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# ON MAKING EFFECTIVE USE OF AVAILABLE FOOD RESOURCES DURING TIMES OF ACUTE SHORTAGE

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## INTRODUCTION

One hopes that the worst will never happen. However, in densely populated countries with rapidly rising population, the vagaries of weather and world prices and supplies of food, fertilizer and energy make it prudent to plan for the worst. One thesis of this paper is that there are important policy issues to be addressed in effectively managing *available* food resources during severe shortage conditions. A second is that there is also important pre-planning that can be done to establish the organizational and infrastructural base required to *implement* desired crisis policies.

Effective food crisis response is a vast and complex problem requiring inputs from many disciplines and linkages to many governmental, multilateral, bilateral and voluntary organizations. We will do no more than briefly outline the overall problem here. The main focus of this paper will be on the so-called "survival models" and the role they can play both in planning for acute food shortages and in managing them as they unfold.

## THE OVERALL PROBLEM

The effectiveness of a country's response to a food crisis is determined by a number of *interrelated* issues. Some of these are:

(*a*) Quantity, quality and location of grain storage facilities.
(*b*) Adequacy of transportation facilities.
(*c*) Adequacy of port facilities.
(*d*) Adequacy of communication facilities.
(*e*) Human nutrition [nutritional status of the population (by region and income class) before the food crisis, recommended rations during and after times of scarcity, etc.].
(*f*) Regional distribution of food production (by season).
(*g*) Regional population distribution and population migration.
(*h*) Land and income distribution.
(*i*) Food distribution policies (sales policies, various rationing schemes, free distribution, food-for-work, etc.).
(*j*) Consistency of disaster plans with on-going country development plans.
(*k*) Appropriate early warning indicators for acute food shortages.
(*l*) Health care before, during, and after crisis.
(*m*) Agricultural production response to crises.

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(*n*) Overall organization for effectively mobilizing available resources (including appropriate roles for international, bilateral and various other agencies committed to provide assistance).

(*o*) Budgetary and foreign exchange considerations as they influence policy actions.

It is helpful to think about this overall problem in two parts:

(1) Planning that leads to the removal of infrastructural and organizational hindrances to effective management of food crises.

(2) Development of the strategies that effectively manage available food resources during a crisis.

The *planning* cited above can only (effectively) be done within the total system context—one is forced to consider how the entire disaster response apparatus might respond as an interrelated system to the kinds of disasters that are most likely to occur. Where are the weak links ? What specific projects are needed to remove these. This is indeed a challenging task and the question arises as to the roles that good models can play in aiding this planning process.

Development of food crisis management strategies is also a challenging task. How should available food supplies (by type) be allocated to various programmes such as market sales, food-for-work, and free distribution to particularly vulnerable groups ? How should these allocations be distributed over time and geographical location ? What price policies should apply ? How should limited health care resources be allocated ? What information is needed to rationally guide the overall crisis management process ? How *can international agencies seeking to aid afflicted countries make effective* use of their limited food resources ? These are some of the relevant questions. Again, one would ask what role good models could play in dealing with this complexity.

In what follows, we will discuss a preliminary "survival model" that addresses some of these issues. The perspective of the model will be a short-run emergency one that seeks to deal effectively with food crises as they evolve and progress over a period of 1-2 years. While it is imperative to simultaneously address the longer run problems of population control and expansion of food production, these areas are outside the scope of this paper. These latter issues have, and are, receiving much more attention than the short-run emergency questions discussed here. This model also has some (limited) capability of determining where infrastructural constraints are likely to inhibit effective response to food crises.

## DESCRIPTION OF A "SURVIVAL MODEL"

In order to begin to address these questions, a simulation model has been developed of a country undergoing a food crisis. While the model contains elements that are common to a number of countries, it does not at this time adequately represent a specific country. The purposes of this simulation exercise are to expand the understanding of the complex issues involved, to shed light on some strategies that might be more effective than others in coping with food crises, and to suggest further work that would lead to more effective planning for and management of food crises in particular countries or regions of a country. In what follows, we will present a description of the model and the results obtained from exploring several survival strategies.

To begin, we describe the country being simulated. This is a small country of 30-40 million people with slightly more than half of its people living in the urban areas. Among the most vulnerable people in the event of a food crisis are urban poor who have no strong family ties to the rural area. Another group of urban poor do have strong rural family ties and are likely to receive some food from their rural relatives in the event of a crisis either from "CARE" packages or as a result of their back-migration to the rural areas. While problems do exist in rural income and land distribution, most rural people are not nearly as vulnerable as the urban poor mentioned above. (In many developing countries there *are* significant numbers of land-poor rural people who would be vulnerable in times of food shortage.) This particular country has a perennial food deficit and annually imports about 20 per cent of domestic consumption in the form of foodgrains, by far the largest source of energy in the national diet. The government has a reasonably effective system for importing and distributing grains domestically. These government food imports and domestic releases are used to control the domestic prices of the basic foodgrains. The country has a foreign exchange problem that would restrict increased food imports in the event of a domestic crisis or increased world grain prices. Domestic grains are produced in two harvests—one occurring in early July and the other in October. The "hungry season" is then the period following the October harvest until the next harvest in July.

## BROAD DESCRIPTION OF MODEL COMPONENTS

The broad outlines of the model are shown in the diagram of Figure 1. The model disaggregates into seven major components. These are: three classes of urban consumers, rural production-consumption, market, government, and "the rest of the world."

Urban people are disaggregated into the following three categories:

Urban 1 : Low income urban people *without* strong rural family ties (the most vulnerable people in the event of a food crisis).

Urban 2 : Low income people *with* strong rural family ties.
Urban 3 : Upper income urban people.

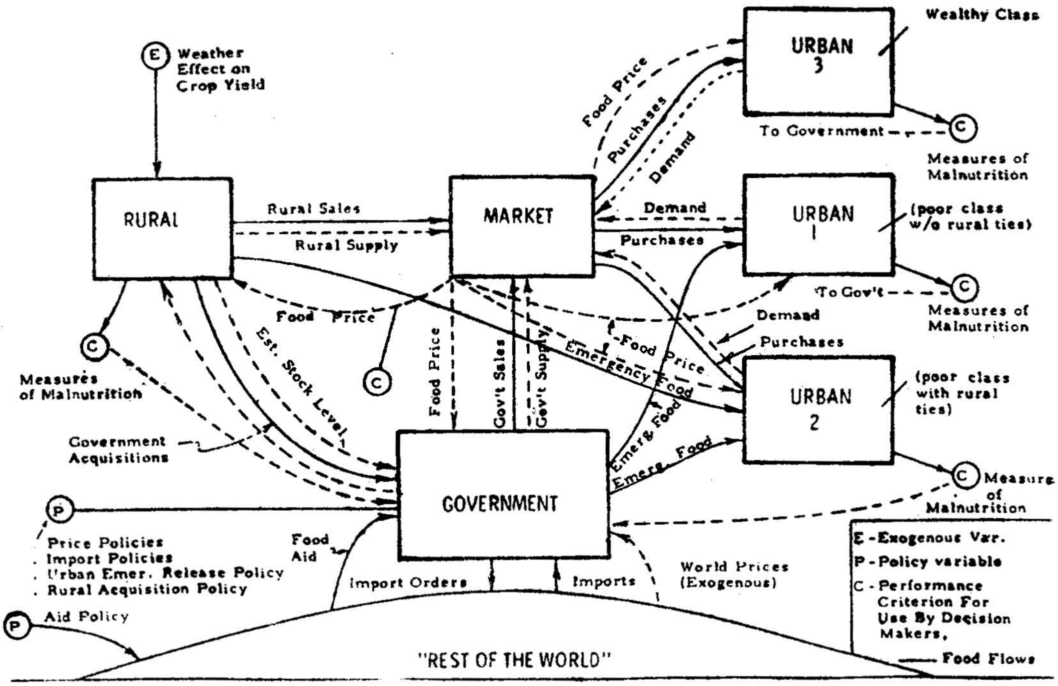


Figure 1—Broad Outlines of a Survival Model

These urban components model food storage, purchases, nutritional requirements, consumption, malnutrition, and any deaths that take place as a result of starvation. An important mechanism included here is the reduction in human food *requirements* (up to a point) that takes place as malnutrition ensures.[1]

The model has one rural component that simulates rural food production in two harvests—one occurring in July and the other in October. The model does not disaggregate by types of food and all food is reduced to grain equivalent produced at the indicated times. This component also models rural food storage, sales (as influenced by food prices and the trend of prices), consumption, food requirements, malnutrition and dealths from malnutrition. In the event of a severe food shortage, the rural component initiates transfers of emergency food to the urban relatives (in Urban 2). ("CARE" packages.)

1. Ancel Keyes, *et al.,* : The Biology of Human Starvation, Vols. I and II, The University of Minnesota Press, Minneapolis, 1950.

The market component of the model in Figure 1 computes domestic food prices over time as influenced by rural supply, government releases and demands from the three urban population groups. In the event that domestic demand exceeds supply the component gives priority to the urban consumers in Urban 3 since they are in a position to outbid consumers in the poorer urban classes.

The government component of the model performs a number of important functions. Chief among these are importation of foodgrains and releases to the domestic market which can be used to regulate internal food prices. As part of normal operations the government component also regulates reserve stock levels in their rural and urban warehouses. In the event of a food crisis the government component can take a range of actions which include expanded demand for food imports, emergency food distribution to needy groups, and pervasive food rationing which includes emergency acquisitions in the rural areas and widespread emergency distribution to the needy in the urban areas. Government actions in the model are constrained by budget limitations, time lags in transactions affecting flows of food, and time lags and errors in the information systems providing inputs to decision processes. While not simulated in great detail, "the rest of the world" component in Figure 1 performs some important functions. Firstly, it is the source of imported food which flows back to the ordering country after appropriate time lags modeled by this component. These lags represent delays in processing import orders and in transporting grain to the ordering country. The "rest of the world" component is also the source of emergency food aid in the event of a crisis. The user of the model can explore the impacts of a number of alternative policies which determine the amount and timing of emergency food aid. This component is constructed to permit evaluation of impacts of aid from large donors and private aid coming from many small contributors.

Readers wishing more details on model structure may consult a paper by this writer.[2]

## SOME RESULTS FROM THE SURVIVAL MODEL

At this point we'll describe some results obtained from model experiments. These experiments explore alternative domestic and international strategies for aiding the country undergoing a food crisis. While the model was subjected to extensive tests for reasonableness and logical consistency, it does not, at the present time, adequately represent a specific country. It does, however, raise important questions and indicates further directions for work which can lead to specific applications.

All the simulation experiments to be described assume that the country undergoes a food crisis described as follows:

2. T. J. Manetsch, "On the Role of Systems Analysis in Aiding Countries Facing Acute Food Shortages," *IEEE Transactions on Systems Man and Cybernetics*, Vol. SMC-7, No. 4, April, 1977.

The country enters a calendar year beginning January 1 ($t = 0$) with an internal food deficit. Further, restrictions make it impossible to expand regular imports to fill this gap. In the normal course of events food becomes very scarce in the 2-3 months preceding the coming harvest in July and large-scale starvation ensues. It is further assumed that adverse weather reduces the size of the July and October harvests somewhat, so the food crisis continues into the next calendar year. The simulation experiments to be described follow the unfolding situation from January 1 of the first year through March of the following year. Expansion of imports is restricted through this entire period and the country must rely on its own food resources, limited imports and international emergency aid (if any). The population is assumed to be reasonably well fed at the onset of the crisis.

The first simulated results are shown in Figure 2. Here two broad domestic policy options were explored. In each case several simulation runs were made for several levels of initial rural food stocks (the major source of reserves in the event of crisis). This effectively makes it possible to investigate food crises of varying severity. In both policy examples there was no international food aid available to the country. The first policy is an attempt on the part of the government to keep food flowing to the vulnerable poor by using its limited releases to keep prices low. This works well until stocks become low and food prices soar. Figure 2 plots deaths from starvation over

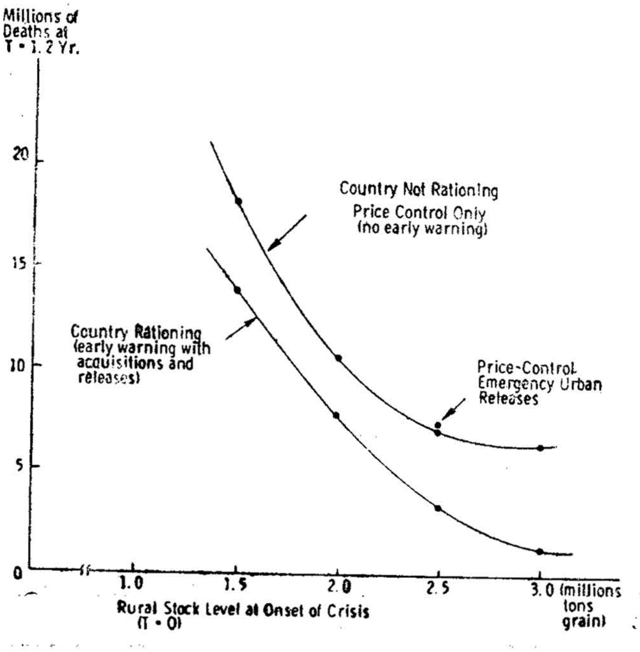


Figure 2—Deaths from Starvation as Influenced by Rural Stock Levels at Onset of Crisis (Country Rationing and Not Rationing)

the course of the 1.2 year simulation run and these are seen to be high even at initial rural stock levels of 3 million metric tons. With this quantity of rural storage it is nearly possible to feed the entire population without malnutrition if food is properly distributed. Model results with initial rural stocks at 4 million metric tons indicate a normal situation with food prices under control and no starvation.

The question arises—Why not use some of the available government stocks to provide emergency aid to the starving poor? Several simulation runs were made to explore this option and the results were generally worse than the "price control only" policy as indicated by the single point in Figure 2. In analysing these simulation results it was clear that: (1) the quantities of food available for distribution to the poor were too small to have a substantial impact on starvation, and (2) withholding food from the cash market caused more rapid price increases (due to the demands of wealthier urban people) which reduced rural supply due to speculative behaviour. (Note that rural supply in the model, while responding positively to high prices also is depressed if prices are *rising rapidly*.)

The other policy option explored in Figure 2 is nation-wide rationing based upon an early warning that a crisis is ensuing. In this example, rationing began early in the year—as soon as the crisis had been detected. The rationing policy in Figure 2 resulted in substantially fewer deaths for all levels of crisis. This is due primarily to more uniform food distribution across the population but also to *reduced nutritional requirements* due to spreading of the nutritional debt more or less uniformly across the population. It is extremely important to note that rationing was an effective policy measure *only* when initiated early by a warning indication of food shortage. This indication was based upon estimates of stock levels and supplies and demands likely before the next harvest.

## EXPLORATION OF IMPACTS OF INTERNATIONAL AID

In the model tests to be described, the domestic situation is similar to that assumed above:

(1) Domestic food stocks are low at the beginning of the calendar year. Rural stock levels are at 2.5 million metric tons as of January 1 ($t = 0$).

(2) Government food imports are restricted as in earlier simulation runs.

In the simulation experiments, different *levels* and *timings* of international food aid were explored for their impacts in easing the adverse effects of the food crises. These international policies were examined under the two broad domestic policy options—country rationing and country not rationing. In both cases it is assumed that the food aid is channelled through the government system and distributed according to the prevailing government policy.

The second graph of Figure 3 assumes that there is country-wide rationing as described in connection with earlier simulation runs. International food aid is varied between zero and one million metric tons (about double the domestic shortage at the beginning of the calendar year), and all aid is initiated at t = .3 years which makes it available when needed most—just prior to the July harvest. From this graph it is seen that the first several hundred thousand tons of aid have a marked influence in reducing deaths from malnutrition. Graph 1 of Figure 3 explores the same issue in the case where the country is *not* rationing but relying upon the price control policy described earlier. Clearly international aid is not as effective in this case in averting deaths due to starvation. This is due mainly to the fact that relatively little aid is getting to the people in need and the overall food requirements are higher as explained above. Figure 3 also shows that for large inputs of foreign food aid more deaths are averted when the country is not rationing. This is simply due to the fact that more people are in danger of starvation in this case—the "rationing" policy will result in fewer deaths in any event.

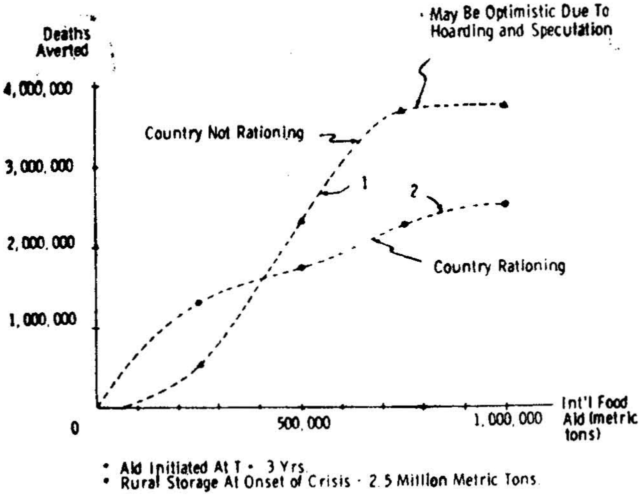


Figure 3—Deaths Averted as Influenced by Quantity of International Food Aid

A number of simulation runs were made to study the question of appropriate *timing* of international food aid. Interestingly, it was found that there is an optimum *time* for the international donor to initiate its emergency shipments. For the case described above, aid initiated at t = .3 year (about mid-March) was most effective in reducing deaths due to starvation. This was generally true—country rationing or not.

One might well ask why aid initiated too early results in higher death rates. The results displayed in Figure 4 will help explain this behaviour that has been observed in the computer model. (In this figure it is assumed that the country is pursuing a price control policy and no rationing.) In (A) of the figure are plotted deaths and food prices for the case of earlier international aid (initiated at t = .15 year). As seen, with the help of international aid, food prices are kept in line and deaths largely averted until about t = .8 years. Then, things get out of control and in excess of 6 million deaths result. In (B), with essentially the same quantity of food aid (about 1.1 million metric tons) arriving later, prices rise much earlier and then come under control as international food aid flows into the domestic market after t = .3 years. In the latter case, there are early deaths (about 2.5 million of them) but in the longer run, total deaths do not rise above this figure.

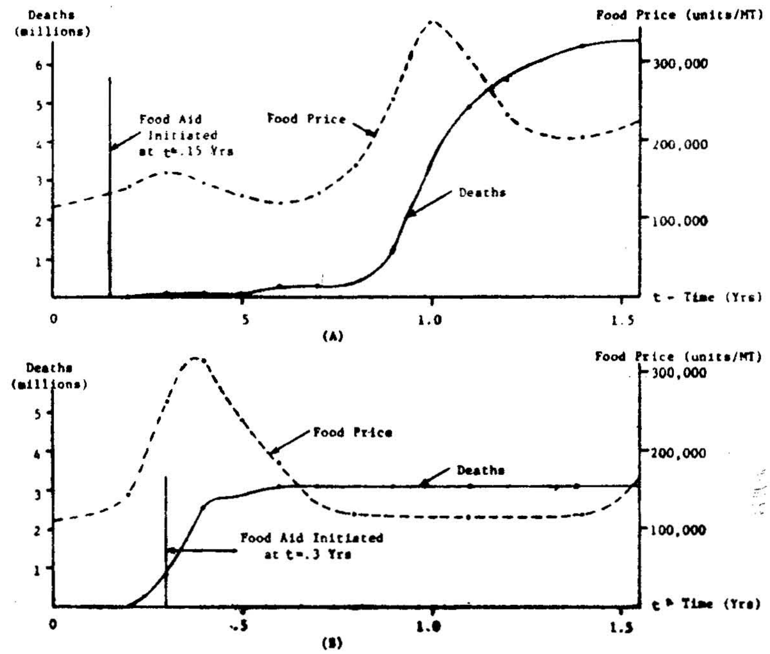


Figure 4—Analysis of the Effects of Early International Aid

How do we explain this difference in behaviour? At least two factors are at work to reduce total deaths in case (B). Firstly, with later international aid, many people in the population are forced to "tighten their belts" early. As discussed, this reduces their physiological requirement for energy and makes for more efficient use of the available food supply. More importantly in this case, the 2.5 million early deaths in (B) increase the quantity of food available for many other vulnerable people later in the crisis. In (A) these 2.5 million people (and many others) subsequently die.

These results also have implications for government policies other than the "price control" option above. They suggest, for example, that the timing of domestic emergency releases should be studied carefully as a means of making effective use of limited food supplies. Clearly, this matter of timing of food aid is extremely complex. Decision-makers require the expert judgements of nutritionists and others in making these decisions.

The final model test results to be reported here involve exploring the impacts of private food aid coming from many small donors. It is assumed that 200,000 private donors contribute an average of $ 25 for food aid, that this money buys grain at world prices that is shipped to the country in need at an appropriate time (t = .3 years) and distributed by government according to prevailing policies. It is assumed in these experiments that the domestic food crisis is as described above and that the country receives no other international aid. Results are tabulated as follows for the cases of government rationing and government not rationing:

| Government policy | Value of private aid | Deaths averted | $ per death averted |
|---|---|---|---|
| Not rationing .. .. | $ 5.5 million | 76,000 | $ 67 |
| Rationing .. .. | $ 5.5 million | 262,000 | $ 19 |

Space does not permit further dicussion of simulation results. Other key areas which could be pursued include additional food distribution strategies and study to determine where transport lags and information lags and errors can adversely affect food distribution strategies.

## CONCLUSIONS

A survival model has been discussed which addresses the questions of food supply management during times of acute shortage. While the model at this point does not adequately represent any one particular country, it illustrates that there are some complex issues to be addressed and that some policies can be much better than others in making effective use of available food and reducing starvation and human misery.

The results indicate that there are benefits to be gained by further development of suvival models for *particular countries or regions* which face the possibility of famine. There are clearly a number of country-specific issues that must be addressed on a country-by-country basis. Among these are regional differences in food supply and demand, the distribution of income and land, the existing food distribution system, the existing communication system and the existing governmental structures. In this case it seems apparent that *if kept in perspective* good models can on a country specific basis:

(*i*) Aid in the development of policies that will make more effective use of available food during a crisis.

(*ii*) Substantially define the variable set that must be measured in order to implement desired policies. (Of key importance here are variables used to synthesize early warning indicators, measures of malnutrition for various population groups, and current stock levels in various areas.)

(*iii*) Aid in determining data specifications for various variables to be monitored (including acceptable time lags and errors).

(*iv*) Aid in determining infrastructural bottlenecks that need to be removed for effective response to large-scale food shortages.

There is also need for models which address the problems of international agencies as they face the problem of allocating scarce food among a number of needy countries.

Given broad policies for dealing with food crises, there is also need for systems for their effective *implementation.* Included are information and communication, transport and health delivery systems. Mayer[3] and Masefield[4] develop a strong case for these and model results can underscore the importance of adequate information and transportation systems. These are challenging system-design problems requiring simple solutions compatible with many aspects of the milieu presented by individual countries.

In the broader context, there is much more to be done to address the overall problem of planning and crises management discussed at the beginning—models simply cannot provide all the information and analysis needed. Several cases in point: experts in human nutrition need to be consulted in the specification of diets and dietary allowances, crop forecasting needs to be included in early warning indicators, specialists in food distribution need to identify organizational and other problems inhibiting timely food distribution, the *overall* organization of the crisis management system must be carefully designed and an appropriate information system established. Current government contingency plans are an excellent basis from which to work. The above is asking: "What more can modern technology offer ?"

In all, these are large efforts involving many disciplines. It is clear that agricultural economists have much to offer along with professionals, for example, in nutrition, system science, health, transportation, and management.

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3. Jean Mayer, "Management of Famine Relief," *Science*, Vol. 9, May, 1975.
4. G. B. Masefield: Food and Nutrition Procedures in Times of Disaster, FAO (United Nations) Nutritional Studies, No. 21, Food and Agriculture Organization, Rome, 1967.