SIMULATION OF FOOD GRAIN STORAGE MANAGEMENT SYSTEM IN BANGLADESH

B.K. Bala *M.A. Satter*

Departmrnt of Farm Power & Machinery
Bangladesh Agricultural University
Mymensingh, Bangladesh

and

Md. Golam Mohiuddin

Department of Industrial and Production Engineering
Bangladesh University of Engineering and Technology
Dhaka, Bangladesh.

ABSTRACT

A system dynamics model of food grain storage, govt. procurement and release, and import in Bangladesh is presented. The simulated results of the model for govt. procurement and release, and import policies are also presented. Finally, the policy implications of the model are discussed.

INTRODUCTION

Bangladesh is a food deficit country and the deficit is met up by import and food aid. Major foodgrains are rice and wheat. The supply of the foodgrains has a profound effect on the movement of the price of the foodgrains over time. The price is lowest at the harvest and then gradually increases with storage time until the next harvest. Such fluctuations have serious impacts on farmer's income and production. Small farmers need cash just after harvest and can not hold the grain for a long time. Hence, they are likely to be more affected by the seasonal fluctuations of the price. Government procurement of the grain at a high price just after harvesting can help to prevent the large amplitude of the fall in price. This procurement immediately after harvest stabilizes the price, encourages production, prevents smuggling across the border and ensures adequate supplies of foodgrain (Islam 1980). Again the supply of foodgrain through rationing system at a subsidised price will stabilize price and provide consumer welfare etc. Thus, an effective procurement and release of the foodgrains can iron out the seasonal variations of price and provide consumer welfare by correcting influence on income distribution. Hence an analytical tool is of vital importance for the foodgrains management system essentially consisting of procurement and release, storage and import of grains.

Islam (1980) discussed the foodgrain procurement, input subsidy and the public food distribution system in Bangladesh. The salient features of the policy package are the procurement of foodgrain by the government at fixed prices during the harvesting season, the provisons of subsidies for important inputs like irrigation and fertilizers and the distribution of foodgrains to consumers at a price lower than the market prices. He provides an overview of the various aspects of the policy package. Furthermore, he suggested for effective procurement of cereal grains immediately after harvest at a price sufficiently high level. He maintained that the time series data does not show any relation between quantity procured, level of gross production and market procurement price relatives . The procurement policy has not been very much successful in reducing seasonal fluctuation of price.

Alamgir and Berlage (1973) used time series data to analyze the foodgrain demands in Bangladesh over the period 1950/51 to 1968/69 and to make projections for the future. They used their projections to calculate import requirements and market price of local rice that would occur if the productions were not realised. They also maintained that it is desirable to build a substantial stock of foodgrain both through local procurement and import in order to avoid unusally large fluctuations in rice price due to fluctuations in rice production.

Berlage (1973) developed a dynamic programming model to design foodgrain import and storage policy in Bangladesh. The model is essentially a multistage one in time period with each period consisting of beginning stock, import ordering, production, local procurement and release from the system.

Gibson (1978) developed a general system simulation model for foodgrain sector in Korea and used the techniques from various disciplines such as system design, economics, operations research, linear and non-linear systems and automatic feedback control theory. The model itself is a non-linear dynamic system model that has time varying parameters. The model was developed for use as an on-line tool for government decisions regarding price, stock, storage and trade of grain.

Shahabuddin (1987) developed an econometric model of the public foodgrain distribution system in Bangladesh. He analysed the impact of different production Scenario on market price, ration offtake, internal procurement, import and total consumption. He also explored the impact of ration price, ration quota and share of rice in the total ration distribution on market price of rice and food grain consumption. The model does not consider the short term scenario and the seasonal effects. The model developed by Shahabuddin is linear and does not include time lag. Bala et al (1990) developed a system dynamics model of food grain procurement, release and import in Bangladesh. The model of Bala et al does not consider the scenario of different production levels, and policy implications of local procurement and release rates on market price and consumption.

The purpose of this paper is to present a system dynamics model of food grain procurement, release and import system in Bangladesh and to analyse the impacts of different production scenario and to explore the policy implications of local procurement and rationing on market price and consumption.

A BRIEF DESCRIPTION OF FOOD GRAIN STORAGE SYSTEM IN BANGLADESH

In Bangladesh foodgrains are stored by the farmers to meet their own consumption and for seeds. The produce thus retained is estimated to vary from 10 to 100%. The average retention is about 70% of the produce (Mohiuddin 1988). Foodgrains are handled either in containers or in bulk. The container in Bangladesh is the jute bag whereas the bulk grains are stored in silos and bins (dool, berh, gola etc.) 90% of the available storages are in bulk.

There are about eight different types of storage systems at farm level use in Bangladesh. Among these, dool, berh and gola are the common types of storage systems. Dool is a closed bottom bamboo structure normally cylindrical in shape and it is kept on a platform. The capacity of a dool varies from 240 to 450 kg. The berh is essentially an oval shaped dool and it is made of woven bamboo. Its top and bottom ends are open and are generally placed above a wooden or bamboo platform. The capacity varies from 700 to 1200 kg. Gola is made of bamboo generally cylindrical or rectangular in shape. It may be indoor or outdoor type. The roof of a outdoor gola is made of corrogated tin or thatched. Its capacity varies from 4000 to 40,000 kg (Bala 1989).

Public foodgrain storage system includes local supply depots 'LSD' (at the rural and district urban areas), central storage depots 'CSD' (at regional level) and bulk silos (at port and national level). Local supply depots and central storage depots are flat type of godowns where foodgrains are stored in jute bags (Mohiuddin 1988).

The food deficit in Bangladesh is met up by large imports. The average annual import of foodgrain in the last few years was about 2.2 million tons (Mohiuddin 1989). To handle the imported and internally procured food grain and to develop a food security stock as against natural calamities, the public distribution and storage system has been developed in Bangladesh.

MODELLING OF THE SYSTEM

Food grain storage management system in Bangladesh is a complex socio-economic system and the modelling of such a complex system is a formidable challenge. System dynamics is the most appropriate technique to handle such a complex system. To simplify the presentation of the model, a verbal description is followed by causal-loop diagram.

The rural storage stock is increased by production of grain and depleted by the consumption and local procurement. The government stock is increased by procurement and import and depleted by release for sale. It is postulated that the amount procured depends both on domestic production and the procurement price relative to market price. The ration quantity is assumed to depend on govt stock and ration price relative to market price.The stock for sale is depleted by consumption. Available food supply from rural stock and govt. stock would determine the open market price and hence the per capita consumption. The per capita food consumption influnces the death rate. Procurement and release policies are of vital importance for stabilization of price and to provide a minimum subsistence amount of food for consumption.

Again, food grain production is seasonal and weather conditions influnce the production. Hence a buffer stock is needed to even out the fluctuations of price. However, there should be a security of food grain against the natural disasters. For reasons of national security and to assure adequate buffer stocks for seasonal price stabilization, it is necessary for the government to maintain reserve stock at some minimum level. The govt. reserve stock should not dwindle below minimum acceptable levels regardless of procurement and release of foodgrains. Shortage of food grain is to be met up by import. There will be some delay in ordering and receiving of the food grains. The grains on order will be equal to the amount ordered minus the amount delivered to govt. stock. The order should be placed well ahead of the time i.e. when the govt. stock is equal to the secuirity stock plus the amount required for consumption during lead time. The lead time requirement is computed from predicted three month's consumption minus expected production over this period. When it is negative no import is needed. A computer model based on system dynamics methodology of Forrester (1968) was developed to explore the dynamic interrelationships among production, procurement, import, ration offtake, market price and consumption. The flow diagram of the foodgrain management system is shown in Fig. 1. The model was programmed in professional DYNAMO.

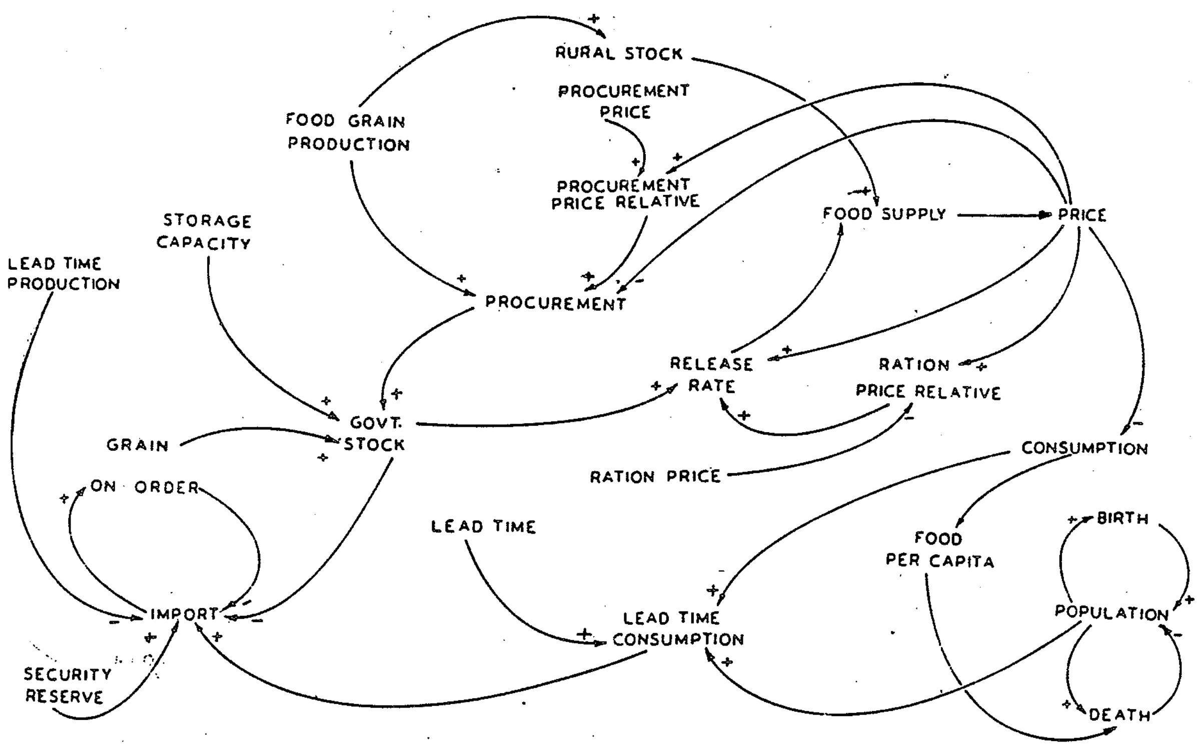

FIG. I CAUSAL LOOP DIAGRAM OF FOOD GRAIN PROCUREMENT RELEASE AND IMPORT SYSTEM IN BANGLADESH.

SIMULATED RESULTS AND DISCUSSIONS

Basic mode

The model was simulated for local procurement based on production and procurement price relative to market price, release rate based on govt. stock and ration price relative to market price, and govt. inport order based on lead time requirement plus security reserve for a simulation period of 35 months starting from January, 1989. The starting food supply is 1.275 million tons and the govt. stock is 0.725 million tons. The security reserve is assumed to be 1.5 million tons.

Simulated food supply, govt. stock and market price are shown in Fig. 2 for a period of 35 months starting from January, 1989. Considerable fluctuations in the supply of food grains are mainly due to the seasonal pattern of crop production and these fluctuations are left even after internal procurement of the grains. Govt. stock fluctuation is considerably low and the dynamic behaviour of the govt. stock gives a measure of the storage capacity required. The simulated results in Fig. 2 gives an indication of the storage capacity of 3.75 million tons. The simulated govt. stock increases with time because of the food requirement for increased population and the requirement of price stabilization to provide consumer welfare. However, the price fluctuation does not die out with time but the amplitudes of the fluctuation are considerably low.

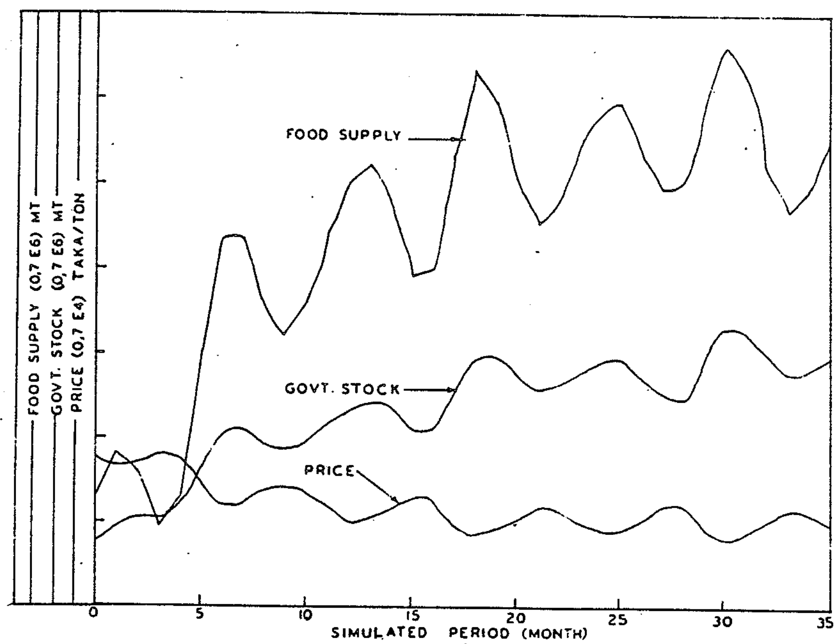

Fig. 2. Simulated food supply, govt. stock and market price : basic mode.

Simulated population, food percapita ratio and the imported foodgrain receiving rate are shown in Fig. 3. The fluctuation of food percapita does not die out with time but the amplitudes of the fluctuations are considerably low. This assures uniform consumer welfare throughout simulated period. Again, the foodgrains arriving at the ports are to be handled timely and speedily to avoid any price instabilization and food crisis. Simulated results indicate that Bangladesh ports should have an annual unloading capacity of about 2.4 million tons. Mohiuddin

(1989) suggested that Bangladesh ports should have a minimum annual unloading capacity of 3 million tons at both Chittagong port and Mongla port. Thus, the simulated result agrees well with the suggested unloading capacity required.

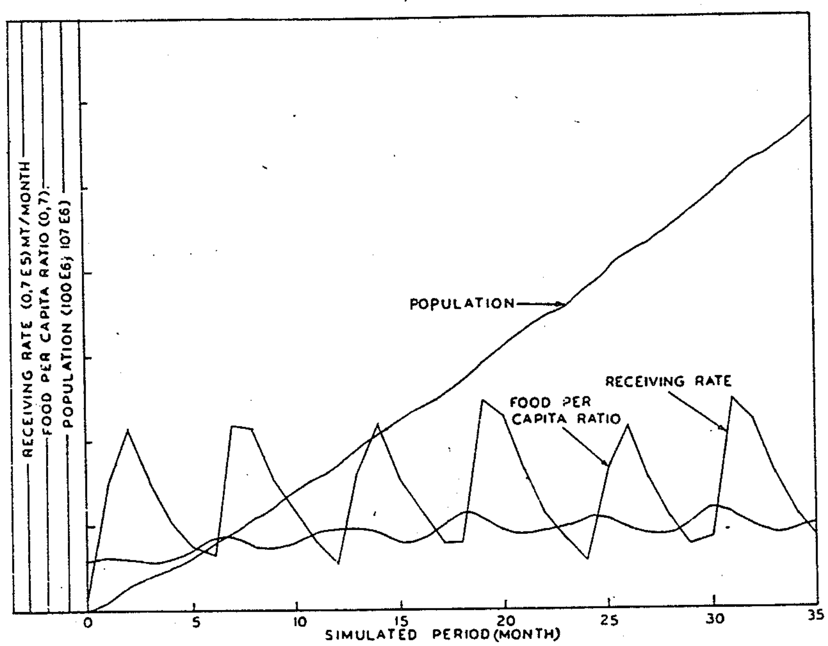

Fig. 3. Simulated population, food per capita ratio and imported foodgrain receiving rate : basic mode

Policy planning mode

The model was also simulated to demonstrate the potentiality of the model for policy implication for ± 25% increase of food production levels, procurement fraction, release fraction, and both procurement and release fractions. The starting conditions are assumed to be same for all the cases as in the basic mode.

Fig. 4 shows simulated food supply, govt. stock and market price for ±25% increase in the levels of food grain production. A reduction of 25% food grain production causes about 40% increase of price from the basic run shown in Fig. 2 while an increase of food production of 25% results about 20% reduction in market price. Shahabuddin (1987) also reported similar results. The low level of market price has resulted from poor procurement and this may affect the farmers seriously. The high level of market price is mainly due to the shortage of food grain. However, the patterns of the price fluctuations are similar in both the cases. The food supply and govt. stock are large for 25% increase of food production in comparison with those for 25% reduction of food production. But, the govt stock is larger for 25% increase of production than the food supply for 25% decrease of food production.

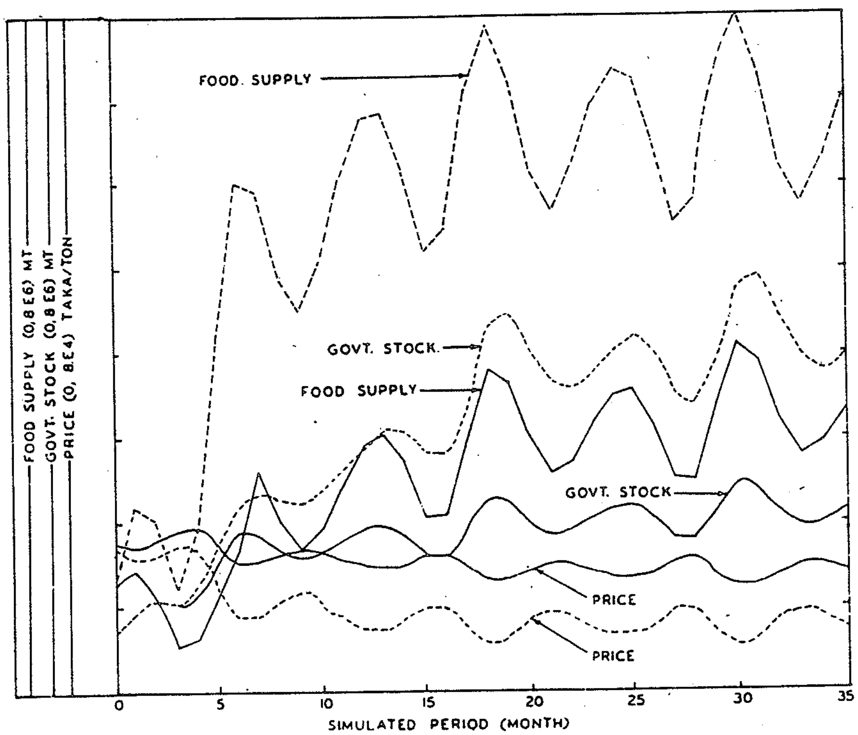

Fig. 4. Simulated food supply, govt. stock and market price : policy planning mode, ——— 25% reduction of food production and ...... 25% increase of food production level.

Fig. 5 shows simulated population, food per capita ratio, and imported grain receiving rate. A reduction of 25% crop production causes 25% reduction in consumption which results a decrease in population while an increase of 25% food production causes 25% increase in consumption which results an increase in population. The imported grain is still higher in the years of good harvest. This is mainly due to the poor level of internal procurement that can not satisfy the minimum requirement for food reserve.

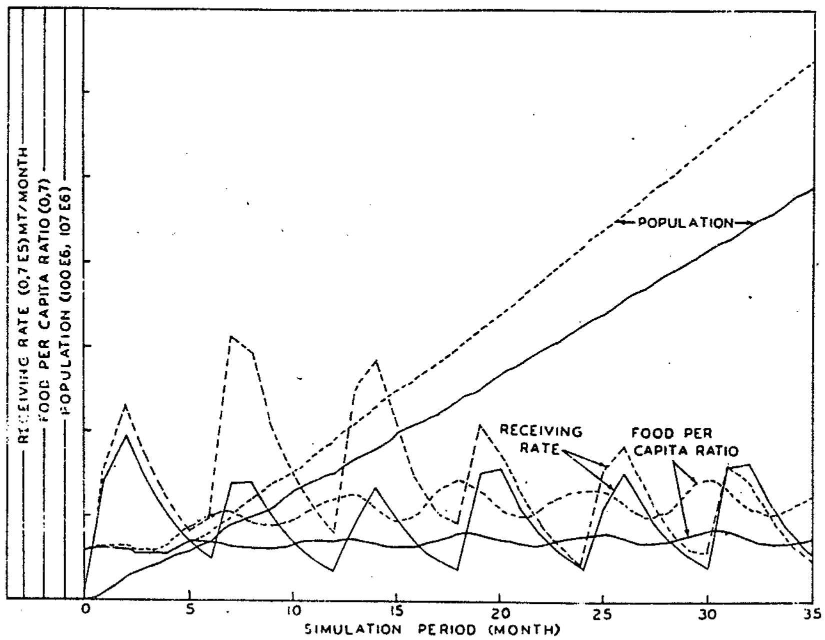

Fig. 5. Simulated population, food per capita ratio and imported foodgrain receiving rate : policy planning mode ; ——— 25% reduction of food production level and .... 25% increase of food production level.

Fig. 6 shows simulated food supply, govt. stock and market price for ±25% increase of procurement fraction. The price is slightly higher for 25% increase of procurement fraction but very close to each other. The govt stock is higher for 25% increase of procurement fractions than those for 25% decrease of procurement fraction. But the case is reverse for food supply. The slightly higher price is mainly due to the relatively higher reduction of rural stock in comparison with the amount of grain released through rationing system.

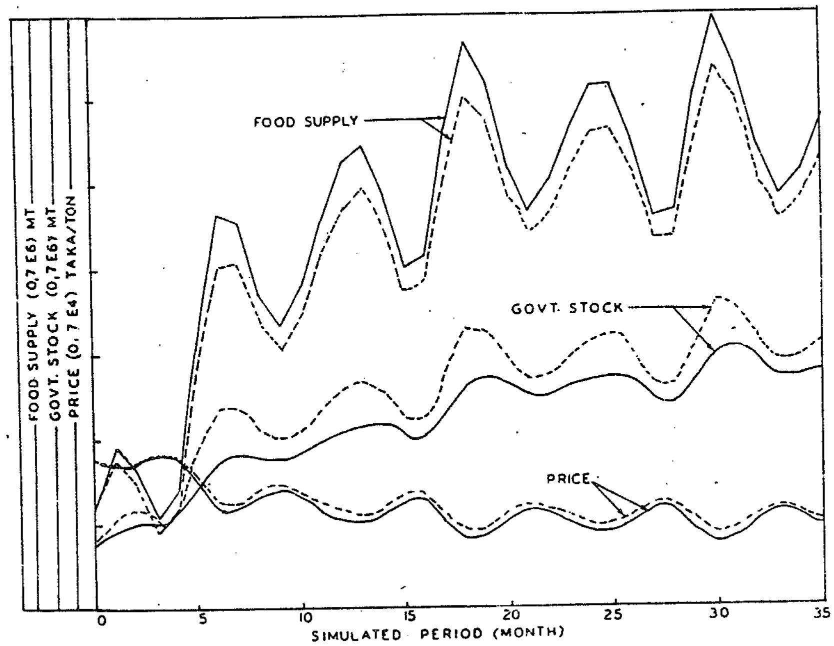

Fig. 6. Simulated food supply, govt. stock and market price : policy planning mode ; ———— 25% reduction of procurement fraction and ...... 25% increase of procurement fraction.

Fig. 7 shows simulated population, food per capita and imported grain receiving rate for ±25% increase of procurement fraction. The per capita consumption is almost equal for both cases. The imported grain is considerably lower for increased procurement because of the fact that the food reserve is maintained using a greater proportion of food from local procurement. The population changes are also almost equal for both cases because of the almost equal per capita food consumption.

Simulated food supply, govt. stock and price, are shown in Fig. 8. for ±25% increase of release fraction. Food supply is larger for 25% increase of relaesed fraction. But the case is reverse for govt stock. Higher release causes higher depletion of the govt. stock resulting high level of food supply. The market price is slightly higher in case of reduced release fraction. However, the difference between the prices for both the cases are very small.

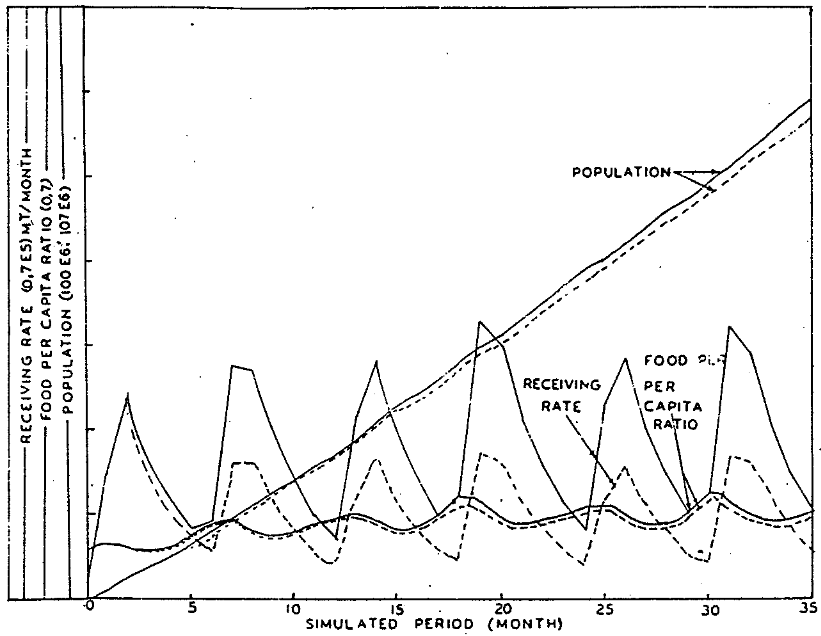

Fig. 7. Simulated population, food per capita ratio and imported foodgrain receiving rate : policy planning mode; ——— 25% reduction of procurement fraction and ...... 25% increase of procurement fraction.

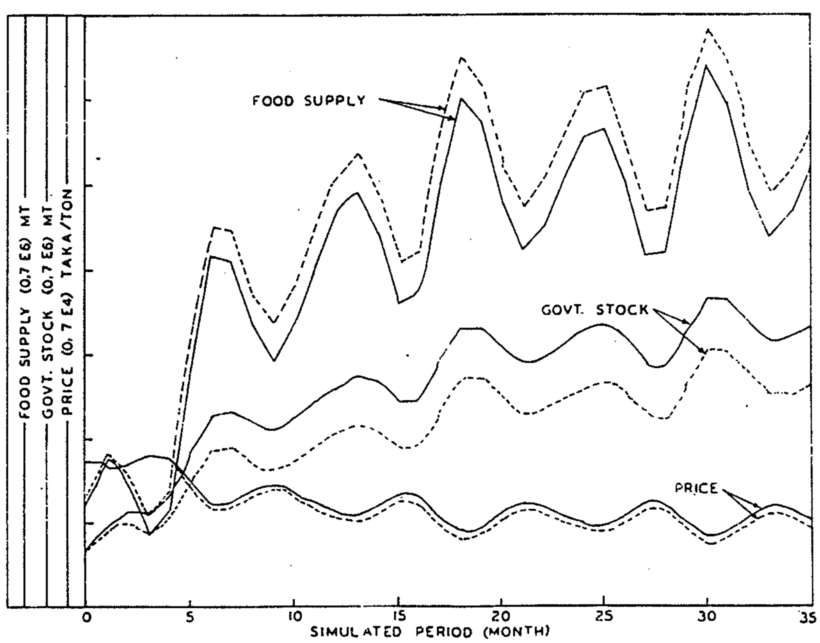

Fig. 8. Simulated food supply, govt. stock and market price : policy planning mode ; ——— 25% reduction of release fraction and ...... 25% increase of release fraction.

Simulated population, food per capita and imported grain receiving rate for ±25% increase of release fraction are shown in Fig. 9. Per capita food consumption is almost same for both cases. But higher amount of imported grain is required for increased release fraction to maintain the security reserve and the food consumption level. The population is almost same for both cases.

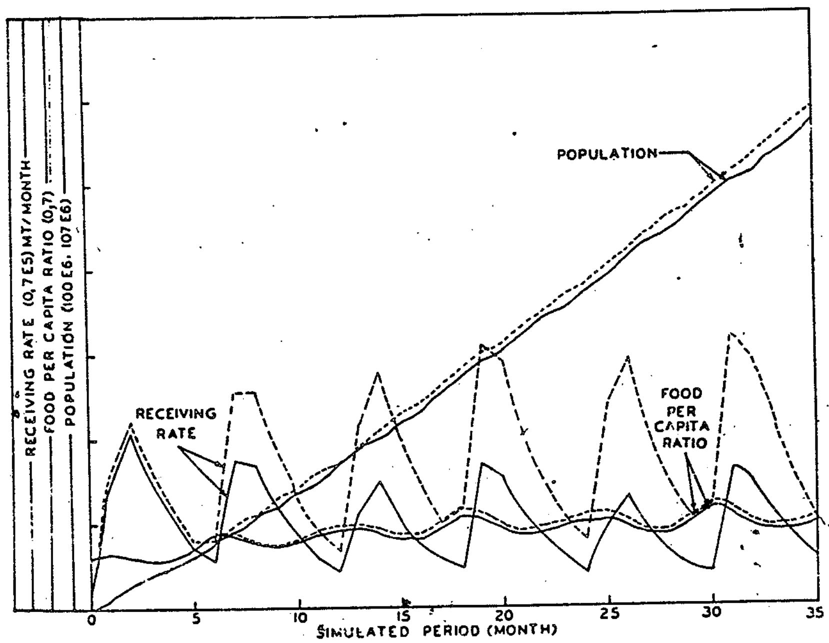

Fig. 9. Simulated population, food per capita ratio and imported foodgrain receiving rate : policy planning mode ; ——— 25% reduction of release fraction and .... 25% increase of release fraction.

Simulated food supply, govt stock and market price are shown in Fig. 10 for ±25% increase of both procurement fraction and release fraction simultaneously. The price is almost same for both cases. The differences in the levels of govt. stock and food supplies are also small.

Simulated population, food per capita and imported grain unloading rate for simultaneous ±25% increase of both procurement fraction and release fraction are shown in Fig. 11. These are almost same in both the cases.

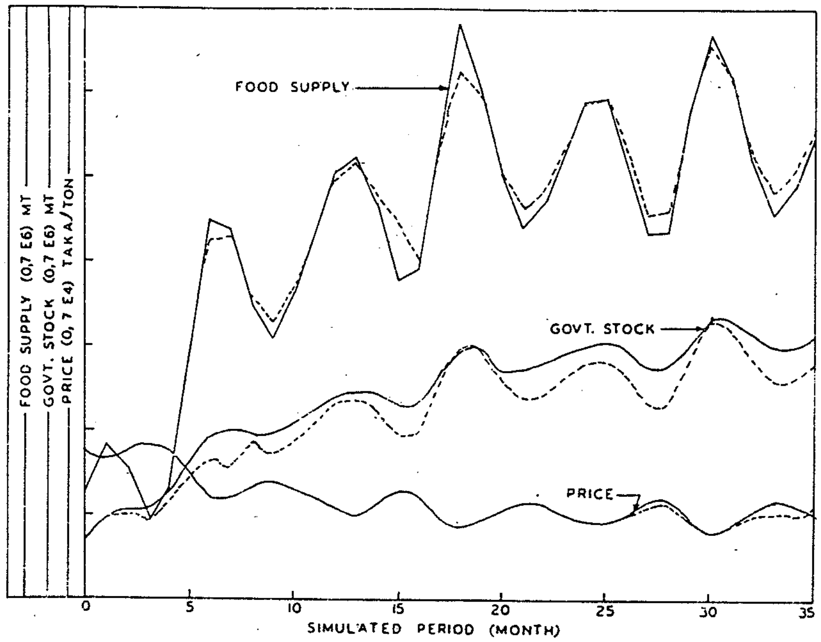

Fig. 10. Simulated food supply, govt. stock and market price : policy planning mode ; ——— 25% simultaneous reduction of both procurement fraction and release fraction, and ...... 25% simultaneous increase of both procurement fraction and release fraction.

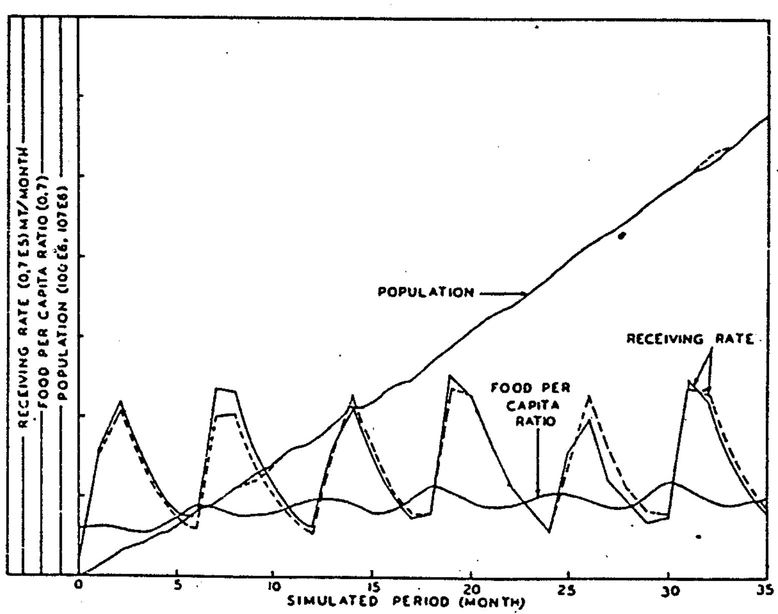

Fig. 11. Simulated population, food per capita ratio and imported foodgrain receiving rate : policy planning mode; ——— 25% simultaneous reduction of both procurement fraction and release fraction, and .... 25% simultaneous increase of both procurement fraction and release fraction.

The implications of the simulated policies are that market price and food per capita are not sensitive to procurement fraction and or release fraction. These are highly sensitive to the different levels of foodgrain production. The amplitudes of fluctuations are small but do not die out with time.

Procurement fraction significantly influences the importation The higher is the procurement fraction, the lower is the amount of the imported food grain for govt. stock. Again an increase of release fraction demands for higher amount of imported grain. Hence, the amount of imported food grain in the years of good harvest can be either reduced or eliminated by improving the internal procurement programme through increased local procurement.

Procurement programme should be enhanced in the year of good crop to raise the market price and at some time either to reduce or eliminate the importation of the grain for maintaining the minimum food reserve required. The case is reverse for the bad year. Establishment of annual food plans and importation of deficit will not assure domestic seasonal price stabilization unless an active role is played in the domestic grain procurement and release through rationing system.

For reasons of national security and to assure adequate buffer stocks during the bad years, adequate importation should be made. This would necessitate a timely and speedy unloading of the imported grains. Hence, an adequate unloading facility is an urgent need for domestic price stabilization during the years of bad crops.

We have clearly indicated the implication of the model for policy planning. This model would not replace policy planners and grain storage managers, rather this model would provide them greater insight and better understanding of the complex grain storage management system. For practical application of the model further requirements and elabortions of the model are required and the success of the policies for the food grain management system depends upon the systems for their effective implementation also. In summary, the model is useful in examining the alternative foodgrain storage management policies.

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REFERENCES

Alamgir, M and L.J.J.B. Berlage. 1973. Foodfrain (rice and wheat) Demand, Import and Price Policy for Bangladesh. *The Bangladesh Economic Review* 1(1) : 25-58.

Bala, B.K. 1989. Studies on Traditional Storage System for Paddy in Bangladesh and Development of Low Cost Efficient Storage Systems for Use at the Farm Level. Annual Report. Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh.

Bala, B.K., M.A. Satter and M.S. Alam. 1990. System Dynamics Simulation of Foodgrain Procurement, Release and Import System in Bangladesh. Presented at the 34th Annual Convention of the Institution of Engineers, Bangladesh. Dhaka.

Berlage, L.J.J.B. 1973. An Application of Dynamic Programming Models to Foodgrain Import and Storage Policy in Bangladesh. *The Bangladesh Economic Review* 1(4) : 341-374.

Forrester, J.W. 1968. *Principles of Systems.* Cambridge, Mass : Wright Allen Press.

Gibson, F.J. 1978. The Grain Management Programme Model. *In Agricultural Sector Planning : A General System Simulation Approach*, ed. G.E. Rossmiller. Agricultural Sector Analysis and Simulation Projects, Department of Agricultural Economics, Michigan State University. Ann Arber, Michigan.

Islam, R. 1980. Foodgrain Procurement, Import Subsidy and the Public Food Distribution System in Bangladesh. *The Bangladesh Develpment Studies* 8(1 & 2) : 89-120.

Mohiuddin, M.G. 1988. Development of Rural Storages in Bangladesh. Presented at a Seminar on Rural Industrial Technology, Dhaka.

Mohiuddin, M.G. 1989. Bangladesh Foodgrain Imports and the Port Unloading Facilities for the year 2000. Presented at the 14th Annual Bangladesh Science Conference. Gazipur.

Shahabuddin, Q. 1987. Interrelations in the Public Foodgrain Distribution System in Bangladesh - An Econometric Analysis. *The Bangladesh Development Studies* 15(1) : 57-81.