviation
	(1)	(2)	(3)	(4)	(5)	(6)
1960-61	373	373	0	0	373	
1961-62	373	381	0	0	373	
1962-63	292	389	- 81	0	292	
1963-64	612	397	320	+108	504	0
1964-65	612	404	0	0	504	
1965-66	612	413	0	0	504	
1966-67	100	421	-670	-460	294	0
1967-68	160	429	60	0	354	
1968-69	205	438	45	0	399	
1969-70	800	446	740	+517	622	0
1970-71	800	456	0	0	622	
1971-72	288	465	-512	-280	-390	
1972-73	288	474	0	0	390	0
1973-74	288	484	0	0	390	
1974-75	288	494	0	0	390	
1975-76	800	504	535	+283	642	0
1976-77	684	514	-116	0	526	

1/ Decision rule for transactions with International Reserve: Amount of excess deviation greater than one-half targeted reserve.

2/ Actual deviation less allowable deviation (Table 3).

3/ Column 3 minus 50 percent of Column 2, ignoring signs, but assigning the sign from Column 3 to Column 4. If the result from the first step is negative, zero is assigned to Column 4.

4/ Average reserve balance is 445,000 mt; standard deviation is 108,000 mt and coefficient of variation 24 percent.

deviations from the minimum supply target exceed 50 percent of the targeted reserve for that year. During the 17-year history it was necessary to draw on the international reserve only twice and to add to it only three times. The international reserve assures full realization of the targeted stability objectives and realizes benefits that otherwise would be forgone. The average annual year-end balance in the LDC reserve is relatively unchanged, but the average utilization of storage capacity is raised from 55.7 percent to 68.5 percent. The LDC reserve required only 650,000 mt of storage capacity compared to 800,000 mt without the international reserve. The added benefits, calculated in the same manner as those in Table 4, are as follows:

Year	Added Benefits for Year
1966-67	$118.49 million
1969-70	$108.96 million
1975-76	$ 8.51 million

The above examples illustrate potential accomplishments of overall supply management of food grains built around use of a LDC reserve. These illustrations do not exhaust possible benefits. Additional benefits may accrue from such additional sources as improved timing of international purchases and a reduction in distress purchasing of food grains in international markets at high prices. Throughout the above exercise, minimum supply requirements, reserve requirements and reserve balances are all based on the assumption of sound and reliable data on production, imports, consumption and stocks. The importance of a reliable data base for a grain supply management program cannot be overemphasized. A grain stock supply management program cannot be sucessful without a high level of statistical integrity in the numbers on which it is based.

The impact of the LDC reserve backed by an international reserve in stabilizing the quantity of food grain available for consumption in Bangladesh over the historical period is shown graphically in Figure 2. The additions to and withdrawals from the reserve are based on the figures in Column 3 of Table 3 and Column 4 of Table 6. The remaining year-to-year variations from the consumption trend line are within the targeted 3 percent variation shown in Column 2 of Table 3. Had such a reserve program been in operation, Bangladesh would have enjoyed relative stability in available food grain supplies to the benefit of the nation's consumers as well as to her food grain producers.

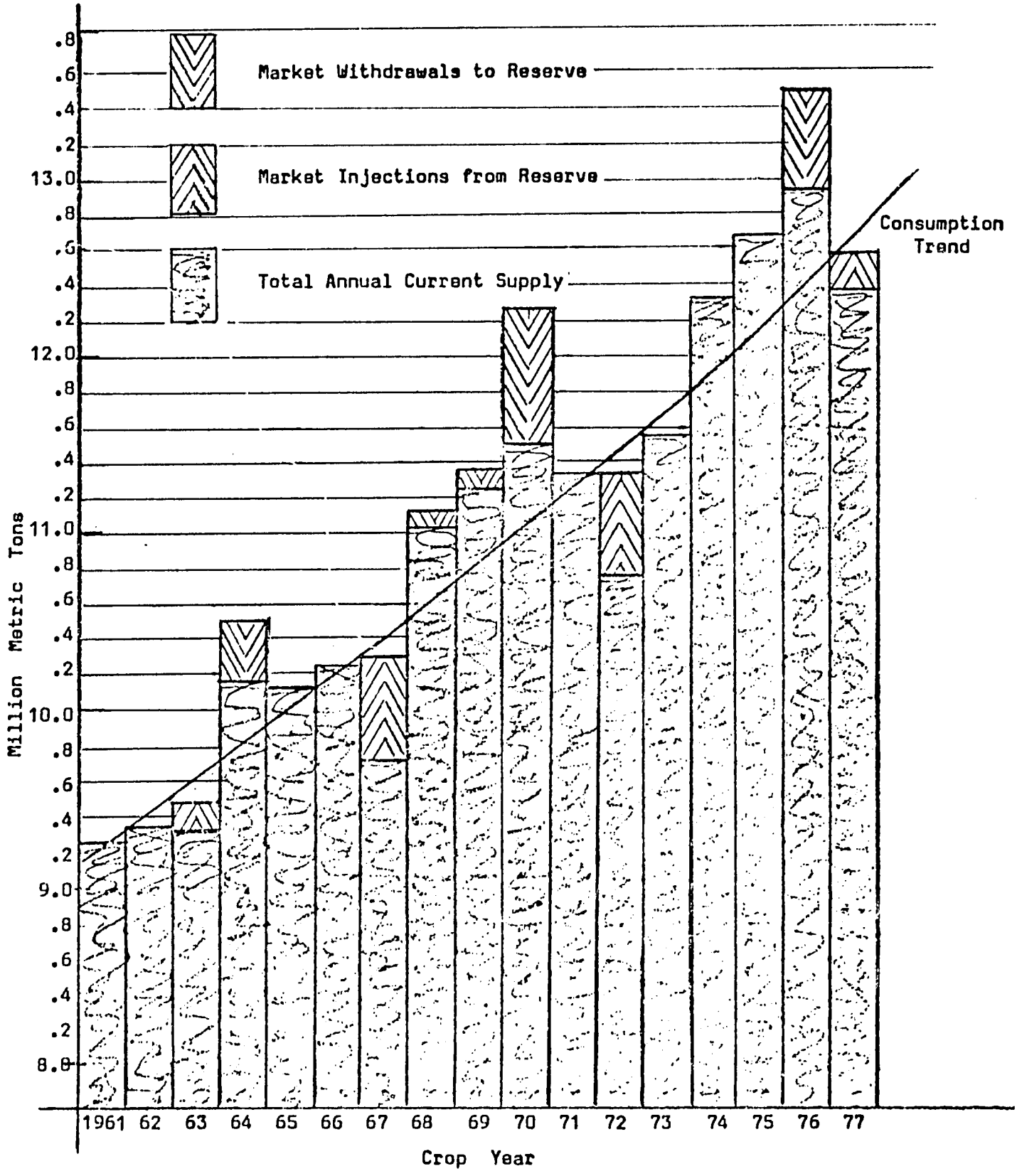
Estimated Costs of Reserves

As outlined in Part I, major costs are incurred in maintaining LDC grain reserve programs. The major categories of cost include (1) grain inventory carrying costs, (2) capital costs for grain storage facilities, (3) storage operating costs, and (4) administrative costs for the reserve program. In the Bangladesh example, additional costs for import adjustments and/or the services of international grain reserves need to be considered for the alternatives involving them.

Grain Inventory Cost

Interest cost related to maintaining grain inventory is a major expense of carrying LDC reserves. If we assume that adjusted year-end reserve balances as determined in Table 6 and investment in inventory at the low value in the price range ($127.50 per metric ton), year-end investment in stocks varies from $37.23 million in 1962-63 to $81.86 million in 1975-76.

FIG. 2. IMPACT OF COMPUTED LOC RESERVES IN BANGLADESH, 1961-1977



Source: Tables 3 and 6

Interest cost is directly dependent upon the interest rate charged. Annual interest costs are calculated in Table 7 for alternative cases of (1) opportunity cost for capital in Bangladesh of 20 percent, (2) a national government project rate of 12 percent, and (3) an international development loan rate of 3 percent. Average annual interest charge is reduced from 11.35 million (20%) to $6.81 million (12%) and with international development loan financing, to $1.7 million (Table 7). Inventory cost per mt, at the inventory value of $127.50 is $25.50 at an interest rate of 20 percent; $15.30 at 12 percent and $3.83 at 3 percent.

Capital Costs for Storage Facilities

Stocks varied under the final supply management rules (Table 6) from 292,000 tons to 642,000 tons. Average stock was 445,200 mt with a standard deviation of 108,000 mt. If we assume that storage space for 650,000 mt would be provided to accomodate the LDC reserve, capital costs for storage facilities can be based on that capacity figure. Historical data indicate average occupancy of 68.5 percent (Table 6).

Investment cost varies markedly by type of facility. If we assume that one-half of the storage space is in flat warehouses for bagged grain that can be constructed for $100.00 per mt and one-half is in concrete silos to be constructed for $150.00 per ton, total investment in storage facilities is $81.25 million. Depreciated over 40 years, annual depreciation is $2.03 million. Interest charged at a rate of 20 percent on one-half of total investment is $8.125 million; 12 percent is $4.875 million and 3 percent is $1.22 million annually. Annual maintenance costs estimated for bag warehouses at 1.5 percent of original cost is $487,500. Annual maintenance cost for silos at 2.0 percent of original cost is $975,000. Total annual maintenance cost is $1,462,500.

TABLE 7. INVENTORY INVESTMENT AND ANNUAL INTEREST CHARGES AT ALTERNATIVE INTEREST RATES, (BANGLADESH LDC RESERVE WITH INTERNATIONAL RESERVE SUPPORT)

Year	Year-End Reserve Balance (1000 mt)	Inventory Investment[1/] ($1000)	Annual Interest Charge at: 20%	12% ($1000)	3%
1960-61	373	47,558	9,502	5,707	1,427
1961-62	373	47,558	9,502	5,707	1,427
1962-63	292	37,230	7,446	4,468	1.117
1963-64	504	64,260	12,852	7,712	1,928
1964-65	504	64,260	12,852	7,712	1,928
1965-66	504	64,260	12,852	7,712	1,928
1966-67	294	37,485	7,497	4,498	1,125
1967-68	354	45,135	9,027	5,416	1,354
1968-69	399	50,873	10,174	6,105	1,526
1969-70	622	79,305	15,861	9,517	2,379
1970-71	622	79,305	15,861	9,517	2,379
1971-72	390	49,725	9,945	5,967	1,492
1972-73	390	49,725	9,945	5,967	1,492
1973-74	390	49,725	9,945	5,967	1,492
1974-75	390	49,725	9,945	5,967	1,492
1975-76	642	81,855	16,371	9,823	2,456
1976-77	526	67,065	13,413	8,048	2,012
Total	7569	965,049	193,010	115,806	28,951
Average	445	56,768	11,354	6,812	1,703

[1/] Year-end reserve balance (Table 6, Column 5) x $127.50 per mt.

Annual capital cost based on these assumptions varies from $11.62 million to $4.71 million with interest rates at 20 percent and 3 percent per year, respectively. With interest rate at 12 percent, annual capital cost for facilities is $8.37 million. Cost per metric ton of storage space provided (650,000 mt) is alternatively $17.87, $12.87 or $7.25 per year depending upon interest rates. Annual capital cost for facilities per metric ton of grain stored (68.5 percent occupancy) is $26.09, $18.80 or $10.58 depending upon interest rate charged.

Storage Operating Costs

Storage operating costs are subject to substantial variation depending upon local conditions and the extent of loss and deterioration while the grain is in storage. Storage operating costs at low turnover in LDCs are likely to fall in a range from $6.00 to $10.00 per ton. Estimating storage operating costs in Bangladesh at the mid-point of that range ($8.00) results in combined annual storage facility and operating costs with average occupancy (445,200 mt) of $34.09 per ton with a 20 percent interest rate, $26.80 with 12 percent interest rate and $18.58 per ton with 3 percent interest (Table 8).

At average inventory (445,200) Table 8 also shows combined annual inventory and storage costs of $59.59 per ton at 20 percent interest, $42.10 at 12 percent interest and $22.41 at 3 percent interest.

Administrative Costs

In addition to inventory, carrying costs and storage costs, as estimated above, costs of program administration will be incurred. Expenditures of $3.00 per ton based on year-end reserve balances would provide $1.34 million annually for program administration. This may seem like a high figure, but it must be remembered that substantial administrative and managerial effort

TABLE 8. POSSIBLE AVERAGE ANNUAL INVENTORY AND STORAGE COSTS AT ALTERNATIVE INTEREST RATES, BANGLADESH EXAMPLE

	20 percent Annual Interest			12 percent Annual Interest			3 percent Annual Interest		
	Total per MT			Total per MT			Total per MT		
	Million Dollars	Dollars	Cents per Bu.	Million Dollars	Dollars	Cents per Bu.	Million Dollars	Dollars	Cents per Bu.
Inventory Cost	11.35	25.50	.68	6.81	15.30	.41	1.70	3.83	.10
Storage Cost:									
Fixed Costs	11.62	26.09	.71	8.37	18.80	.51	4.71	10.58	.29
Operating Costs	3.56	8.00	.22	3.56	8.00	.22	3.56	8.00	.22
Subtotal	15.18	34.09	.93	11.93	26.80	.73	8.26	18.58	.51
Administrative Costs	1.34	3.00	.08	1.34	3.00	.08	1.34	3.00	.08
Total Cost	27.87	62.59	1.69	20.08	45.10	1.22	11.30	25.41	.69

is required to operate a food grain reserve program effectively, and that a functional organization must be developed for doing so. The program must be interfaced with the overall food policies and programs in Bangladesh and must have continuous public support. For these reasons, the $3.00 per ton annual administrative cost is believed to be in the right "ball park."

Costs of Import Adjustments

The cost of import adjustments by varying the volume of food grain purchases in international markets is hard to estimate. In some years, the adjustments could have been made at no additional cost per mt or even at a savings. In other years a substantial additional price would have been required for marginal purchases. In the Bangladesh example, it is assumed that a $25 per mt premium would have been necessary to make the import adjustments required to supplement the LDC reserve.

International Reserve Service Charges

Costs will be involved for an international reserve program in order to provide the "reinsurance" services indicated in Column 4, Table 6. There are many ways that such costs could be shared among donor agencies and LDCs which use the international reserve. As with the LDC reserve, substantial costs for capital facilities, for storage operating costs, for inventory carrying costs and for administration will accrue for any international reserve program capable of back-stopping the reserve programs in participating LDCs.

For purposes of feasibility analysis of the Bangladesh case, let us assume that major costs of the international reserve are borne by the user LDCs. For simplicity, let us assume that the total costs are reflected through a service charge to the LDCs as the country uses the international reserve. This could be done by a depositor charge as grain is placed in the

international reserve for the account of the LDC plus a withdrawal charge when grain is taken from the international reserve to supplement the LDC reserve. Let us suppose for the Bangladesh case that the depositor charge is $25.00 per mt and that the withdrawal charge is $50.00 per mt. If, in addition, total marketing transport and handling costs for transferring grain from the international reserve to the LDC reserve and vice versa are $25.00 per ton, then the total charge to the Bangladesh reserve program would be $50.00 per mt for grain deposited in the international reserve and $75.00 per mt for grain withdrawn from the international reserve.

These charges are used only as examples for purposes of illustrating feasibility analysis of the Bangladesh case. The authors are not recommending this method of assessing costs to user countries and certainly not the specific charges for Bangladesh or any other LDC.

Cost Recovery Through Transactions

A portion of program costs for a LDC reserve can be recovered when stocks are acquired at a low price and sold at higher prices to dampen price upswings, but historically, reserve stock programs have not been self-supporting. If all grain acquisitions for the LDC reserve were purchased at $127.50 per mt and all sales from the reserve priced at $172.50 per mt, the net balance from transactions over the 17-year period (including closing inventory) would have been $126.525 million. Transaction gains or losses have not been included in the feasibility analysis that follows, however.

Feasibility Analysis of Benefits and Costs

The Kansas State University Computer Program for Investment Feasibility Analysis was used to test the feasibility of the three Bangladesh examples presented in Table 3, 5 and 6. The program reads the cash flow input for (1) total capital cost for storage facilities, (2) working capital invested in grain inventories in the reserve, (3) projected net benefits and (4) fixed and variable operating costs for the program, and prints a listing of this cash flow data. It then calculates the direct rate of return on total capital investment by solving for d in the formula, $\sum_{i=o}^{n} \frac{Ii}{(1+d)^i} = \sum_{i=o}^{n} \frac{Bi-Ci}{(1+d)^i}$, where I is the total capital investment (storage facilities plus grain inventory) for periods o through n, B is the annual net benefit and C is the total operating cost (excluding interest and depreciation) for each of the periods. The program also solves for the fully-discounted benefit/cost ratios and the discounted net present values at six specified discount rates representing different opportunity costs for capital. The solutions are independent of the rates of interest and methods of depreciation a LDC wishes to use, since these do not enter into the computations.

All three of the examples, (1) the LDC reserve alone, (2) the LDC reserve with import adjustments and (3) the LDC reserve supported by an international reserve are feasible under the assumptions made (Tables 9, 10, 11). They rank in the reverse order in terms of direct earning power on total investment (and benefit/cost), the LDC reserve supported by an international reserve ranking highest with an annual direct rate of return of 37.867 percent. The corresponding direct rate of return is 35.645 percent for the LDC reserve with import adjustments and 32.162 percent for the LDC reserve alone. The difference in rate of return between the LDC

A LISTING OF THE DATA

1 1 1 3 2 0 0 1 0.0

TABLE 9. L.E.C. FOOD GRAIN RESERVE FOR BANGLADESH, 1960-61 THROUGH 1976-77

PERIOD	CAPITAL COST	GRAIN INVENTORY	NET BENEFIT	MAINT. COST	ADMIN. COST	OPERATING COST	INT. RESERVE	IMPORT ADJUST.	OTHER COSTS
0	100000.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	47558.	0.	1801.	1336.	2984.	0.	0.	0.
2	0.	0.	0.	1801.	1336.	2984.	0.	0.	0.
3	0.	-10328.	45420.	1801.	1336.	2336.	0.	0.	0.
4	0.	40800.	147330.	1801.	1336.	4896.	0.	0.	0.
5	0.	0.	0.	1801.	1336.	4896.	0.	0.	0.
6	0.	0.	0.	1801.	1336.	4896.	0.	0.	0.
7	0.	-65280.	363910.	1801.	1336.	800.	0.	0.	0.
8	0.	7650.	22560.	1801.	1336.	1280.	0.	0.	0.
9	0.	5738.	16860.	1801.	1336.	1640.	0.	0.	0.
10	0.	75863.	258140.	1801.	1336.	6400.	0.	0.	0.
11	0.	0.	0.	1801.	1336.	6400.	0.	0.	0.
12	0.	-65260.	384200.	1801.	1336.	2304.	0.	0.	0.
13	0.	0.	0.	1801.	1336.	2304.	0.	0.	0.
14	0.	0.	0.	1801.	1336.	2304.	0.	0.	0.
15	0.	0.	0.	1801.	1336.	2304.	0.	0.	0.
16	0.	65280.	216520.	1801.	1336.	6400.	0.	0.	0.
17	0.	-14790.	65120.	1801.	1336.	5472.	0.	0.	0.
18	-57500.	-87211.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

TABLE 5. L.D.C. FOOD GRAIN RESERVE 1960-61 THROUGH 1976-77

DIRECT RETURN ON TOTAL 12 PERCENT

PERIOD NO.	PERIOD IDENT.	INVESTMENT (1 $1000) FACILITIES	WORKING CAPITAL	TOTAL	DIRECT BENEFIT		NET BENEFIT	PRESENT VALUE FACTOR	PRESENT VALUES TOTAL INVESTMENT	NET BENEFIT
0		100000.	0.	100000.	0.		0.	1.0000	100000.	0.
1		0.	47558.	47558.	0.		121.	0.7566	35985.	-4631.
2		0.	0.	0.	0.		-121.	0.5725	0.	-3504.
3		0.	-10328.	-10328.	45420.		39947.	0.4332	-4474.	17305.
4		0.	40800.	40800.	147330.		139297.	0.3278	13373.	45657.
5		0.	0.	0.	0.		-8033.	0.2480	0.	-1992.
6		0.	0.	0.	0.		-8033.	0.1877	0.	-1507.
7		0.	-65280.	-65280.	383910.		379973.	0.1420	-9269.	53951.
8		0.	7650.	7650.	22560.		18143.	0.1074	822.	1949.
9		0.	5738.	5738.	16860.	[illegible]	12083.	0.0813	466.	982.
10		0.	75863.	75863.	258140.	9537.	248603.	0.0615	4666.	15291.
11		0.	0.	0.	0.	9537.	-9537.	0.0465	0.	-444.
12		0.	-65280.	-65280.	384200.	5441.	378759.	0.0352	-2299.	13337.
13		0.	0.	0.	0.	5441.	-5441.	0.0266	0.	-145.
14		0.	0.	0.	0.	5441.	-5441.	0.0202	0.	-110.
15		0.	0.	0.	0.	5441.	-5441.	0.0153	0.	-83.
16		0.	65280.	65280.	216520.	9537.	206983.	0.0115	753.	2389.
17		0.	-14790.	-14790.	65120.	3609.	56511.	0.0087	-129.	494.
18		-57500.	-87211.	-144711.	0.	0.	0.	0.0066	-956.	0.
TOTAL		42500.	0.	42500.	1540060.	113929.	1426131.		138938.	138938.

INTEREST PER CENT	BENEFIT/COST RATIO	PRESENT VALUE IN $1000 BENEFIT	OUTLAY	BALANCE
3.000	12.125	1063616.	87722.	975894.
12.000	3.691	494711.	134016.	360695.
20.000	2.005	281433.	140363.	141070.
30.000	1.117	155812.	139467.	16345.
40.000	0.692	94646.	136814.	-42168.
50.000	0.458	61482.	134130.	-72648.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
FACILITIES COST = 800,000 MT @ $125. WORKING CAPITAL @ $127.50 PER MT. BENEFITS FROM TABLE 4 AND TEXT.
MAINTENANCE COST @ $2.25 PER MT. OPERATING COST @ $8.00 PER MT.

A LISTING OF THE DATA

1 1 1 6 2 0 0 1 0.0

TABLE 1C. L.D.C. FOOD GRAIN RESERVE FOR BANGLADESH, 1960-61 THROUGH 1976-77
SUPPLEMENTED BY ANNUAL IMPORT ADJUSTMENTS

PERIOD	CAPITAL COST	GRAIN INVENTORY	NET BENEFIT	MAINT. COST	ADMIN. COST	OPERATING COST	INT. RESERVE	IMPORT ADJUST.	OTHER COSTS
0	93750.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	47558.	0.	1688.	1336.	2984.	0.	0.	0.
2	0.	0.	0.	1688.	1336.	2984.	0.	0.	0.
3	0.	-4080.	45420.	1688.	1336.	2728.	0.	1225.	0.
4	0.	30600.	147330.	1688.	1336.	4648.	0.	4600.	0.
5	0.	-16448.	0.	1688.	1336.	3616.	0.	3225.	0.
6	0.	0.	0.	1688.	1336.	3616.	0.	0.	0.
7	0.	-57630.	497040.	1688.	1336.	0.	0.	5275.	0.
8	0.	52658.	22560.	1688.	1336.	3304.	0.	7300.	0.
9	0.	9690.	16860.	1688.	1336.	3912.	0.	3325.	0.
10	0.	29198.	367100.	1688.	1336.	5744.	0.	9150.	0.
11	0.	-40035.	0.	1688.	1336.	3232.	0.	7850.	0.
12	0.	-28688.	384200.	1688.	1336.	1432.	0.	7175.	0.
13	0.	37103.	0.	1688.	1336.	3760.	0.	7275.	0.
14	0.	0.	0.	1688.	1336.	3760.	0.	0.	0.
15	0.	0.	0.	1688.	1336.	3760.	0.	0.	0.
16	0.	34808.	225000.	1688.	1336.	5944.	0.	5975.	0.
17	0.	-44625.	65120.	1688.	1336.	3144.	0.	5850.	0.
18	-53908.	-50109.	0.	0.	0.	0.	0.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

TABLE 10. L.D.C. FCCC GRAIN RESERVE FOR BANGLADESH, 1960-61 THROUGH 1976-77
SUPPLEMENTED BY ANNUAL IMPORT ADJUSTMENTS

DIRECT RETURN ON TOTAL CAPITAL 35.645 PERCENT

PERIOD NO.	PERIOD IDENT.	INVESTMENT (\$1000) FACILITIES	INVESTMENT (\$1000) WORKING CAPITAL	INVESTMENT (\$1000) TOTAL	OPERATING (\$1000) DIRECT BENEFIT	OPERATING (\$1000) OPERATING EXPENSES**	OPERATING (\$1000) NET BENEFIT	PRESENT VALUE FACTOR	PRESENT VALUES TOTAL INVESTMENT	PRESENT VALUES NET BENEFIT
0		93750.	0.	93750.	0.	0.	0.	1.0000	93750.	0.
1		0.	47558.	47558.	0.	6008.	-6008.	0.7372	35061.	-4429.
2		0.	0.	0.	0.	6008.	-6008.	0.5435	0.	-3265.
3		0.	-4080.	-4080.	45420.	6977.	38443.	0.4007	-1635.	15403.
4		0.	30600.	30600.	147330.	12272.	135058.	0.2954	9039.	39893.
5		0.	-16448.	-16448.	0.	9865.	-9865.	0.2178	-3582.	-2148.
6		0.	0.	0.	0.	6640.	-6640.	0.1605	0.	-1066.
7		0.	-57630.	-57630.	497040.	8299.	488741.	0.1183	-6820.	57842.
8		0.	52658.	52658.	22560.	13628.	8932.	0.0872	4594.	779.
9		0.	9690.	9690.	16860.	10261.	6599.	0.0643	623.	424.
10		0.	29198.	29198.	367100.	17918.	349182.	0.0474	1385.	16558.
11		0.	-40035.	-40035.	0.	14106.	-14106.	0.0350	-1400.	-493.
12		0.	-28688.	-28688.	384200.	11631.	372569.	0.0258	-739.	9602.
13		0.	37103.	37103.	0.	14059.	-14059.	0.0190	705.	-267.
14		0.	0.	0.	0.	6784.	-6784.	0.0140	0.	-95.
15		0.	0.	0.	0.	6784.	-6784.	0.0103	0.	-70.
16		0.	34808.	34808.	225000.	14943.	210057.	0.0076	265.	1599.
17		0.	-44625.	-44625.	65120.	12018.	53102.	0.0056	-250.	298.
18		-53508.	-50109.	-104617.	0.	0.	0.	0.0041	-430.	0.
	TOTAL	39842.	0.	39842.	1770630.	178201.	1592429.		130565.	130565.

INTEREST PER CENT	BENEFIT/COST RATIO	PRESENT VALUE IN \$1000 BENEFIT	OUTLAY	BALANCE
3.000	14.417	1194673.	82867.	1111806.
12.000	4.427	561299.	126799.	434500.
20.000	2.407	319522.	132750.	186771.
30.000	1.332	175717.	131905.	43813.
40.000	0.815	105534.	129462.	-23928.
50.000	0.533	67663.	127009.	-59346.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
FACILITIES COST = 750,000 MT @ \$125. WORKING CAPITAL @ \$127.50 PER MT. BENEFITS FROM TABLE 4 AND TEXT ACCOMPANYING TABLE 5. MAINTENANCE COST @ \$2.25 PER MT. OPERATING COST @ \$8.00 PER MT. IMPORT ADJUSTMENTS AT \$25.00 PER MT ADDITIONAL COST.

A LISTING OF THE DATA

1 1 1 6 2 0 0 1 0.0

TABLE 11. L.C.C. FOOD GRAIN RESERVE FOR BANGLADESH, 1960-61 THROUGH 1976-77
SUPPLEMENTED BY AN INTERNATIONAL GRAIN RESERVE

PERIOD	CAPITAL COST	GRAIN INVENTORY	NET BENEFIT	MAINT. COST	ADMIN. COST	OPERATING COST	INT. RESERVE	IMPORT ADJUST.	OTHER COSTS
0	81250.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	47558.	0.	1463.	1336.	2984.	0.	0.	0.
2	0.	0.	0.	1463.	1336.	2984.	0.	0.	0.
3	0.	-10328.	45420.	1463.	1336.	2336.	0.	0.	0.
4	0.	27030.	147330.	1463.	1336.	1032.	5400.	0.	0.
5	0.	0.	0.	1463.	1336.	4032.	0.	0.	0.
6	0.	0.	0.	1463.	1336.	4032.	0.	0.	0.
7	0.	-26775.	502400.	1463.	1336.	2352.	27000.	0.	0.
8	0.	7650.	22560.	1463.	1336.	2832.	0.	0.	0.
9	0.	5753.	16860.	1463.	1336.	3192.	0.	0.	0.
10	0.	28432.	367100.	1463.	1336.	4976.	25850.	0.	0.
11	0.	0.	0.	1463.	1336.	4976.	0.	0.	0.
12	0.	-29580.	384200.	1463.	1336.	3120.	21000.	0.	0.
13	0.	0.	0.	1463.	1336.	3120.	0.	0.	0.
14	0.	0.	0.	1463.	1336.	3120.	0.	0.	0.
15	0.	0.	0.	1463.	1336.	3120.	0.	0.	0.
16	0.	32130.	225000.	1463.	1336.	5136.	14150.	0.	0.
17	0.	-14790.	65120.	1463.	1336.	4208.	0.	0.	0.
18	-46720.	-67065.	0.	0.	0.	0.	-20100.	0.	0.

INVESTMENT FEASIBILITY ANALYSIS

TABLE 11. L.C.C. FOOD GRAIN RESERVE FOR BANGLADESH, 1960-61 THROUGH 1976-77
SUPPLEMENTED BY AN INTERNATIONAL GRAIN RESERVE

DIRECT RETURN ON TOTAL CAPITAL 31.861 PERCENT

PERIOD NO.	PERIOD IDENT.	INVESTMENT (\$1000) FACILITIES	INVESTMENT (\$1000) WORKING CAPITAL	INVESTMENT (\$1000) TOTAL	OPERATING (\$1000) DIRECT BENEFIT	OPERATING (\$1000) OPERATING EXPENSES**	OPERATING (\$1000) NET BENEFIT	PRESENT VALUE FACTOR	PRESENT VALUES TOTAL INVESTMENT	PRESENT VALUES NET BENEFIT
0		81250.	0.	81250.	0.	0.	0.	1.0000	81250.	0.
1		0.	47558.	47558.	0.	5783.	-5783.	0.7253	34496.	-4195.
2		0.	0.	0.	0.	5783.	-5783.	0.5261	0.	-3043.
3		0.	-10328.	-10328.	45420.	5135.	40285.	0.3816	-3941.	15373.
4		0.	27030.	27030.	147330.	9231.	138099.	0.2768	7482.	38225.
5		0.	0.	0.	0.	6831.	-6831.	0.2008	0.	-1371.
6		0.	0.	0.	0.	6831.	-6831.	0.1456	0.	-995.
7		0.	-26775.	-26775.	502400.	32151.	470249.	0.1056	-2828.	49672.
8		0.	7650.	7650.	22560.	5631.	16929.	0.0766	586.	1297.
9		0.	5738.	5738.	16860.	5991.	10869.	0.0556	319.	604.
10		0.	28432.	28432.	367100.	33625.	333475.	0.0403	1146.	13442.
11		0.	0.	0.	0.	7775.	-7775.	0.0292	0.	-227.
12		0.	-29580.	-29580.	384200.	26919.	357281.	0.0212	-627.	7577.
13		0.	0.	0.	0.	5919.	-5919.	0.0154	0.	-91.
14		0.	0.	0.	0.	5919.	-5919.	0.0112	0.	-66.
15		0.	0.	0.	0.	5919.	-5919.	0.0081	0.	-48.
16		0.	32130.	32130.	225000.	22085.	202915.	0.0059	189.	1191.
17		0.	-14790.	-14790.	65120.	7007.	58113.	0.0043	-63.	247.
18		-46720.	-67065.	-113785.	0.	-20100.	20100.	0.0031	-351.	62.
	TOTAL	34530.	0.	34530.	1775990.	178435.	1597555.		117656.	117656.

INTEREST PER CENT	BENEFIT/COST RATIO	PRESENT VALUE IN \$1000 BENEFIT	OUTLAY	BALANCE
3.000	15.879	1195719.	75300.	1120419.
12.000	4.811	560170.	116439.	443731.
20.000	2.628	319159.	121431.	197729.
30.000	1.469	176135.	119901.	56234.
40.000	0.908	106296.	117042.	-10746.
50.000	0.599	68520.	114337.	-45817.

**EXCLUDING DEPRECIATION, INTEREST, AND INCOME TAX

ALTERNATIVE:
FACILITIES COST = 650.000 MT @ \$125. WORKING CAPITAL @ \$127.50 PER MT. BENEFITS FROM TABLE 4 AND TEXT ACCOMPANYING TABLE 6. MAINTENANCE COST @ \$2.25 PER MT. OPERATING COST @ \$8.00 PER MT. INTERNATIONAL RESERVE AT \$50.00 PER MT IN AND \$75.00 PER MT OUT.

reserve alone and the reserve supported by import adjustments or an International Reserve would have been much greater had those years in which the additional support was needed happened to occur earlier in the time series (so that they would have received heavier weight in the discounted cash flow analysis).

Tables 9, 10 and 11 illustrate the standard format of the Kansas State University computerized system for feasibility analysis.[5/] The main section of the output table (second page of each set) shows the projected year-by-year cash flow, (1) for investment in storage facilities, (2) working capital in the form of grain inventories in the reserve, (3) direct benefits to Bangladesh, and (4) annual operating expenses for the reserve program. Depreciation and interest charges are excluded in this computation to avoid double counting and to make the annual direct rate of return directly comparable with the opportunity cost of capital. Investment credits are taken for the value of fixed assets and grain inventories in the reserves (including those in the international reserves) in period 18 at the end of the planning horizon.

The present value factors and discounted present values shown in the right-hand section of the Investment Feasibility Analysis output tables are applicable for the solution rate of return only. This is the rate which provides a benefit/cost ratio of exactly 1.0 and a discounted net present value balance of exactly zero. The benefit/cost

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[5/] Phillips, Schruben, Tiao. User's Guide to Computerized System for Feasible Agribusiness Development. Special Report No. 2. Food and Feed Grain Institute, Kansas State University, Section 9, Volume 2, 1977.

ratios and discounted present values at alternative interest or discount rates are summarized in the lower section of Tables 9, 10 and 11.

It will be noted from the feasibility analysis tables that all of the measures of feasibility (direct rate of return, benefit/cost rations and net present values) are dependent upon the time distribution of the benefits. The time distribution of the benefits is a direct function of when the need for transactions with the reserve occurs (see Figures 1 and 2). Had the need for the reserve occurred earlier, the present value of the benefit stream would have been greater. Had the need for the reserve not occurred until 10 years after the reserve was established, the present value of the benefits would have been less. As with any insurance program, the uncertainty of when the need for the program will occur is one of the strong arguments for the program.

Conclusions

The Bangladesh case based on the historical period from 1960-61 through 1976-77 illustrates the potential operation and feasibility of a LDC food grain reserve program. The historical statistics of production, imports and consumption are believed to be representations of actual conditions in the past, and show how the reserve could have been operated to cope with the stresses of unpredictable year-to-year fluctuations in the total supply of food grains. The magnitude of the benefits and costs associated with the reserve program for purposes of the illustration are not based on "hard numbers" for Bangladesh or any other LDC. The cost used in this illustrative analysis may be inaccurate by as much as 15 or 20 percent. The benefits used may be in error by $\pm$ 50 percent, or more. To the knowledge of the authors, impact analyses of the kind necessary to quantify the benefits of more stable food supplies have not been made for Bangladesh. Still, the analysis indicates that the reserve program probably would have been feasible if total benefits were only one-half the magnitude postulated.

In many ways, the more interesting features of a potential LDC food reserve program for Bangladesh arise from the dynamics and uncertainties involved. The schedule of benefits (Table 9, 10 or 11) is a direct function of the pattern of deviations from "normal" food grain supplies. Except in a statistical probability sense, this kind of schedule cannot be predicted. The whole idea of food grain reserves is to cope with problems which arise because of the fact that variations in supply cannot be anticipated. This means that, by definition, orthodox benefit/cost analysis of potential reserve programs is subject to large margins of error.

Closer reference to the direct benefit schedule in Table 4 will illustrate this point. Let us suppose that we are confident of the magnitude of the numbers and frequency with which they will occur. We are confident that in a 17-year period, there will be zero benefit in eight of the years, benefits of less than 25 million in two, 45 million to 70 million in two, of roughly 150 million in one, of roughly 225 million to 250 million in two, and roughly 385 million in two of the years. Even under these circumstances, what we cannot know is the order in which these various levels of benefits will occur. Yet this is exactly what we must know in order to apply accurately any of the measures of economic feasibility.

Let us further illustrate from Table 9. Had one of the large benefits occurred in year 1, its present value alone would have been more than twice that of the entire benefit schedule shown in Table 9. At the solution rate of return in Table 9, it would have been worth about 76 cents on the dollar (note the schedule of present value factors). Had this same large benefit occurred instead in year 17, it would have been worth about 0.9 cents on the dollar and its contribution to the present value of the 17-year schedule of benefits would have been negligible.

We must recognize that when year-to-year fluctuations in benefits are very wide as in this case, (and of benefits from food grain reserves by nature), the time sequence of the benefits has far greater impact on the benefit/cost ratio than does the magnitude of the average annual benefit. Under such circumstances it may be uneconomic to devote major resources to measuring the average annual benefit when the important determinate cannot be measured in advance.

The Bangladesh example has been a rewarding experience for the authors. Hypothetical as it is in many respects, we believe that it illustrates the priority issues regarding food grain reserves to support economic development in the LDCs which we have attempted to point out in Part I. It has strengthened our conviction of the necessity for well-planned food grain reserve programs in LDCs to help avoid widespread hunger and support economic development for the betterment of mankind.