*Journal of Rural Development 3 (April 1980) :83–101*

# SIMULATING THE IMPACT OF ALTERNATIVE FOOD RESERVE PROGRAMS: THE ASEAN CASE*

RICHARD PHILLIPS**
DOYLE JEON

## Why Food Security Reserves?

Most Asian countries have good reason to be concerned about the problems which food security reserves can help solve. They are anxious to avoid the danger of mass starvation with only a few days' supply of food grain on hand prior to the new harvest. They are anxious to minimize the repercussions of serious localized food scarcity resulting from possible disasters. 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 bankrupcy of farmers caused by food grain prices which are temporarily very low. In short, developing countries are anxious to maintain reasonable levels of reserve stocks of food grains for the protection of their consumers, their farm producers, and their national economies.

Effectively meeting the daily food grain requirements of their people is a large and priority task for them most countries. For example, the current daily requirements for ASEAN total about 102,000 metric tons, milled rice equivalent. It requires distribution among 258 million people an average of 0.87 pounds of milled rice each day. In equivalent whole grain, it corresponds to a supply of about 157,400 M/T per day or 5,745,000 M/T per year.

The challenge is magnified by great and largely unpredictable variations in food grain supplies from year to year. Climatic factors, crop pests and diseases, restrictions affecting the use of farm inputs, changing

* Based upon *ASEAN Food Security Reserves; How That Might Have Worked from 1960 to 1977*, Special Report 9, Food and Feed Grain Institute, Kansas State University, Jan. 1980. Prepared for Agency for International Development, United States Department of State. *Release of the publication implies neither endorsement nor rejection by A.I.D. of the analysis, findings and recommendations presented.*

** Dr. Phillips is Professor of Economics, Kansas State University; Dr. Jeon is World Bank marketing advisor now stationed at KREI.

food policies and uncertain grain prices combine to cause wide variations in domestic production. Irratic world prices and shifts in other factors affecting international trade cause wide fluctuations in the opportunities to import (or export) to balance total food supplies with domestic requirements. For example, among the ASEAN countries since 1960, Indonesia'a annual food grain supply-requirement balance has varied from a deficit of 1,658,000 $^{M}/_{T}$ to a surplus of 1,353,000 $^{M}/_{T}$ — a variation of about ± 13 percent of total annual requirements. Over the past 18 years, comparable percentage variations in available food grain supplies have occurred in the other ASEAN countries, ranging from −11.5 percent to +8 percent in Malaysia, −10 percent to +6.5 percent in the Philippines, −44 percent to +28 percent in Singapore, and −10.5 percent to +20 percent in Thailand. These imbalances have occurred even after activities to offset the wide fluctuations in domestic production, including (1) imports and/or exports, (2) consumption substitution among the alternative food grains, and (3) adjustments to year-end food grain inventories.

These conditions, and the problems and inequities that arise from them, can be prevented by an effective food security reserve program. Food security reserves can be built up in years of surplus, stored in facilities suitable for maintaining the grain quality, and drawn upon in years of scarcity and relief of local disaster. Security reserves can be developed to a size needed to achieve any targeted degree of stability in food supplies, but excessive reserve stocks can become a costly burden. By approaching the security reserve program jointly, groups of countries can achieve targeted levels of stability in food grain supplies much more efficiently than each could do alone.

## Need for Effective Security Reserve Guidelines

Asian countries are joined by world organizations and international donor agencies in support of goals which food security reserves of food grains can achieve. The United Nations, the World Food Council, the International Bank for Reconstruction and Development, and the International Food Policy Research Institute are among leading organizations dedicated to the need for food security reserves to serve stability, development, and humanitarian goals in all nations. All agree that the needs are particularly great in the developing nations of the world.

The lack of well-established guidelines for planning, using, and maintaining security reserves of food grains continues to represent a serious constraint. If they are to operate successfully, security reserves must be managed in connection with and complementary to national grain management policies and programs. Guildlines are needed (1) for determining the size, type, and location of reserve storage facilities, (2) for designing specific triggers governing additions to and withdrawals from inventories in storage reserves, (3) for interfacing reserve programs with potential stabilizing adjustments in international grain trade among the participating nations, (4) for establishing effective interrelationships among (a) security reserves held in-country, (b) regional security reserves and, (c) world security reserves, (5) for interfacing security reserves in total with grain reserves and storage inventories maintained for other purposes, (6) for interfacing security reserve programs with national, regional, and international food policies.

Successful detailed guidelines covering all dimensions of food security reserves will be evolved through time as Asia and other regions of the world gain experience with reserve programs. This learning experience can be facilitated greatly if policy makers have access to rigorous analysis of the consequences of the various alternatives open to them. Because of the complexities and uncertainties involved, the analysis needs to be detailed and penetrating. It needs to be multi-disciplinary and international in approach. It deserves the stimulation and support of heads of state and leaders of international organizations and donor organizations. Effective analytical teams in each nation need to have an organized way to share concepts and procedures and to benefit from one another's experiences. This is the kind of effort which will produce the analysis of alternatives needed by policy makers to facilitate the first-hand learning experience in planning and operating food security reserve programs. This is the kind of effort that will hasten the development of detailed organizational and operational guidelines for food security reserves. This is the kind of effort which will support programs to achieve more effectively and economically the stability, development, and humanitarian goals of security reserves.

It is to this need that the present article, and the methodology upon which it is based, are addressed. The data, procedures, computer programs, manuals, and training programs are available to all who can use them. The methodology provides a general framework within which many alternatives can be evaluated; the evaluations can be made in more detail in those dimensions of direct concern to policy makers and grain management agencies. The analysis can be extended for projected periods into the future. It can be disaggregated to deal with sub-areas within each nation and with sub-periods within crop years. It is hoped that the analysis and findings contained herein will be viewed as a starting point for more detailed work in each country, and more complete work on a regional and world-wide basis.

## Methodology for Testing Alternatives

The methodology used to test alternative security reserve programs is based upon the historical patterns of food grain production, international trade, and utilization as they have existed within each nation over the past 18 years. Three basic procedural steps are involved. The first is to measure the needs for food security reserves by country and region. The second is to simulate the performance of alternative programs for meeting the need, had they been in operation over the historical period. The third is to measure the cost-effectiveness of the alternative schemes. A possible fourth step of cost-benefit analysis for each of the alternatives is not addressed in this study, but can be added to the methodology at any time.

The data used for the ASEAN analysis includes annual food grain supply and utilization information and aggregate human population data for each country over the period 1960 through 1977. The country-by-country food grain supply and utilization data is taken from the USDA Foreign Agriculture Circular of March 1978 and previous issues. The country-by-country mid-year total population estimates are taken from the United Nations Demographic Yearbook of 1977 and previous issues.

The complete model is described by the following steps and equations.

*I. Measuring Needs for Security Reserves*

*Step 1A* Develop supply-utilization balance sheets by crop year for each major grain in each country such that the total *supply quantity*, Q, equals the total *quantity utilized,* U:

(1A) $Q_{ijk} = U_{ijk}$,

for crop year (i), specific grain (j), and country(k).

For each ijk, total supply quantity, Q, is the sum of the quantities available from each source:

(1B) $Q = Q1 + Q2 + Q3$, where

$Q1 \equiv$ beginning inventory at the start of the crop year
$Q2 \equiv$ domestic production during the crop year
$Q3 \equiv$ net imports during the crop year (if exports of the grain of concern exceed imports, Q3 is negative).

Likewise, for each ijk, total quantity utilized, U, is the sum of the quantities absorbed by each use:

(1C) $U = U1 + U2 + U3 + Q4$, where
$U1 \equiv$ on-farm disappearance (seed, loss, animal feed)
$U2 \equiv$ total consumption for food
$U3 \equiv$ total industrial utilization
$U4 \equiv$ ending inventory at the close of the crop year

The quantities available from each specific source and those utilized in each specific use from Equations 1B and 1C are substituted into

Equation 1A to form the basic supply-utilization equation. Thus, for each ijk:

(1) Q1 + Q2 + Q3 = U1 + U2 + U3 + U4

*Step 1B* Convert the balance sheets from Step 1A to a common denominator, g, (for exampel, milled rice equivalent), by applying appropriate conversion factors for each ijk. Thus, Equation 1A becomes $Q_{igk} = U_{igk}$, and comparable translation is made for Equation 1.

*Step 1C* For cases where the concern is for reserves of *total food grains,* sum across the g's for each ik combination from Step 1B to obtain the equivalent quantities of *total food grains,* f, in terms of the common denominator, such as milled rice. Thus, Equation 1A becomes $Q_{ifk} = U_{ifk}$, and comparable summation is made for Equation 1. For cases where other types of grain reserves may be of interest, (total *feed grain* reserves, total *oilseed* reserves, total *domestic utilization* reserves, etc), corresponding summations are made for such uses other than solely for human food.

*Step 2* For the specific type of utilization of concern reorder Equation 1 to focus on the historical quantities available. For example, where the concern is food supply quantities Equation 1 is reordered for each ijk, igk, or ifk as follows:

(2) U2 = Q1 + Q2 + Q3 − U1 − U3 − U4

*Step 3* Convert the total quantities for U2 (or other utilization of concern) to the equivalent quantities available per capita over the historical period in each country. The corresponding per capita quantities in Equations 1 and 2 can be designated by the lower case q and u, respectively, and obtained by dividing these total equations through by the appropriate total human population figures, $H_{ik}$. Thus, for each ijk, igk, and ifk, the coresponding per capita quantities are defined by:

(3) q1 + q2 + q3 = u1 + u2 + u3 + u4, and

(4) u2 = q1 + q2 + q3 − u1 − u3 − u4.

Note: Accurate annual mid-year population figures are required for the conversion; source population data should be checked carefully.

*Step 4* Fit statistical time trends to the historical *per capita quantiites* of the $u_{igk}$ (or $q_{igk}$) of concern, using suitable regression equations. Thus, over the relevant historical period, a set of trend estimates, q and u, is developed for each quantity in Equations 3 and 4 which is of interest. Linear trend estimates often are suitable for the per capita quantities, but in individual cases logarithmic or exponential equations may be needed.

The trend estimates are fitted by the method of least squares to the historical quantities, estimating the per capita quantity as a function of time, i. The linear estimating equation is simply:

(5) $\hat{q}_i = a + b_i$

Other common time trend equations include the natural logarithmic functions.

(6A) $\log_e \hat{q}_i = \log_e a + \log_e b_i$,

and exponential functions,

(6B) $\hat{q}_i = a + b(i)^x$, where $\chi$ is some power greater or less than 1.0.

In lieu of time trends, more complex multi-variable estimating equations may be used to reflect such factors as anticipated changes in relative real prices of alternative food grains, and changes in the anticipated rate of growth in real per capita incomes. Even though the concern in this analysis is not with the estimates, *per se,* but rather in the pattern of deviations from the estimates, still the more complex estimators may yield more accurate results in some cases. If more complex estimators have been developed for other kinds of economic planning, then their use also for this purpose is recommended.

*Step 5* Determine for each crop year the deviations from trends in available per capita quantities. Thus,

(7) $\dot{q}_{ijk} = \hat{q}_{ijk} - q_{ijk}$, and $\dot{u}_{ijk} = \hat{u}_{ijk} - u_{ijk}$, where

q and u $\equiv$ observed quantities
$\hat{q}$ and u $\equiv$ estimated quantities
$\dot{q}$ and u $\equiv$ deviations from trend, plus or minus; ijk subscript identifies the crop year, the grain and the country, as before.

*Step 6* Convert the per capita deviations from the above step to the corresponding total tonnages for each country by applying the approppriate total population figures. Thus,

(8) $\dot{Q}_{ijk} = \dot{q}_{ijk} * H_{ik}$, and $\dot{U}_{ijk} = \dot{u}_{ijk} * H_{ik}$

*Step 7* Compute the corresponding deviations which are in excess of that acceptable were a security reserve program in operation. Thus,

(9) $\ddot{Q}_{ijk} = \dot{Q}_{ijk} - \acute{Q}_{ijk}$, and $\ddot{U}_{ijk} = \dot{U}_{ijk} - \acute{U}_{ijk}$, where

$\ddot{Q}$ and $\ddot{U}$ $\equiv$ excess deviations $\equiv$ needed annual transactions with reserves
$\dot{Q}$ and $\dot{U}$ $\equiv$ observed deviations (from Step 6)
$\acute{Q}$ and $\acute{U}$ $\equiv$ acceptable deviation levels, as determined

exogenously.

Note: Given the trend and deviation patterns, the wider the range of acceptable deviation from trend, the lower the security reserve requirement, and vice versa.

*Step 8* Define the need for annual transactions with security reserves as the tonnages, $\ddot{Q}$ and $\ddot{U}$, for each basic grain in each country each year. If such potential transactions are designated as RT, then Equation 2 (above) can be restated as:

$$(10)\ U2 = Q1 + Q2 + Q3 - U1 - U3 - U4 - RT, \text{ where } RT \equiv \ddot{Q}, \text{ or } RT \equiv \ddot{U}$$

In years when additional supplies are needed for consumption, withdrawals are made from the reserves (RT is negative), so that the sign for the last term in Equation 10 becomes +; in years when current supplies are greater than needed for consumption, additions are made to the reserves (RT is positive); in years when total supply quantities are in balance with total utilization requirements no transactions are made with the reserves (RT is zero).

## *II. Testing Performance of Alternative Security Reserve Programs*

*Step 9* Determine reserve stock levels and net reserve transactions for economic and acceptable levels of security reserves for food grains within each country over the historical test-period. For each ijk, establish realistic bounds on in-country reserve levels, and compute the possible reserve transactions subject to these bounds, as follows:

$$(11)\ RT1 = RT, \text{ provided } L1 \leq RB1 \geq M1, \text{ where}$$

$RT_{ijk} \equiv$ total reserve transactions, as above
$RT1_{ijk} \equiv$ transactions with in-country reserves
$RB1_{ijk} \equiv$ balance in in-country reserves
$L1_{ijk} \equiv$ lower limit for in-country reserve levels
$M1_{ijk} \equiv$ maximum limit for in-country reserve levels

Furthermore,

$$(12)\ RB1_t = RB1_{t-1} + RT1_t$$

This is a simultaneous computation, with RBL a function of RT1, and RT1, subject to constraints on RB1.

*Step 10* Determine the indicated residual transactions with regional reserves by each country in order to meet the targeted stability level in that country. Following Equation 11, this is done for each ijk subject to bounds on the regional reserves as follows:

$$(13)\ RT2 = RT - RT1, \text{ provided } \sum_k L2 \leq RB2 \geq \sum_k M2, \text{ where}$$

RT and RT1 are identified as above

$RT2_{ijk} \equiv$ transactions with regional reserves
$RB2_{ijk} \equiv$ balance in regional reserves
L2 and M2 $\equiv$ represent the limit on stock levels in regional reserves.,

Likewise, following Equation 12

(14) $RB2_i = RB2_{i-1} + RT2_i$

*Step 11* If residual needs for further reserve transactions to meet targeted levels stability still remain from the above step, the analysis can be extended to a still higher level of world-wide reserves, RT3 and RB3, following the procedures outlined above. Thus, corresponding to Equations 13 and 14 are:

(13′) $RT3 = RT - (RT1 + RT2)$, provided $\sum_k L3 \leq RB3 \geq \sum_k M3$, and

(14′) $RB3_i = RB3_{i-1} + RT3_i$.

These steps can be repeated for as many alternative configurations, targeted stability levels and constraint levels for reserve stocks as may be needed to support planning decisions by officials in each country and region.

*Step 12* Determine the potential adjustments in international trade to stabilize supply quantities in each country, using the relevant historical data from the above steps as base. This requires realistic determination of (1) the date within the crop year by which accurate estimates of domestic production, $Q1_i$, can be known, and (2) the time lag required for completing delivery of adjusted transactions in international trade. These two factors determine the fraction of the indicated adjustment which can be achieved during the same crop year, F1 and the fraction that will not be effective until the following crop year, F2.

Given this information, the potential adjustments in international trade are computed from the excess deviations in the hisotircal quantities of grains in each country, $\ddot{Q}_{ijk}$ from Equation 10. For each ijk, the net quantity adjustment in international trade, A, has two components, (1) the effective adjustment for the current crop year, $A1_i = F1 * \ddot{Q}_i$ plus the carryover adjustment for the previous crop year, $A2_i = F2 * Q_{i-1}$. This time lag gives rise to the possibility of additional trade adjustments to offset last year's adjustment, so that the simple adjustment equation:

(15A) $A_i = F1 * \ddot{Q}_i + F2 * \ddot{Q}_{i-1}$, becomes

(15B) $A_i = F1 * (\ddot{Q}_i + A2_{i-1}) + F2 * (\ddot{Q}_{i-1} + A2_{i-2})$, or

(15) $A_i = F1 * \ddot{Q}_i + (\ddot{Q}_{i-1} * F2) + F2 * \ddot{Q}_{i-1} + (\ddot{Q}_{i-2} * F2)$

It will be noted that as F1 approaches 1.0 (F2 $\rightarrow$ 0.0), trade adjustments approach excess deviations, except with opposite sign. As F2 approaches 0.0 (F2 $\rightarrow$ 1.0), trade adjustments may exhibit far greater frequency and amplitude than the excess deviations they are designed to overcome.

*Step 13* Define the need for transactions with security reserves after adjustments in international trade by each country. Thus, Equation 10 from Step 8 becomes:

$$(16)\quad U2 = Q1 + O2 + Q3 + A - U1 - U3 - U4 - AT,$$
$$AT = \ddot{Q} - A, \text{ where}$$

A $\equiv$ net adjustment in international trade as specified by Equation 15

AT $\equiv$ annual transactions with security reserves after trade adjustments.

*Note* that if AT = O through time, then there is no need for food security reserves if full advantage is taken of potential adjustments in international trade by each country.

*Step 14* Determine the required stock levels and net reserve transactions for each country after trade adjustments. This step parallels Step 9 so that for each ijk Equations 11 and 12 become:

$$(17)\quad AT1 = AT, \text{ provided } L1 \leq AB1 \geq M1, \text{ given}$$

$$(18)\quad AB1_t = AB1_{t-1} + AT1_t, \text{ and where}$$

AT $\equiv$ as identified in Step 13

AT1 $\equiv$ transactions with in-country reserves after trade adjustments

AB1 $\equiv$ balance in-country reserves after trade adjustments

L1 and M1 $\equiv$ limits on stock levels for in-country reserves, as in Step 9.

*Step 15* Determine the indicated residual transactions with regional reserves after trade adjustments by each country in order to meet the targeted stability levels in that country. Following Equation 13 this is done for each ijk subject to bounds on the regional reserves as follows:

$$(19)\quad AT2 = AT - AT1, \text{ provided } \sum_k L2 \leq AB2 \geq \sum_k M2, \text{ given}$$

$$(20)\quad AB2_t = AB2_{t-1} + AT2_t, \text{ and where}$$

AT and AT1 are identified as in Step 14

$AT2_{ijk}$ $\equiv$ transactions with regional reserves after trade adjustments

$AB2_{ijk}$ $\equiv$ balance in regional reserves after trade adjustments

L2 and M2 $\equiv$ represent the limits on stock levels in regional reserves, as in Step 10.

*Step 16* As in the case of Step 11, if residual needs for further reserve transactions to meet targeted levels of stability still remain from Step 15, comparable analysis can be extended to a still higher level of world-wide reserves (after international trade adjustments), AT3 and AB3, following the procedures outlined in Step 15. Corresponding to Equations 19 and 20 are:

(19′) $AT3 = AT - (AT1 + AT2)$, provided $\sum_k L3 \leq AB3 \geq \sum_k M3$, and given

(20′) $AB3_i = AB3_{i-1} + AT3_i$.

*III. Measuring Cost-Effectiveness of Alternative Schemes*

*Step 17* Compute the annual fixed costs for maintaining the required grain storage capacity for in-country security reserves. If this capacity is assumed to be committed for security reserves and not available for alternative use, the annual fixed cost is defined for each ijk as,

(21) $FC1 = RC1 * K1 * fc1$, where

FC1 is the total annual fixed cost of in-country storage facilities for security reserves.

K1 is the appropriate constant for converting from milled rice equivalent to the form in which the grain would be stored for the reserve.

fc1 is the annual fixed cost per metric ton for the in-country storage facilities.

The required storage capacity is determined directly from the in-country reserve balances given from Equation 12 by the following:

(12′) $RC1_i = RB1_i$ or $RB1_{i-1}$, whichever is greater.

The per unit total annual fixed costs for maintaining in-country reserve storage are given by the following:

(21′) $fc1 = fca + fcd + fcc + fcm + fco$, where

fca is the annual per ton costs for administrating the program, taken at \$3.00 for ASEAN.

fcd is the annual per ton facility depreciation expense, taken at \$5.00 ( \$2.50 Bldgs + \$2.50 Equip) for ASEAN.

fcc is the annual per ton charge for capital invested in the storage facilities, taken at \$7.50 ( \$125/2 × 12) for ASEAN.

fcm is the annual per ton repair and maintainence cost for the storage facilities, taken at \$2.50 [( \$150 × .02 + 100 × .02)/2] for ASEAN.

fco is the annual fixed cost per ton for other expenses of the storage facilities, taken at \$3.80 for ASEAN.

*Step 18* Compute the annual variable cost for maintaining the required grain inventory for in-country security reserves. If such inventory is held at strategic locations so that no extra handling nor transportation is required, the annual variable cost for each ijk is defined as,

(22) $VC1 = RB1 * K1 * vcl$, where

RB1 is as defined by Equation 12
K1 is as specified for Equation 21, above
vcl is the annual variable cost per metric ton for maintaining the in-country reserve inventories.

This per ton cost is given by the following:

(22′) $vcl = vcc + vcm + vco + vcs$, where

vcc is the annual per ton carrying charge for grain in security reserves, taken at \$15.30 ( \$150 × 10.2%) for ASEAN.

vcm is the annual per ton cost for quality maintenance, taken at \$4.00 for ASEAN.

vco is the annual per ton cost for operating expense, taken at \$3.00 for ASEAN.

vcs is the annual per ton cost for grain shrinkage, taken at \$1.00 for ASEAN.

*Step 19* Sum the annual fixed cost and the annual variable cost for the estimated annual total cost of in-country reserves. This is done by straight summation for each ijk as indicated by Equation 23.

(23) $TC1 = FC1 + VC1$

*Step 20* Repeat Steps 17 through 19 for the regional reserves. Annual fixed costs for regional storage facilities are given by Equation 24.

(24) $FC2 = RC1 * K1 * fc2$, where

fc2 is defined in the same manner as fcl in Equation 21′.

K1 is defined as in Equation 21.

RC1, the required regional storage capacity, is determined directly from the regional reserve balances given by Equation 14 as follows:

(14′) $RC2_i = RB2_i$ or $RB2_{i-1}$, whichever is greater.

Annual variable costs for regional reserve inventories are defined for each ijk by Equation 25.

(25) $VC2 = RB2 * K1 * vc2$, where

vc2 is defined in the same manner as vc1 by Equation 22′.

K1 is defined as in Equation 21.

RB2 is defined by Equation 14 and shown in Table 14. Negative balances by individual participating nations are charged at the same rate as corresponding positive balances in the regional reserves.

Annual total costs for regional reserves are obtained by summation as indicated by Equation 26.

(26) $TC2 = FC2 + VC2$

*Step 21* Determine the combined total costs for the regional reserve program. This is done by summing the total costs for in-country reserves and the total costs for regional reserves for each ijk.

(27) $CTC = TC1 + TC2$

*Step 22* Compare the relative total costs of alternative security reserve programs to measure the cost-effectiveness of the alterantives. The comparison varies depending upon the kinds of alternatives under analysis. Following are common examples.

The additional cost of more complete programs is obtained by subtracting the combined total costs of the two cases. Thus, for each ijk,

(28) $ATC = CTC_c - CTC_s$, where

ATC is the additional total cost.

$CTC_c$ is the combined total cost from Equation 27 for the more complete case.

$CTC_s$ is the combined total cost from Equation 27 for the more simple case.

The magnitude of cost savings between two alternatives capable of producing the same level of benefits is obtained by subtracting the combined total costs for the two alternatives. Thus, for each ijk,

(29) $STC = CTC_2 - CTC_1$, where

STC is the saving in total cost.

$CTC_2$ is the combined total cost for the second best alternative.

$CTC_1$ is the combined total cost for the best alternative.

*Step 23* Compute the costs of using adjustments in imports and/or exports to help stabilize food grain supplies in each country. This is done by applying the average total per ton extra cost for the adjustments in international trade to the calculated volumes of trade adjustment. Thus, for each ijk,

(30) CAT = AT * cat, where

CAT is the total additional cost for net adjustment in international trade.

AT is the net plus or minus adjustment in tonnage of grain imported (see Equation 15).

cat is the average total additional cost per metric ton for making the adjustment in international trade transactions. For the ASEAN case, cat is taken at \$57.69 [( \$25.00 × 1.5) /.65), assuming extra cost for trade adjustments of \$25/M/T, total adjustment of 1.5 M/T per M/T net adjustment, and average rice milling rate of 65 percent.

*Step 24* Repeat Steps 17 through 19 for the costs of in-country reserves after net import adjustments. Following Equation 21, annual fixed costs for in-country reserve storage facilities are given by Equation 31.

(31) FCA1 = RCA1 * K1 * fc1, where

FCA1 is the total annual fixed cost for the needed in-country reserve storage facilities after import adjustments.

K1 and fc1 are the same as difined in Equation 21.

RCA1 is the required storage capacity for in-country reserves, and is computed directly from the in-country reserve balances given in Equation 18 as follows:

(18′) $RCA1_i = AB1_i$ or $AB1_{i-1}$, whichever is greater.

Following Equation 22, the annual variable costs for in-country reserves after import adjustments are given by the following:

(32) VCA1 = AB1 * K1 * vc1, where AB1 is as defined in Equation 18 and K1 and vc1 are as defined for Equation 22.

Annual total costs for in-country reserves with import adjustments are computed by straight summation. For each ijk,

(33) $TCA1 = FCA1 + VCA1$

*Step 25* Repeat Steps 17 through 19 for the costs of regional reserves after net import adjustments. Following Equation 21, annual fixed costs for regional storage facilities after import adjustments are given by Equation 34.

(34) $FCA2 = RCA2 * K1 * fc2$, where

K1 and fc2 are comparable to the corresponding variables in Equation 21.

RCA2 is the required regional storage capacity with import adjustments, as given by the equation,

(20′) $RCA2_i = AB2_i$ or $AB2_{i-1}$, whichever is greater.

Following Equation 22, annual variable costs for needed regional reserve stocks after import adjustments are computed as follows:

(35) $VCA2 = AB2 * K1 * vc2$, where AB2 is as defined in Equation 20 and K1 and vc2 are as defined in Equation 22.

Following Equation 23, annual total costs for regional reserves after net import adjustments are computed by summation. For each ijk,

(36) $TCA2 = FCA2 + VCA2$

*Step 26* Determine the combined total costs for the regional reserve program with net import adjustments to help stabilize supplies in each member country. This is done by summing the total costs for adjustments in international trade, total costs for in-country reserves and total costs for regional reserves with the trade adjustments. Thus, for each ijk,

(37) $CTCA = CAT + TCA1 + TCA2$

*Step 27* Compare the costs of alternative regional reserve programs after net import adjustments to measure relative cost-effectiveness. Following the equations in Step 22, alternative comparisons can be made. For example, to compare the after-trade-adjustment cost of a more complete program with one which is less complete, the following equation is used:

(38) $ATCA = CTCA_c - CTCA_s$, where

ATCA is the additional total cost.

$CTCA_c$ is the combined total cost from Equation 37 for the more complete program.

$CTCA_s$ is the combined total cost from Equation 37 for the more simple case.

## Summary of Findings for ASEAN

The special routines for buffer-stock analysis contained in Kansas State University's "Master Projection" (MPJ) computer program were used for the analysis of alternative food reserves for the ASEAN countries.[1] The propose of the analysis was to test the performance and estimated costs of alternative ASEAN food reserve programs had they operated over the period 1960–1977. The alternatives tested include a 2 × 2 matrix, (1) rice only and (2) all food grains by (A) without and (B) with import (export) adjustments. All four include a mix of in-country plus ASEAN regional reserves, and all are capable of achieving stability in annual supplies within the targeted ±3 percent of total food requirements in each country. The total size and estimated cost of the reserve program vary from one alterantive to another.

The required grain storage capacity for reserve programs to achieve the targeted ±3 percent stability under each alternative is shown in units of 1000 M/T milled rice equivalent in Summary Table 1. Without import adjustments the required grain storage capacity would have been 4,301,000 M/T for rice and 5,129,000 M/T for all food grains. With import adjustemtns the capacities would have been reduced to 2,496,000 M/T and 3,039,000 M/T, respectively. The major reduction comes in the needed capacity for the regional reserves—from 2,867,000 M/T to 1,013,000 M/T for rice reserves, and from 3,411,000 M/T to 1,368,000 M/T for food grain

SUMMARY TABLE 1 COMPUTED RESERVE STORAGE CAPACITY

(1,000M/T milled rice equivalent)

| Alternative | 1. Rice Only | | 2. All Food Grains | |
|---|---|---|---|---|
| Location | A. Historical Trade | B. Adjusted Trade | A. Historical Trade | B. Adjusted Trade |
| *In-Country:* | *1,434* | *1,393* | *1,718* | *1,671* |
| Indonesia | 603 | 603 | 690 | 690 |
| Malaysia | 68 | 68 | 84 | 73 |
| Philippines | 143 | 139 | 173 | 137 |
| Singapore | 43 | 43 | 61 | 61 |
| Thailand | 557 | 540 | 710 | 710 |
| *Regional:* | *2,867* | *1,103* | *3,411* | *1,368* |
| Combined: | 4,301 | 2,496 | 5,129 | 3,039 |

[1] Phillips, Schruben, Tiao and Borsdorf, *User's Guide to Computerized System for Feasible Agribusiness Development* Vol. 2, Computer Programs, Food and Feed Grain Institute, Kansas State University. Revised Aug. 1979. These programs have been installed at the E.P.B. Department of Statistics Computer Center in Seoul.

reserves.[2]

Average annual utilization of the storage capacity for the security reserves would have varied as indicated in Summary Table 2. Under the adjusted trade alternatives the utilization of capacity for the regional reserves would have been nearly twice the rate of that for the historical trade alternatives. In general, the indicated rate of capacity utilization is somewhat higher for all food grain reserves than for rice reserves alone. The rate of capaicty utilization is higher for the Philippines than for the other countries under all alternatives considered.

SUMMARY TABLE 2 AVERAGE UTILIZATION OF RESERVE CAPACITY

(percent)

| Alternative / Location | 1. Rice Only | | 2. All Food Grains | |
|---|---|---|---|---|
| | A. Historical Trade | B. Adjusted Trade | A. Historical Trade | B. Adjusted Trade |
| *In-Country:* | *45.4* | *48.2* | *45.5* | *52.2* |
| Indonesia | 26.3 | 26.5 | 28.7 | 40.7 |
| Malaysia | 54.8 | 59.8 | 69.6 | 67.4 |
| Philippines | 79.1 | 88.8 | 64.8 | 75.3 |
| Singapore | 46.9 | 51.6 | 55.2 | 55.2 |
| Thailand | 63.1 | 69.8 | 60.0 | 63.1 |
| *Regional:* | *34.1* | *65.0* | *35.5* | *59.6* |

The simulated storage capacity and inventory levels for alternative 2B are shown for the five countries in Figure. The "silo" charts depict the regional storage immediately above that in country, so that the total reserve storage for each nation is indicated by the height of the total bar

SUMMARY TABLE 3 COMPUTED AVERAGE ANNUAL TOTAL FOR RESERVES

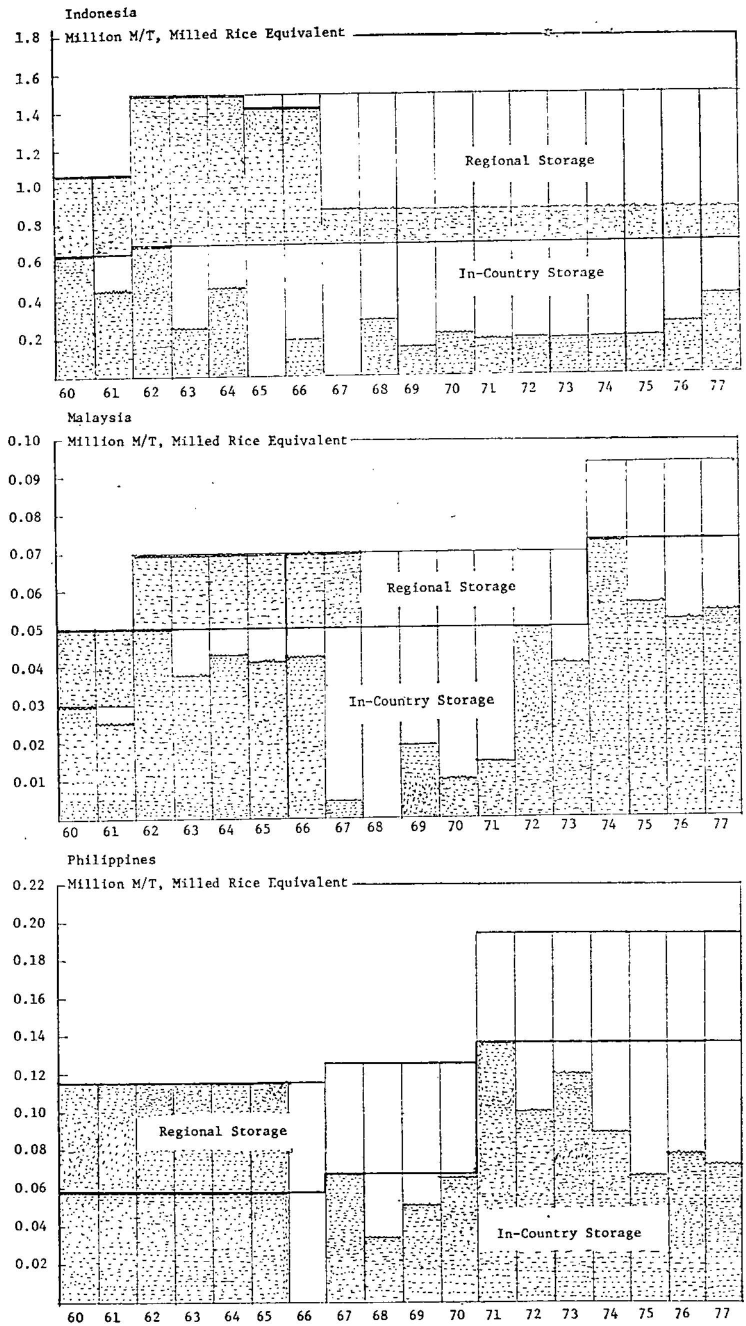
($ million)

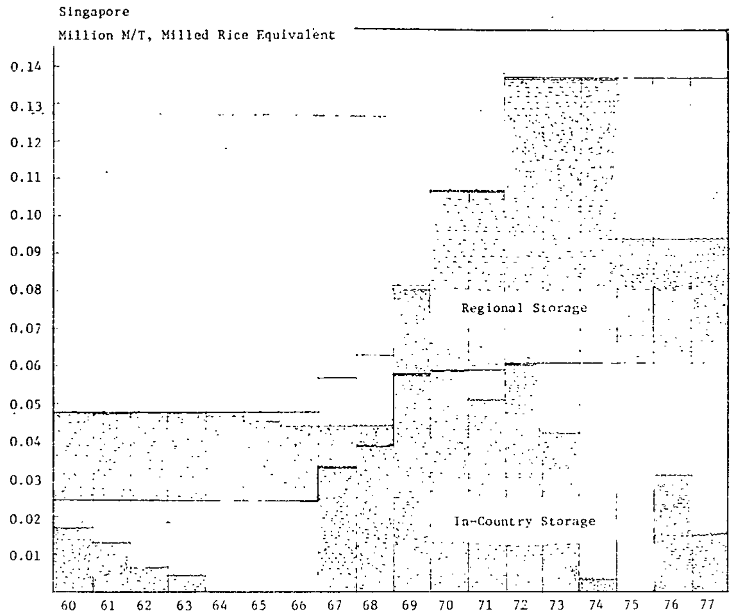
| Alternative / Location | 1. Rice Only | | 2. All Food Grains | |
|---|---|---|---|---|
| | A. Historical Trade | B. Adjusted Trade * | A. Historical Trade | B. Adjusted Trade * |
| *In-Country:* | *79.2* | *100.6* | *92.2* | *117.7* |
| Indonesia | 33.5 | 43.9 | 39.1 | 54.8 |
| Malaysia | 3.4 | 3.9 | 5.0 | 5.0 |
| Philippines | 7.0 | 9.1 | 7.6 | 8.8 |
| Singapore | 2.1 | 3.2 | 3.2 | 4.4 |
| Thailand | 33.2 | 40.5 | 37.3 | 44.7 |
| *Regional:* | *166.5* | *78.7* | *170.6* | *83.2* |
| Combined: | 245.7 | 179.3 | 262.8 | 200.9 |

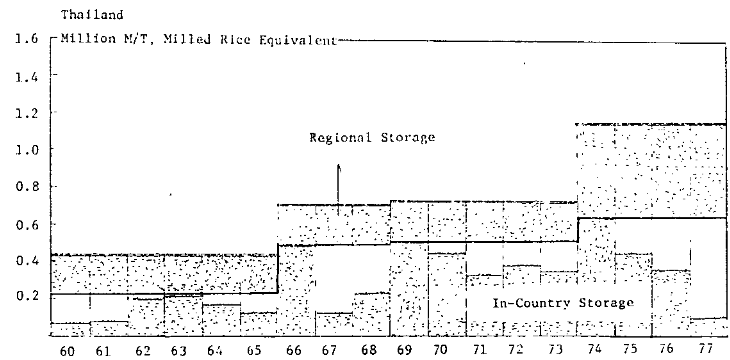
* In-Country costs include those for import (export) adjustments.

[2] It should be noted that these estimated capacity requirements are in addition to capacities required for storage from harvest to time of consumption, for normal carry-over, and for "pipeline" requirements.

FIGURE Computed Storage Capacity and Inventory for ASEAN Security Reserves (All Grains with Stabilizing Trade)






that year.

Based on uniform unit costs for grain storage facilities, inventory costs and annual operating costs, the computed average annual total costs for the alternative food security programs are shown in Summary Table 3. Under the adjusted import (export) alternatives, the in-country reserve costs include the computed costs for the adjustments. For ASEAN as a whole, the average total annual costs over the 18-year historical period would have ranged from $179.3 million for rice reserves with import adjustments to $262.8 million for all food grain reserves without import adjustments. Import adjustments reduce the total costs of regional reserves by about onehalf, but add to the total costs for the individual countries. The all food grain reserves are somewhat more costly than the reserves of rice only in all cases except the Philippines. However, such reserves are a bit more efficient, providing equal stability to the greater food consumption base.

No attempt was made in the study to measure the benefits that would have resulted from the food reserve expenditures shown in the table, but one can expect that they would have been very large. For one approach to measurement of net benefits to be expected from food security reserve programs, the reader is referred to Special Report No. 6, "Food Grain Reserves in Developing Countries," Food and Feed Grain Institute, Kansas State University, March, 1978, pages 48–63.

The methodology tested in this study, including the supporting computer programs and users manuals, is available through U.S. Agency for International Development or the Kansas State University Food and Feed Grain Institute to anyone interested. Policy makers and analysts concerned with these problems in the developing countries of East Asia and elsewhere are encouraged to contact the study sponsors directly, through KREI or through SEARCA in Los Baños, Philippines.

빈 면