A SYSTEM SIMULATION APPROACH TO POLICY PLANNING AND EVALUATION IN THE CONTEXT OF INTEGRATED RURAL DEVELOPMENT IN BANGLADESH

Dissertation for the Degree of Ph. D.

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ANWARUL HOQUE

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ABSTRACT

A SYSTEM SIMULATION APPROACH TO POLICY PLANNING AND EVALUATION IN THE CONTEXT OF INTEGRATED RURAL DEVELOPMENT IN BANGLADESH

By

Anwarul Hoque

The combined effects of technological transfers in seed, fertilizer and irrigation and the institutional innovation embodied in the so called Comilla approach to integrated rural development provide a means of transforming traditional agriculture in Bangladesh. Increasing concerns, however, are being expressed about its distributive effects. This study critically examines the long run trends of agricultural transformation, issues of growth and equity, and possible consequences and implications of policy changes being considered in order to deal with rural problems.

The study is presented in three parts. In the first part the conceptual basis of agricultural transformation through an intermediate level organizational approach is established, and a policy analysis framework based on systems analytic approach is proposed. The systems approach allows for modelling of technological, behavioral, and institutional changes with a maximum of interaction. Within the intermediate level organizations, policy interventions that may be necessary for attaining multiple rural development objectives can be pursued. Decentralized regional development

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planning would be helpful in this respect. The case of using the systems simulation methodology for studying the mechanisms of rural development is presented.

A conceptual model of agricultural transformation is displayed in the second section of the thesis. For five components of this model, mathematical structures and computer simulation programs have been developed. These five components generate long run information about farms, production, consumption, employment and income of the region. Components of the overall model which have yet to be developed in mathematical and simulation form include modernization, organization and decision making.

By disaggregating total farms into eight classes according to landholding size and institutional membership the performances of class participants could be separately examined. With data from Comilla Thana the computer simulation model was operationalized and through various tests it was validated.

In the third section of the thesis the model was used to evaluate the impact in the year 1981 of ten alternative policy mixes of different technological and institutional ingredients. From the tentative results it has been observed that despite projected increases in aggregate regional production, income and employment under the policy presently pursued, these variables will decline during eight year run period in per capita terms. Population increase will outpace the slow agricultural growth projected in the policy. A combined policy package with better seed, irrigation, training, extension, organization and population control will increase total and per c

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and per capita performances substantially. Such a production-oriented policy will also widen income disparities among classes of the rural populations. If there is to be growth without a widening of these disparities, government policies such as land reform, taxation, employment creation, and migration need to be adopted. In terms of effects on income distribution, taxation and employment policies can be as effective as land reform.

Considering the complexities of interactions and the trade-off among objectives in integrated rural development, it is suggested that systems simulation is a useful approach both for national policy determination and for regional development planning. Region specific studies can be made by feeding pertinent local data into the model. The approach is flexible to form and availability of data, but for some micro-data small scale survey may be needed. The general application characteristics inherent in the model allows its use for any region within the country. With this approach implementation and monitoring of rural development plans are made at regional levels, whose aggregation leads to obtain national evaluation.

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A SYSTEM SIMULATION APPROACH TO POLICY PLANNING AND EVALUATION IN THE CONTEXT OF INTEGRATED RURAL DEVELOPMENT IN BANGLADESH

By

Anwarul Hoque

A DISSERTATION

Submitted to
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Department of Agricultural Economics

1977

To my Father

Who planted the seed of learning in
my mind and asked me not to fail
nurturing it even in adversity.

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I have had the good fortune to be closely associated for many years with Dr. Akhter Hameed Khan and his work in rural development. My interest in rural development is largely attributable to him. With deep knowledge and clear vision he inspired my learning. I shall remain ever grateful for his encouragement and advice, and for the confidence he has in me.

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In the course of the thesis preparation I was helped greatly by several of my good friends, including Allan Knapp and Blake and Margo Smith. Allan was pivotal in devising the computer program that was as demanding and time consuming a task as was attending to my insistence. Blake, with his understanding of the Comilla program and his deep interest in this work was very helpful to me; in addition, he and his wife willingly took the pains of going through the draft and editing it. I am immensely indebted to all of them for being so tolerant, friendly, and cooperative. I also express my appreciation to Mabel Buonodono, Donavieve Taylor, Enid Maitland and Marilyn Bandfield for typing the draft, and for extending secretarial services, and th Pamela Marvel for providing computer services.

My wife Naseem and son Akash sacrificed much of their happiness to make me happy. Thousands of miles away back home members of our extended families and well wishers sacrificed the company of their loved ones to see us get educated. No word can express my gratefulness to all of them, but I hope they will understand.

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PART A: FORMULATION OF THE STUDY

CHAPTER I

THE BACKGROUND AND PROBLEM SETTING

With a view to increasing agricultural production and decreasing rural poverty in Bangladesh, vigorous attempts are being made to transform and modernize her traditional agriculture. These efforts have been encouraged by technological transfers in seed, fertilizer and irrigation and by the advent of an institutional framework called the Integrated Rural Development System.[1] Technological breakthroughs in combination with this institutional innovation have provided an effective means of bringing about a change in the traditional subsistence agriculture of the country. There is now a basis for hoping that food production, which has fallen chronically short of demand, can be increased substantially.

In order to achieve self-sufficiency in food, various plans and policies have been undertaken to introduce and spread innovations among farmers. But even before these programs could be launched effectively, a spectre of gloom engulfed the country as a result of political upheavals, economic frustrations and natural vagaries.

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[1]The term "Integrated Rural Development System (IRDS)" as used in this study does not denote the same thing as the "Integrated Rural Development Program (IRDP)". The IRDS is an institutional model for rural development while the IRDP refers to the government program whose purpose is to replicate the institutional model contained in the IRDS.

These problems, nevertheless, emphasized the need to evolve effective policies and programs to bring the economy back to vitality.

While agricultural transformation through technological and institutional innovation has been pursued, it has given rise to a new kind of concern among development workers and policy planners. The concern relates to the structural changes resulting from the agricultural transformation and specifically to those production, employment and income distribution aspects of agriculture which form a nucleus of objectives in the milieu of rural development.[2] It has been argued that although new technologies and institutional innovations are bringing about changes in the agricultural sector that were needed to increase production and employment, these same changes are introducing concomitant problems of income and resource maldistribution (Bose, 1974; Wood and Huq, 1975). Though such structural change effects are not altogether unexpected (Wharton, 1969; Falcon, 1970; Griffin, 1972), nor even different from the findings obtained from other countries (Frankel, 1971; Gostch, 1971), their significance in the present socio-economic and political climate of Bangladesh is obviously profound. It has, therefore, become necessary to search for alternative policies that would alleviate problems arising from such structural effects without, however, diminishing the growth and transformation that are essential for agricultural development.

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[2] This was the main theme of various papers presented in the International Seminar on "Socio-Economic Implications of Introducing HYV in Bangladesh" held in Comilla, Bangladesh in April 1975. For details see Wood and Huq, 1975.

This study attempts to analyze possible implications of some alternative policies that are or could be considered in dealing with problems of the rural sector in Bangladesh. A conceptual systems simulation model has been developed. The model can help evaluate dynamic effects of rural development policies. The model also contributes to understanding of the mechanisms of agricultural transformation embodied in the Integrated Rural Development System. This study, therefore, aims at examining the extent to which policy strategies will lead to (i) simultaneously realizing multiple objectives of rural development; (ii) enhancing the process of transformation in traditional agriculture, and (iii) setting the stage for development interactions in the subsistence rural sector, under the framework of the Integrated Rural Development System.

Characteristics of Bangladesh Agriculture

Bangladesh, a land of 55,125 square miles and 72 million population, is predominantly an agricultural country. Its vast deltaic topography, alluvial soil structure and tropical monsoon climate all favor agricultural crop production. In fact, the agricultural sector accounts for 60% of the country's G.N.P. and 80% of all exports. Practically all of her 22.5 million acres of cultivable land is under cultivation with a cropping intensity of 1.4 (GOB, 1972). Ninety three percent of the cropped area is used for growing food crops, rice alone accounting for 75%. Only 6% of the cropped area is utilized for growing jute, which serves as the main cash crop to farmers and as the major exportable commodity that earns 80% of the country's total foreign exchange. In spite of the intense use of land for growing food crops the country is short of food. While the demand for food grain is increasing at the rate of 3.6% per year due to the population growth rate of 3.0% per year, the production of food grain is increasing at a rate of 2.9% per year, thereby leaving a gap that has to be met through increased food imports (Islam, 1973). Every year the country has to import food grains in excess of 1.5 million metric tons, which causes a heavy strain on the foreign exchange reserves.

With virtually no cultivable waste land available in this land-locked country, the plausible means open to increase food production are increasing cropping intensity and increasing yield. Rice is grown in three seasons a year. The Aus (mid-March to mid-July) crop is predominantly rainfed and accounts for 32 percent of rice acreage and 25 percent of rice production. The Amon (mid-July to mid-November) crop is also a predominantly rainfed and accounts for 60% of rice acreage and production. The Boro (mid-November to mid-March) crop accounts for 8 percent of rice acreage and 15 percent of production. Since it is a dry season crop, Boro rice must be irrigated. In terms of weather, this is the best season not only for rice but also for growing vegetables and spices. While rainfed Aus and Amon is completely at the mercy of nature - constantly threatened by either drought or flood - Boro is a less risky crop. Despite such possibilities, land remains fallow in the Boro season, mainly due to the lack of adequate irrigation facilities.

On the other hand, the traditional technology which was pursued for so long had reached a state of stagnation. The yield rates of local rice strains have stabilized for a long time around an average of 12 mds/acre. Such a yield rate is considered low compared to that of other countries (Japan, for example, grows three times as much rice per acre as Bangladesh). The limited production potential of traditional local rice varieties for increased production was apparent in their low response to chemical fertilizers.

In addition to the land and yield constraints, Bangladesh agriculture faces a variety of natural constraints. Bangladesh has a tropical monsoon climate with high rainfall, humidity and temperature. The crops grown in the country are heavily oriented towards the monsoon and are therefore susceptible to its failure. Although the country has over 80 inches of average annual rainfall, its considerable seasonal and regional variations create further problems. Eighty percent of the annual rainfall comes between May and September of the monsoon season, causing problems of excess water. Only 5 percent occurs during November through March, providing too little water for cultivation. As a result of this rainfall pattern, 30 percent of the total cultivated area is flooded during the monsoon season to depths of three feet and more; 15 percent of the area is flooded to depths of more than six feet and cannot sustain monsoon crops. During the dry season the average rainfall is only 5 to 9 inches, which is insufficient to sustain the growth of crops. Because of regional variation in rainfall, the northeast and southeast parts of the country receive over 200 inches of rainfall per year, while the northwest and southwest get only about 50 inches. These latter regions experience a drought which is especially severe in the dry season.

Furthermore, yearly weather fluctuations in Bangladesh sometimes cause extreme conditions of drought and flood. It is estimated that flood affects an average of 5.9 million acres. In several years during the last decade more than ten million acres, or 50 percent of the land, was flooded. The extent of uncertainty and risk associated with this problem is obvious.

More restrictive, however, are the socio-economic and institutional constraints in the rural sector. The rural economy dominates the national economy overwhelmingly. Ninety-five percent of the population lives in about 64,000 villages in 413 geographical units called Thanas. Eighty percent of the country's total labor force of 27 million is directly involved in agriculture. The rural population of seven million farm families have average land holdings of three acres per family, with a land-man ratio of about 0.5 acres. They derive their income and livelihood from agriculture.[3] The rural income, however, is very low - about $75 per family per year. With such small farm and low production the farm population lives in economic distress and subsists in misery and malnutrition.

While land assumes a vital role in this subsistence rural economy, the land ownership pattern is more skewed than the average

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[3]A crude estimate of the rural income directly attributable to agriculture is about 70 percent (Bose, 1968). However, if all rural activities which have either direct or indirect links to agriculture are considered, the proportion would be much greater, possibly almost total.

land holding suggests. In 1967-68 as many as 25 percent of the families were landless and/or near landless.[4] Fifty-seven percent of all farms have land holding of less than two and a half acres for a total of 21 percent of the land, while 83% of the farms are less than five acres and own 51 percent of the land (Table I.1). The remaining 39 percent of the land is owned by 13 percent of the farmers who own more than five acres. In the Bangladesh situations, this group is known as the large farmers; they either operate their land themselves, employing laborers, or lease out to others on a sharecropping or rent basis. Sixty-six percent of the farmers cultivate 83% of the total land on their own, while only 4% are pure tenants and the remainder are owner-cum-tenant farmers (Table I.2). Therefore, the majority of the land is in the hands of owner farmers while about 17% of the land is under tenancy or sharecropping.

Landlordism was abolished soon after the partition of India; land was redistributed to the tenants in 1952. The land holding order of 1972 further restricted individual holdings to 33.3 acres, a ceiling which affects 3% of all land and 25,000 farmers. Moreover, farms continue to be divided under the Muslim Law of Inheritance, which dictates that land should be distributed among a farmer's children. As a result, the land is highly fragmented - 63% of all land is divided into parcels of 0.5 acres or less. From 1960 to 1970 economic pressure and the law of inheritance combined to reduce the average farm size from 3.5 to 2.6 acres; cropped area per person

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[4]According to some estimates this figure has increased since independence to as much as 40% (USAID, 1974).

Table I.1: Percentage distribution of farms and farm area according to size of farm in Bangladesh 1960, 1968.

Size of Farms (in acres)	Percentage of farms[a] 1960	1968	Percentage of farm area[a] 1960	1968
less than 2.5	51 (51)	57 (57)	16 (16)	21 (21)
2.5 to under 5	26 (77)	26 (83)	26 (42)	30 (51)
5 to under 7.5	12 (89)	9 (92)	19 (61)	18 (69)
7.5 and above	11 (100)	8 (100)	39 (100)	31 (100)
Average Farm Size			3.5 acres	3.2 acres

[a]Cumulative percentages are given in the parenthesis.

Source: Census of Agriculture 1960, Master Survey of Agriculture 1967-68, M.S.A. Report No. 9.

Table I.2: Percentage distribution of farms and farm area according to tenure type in Bangladesh, 1960, 1968.

Type of Tenure	Percentage of farms[a] 1960	1968		Percentage of farm area 1960	1968
Owner-operated	61 (61)	66 (66)	Owner-operated	82	83
Owner-cum-tenants	37 (98)	30 (96)	Under tenancy and/or share-cropping	18	17

[a]Cumulative percentages are given in the parenthesis.

Source: Census of Agriculture 1960, Master Survey of Agriculture 1967-68, M.S.A. Report No. 9.

declined in the same decade from 0.575 acres to 0.468 (USAID, 1974). Although no agricultural census has been taken in the 1970's, it is suspected that the number of landless farmers is increasing, and that a concentration of land in the hands of the large farmers is accelerating.

Although agriculture shelters 80% of the total labor force, it provides employment of only 13 million man years to the agricultural labor force of 22 million. The rural unemployment rate runs at 35%, and soars even higher in the lean agricultural seasons. Since the scope of non-farm employment is limited, the agricultural sector has to bear the burden of providing jobs. With the three percent population growth rate, it is estimated that 0.8 million people will be added to the labor force every year. Even if non-agricultural employment expands at a rate of five percent per year, it would absorb only 0.3 million, leaving the remaining 0.5 million to be absorbed in the agricultural sector (Bose, 1974). For the next several decades, at least, until the industrial sector develops adequately to absorb the surplus, agriculture must provide productive employment opportunities to the population.

Present Strategy of Agricultural Development

Despite these constraints, there exists a possibility that agricultural production can be increased in Bangladesh. In view of factors such as soil, climate, and topography, experts believe that per acre yield can be increased many fold under certain conditions of input use and cultural practices. Similarly, the cropping intensity can be increased from the present 1.4 to at least 2.5 through multiple cropping. An even greater possibility for increasing production could result from bringing currently fallow land under cultivation, and from protecting cultivated land through the provision of land development infrastructure, e.g. flood control and irrigation. The present strategy of agricultural development in Bangladesh is pursuing these possibilities.

With the objective of initiating a rapid transformation favorable to an increase of production in the agricultural sector, a multiprong attack is being made. On the technology side, heavy emphasis is being given to the expansion of a seed-fertilizer-irrigation combination which has very good prospects of increasing food production in the country. The high yielding rice variety IR-8 brought from IRRI at Los Banos was first introduced in the 1966 Boro Season. IR-8 demonstrated two to three times higher per acre yield than the local rice variety. This encouraged the farmers to grow high yielding varieties (HYV) not only in the Boro season, which best suits its characteristics, but also in the Aus and Amon Seasons, respectively. As a result, the land under HYV's increased to 2.5 million acres in 1974, with 1.3 million acres in the Boro Season alone. As HYV depend heavily upon water control, fertilization, pest control and cultural practices, a sharp increase in demand for modern inputs resulted. By 1974, 1.4 million acres were brought under irrigation through the use of 33,000 low lift pumps, 3,000 deep and shallow tube wells, and several large scale irrigation projects. The HYV seed distribution increased from 11,000 mds.[5] in 1969/70 to

[5]Md . is the standard abbreviation for maunds, a South Asian unit of measure equalling 82.5 pounds.

443,000 mds. in 1972/73. Fertilizer consumption increased at the rate of 12.1 percent annually from 102,000 tons in 1964/65 to 375,000 tons in 1972/73 while pesticide consumption showed a similar trend. As a result rice production in the country increased from 9.7 million tons in 1964/65 to 11.8 million tons in 1969/70 (GOB, 1973).

To sustain this trend, the government initiated several institutional policies. Necessary inputs are supplied through different government agencies and departments, constituted primarily for this purpose. Government policies were implemented including subsidization of input prices, fixing of minimum output prices and the establishment of a broad based rural institutional structure. Until recently, irrigation was being subsidized at 95 percent, fertilizer at 55 percent and pesticide at 100 percent.[6] Every year a new minimum floor price and procurement policy is declared. The First Five-Year Plan (1973-78) allocated[7] ten billion in the agricultural sector. The plan projects that by 1978, 4.13 million more acres will be brought under irrigation, and fertilizer consumption will increase to 857,000 tons per year (GOB, 1973). The plan assumes that rice production will increase to 15.1 million tons from 11.2 million tons in the year (1972/73), mainly through the replacement of local varieties with HYV's.

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[6] The extent of subsidies is now being gradually decreased.

[7] The Taka (or Tk.) is the unit of currency in Bangladesh. \$1 = 13.60 Tk. (approximately).

To motivate and organize farmers for the diffusion of these policies, a streamlined version of the Comilla institutional framework has been devised. The Integrated Rural Development Program (IRDP), as it has been named, is entrusted with the task of organizing farmers in a cooperative organization within every thana by 1978. By 1974 the IRDP covered 40% of the thanas (152 out of 413, Khan, 1974). In non-IRDP thanas a temporary arrangement has been made through the Thana Irrigation Programs (TIP) which is charged with spreading the transformation until the IRDP takes over. Although most of the distribution of inputs, including institutional credit, is made through the IRDP cooperative organization, non-members are not restricted from obtaining the required inputs. In fact, the seed-fertilizer-irrigation combination has created enough enthusiasm among all classes of farmers so as to generate a widespread agricultural transformation.

Problems of Income Distribution and Employment

The present approach to rural development puts great emphasis upon increasing agricultural production, especially of rice, in order to increase the food supply and ameliorate conditions of poverty. So far as the production of rice is concerned, indicators show an increasing trend. Nonetheless, development workers are presently expressing serious concern about income distribution and employment effects of the present approach (Wood and Huq, 1975). It is argued that while new technology is helping to increase production, it is also aggravating income disparities among farmers. The shift in the production function effected by land augmenting inputs such as seed, fertilizer and irrigation increases returns to land due to a non-marginal change in yield. Since the distribution of landholding is uneven, the larger land holders can multiply the return from new technology more than can the smaller land holders who face severe constraints. Thus, the new technology is biased not only towards the land owners, but also towards the larger landholders who have the capacity to multiply income by bringing more land under the new methods of cultivation. While no study has yet established the differences in total farm income among the classes of farmers adopting the new technology, it has been observed that the new technology pays higher income to adopters, and that large landholders do bring a slightly higher amount of land under the technology than do the small farmers (Bari, 1975; Alam, 1975).

Moreover, the large farmers are believed to be making greater use of the institutional support structure. The inputs necessary for expansion of the new technology are being provided by the government under heavy subsidy, mainly to help small farmers. However, the larger farmers possibly acquire greater shares of such scarce modern inputs at subsidized prices which increase their margin of profit (Alam, 1975). Even the cooperative institutional structure that presumably is meant for the small farmers has fallen prey to the large farmers, who have taken over key positions so as to manipulate decisions to their favor (Mannan, 1972; Ahmed, B., 1972). The large farmers have taken control of the cooperative institutions so as to receive more of the subsidized inputs and cooperative services, and as a result they have brought larger proportions of their land under the new technology. Therefore, the very cooperative institutions which were supposed to be biased in favor of the small farmers are in actuality biased in favor of the large farmers.

As a consequence of these trends, the income gap between the small and large farmers is widening at a rate which is probably faster than before. The liquid capital obtained from the high non-marginal pay off of the HYV's is accumulating in the hands of large farmers. Since no investment outlet is to be found in the rural areas for this liquid capital, it is causing an inflationary trend in land values (Bari, 1975; Townsend, 1975) as well as in factor and product prices. The resulting economic pressure upon small farmers is causing a decrease in their landholding size through disinvestment, thereby pushing them further towards landlessness. The large farmers are buying up land, since their present solvency permits them to do so, and their numbers are increasing. As a result, ownership of land is concentrating in the hands of a class of solvent farmers, while another class of insolvent farmers are reducing their landholding.

For the land constrained small farmers, including the landless and near landless, share cropping and land lease are among the traditional means of bettering their income. In Bangladesh 18 percent of the land is share cropped or rented by 28 percent of the farmers (Zaman, 1973; GOB, 1972). Sharecroppers provide all inputs necessary for production except the land. They usually receive a 50 percent share of the output, but this provides a poor return to their labor after other costs of production are defrayed. Yet, as farming becomes profitable, the land owners who previously used to hire out land are now cultivating it themselves and thereby cutting down the opportunities for sharecropping of renting land.

On the other hand, the 30 percent of the farmers who are landless and near landless are not being directly benefitted by the present approach. As they do not possess any land, neither technological inputs not institutional facilities are generally extended to them. They try to derive their income in the agriculture sector from farming other people's land of by finding employment as agricultural laborers. It has been observed that the new technology increased labor requirements by 50 percent, and that as much as 70 percent of the total labor for winter HYV crop cultivation is hired (Hoque, 1968, 1970). The potentiality of increasing seasonal agricultural labor employment does exist (Inukai, n.d.). Nevertheless, a shift now is taking place towards reducing hired labor use because of a trend to use more family labor and to use labor decreasing small mechanical implements (Obaidullah, 1975). The net result, therefore, is probably to decrease underemployment rather than to decrease unemployment. Unemployment shows a rising trend due to population growth and a lack of opportunities for the absorbtion of surplus rural labor in the infant industrial sector.

Policy Issues

On the whole, the concerns described above impose a pessimistic evaluation of the trend of the agricultural transformation in Bangladesh. If, indeed, income disparity and unemployment are increasing, in part as a result of the transition to new agricultural technologies, then the results are in conflict with the stated objectives. The forces set loose by the transformation of agriculture must be studied and, if possible, controlled.

In contrast to the general tendency toward branding technological change as responsible for such effects, it is our view that the existing agricultural structure and institutions are inadequate to cope with the stress of the transformation process. However, any renovation of the structure of any institutional redirection has to come about through policy changes both at national and local levels. Notwithstanding this need, it is difficult to choose a policy that would simultaneously help to increase agricultural production and decrease income disparity and unemployment among the economic strata. Indeed, any attempt to pursue multi-objective rural development effectively is problematic inasmuch as there are trade-offs among performance criteria. As a result of such trade-offs, a policy emphasis on one criterion usually depresses performance as measured by another.

For Bangladesh a simultaneous stress on all development performance criteria may seem crucially important. Yet it is difficult to devise a multi-objective policy strategy. Furthermore, no serious attempt has been made to evaluate the long-run effects of proposed alternative policies upon different performance criteria.

Over the years, development thinkers have suggested various policy changes for Bangladesh. Among the policy changes that are thought to be most relevant for the country are (i) land reform; (ii) desubsidization of input prices; (iii) cooperativization;

(iv) imposition of development tax; (v) development of new seed varieties; and (vi) population control.

Most vociferous have been those who argued in favour of land reform to reduce the largest land holdings from the present ceiling of 33.3 acres to a substantially smaller holding limit of 7.5 or even 5 acres (Abdullah, 1973; Zaman, 1975). It has been strongly argued that land reform and redistribution would, in fact, lead to higher output and employment, contrary to the belief that it would do otherwise. Another strong argument has been made in favor of lifting the present subsidies from inputs (IBRD, 1975). This will not only reduce the margin of profit and cut the income of large farmers who generally have marketable surpluses, but will also make farming competitive and will optimize the use of resources. The small farmers for whom subsidies are provided would, however, benefit more from the institutional structure if the efficiency of input distribution were improved. A likely policy direction would be to spread institutional membership to all farmers and to channel inputs through the cooperative organization without, however, imposing land collectivisation. Another policy suggestion that has resurfaced in recent years is that of imposing some kind of tax (Lewis, 1974; Stevens, 1975; Biggs, 1975). It is argued that this policy is suitable for effecting adjustments in the disposable income of various classes of farmers, it could have the additional advantage of promoting the reinvestment of surplus agricultural income in the rural development sector. At present such a tax does not exist because existing agricultural land tax does not serve this purpose as the landholding floor for imposing the tax has been fixed at too high a level to be effective. The policy would, of course, benefit the national exchequer as in Japan or China, and would be a useful macroeconomic tool for combating inflation.

A study of the implications of these policies is necessary for several reasons. First, how would they affect food production as well as other performance criteria? In other words, would they lead to the simultaneous achievement of the multiple goals of attaining acceptable levels of production, income distribution, consumption and employment? Second, how would they work within the institutional framework of the Integrated Rural Development System (IRDS)? This is crucial because under the First Five-Year Plan the IRDP is going to cover the whole country, and if the policies are not compatible with th system, then neither the policies nor the IRDP would be effective. A prior analysis of this issue would permit modification of IRDP according to its perceived strengths or weaknesses before it is spread throughout Bangladesh. Third, would the policies strengthen or weaken the motivation toward development, or unleash forces which would influence development? Fourth, it is the long-term effects that are important in policy analyses of rural development. Even though the effects may not be impressive in the short run, they may initiate a recursive growth generating process which can only be grasped through long run analyses.

Objective of the Study

The main purpose of this study is to examine the economic implications of alternative rural development policies which are under consideration in Bangladesh. With this view in mind we have set our objectives for the study as:

(1) The development of a conceptual and analytical framework that can provide a means of exploring alternative policies, and mixes of policies, in terms of their impacts on performances with respect to rural development performance objectives.

(2) The development of simulation components that will:

(a) have a limited usefulness in their own right in exploring consequences of alternative policies, and,

(b) fit into the overall conceptual framework of (1) above and constitute a contribution toward the largest model needed to meaningfully address these

(3) To test the efficacy of system simulation in rural development evaluation and policy planning.

It is tempting to set higher objectives for this study but to do so would not be realistic in light of the time and manpower available at this juncture. The possibility exists for an extended commitment of time and manpower if the results of this study indicate that it would be appropriate to do so.

This initial study will stress micro-level policy effects in a region covering a segment of the agricultural sector, so it is not intended to analyze policy effects on the total economy or on the country as a whole. Also, the study is not directed at finding or devising definite policies to solve the stated problems, or even at

making policy recommendations, except insofar as is implied by the results of exploring the consequences of alternative policies.

Overview of the Study

In the remaining chapters of Part A the formulation of the study is further pursued. In Chapter II the basic tenets of the new institutional system for integrated rural development in the country are sketched. Chapter III presents the conceptual basis of the analytical framework developed in this study for integrated rural development policy planning and evaluation.

Part B presents the systems simulation model in detail. In Chapter IV the mathematical structures of the model components are explained while in Chapter V validation of the model is discussed through an analysis of the results of consistency and sensitivity tests.

Part C presents applications of the model in conducting policy experiments. In Chapter V consequences of several alternative policies are explored and their implications are examined. Finally Chapter VI contains a summary and the conclusions of the study as well as an outline of areas for future research and for data refinement.

CHAPTER II

THE RURAL DEVELOPMENT APPROACH IN BANGLADESH

In this chapter the emergence of a new system of cooperative institutions in Bangladesh is briefly sketched. This chapter should not be construed as a complete history of rural development initiatives in Bangladesh. Our purpose rather, is to familiarize the reader with long term trends and with the present setting of rural development organizations. The overall nature and basic tenets of these organizations are set forth in this chapter.

Past Rural Development Efforts

Bangladesh has a long, often frustrating history of institution building for rural development.[1] Since the British Colonial period numerous government and private attempts have been made to solve rural problems. Except for a few, most of these were regional, occasional, and individual efforts; they did not usually last long enough to become institutionalized as rural development systems with form, purpose and effectiveness. Prominent among these initiatives were two government organized programs in the first half of this century - the cooperatives and the Rural Reconstruction Program.

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[1] For a detailed account of the historical trend see speeches of Akhter Hameed Khan: Rural Development in East Pakistan (spring 1965) and Community and Agricultural Development in Pakistan (Spring 1969), Occasional Paper Series, Asian Studies Center, Michigan State University, East Lansing, Michigan.

The cooperative movement, which was inspired by the German and Danish system of cooperation, started in 1904 and has continued since. It was at first embraced enthusiastically both by public officials and by the peasantry. During the first several decades of the movement these cooperatives spread steadily. But gradually the cooperatives became aloof and relatively uninvolved in the mainstream of rural development. Lacking support and direction, they degenerated into lifeless, stagnant organizations. After the second World War the cooperative societies existed only in name; functionally, they were almost dead.

The Rural Reconstruction Program was initiated in the 1930's to help solve problems of villages and improve their condition. It failed to achieve its purpose and finally was abolished around 1944.

After the partition of India, the Zamindari (landlordism) system was abolished. Ever since the Permanent Settlement Act of 1790, the Zamindars had collected taxes on behalf of the government in British-ruled Bengal. In addition to their tax collecting powers, the Zamindars had status very similar to that of landlords in relationship to the tenant-peasants and responsibilities to caretake local institutions. The Zamindari system was responsible to a large degree for the deterioration of rural conditions in Bengal prior to the establishment of East Pakistan. It should be recognized, nevertheless, that they had comprised one of the very few links between the colonial government and the villages. After the Zamindari was abolished, the only vestige of a broad based rural development, however meagre it might be, was gone.

In the 1950's an agricultural extension program was launched by the East Pakistan government with a view to diffusing information and training farmers through extension agents. The program was handicapped by the shortage of well trained agents, the lack of useful agricultural information, and the inadequacy of input supplies.

Interest soon shifted to another program called V-AID, (Village Agricultural and Industrial Development), launched in 1953 which followed a community development approach. Under this program, Village Level Workers (VLW) were sent to the villages to serve as extension agents and teachers; VLW's were to be the link between the villages and the bureaucratic organizations at the district level that provided inputs and information. The objective of V-AID was to improve the condition of village life by changing the traditional outlook, not only in agriculture but in the whole sphere of rural activities. This was a more intensive approach but faced problems similar to those of the extension program. In spite of a decade's trial the V-AID program hardly made a dent in transforming village conditions. In addition V-AID became tangled in a myriad of coordination and internal problems. So in 1961 the V-AID program was abandoned.

During the same period an attempt was made to reinstitutionalize the cooperative movement by creating 4,000 Union Multipurpose Cooperative Societies whose primary function was the disbursement of agricultural credit. In the absence of supporting programs, strict enforcement of repayments, or the replenishment of loan funds, the multipurpose cooperative Societies decayed into dry organizations. They experienced the same uneventful history as the earlier cooperative movement.

In the 1960's the flicker of rural development activities included some other programs. The Basic Democracy System, which had been founded to revitalize rural administration, was given some developmental tasks. Primary among these was the job of laying down a physical infrastructure of roads, drains, embankments and canals. It was expected that government production campaigns and departmental nation-building activities would be supported by this infrastructure. The political features of basic democracy overshadowed its development functions, however, the system expired after a decade.

In the 1960's a pilot program was initiated in the Mymensingh area involving the Union and the Thana level officials of the basic democracy councils; these officials coordinated rural development functions in their jurisdictions. While the initial performance of the Mymensingh pilot program was noteworthy,[2] the coordination problem was as insurmountable as the lack of an enthusiastic demand from the farmers for a rural transformation. Eventually the pilot program in Mymensingh terminated along with the Basic Democracy system on which it had heavily depended. Another pilot program started in that period was located in Comilla Thana; its objective was to evolve a viable rural development system following cooperative principles.[3]

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[2]The Mymensingh program was initiated by Ben Ferguson, a USAID official.

[3]The Comilla program was led by Akhtor Hameed Khan under the auspices of the Academy for Rural Development, Comilla.

The Comilla Approach

The overwhelming nature of rural problems and the failures of past programs to deal with them resulted in the emergence of two Rural Development Academies in 1959.[4] Although the initial charge to the academies was to engage in training and research on aspects of rural development, the Academy at Comilla embarked, in addition, upon a program of experimentation in the field with some synthesised programmatic ideas, derived mainly from the lessons of past failures in the V-AID program, the cooperative movement and the like. The Comilla approach focused on the grass roots aspects of rural problems, and attempted an all out integrated attack upon them orchestrated by the farmers' initiative and the government agencies' drive for development. The basic objectives were not only to develop the particular region of Comilla, but also to evolve a viable replicable model of a rural development system which could catalyze a socio-economic and agricultural transformation among the large mass of small subsistence farmers. The system which emerged from these experiments is known as the Comilla approach; it is the backbone of the present rural development program in Bangladesh.

The Comilla pilot program was started in 1960 in a geographical unit called a Thana. The Comilla Thana has an area of 107 square miles, in which are to be found 246 villages and 29,000 farm families; it is one of the 413 Thanas of the country. In terms of basic

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[4]The Academies were established, one in each wing, of what was then Pakistan. For a history of their development see Raper , 1970.

characteristics, conditions in Comilla Thana in 1960 were harsher than the national average. It was one of the most densely populated areas in East Pakistan, having 2,031 persons per square mile, an average farm size of 1.7 acres (as against the national average of 3.5 acres), and less than five percent of its farms larger than five acres. Basically a rice growing area, the Thana used to grow two crops, Aus and Amon, which never gave good returns because of constant flooding caused by the Thana's basin-like formation and low elevation. Cultivation in the Boro (dry) season was negligible due to the non-availability of surface water. The soil type was not suited to growing crops other than rice. As a result subsistence was difficult, the per capita income was low, around $50 against which per capita indebtedness was about $20.

During the nineteen sixties the experimental area of Comilla Thana showed a trend of agricultural transformation. By 1971, 36 percent of the Comilla farmers holding 51 percent of the land had joined in 328 Village Cooperative Societies that covered 65 percent of the villages of the Thana (Obaidullah, 1973). 15,700 acres, or 40 percent of the cultivated land of the Thana, was brought under Boro (dry season) cultivation through irrigation by 288 low lift pumps and tubewells. Ninety-nine percent of the irrigated area is used to grow HYV, which increased the per acre yield rate by more than 100 percent (Karim, 1974a). The cropping pattern changed towards emphasizing HYV rice cultivation under irrigation and as a result the production of Boro paddy increased from 60,000 mounds in 1965-66 (the time when new seed was introduced) to 600,000 mounds in 1970. HYV seeds for the

Aus and Amon rice crops were introduced as they became available, but their acceptance was not spectacular. The combined effect of changes in the practices of cultivation during the Boro, Aus, and Amon seasons increased the total annual paddy production from 1.2 million mounds in 1965-66 to 2.0 million mounds in 1972, thereby turning this rice deficit area into one of surplus (Obaidullah, 1975). Per capita farm income showed a 172 percent increase between 1963-64 and 1969-70 (Rahim, 1972).

This achievement would not have come about through the introduction of new technology alone; it derived from the broad-based institutional support inherent in the Comilla approach. The comprehensive Comilla approach to rural development has many facets,[5] for our purposes we have indicated below some of the important basic tenets of the Comilla approach (Hoque, 1974).

(i) Level of Jurisdiction

The chosen unit of rural development administration is the Thana, instead of the district (which is too large) or the village (which is too small). Selection of Thana as center of development activities reduced proximity problems of farmers and development officials alike. Within a Thana, activities can be concentrated for intensive area development, creating an approximation of a closed system within the jurisdiction.

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[5]The Comilla approach is well documented in many publications. For details of its various facets see Annual reports (1961-74) published by the Academy for Rural Development, Comilla; Raper, 1970; Stevens, 1972, 1974.

(ii) Local and Intermediate Level Organization

The creation of Village Cooperative Societies (VCS) at the local level, and a Thana Central Cooperative Association (TCCA) at the intermediate level established an effective organizational structure for agricultural transformation. Around the multitiered cooperative institution both the farmers and the development agency workers were organized. The realization of their respective objectives was facilitated by the linkages established within the cooperatives. Small subsistence farmers grouped together in the VCS to receive information, training, supplies and support services needed for effecting an agricultural transformation. The TCCA served as the federation of VCS's. It supported their activities by extending various supplies and services, and become a fountainhead for the diffusion of social and agricultural innovations leading to a planned change in the area. The Comilla organizational framework, rooted in the villages and self-supporting, was a major breakthrough in resolving the institutional problem associated with agricultural development (Stevens, 1974; Uphoff and Esman, 1974).

(iii) Ancilliary Linkages

While the cooperative institutional structure organized the farmers around itself, it did not possess enough resources, expertise and supplies to induce a transformation. The necessary additional inputs were derived from the Thana level representatives of government agencies such as the agriculture department, the animal husbandry department, the health department, and so forth.

Typically, the department hierarchies had extended down to the Thana level, but their effectiveness had been impaired by the lack of manpower to reach the grass roots. Nor was there any coordination to unify the effects of individual departmental activities. The Comilla approach included an organizational device for bringing the departmental representatives into close proximity, and into contact with the cooperative institution. The device was known as the Thana Training and Development Center (TTDC). The links established therein were the basis for the interdigitation of a wide variety of rural development activities (Stevens, 1974).

(iv) Input Distribution System

The Comilla approach developed a new system of input distribution. Those services and input supplies necessary for the agricultural transformation were channeled from the Thana cooperative association to the farmers through the village cooperative societies. The inputs provided fall into three categories: (1) biological (seeds, plants, breed, etc.), chemical (fertilizer, pesticides, etc.) and mechanical (pumps, tubewells, tractors, threshers, etc.); (2) institutional (e.g. credit, banking, marketing, storaging, processing); and (3) behavioral (e.g. extension training, information and advice, diffusion of innovations, etc.). The arrangement of distribution of such a long list of inputs through the organizational structure helped farmers to obtain relief from many constraints, and encouraged them to strive for increased production, higher income and greater welfare (Hoque, 1970a). Thus the system ensured that appropriate inputs could be delivered almost to the doorstep of the cooperative participants.

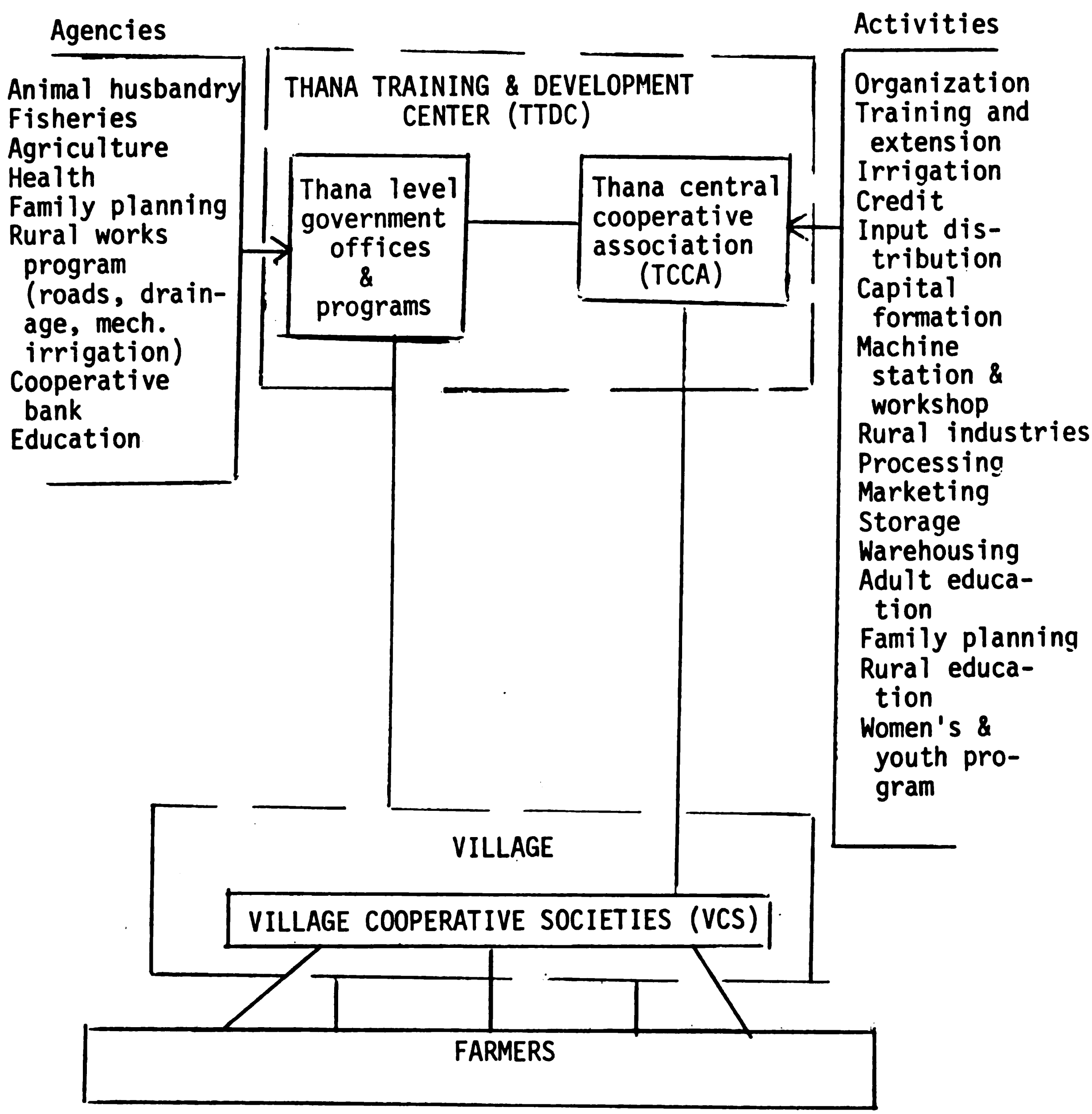


Figure II.1. Organizational Structure and Interaction in the Comilla Approach.

(v) Reliance on Cooperation and Group Pressure

Adhering to the principles of cooperation, the Comilla approach tried to generate motivation, self-reliances, strict discipline and group pressure among the participants. The recipients had to abide by certain rules and regulations, which were enunicated by the organization and strictly enforced. To stimulate the formation of collective consciousness, the participants were recognized as an organized body (VCS), and were required to deal with the central cooperative association as a group rather than as individuals. The stated role of the TCCA in this aspect was to induce a change among the participants. However, many problems in the sphere of power control, resource distribution, participation and factions were not fully settled which led many to criticize this aspect to the Comilla approach (Ahmed, B., 1972; Blair, 1974; Dumant, 1975).

(vi) Comprehensiveness

The institutional linkages and the integrated attack on rural problems helped initiate comprehensive area development encompassing all aspects of rural life, e.g., education, family planning, health and nutrition, women and youth development. Various activities concerning meaningful rural development objectives could be attached to the deep rooted institutional structure.

The Integrated Rural Development Program (IRDP)

The IRDP is the national program for duplicating the Comilla model throughout Bangladesh. The evolution of the IRDP started slowly and cautiously in 1963. In the beginning, the Comilla approach was tested in three remote Thanas of the country. Then between 1964 and 1968 all 20 Thanas of Comilla District were brought under the program. This preliminary phase provided experiences in Thana level replication, as well as a model for coordination of the expansion program within a dictrict. During this period several other duplication experiments were started in the districts of Chittagong, Dinajpur and elsewhere. These initiatives were quite significant in that they were generated outside the IRDP, by people with little financial and governmental backing. The success of these relatively unassisted projects proved that the Comilla appraoch could work without the parental care of the government machinery. They also established that the approach could be effective when sponsored by the people themselves.

Between 1964 and 1968 an increased concern for food self-sufficiency was intermingled with the success of IRRI crops and irrigation. Finding that the Comilla method was successful in training and organizing a large mass of the rural population for agricultural modernization, the government decided to undertake a modified Comilla method for accelerating food self-sufficiency with the use of IRRI crops and irrigation. In 1968 the Thana Irrigation Program (TIP) was extended throughout East Pakistan. Under the TIP cooperative groups were organized, rapidly trained, and issued credit and irrigation devices, either low-lift pumps or tubewells. The TIP was a modification of the Rural Works Program, which had been launched several years before (also as a result of the Comilla experiment).

The works program built up a physical infrastructure in the province of East Pakistan by utilizing the unemployed/underemployed rural labor force.

The IRDP was officially initiated in May 1971 during Bangladesh's liberation crisis period. After the liberation, the Government of Bangladesh adopted it as a major program and in July 1972 it was launched with vigor.

The First Five-Year Plan gave special emphasis ot rural institutions in general and to the IRDP in particular. It was planned that by 1976, 250 Thanas would be brought under the IRDP. The extension of the IRDP to the country's other 262 Thanas would proceed after an evaluation of initial achievements. Allocations for the period of 1973-78 amounted to Taka 313.85 million as a grant and Taka 1,266.40 million as a loan towards the IRDP alone. In addition, the IRDP was to provide a conduit through which other programs and agricultural sector activities would be channeled into the rural areas. The total amount to be allocated for such programs in the agricultural sector during 1973-78 is estimated at Taka 10,410 million, of which a sizeable portion would be utilized in IRDP-covered areas. The basic objectives of the IRDP were laid down as (Haque, 1971):

1. To create an institutional infrastructure which would promote the effective utilization of available resources, and which would serve as a vehicle for carrying out development programs. Within the organizational infrastructure, peasants were to form permanent, cohesive, disciplined, voluntary cooperative groups at the village

level, and these groups were to federate into Thana level cooperative associations.

2. To organize and develop the Thana Central Cooperative Associations (TCCA's) into strong development agencies promoting technological and social innovations, providing supervised credit, assisting in capital formation, arranging input supplies and services, and organizing continuous training programs for the Village Cooperative Society (VSC) representatives.
3. To develop local leadership through mass participation in cooperative activities at the village and Thana levels.
4. To help Thana and village cooperatives attain self-sufficiency in management and finance.

The basic unit of the IRDP operation is the TCCA at the Thana level. Its activities are directed downward to the federated VCS's and their members. The IRDP serves as the basic institution for rural development; the related activities of all nation building departments are linked, in some way, to the IRDP institutions at different levels.

At the Thana level, the departments of Agriculture and Extension, Fisheries, Livestock, Local Government, Cooperatives, Health, Family Planning and Education, the Agricultural Development Corporation (ADC), and the Cooperative Bank have officers and staff with specific functions. In the IRDP Thanas all of these officers and the TCCA are brought together and located in the Thana Training and Development Center. Planning, coordination, training, distribution, diffusion, etc. are unified and channeled through the TCCA. The

Thana Central Cooperative Association serves as the launching pad for all these institutions and as the supporting, supplying and servicing institution of its federated VCS's. The Thana Association maintains its own activities such as training and extension, issuing credit and collecting repayments, generating capital formation through savings deposit and share purchase, distributing inputs, processing, storaging, marketing, machine station, rural industries, and others - some of which have not yet been implemented. Also, social, educational, health, family planning, home development, and women's program activities will be initiated, as in the Comilla model, as soon as the IRDP institutions have been built.

Small and medium size farmers join the VCS as primary members. The VCS, in weekly meetings, draws up production plans and applies for supervised credit, disburses loans received from the TCCA, collects repayment and savings deposits and makes decisions concerning the members' needs. The manager, on behalf of the VCS, visits the TCCA to implement the VCS's resolutions. He and the supervisor representing the TCCA maintain the link between the two institutions in their mutual operation.

The initial cost of TCCA is borne by the IRDP through Government grants. This will continue for some time until the TCCA generates enough funds to finance itself. The source of such funds would be generated from the service fee that TCCA charges to the VCS at the rate of 7% for loans extended. The seed capital for credit operation will be provided by the government through the National Cooperative Bank in the form of long term loans (Taka 2 million in five years)

which are repayable in 20 years with a five year moratorium. Short term crop loans may also be obtained from the government (Taka 3 million in 5 years) and from commercial banks.

In addition, the members' savings deposits and share purchases increase the equity capital at the disposal of each TCCA, generally accounting for one third of the loan fund. It is thought, therefore, that within 20 years each TCCA will be on a footing to run its credit operation and bear its administrative cost from its own funds.

In spite of a difficult period in Bangladesh, the IRDP has progressed well. A preliminary report shows that the program is under way as per the plan and is fulfilling the physical targets laid down therein (Khan, 1970). As of August 1974, 152 Thanas have been brought under the Program with a membership of about 15,000 VCS's and 0.4 million farm families. About Taka 22 million has accumulated as farmers' capital through savings and shares with the TCCA. Taka 119 million have been distributed as loans of which Taka 66 million have been repaid. In the month of August, 1974 as many as 638 classes for managers, 412 classes for village accountants and 91 classes for chairmen were held - which indicates the intensity of the training activities of the IRDP. In all areas under the IRDP the demand for fertilizer, seed, pesticides and irrigation has increased substantially and rice cultivation under improved practices has intensified.

The IRDP's initial aim is to build up the institutional infrastructure around agricultural development. As the institution takes root, it will incorporate social, educational, health, family planning, women's development and industrial programs. Already action along this line has been undertaken by the IRDP, the Bangladesh Academy for Rural Development (BARD), and other agencies.

However, at this stage it is not possible to evaluate the impact of the IRDP in the attainment of national objectives at the grass roots level. Evaluation studies have been launched by the IRDP itself and by BARD, as well as by universities and several other research institutions. These studies will create the basis for critical analysis of the program.

CHAPTER III

CONCEPTUAL FRAMEWORK FOR POLICY ANALYSIS UNDER AN INTEGRATED RURAL DEVELOPMENT SYSTEM

Development planning is concerned with the design and application of a set of policies that encourage a development process and is therefore very much policy oriented (Zarembka, 1972). Development itself is a goal-oriented process in which policies describe mechanisms for obtaining the goals. As such, policy objectives are not different from development objectives. Rural development objectives, as identified by Uphoff and Esman (1974), contain three central dimensions which are: (i) agricultural productivity, (ii) rural income and (iii) rural welfare in terms of health, nutrition, education, etc. Along the same lines, the World Bank, which substantially influences development in the LDC's by its lending policies, defines the objectives of rural development as: to improve productivity; to increase employment and income; and to provide a minimum acceptable level of food, shelter, health and education (IBRD, 1975a). In all these definitions of objectives, agriculture has been reckoned as the pivotal dimension because of its central role in the economies of the LDC's.

When increasing agricultural production, and thereby increasing aggregate rural income, was the major objective of rural development, policy objectives centered on initiating rapid agricultural

growth. When this objective was single-mindedly pursued, income distribution, employment and social welfare became side issues, concomitant effects of structural changes in the process of growth. However, increasing concern for such issues has lead to their being considered as rural development objectives in their own right. Rural development itself must be redefined in accordance with these multiple objectives and policies should be drawn to achieve them all at the same time. In this chapter we evolve a framework for policy analysis which is expected to help in the planning and evaluation of strategies to meet the development objectives of Bangladesh. First, however, we will discuss the theoretical issues of agricultural transformation and policy planning in order to indicate the basis for the policy framework.

The Conceptual Basis

It has been established that a rapid transformation of traditional agriculture in Bangladesh is essential for the achievement of the objectives of rural development. In pursuing such an approach, however, we must seek the congruent achievement of multiple objectives, and if this does not occur, some policy intervention may be necessary to keep the trade off balanced. For such reasons, it is also necessary to understand how the transformation would take place and how policies can be applied effectively.

In general, there is a great deal of agreement that technological change is a crucial factor in the transformation of agricultural production. The production process is a technical phenomenon and a change in it would inherently change output. Technological change brings about new factors of production and alters the state of the art for combining factors of production. The result is that as the factors of production and the state of the art improve, the production function changes and output is increased. When a new technology (as for example, seed, fertilizer, water availability, or pest control) becomes available, it is critically important that farmers adopt the new techniques in their production processes and thereby cause a change in the state of the art. In a free economy, however, farmers retain their independence in deciding whether to adopt the new techniques. The farmers' decisions on the other hand, are constrained by many social, economic, and ecological factors. Such constraints are prevalent among small self-sufficient subsistance farmers who consume all or most of their produce leaving little or no marketable surplus (Wharton, 1969a). Because they live on the verge of subsistance, such farmers cannot take heavy risks by accepting new technology which is unknown to them. They stay within the bounds of old but known production techniques and established socio-cultural beliefs and values (Rogers, 1969).

Schultz (1964), however, has argued that small subsistence farmers in traditional agriculture are rational economic men and manage their farm operation as efficiently as the large commercial farmers. He argues that the small subsistence farmers are profit minded too, and that they want to maximize profits from their farming. If technology provides new and profitable factors and methods of production, the small farmers would not hesitate to adopt them. In fact, Schultz has argued that a demand for new factors of production exists, but that the supply of such factors is restricted. He has emphasized the need for more investment in institutions which can provide a continuous supply of new technological factors and methods.

This line of argument was pushed much further by Hayami and Ruttan (1971) who emphasized that technological change cannot proceed alone without the necessary institutional changes to support it. They argued that technological change can be achieved through market mechanisms and their interplay. In fact, under an appropriate price structure, transformation results from induced investment arising from the interaction between demanders and suppliers of technological change. Institutional change is necessary to maintain a price structure and to maintain the effectiveness of the market. However, inasmuch as Hayami and Ruttan's induced development process provides a method for agricultural transformation, it is inadequate in the light of the LDC environment. There market institutions are less than perfect. Self-created scarcities, coercion, and inefficient rules and regulations often create price distortions and fluctuations. On the other hand, subsistence farmers generally remain removed from the market institutions so that their connections with them are minimal. As a result, the expected interactions of demanders and suppliers do not take place with sufficient intensity to cause the process of induced development. Therefore, there is a need for evolving an alternative institutional mechanism not only to correct the inadequacies of markets but also to accelerate the expansion of new technology. As more information becomes available, their decision making is influenced towards accepting better and more profitable technology and their efficiency of allocation improves. Such behavioral change occurs, according to Schultz (1964), because of the profitability of new technology, the existence of price incentives and the availability of inputs. In other words, economic gains from technological change ushers in a behavioral change. The behavioral change, however, does not necessarily depend on economic factors alone. A host of sociocultural values and beliefs also are involved. These values and beliefs slowly change through constant diffusion of the effects of modernization (Rogers, 1969).

From this disucssion, it appears that technological change is a necessary but not a sufficient condition for transformation. Institutional and behavioral support is required to sustain technological change. One kind of change cannot be chosen and emphasized to the extent of neglecting the others. Institutional change alone would not bring on an agricultural transformation without sufficient technological and behavioral change (Hayami and Ruttan, 1971). The case is similar with behavioral change, for without institutional and technological support, it cannot induce an overall transformation. Each of these kinds of changes must be fostered and combined with the others. Their interaction can give rise to an overall transformational dynamic and the more the interaction, the more rapid would be the transformation. Such interaction should be sustained by a constant supply of technological, institutional and behavioral inputs, which also serves as the mechanism for keeping the combined effects in balance. In fact, such a balance of input supplies and the dynamic effects of transformation follows a planned path towards the set of objectives.

On the other hand, technological change is not neutral to distributive effects such as those of income and employment. Whether such effects would be positive or negative depends upon the initial structural conditions and the manner in which technological change is implemented. Implementation of technological change involves the supply of related inputs, their divisibilities, distribution, incentives for their use, and so forth. For example, if water cannot be supplied, HYV cannot be grown; if irrigation cannot be provided without constructing a dam, farmers would have to wait; if water charges are high, the incentive to use it would be lower, and so on. Distributive effects depend on how such implementation is pursued and whether it gives adequate attention to such questions. Indeed, such issues are in the area of administrative and institutional arrangements which are responsible for efficient propagation of the technological change (Gotsch, 1971; Ruttan, 1973).

How effective implementation, structural conditions and choice of combination of changes are to be attained is a much discussed subject in rural development. There is no clear theory or methodology available which can be accepted readily (Ruttan, 1974; Crosson, 1975). These differ from country to country and environment to environment, and even from one government to the next within a country. However, it clearly appears that for maximum interaction of the changes, a close integration is essential to satisfy their respective interrelationships. Such integration can possibly be attained by so called 'invisible hands,' or for that matter, by the present day market institutions of the LDC's in a context of slow growth. But for accelerated growth inducements must be generated by the supply of change inputs through alternative institutions. In the LDC's the public sector provides the insitutions for such inputs and holds the major responsibility for initiating developmental activities. The public sector bears the financial burden of providing such inputs to satisfy the farmers' demand. Farmers are ambivalent toward the government; they distrust government policy and government officials, yet they display a 'help me' attitude (Rogers, 1969). Although the public sector cannot divest itself of its role as initiator, supplier and caretaker of development, its capabilities are in actuality limited. Neither is it reasonable to expect the private sector in a developing country to accelerate development without support and control from the public sector. In most developing countries, the private sector is more handicapped than the public sector.

Moreover, the maximum interaction and integration of technological, institutional and behavioral changes can be effectively attained at the grass roots level rather than at a higher or national level. Lower level integration takes place within a workable goegraphical jurisdiction, which increases the proximity of participants. Choice of such level from where development work will be coordinated is essential for effectively matching the demand and supply of induced changes. Further, public institutions at this level can help in the evolution of private institutions and their growth so that eventually the private institutions can take over the management of the transformation.

These arguments bring us closer to the acceptance of the organizational approach as an effective means for inducing transformation in a traditional subsistence agriculture (Weitz, 1971; Owens and Shaw, 1974). Indeed, such an approach has been observed to be effective in many countries and has been generally overlooked until the rediscovery of the Chinese model (Aziz, 1974). More recently, as a result of failing to achieve rural development objectives under the sectoral approach and its limitations, a definite interest has grown among the development workers in the integrated approach to rural development (Mosher, 1972; Kotter, 1974). There is as yet no definite concept or method developed on this approach and it varies in operation from country to country. Some say the integrated approach is synonymous with the comprehensive approach or to the area development approach while some see it as an administrative and coordinating mechanism for the supply and service for rural development. We have, however, looked into the integrated approach under the system framework, and have considered the interactions and integration of technological, institutional and behavioral inputs and their controlling mechanisms to be the integrated approach.

In initiating successful integrated rural development, the role of the intermediate level organization is crucial. The

intermediate level organization can be a government, or senior non-government institution located in the hierarchy between the village and the central level of the development organization. It can act as a catalytic institution not only for introducing technological, institutional and behavioral inputs but also it can simulate decentralizing planning action and can be used for policy intervention. Mosher (1972) has shown that intermediate level organizations can effectively pursue integrated rural development in a limited area by establishing linkages and by intensifying development activities. In analyzing the role of local organizations in developing countries Owens and Shaw (1974) categorically supported farmers' associations and the activities of cooperative institutions in rural development. Considering the stringent conditions in Bangladesh, Akhter Hameed Khan strongly emphasized the creation of intermediate level farmers' organizations.

Most recently the Rural Development Committee of Cornell University conducted a study of many Asian countries to ascertain the role of rural institutions and local organizations in rural development. The committee observed from 18 case studies that there was a clear relationship between organization and rural development performances (productivity, income, and welfare); these performance variables were enhanced in those cases where rural people participated in local organizations (Uphoff and Esman, 1974). The committee observed that in the total rural development functions local organizations of Comilla scores 48 (of which KTCCA itself accounts for 36) and the State Administration (government) scores 26. Comparable figures for China are 42 and 41 respectively. The committee found that rural welfare (income distribution, education, health, security, etc.) in the most organized cases levels high, while disparities, unemployment, population growth are lower. The study concluded that local organization, whether governmental or autonomous, makes a substantial impact on rural development performance.

Policy intervention is essential if the goals of rural development are to be fulfilled. In general, policy intervention is throught to be necessary for improving the distribution of income. After studying Pakistan, Gotsch (1971) maintained that without government policy intervention, the effects of the green revolution would favor the larger farmers. In another study, Inayetullah (1974) conceptualized that rural development performance and welfare depend upon policy intervention and that the higher the intervention, the more the equality. It is assumed that policy intervention does not have to occur through the market, as is generally done in a mixed economy, but can also be extended through organizations, the latter method of policy intervention may well be more effective.

With this view we shall focus our attention on how a policy intervention can be conducted through the intermediate level organizations with the objective of effecting agricultural transformation as well as improving distribution.

Difficulties in Policy Planning

A multiple objective function introduces the problem of tradeoffs. While the ideal policy strategy may be to maximize all objectives in the function, it is difficult to find a policy or a set of policies that will simultaneously accomplish this. A given policy may help attain a just distribution of income, yet force production and employment to decrease. The choice of policies then seems problematic due to at least three fundamental difficulties (Johnson and Zerby, 1973). These are:

1. The first difficulty arises due to the absence of an interpersonally valid common denominator to handle multiple objectives. If there were a common denominator available, the multiple objectives could be maximized in terms of this denominator in order to achieve a single composite objective. In the absence of a common denominator policy planners often use an approach that considers production, income distribution, and employment separately and maximizes one irrespective of the others.
2. The second difficulty lies in determining the optimum order in which a program should be executed within a policy, or the order in which various policies should be executed in developing a sector. In the interrelated activities of development, there are many facets that need to be handled or executed to ensure that the development process moves dynamically towards the achievement of the objectives. For example, in agricultural transformation, many programs dealing with technological, institutional and behavioral inputs have to be initiated and many policies have to be developed to support them. When programs or policies

involve technological, institutional, and human changes, such as these there is no ready-made optimum sequence of alternative actions that would result in a path of maximum gain. It is not possible, then, to prescribe the sequence of policies or programs, which would bring the optimum realization of objectives. (If there were a common denominator, it might be possible to chart a particular policy sequence that would maximize gain. However this might not result in the full realization of rural development objectives due to the effect of variations in combinations of the structural changes.)

3. The third difficulty arises in the determination of decision-making rules to select a program, or policy, that would serve as the best alternative. The choice of an appropriate decision-making rule becomes problematic due to imperfect knowledge, the deficiencies of foresight, and the lack of a common denominator and an order sequence. As a result alternative policies are chosen on the basis of some apriori rules set by the decision makers. Such rules are in some cases defined in terms of the political, social and economic needs of the populace, but often in developing countries they are directed by the attitudes, vested interests and ideologies of those who control power. In effect, the policy priorities may shift towards the selection of policies which are not those most suitable for the country.

It is difficult, although desirable, to examine the long-run effects of the policy under consideration. Since rural development is by definition a dynamic concept, the long-term trend of the performances generated by the policy has to be assessed through dynamic analysis to determine the effectiveness of the policy. But serious difficulties arise when dynamic analysis is attempted, for input combinations, policy variables and even the structure may change. More analytical difficulties arise because the dynamic effects of technological, institutional and behavioral changes remain undefined even in theory (Jonson, 1972). A dynamic analytical framework for policy effects is not yet fully developed, and has never been attempted in the area of rural development.

In cognizance of these fundamental difficulties in policy planning the present study has attempted to look at rural development objectives, such as productivity, consumption, employment and income distribution at the same time rather than separately. The effects of the policies are demonstrated along a sequential time path derived through systems imulation techniques. Several performance indicators have been introduced to measure the multiple effects. No decision making rule has been imposed rather the choices have been kept open for consideration by the decision makers.

The Systems Simulation Approach in Policy Planning

Accompanying the problems in policy planning mentioned in the previous section, there is a need for a technique for dealing with these problems. It is now obvious that the roots of such problems lie deep in methodological inefficiencies. Existing analytic techniques such as linear programming, simultaneous equation systems, and cost-benefit analysis impose their own theoretical rigidities on the solutions. Moreover, these techniques are limited in their capacities to deal with the complex interactions of a development process (Manetsch et al., 1971). In dynamic analysis, such complexities are greatly increased and impose further limitations upon the existing programming, econometric and input-output techniques.

The system simulation approach is a flexible, iterative, problem-solving process that involves stages of problem formulation, mathematical modelling, model testing and refinement, and problem solution in close contact with decision making (Manetsch et al., 1971). A system simulation can be adjusted to the type and sources of data, and to the estimation and approximation procedures used in a policy analysis. In other words, the systems simulation approach uses all available methods which are beneficial to its iterative process.

Iteration involves repeating the simulation cycle as required to incorporate feedback from decision makers as well as from people in the field. A mathematical structure developed by studying the real system is continuously tested and refined through validation, and serves as the basis for suggesting alternative solutions to the problem. The systems approach does not impose a particular solution upon the decision maker but it clarifies various possibilities from which a solution can be chosen depending upon the decision maker's objectives. Moreover, the approach is not confined to any one field, but can be used to analyze problems in many disciplines.

The systems simulation approach accommodates complex interactions present in the real system. This is done by breaking the total system into interrelated functional components which are called building blocks, and by specifying the linkages within and between the components. Systems analysis is the process through which such interactions are studied. For that purpose the system linkages have to be understood through a detailed and penetrating study of the real system. If the systems interactions can be specified, they can be made dynamic through computer simulation by tracing out over time the probable trends of complex interactions.

The use of systems simulation in dynamic agricultural policy planning is a quite recent approach and is still in the development stage (Johnson and Ranser, n.d.). This approach has been applied to sector analysis in various developing countries such as Nigeria (Manetsch et al., 1971), Korea (Rossmiller et al., 1972), Venezuela (Holland et al., 1966), Colombia (Posada, 1974), Brazil (Ahn and Singh, 1973) and India (Mellor and Mudahar, 1974). The systems approach to rural development policy planning has been emphasized only recently (Billingsley and Lacewell, 1972). Earl Kulp (1970) first introduced systems analysis in rural development planning in 1970. Since then, several attempts have been made by Macmillan (1974) in Canada, Tweeten (1974) in the U.S. and Herdt and Kellogg (1973) in India. Except the work of Herdt and Kellogg , the author is unaware of any substantial study in this field that analyzes the micro-level effect on production, income, and employment of policy alternatives in developing countries. Indeed, no systems analytical study has been undertaken anywhere which considers integrated rural development in Bangladesh or elsewhere. However, several systems conceptualizations have been suggested and of these Kotter's (1974) was the most significant.

Although the systems analysis approach is a powerful policy planning tool, it has several limitations which need to be discussed. It has already been indicated that the approach requires a deep understanding of the real system and its interactions. To incorporate these interactions in the mathematical model, a large number of equations, variables and parameters have to be specified. To make the model operational a large amount of data must be specified and the model must be validated. In addition to the model itself, the simulation results have to be interpreted for decision makers. This approach involves many kinds of resources -- time, money, personnel and access to a computer -- and the availability of such resources in LDC's is generally limited. Though such issues have not been solved, it is argued that the cost-benefit ratio of the approach would not fall below that of other approaches and that such limitations would not be insurmountable. Consideration of the systems simulation approach, therefore, should emphasize its capabilities as an effective planning tool rather than its limitations.

The Systems Analysis Framework for Integrated Rural Development

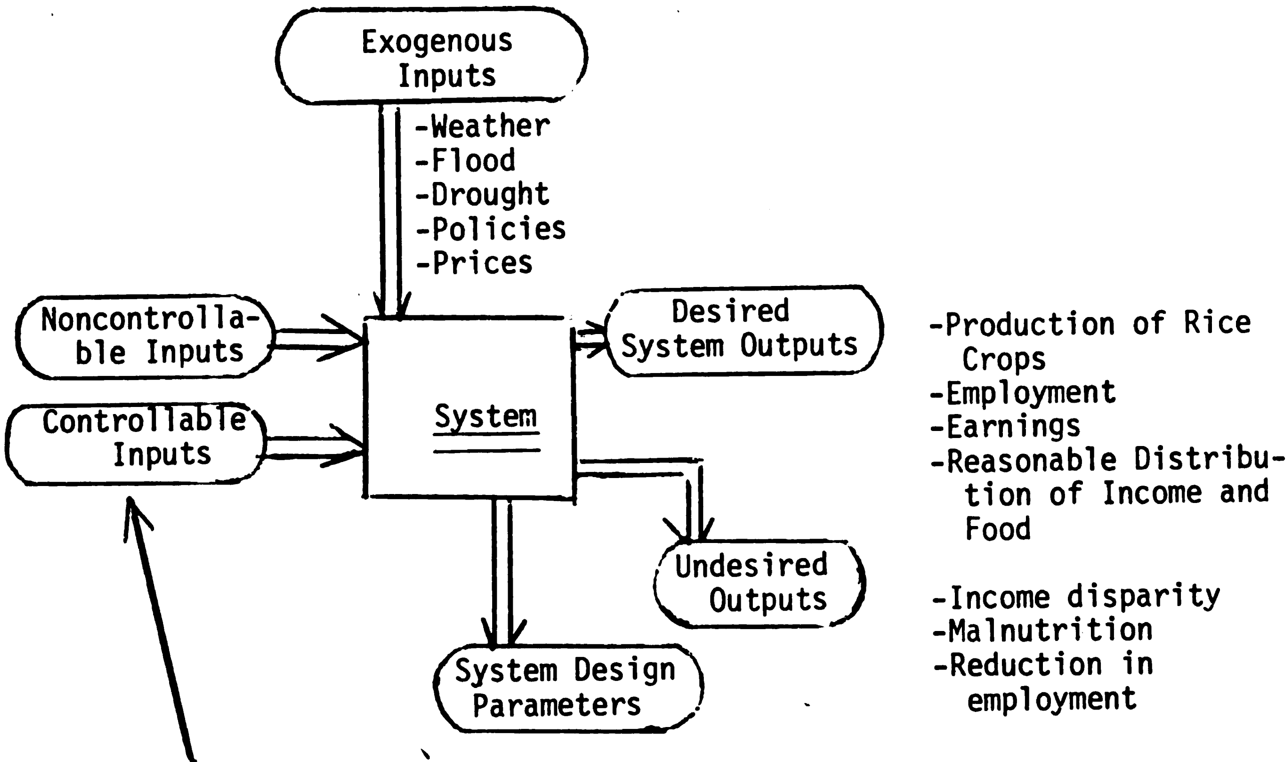
The Integrated Rural Development System (IRDS) is a structure in which a network of directly interacting linkages is established between the demanders (farmers) and the suppliers (private or public institutions). In this system, an intermediate level organization assumes a crucial catalytic role; through the organization combinations of technological, institutional and behavioral change inputs are channeled into the system. The linkages thus established help loosen constraints upon the farmers and the organization, create a feedback loop around them and overcome market problems. The integration of technological, institutional and behavioral inputs in the system by means of an intermediate level organization can help to bring about planned change in many aspects of rural development. Also, the existence of an intermediate level organization opens up possibilities for decentralized area planning, which could in turn form the basis of a meaningful national development policy.

The system is conceived to include a structure, multiple inputs and multiple output. The structure is defined by the wide ranging linkages, established under the organizational framework, that help in attaining planned changes and objectives. The multiple outputs of the system are set by the rural development objectives which in our case are production, employment, nutrition and income. These are considered as desired outputs. There are several outputs which the system may bring about but are not desired such as inflation, malnutrition, income disparity, etc. Multiple inputs are channeled into the system through various means so that desired outputs can be obtained.

Inputs can be broadly classified under two classes. Exogenous inputs are those which enter into the system from outside, affect it but are not influenced by it. Examples of this class of input are weather conditions (floods, droughts), government policies, prices, etc. The other class of inputs occur in two forms -- noncontrollable and controllable. Noncontrollable inputs are mostly socio-psychological and political. They affect the system but cannot be manipulated or varied as much as the physical inputs. Almost all the inputs than can be manipulated during the operation of the system to achieve the objectives are classified under controlled inputs.

In the IRDS we recognize that many controllable inputs are provided by the organization. Through the organizational structure, member-farmers receive technological innovations, e.g., biological inputs (seed, plants), chemical inputs (fertilizer, pesticide, etc.) and mechanical inputs (pumps, tubewell, tractors, threshers). Institutional inputs (e.g., credit, banking, marketing, storage) and behavioral inputs (e.g., training, information, innovative ideas, etc.) are also provided through the organizational structure. In effect, this helps farmers to get relief from constraints in land and capital and to strive for increasing production, income and welfare.

System design parameters represent the characteristics which specify the structure of the system. Inherently these are the parameters which help realize the objectives through varying inputs and as such they are the most important variables. However, they differ from system to system and approach to approach and their changes in a system will change the structure. In our model, we have taken system design parameters as defined by the Comilla approach and accepted them as given. We recognize that any change in the Comilla approach would call for modification of our model. By basing our model on the Comilla



Organizational

Technological

Fertilizer
Mech. Irrigation
HYV Seeds
Pesticides, etc.

Institutional

Credit
Banking
Extension
Marketing, etc.

Behavioral

Training
Motivation

(discipline and group pressure, etc.)

Farmers

Land
Labor
Capital

Figure 1. Major Inputs and Outputs of the Rural Development System.

approach, we give the model a definite footing. This allows us to analyze the impacts of policies on the systems. Otherwise we would end up evaluating the approach itself.

Once the system design parameters are specified, the performances of the system can be affected in two ways -- by varying inputs and by policy changes. Different combinations of inputs would give different output combinations. Such differences in input combinations would come about through organizational and national policies of input distribution, timing, procurement, quantity, etc. On the other hand, the agricultural structure (different from the system structure) of the area can be subjected to policy change such as land reform, mechanization, etc. Some policies may induce price changes, whereas other policies, such as laws or decrees, may direct change. These policies can affect the output levels in two different ways, either through input distribution or through a structural change mechanism. If the input and policy variables are specified and the system structure is identified by its flows, it should be possible to identify the resulting changes in the output levels (performances).

As discussed earlier, the policies in Bangladesh agriculture need to have multi-objectives so as to increase all the development performances simultaneously at both the micro and macro levels. The intermediate level organization in this aspect provides a ground to operationalize the policies at the level where development actually begins to work. Policies affecting the micro level farmers can be generated at two levels: the national level and the intermediate organization level. The national policies of the government would have wide and equal applicability to all farmers in the country, while organizational policies would be applicable only to the geographical area and participating members of an organization. From the IRDS viewpoint, these policies can be thought of as working in a system both exogenously and endogenously. Some policies such as land reform or taxation would act on the IRDS exogenously while co-operativization could be endogenous in that it would work within the system. Since both categories of policies, exogenous and endogenous, would affect the system's performances, it is possible to estimate the effects contingent upon them by the use of some analytical techniques. It is all the more possible because under the IRDS system the input, output and even the structure of the system are clearly observable.

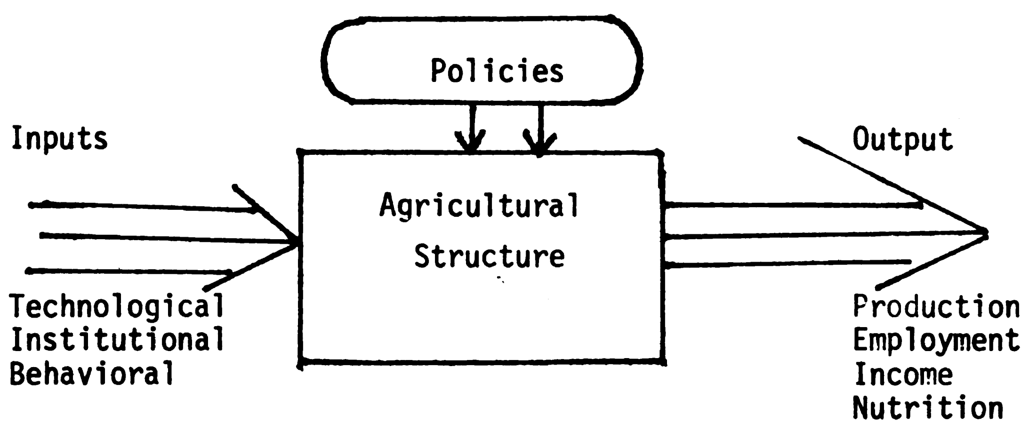


Figure 2

Thus, under this systems framework it is possible to identify the area that needs policy attention. Considering desired performances in terms of output, it is possible to observe whether their attainment came about by changing input combinations or by changing the agricultural structure. Moreover the systems framework can serve our purposes in the following specific ways:

1. The distributive effects of policies involving the output and the agricultural structure arise mainly from resource endowments of the micro level farmers. In aggregative analysis, distributory impacts among classes of farmers are hidden, and therefore cannot be handled in terms of policies which are based on aggregative information. Using the systems analysis framework, farmers in the area can be disaggregated into several classes according to their respective resource endowments, providing the basis for comparing trends of performances under alternative policies. Much could then be learned by manipulating the combination of inputs or the system structure, so as to ascertain which changes lead to favorable distribution effects.
2. Dynamic processes, which are crucial to the understanding of rural development, can be studied within this framework. The complex interactions which occur within the system, and which are expressed by model linkages, would be demonstrated as the model variables influence one another recursively during a simulation run. The system simulation model would trace changes in performance variables for disaggregated classes of farmers over time. The simulation would also trace interclass transfers of land, labor and capital resources as a dynamic process.

3. The systems framework increases the scope for decentralized area development planning. Given national policies, local organizational policies could be evolved in terms of input distribution and structure by taking into account characteristics of the area. Different Thanas will have different cropping patterns, farm size, labor availability, etc. which may call for different policies. Within the national IRDP replication program it is necessary to have flexibility, otherwise inter-thana differences in performance would result. Since the systems structure contained in the Comilla approach is actually being replicated, it will remain the same for all areas. This kind of systems framework, it would seem, could be used to adjust national policies to the special requirements of different localities.

4. It is not our contention that the system inherent in the Comilla approach should be rigidly maintained, or that its further modification would not be necessary. However, it is obvious from the Comilla experience that both time and money are needed to evolve systemic modifications and to choose from alternative designs. While adoptive experimentation in the field will always be required, so as to ascertain whether new approaches to rural development are viable and workable, the design process can be simplified, shortened, and rendered less costly if systematic alterations can be tested out on the computer before they are

implemented in practice. The use of a computer would reduce the time needed for practical experimentation, and would aid in the selection of an efficacious design.

The Framework of Policy Analysis

A system simulation model describing the interrelationships of the variables and their interactions in the Integrated Rural Development System (IRDS) has been proposed as the framework of policy analysis. The outputs of the model are defined as performances criteria and are selected according to their conformity to the multiple objectives stated above. Changes in performance criteria which are due to changes in the policies are considered as policy effects.

To operationalize the framework of policy analysis, certain basic assumptions were made which are as follows:

(a) although a multitude of social, economic and political implications are involved in a policy analysis, for our present purposes we have limited our attention to economic aspects only.

(b) the pattern of the IRDS is similar to that of the Comilla approach (as indicated in Chapter II) on which basis the systems model has been based. Specifically, there exists an intermediate level of organizational structure through which rural development is pursued.

(c) the operational boundary of the IRDS is governed by a given geographical jurisdiction, such as the _Thana_, which is smaller than the national area. Also, it is assumed the farm

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that the system is closed within the Thana, though in reality, various external economic influences are apparent. Many outside interactions will be neglected in this model but a few which significantly affect the system will be taken into account as exogenous variables.

(d) the state of the economy is mixed, with activities of both public and private institutions recognized. Policy interventions are possible and do not impare the rights of farmers to make independent decisions.

To measure the distributive effects among classes of farmers, the farming population is disaggregated into four distinct classes on the basis of the sizes of their land holding. In the Comilla approach, however, farmers may or may not join the cooperative organization, although the integrated system covers the whole Thana. Those who join the organization obtain certain inputs from it, while those who do not can still obtain many of the inputs from the distributing agencies or from the market. It has been found that participation in the organization has an impact on the performance of the farmer, so we have categorized farmers according to their membership in the organization. The distribution of the total farming population, therefore, falls into eight classes as shown in Table III.1.

The gross structure of the IRDS model is shown in Figure 3. There are eight (8) interrelated components (building blocks) in the model and each performs certain functions. Each component is considered as a submodel which employs certain variables. These variables are calculated by other related components in order to provide

Table III.1. Classification of farmers of Comilla Thana according to farm size and membership in cooperative organization

Farm Size Category	Farmer Groups: Cooperative Member	Cooperative Non-member
Less than 1 acre (near landless)	Class 1	Class 2
1 to under 3 acres (small)	Class 3	Class 4
3 to under 5 acres (medium)	Class 5	Class 6
5 acres and over (large)	Class 7	Class 8

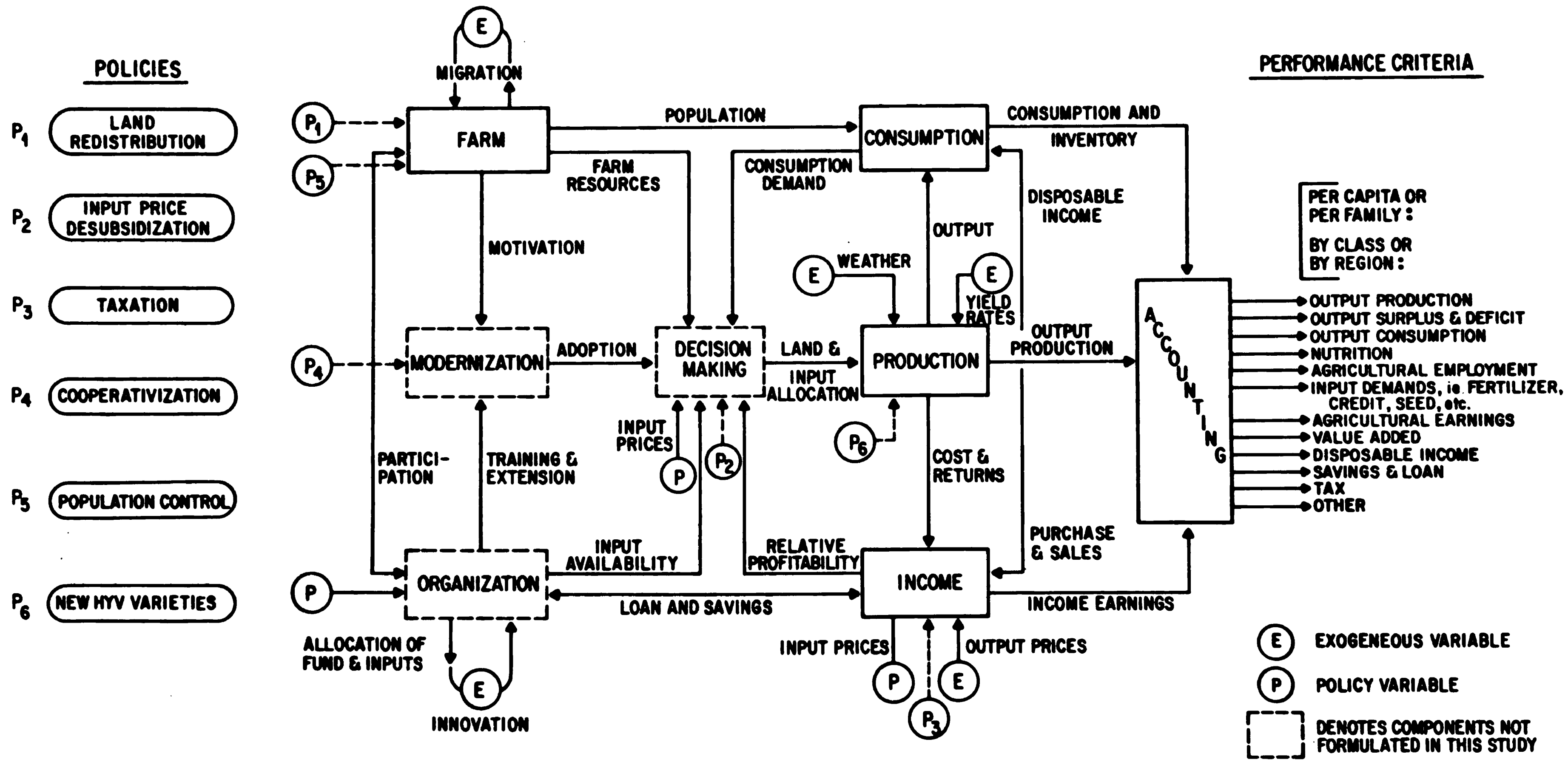

FIGURE 3 — GROSS STRUCTURE OF INTEGRATED RURAL DEVELOPMENT SYSTEM MODEL

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information that is required by the model. Policy variables, shown on the left hand side of the figure, enter directly into the components at impact points. Similarly, the exogenous variables enter into the respective components to which they are most related. The physical input requirements are determined endogenously by the respective components. Beginning with the given initial conditions, the model generates information that has been calculated by the different interacting components for each of the three (3) cropping seasons of the year. The performance variables listed on the right hand side of the figure are the seasonal or annual outputs of the model.

The components and a brief description of their functions as conceptualized are given below:[1]

1. Farm: This component includes the rural population, farm families and their sizes, the agricultural labor supply, and aggregate land holding sizes. Within the given initial conditions, the growth of the population is calucluated on the basis of the existing intrinsic rate of a natural increase of population. In-migration and out-migration in the Thana are not considered for the sake of brevity as well as for their negligibility. However, interclass transfers of population are taken into account. A change

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[1] It is to be remembered that the total model represents and runs for each of the eight (8) disaggregated classes of farmers in the Thana. For each class the model variables are aggregates.

of aggregate land holding size which might occur due to the sale or purchase of land by a class is not considered but that due to sharecropping is taken into account.

2. Consumption: This component calculates the consumption demand for staple food, nutritional intake, debt, marketable surplus, sales and purchases of food grains and case expenditures on non-food items. These items are endogenously determined by the related information received from other components such as population, production and income.

3. Intermediate Level Organization: In this component, certain activities of the organization that are related to agricultural transformation, e.g., distribution of technological, institutional and behavioral inputs, are simulated. Since variability in procurement, control, supply, distribution and prices of the inputs affects output performances, the organization becomes a manipulator in the IRDS. This component also simulates growth of the capital formation of the organization as well as membership growth.

4. Modernization: This component underlies the farm and organization components and simulates the trend of transformation among the classes of farmers. As farmers participate in the organizational activities of training, extension, and diffusion of innovations, their motivation and adoption of techniques are likely to increase. The direct participation of the members results in a sharper adoption curve while non-members who receive only the benefits of

demonstrations follow a slower trend. This component calculates the rate and levels of modernization for the classes that influence their decision making for agricultural transformation.

5. Decision making: This component simulates the crucial functions of agricultural transformation. It receives information from all the components and makes decisions on land, labor and capital as well as on other input allocations. It also makes decisions on crops and the selection of varieties. As the modernization trend increases, the traditional variety is replaced by high yielding varieties and the necessary input allocations are made. Such decisions are made under constraints that are prevalent in a class and which have bearing upon this production pattern.

6. Production: This component computes agricultural output under the allocations made in the decision making component. It also calculates the inputs used for seasonal labor employment, storage and disposal of produce. The simulation of input use provides the trend of input requirement including labor.

7. Income: This is mostly an accounting component that calculates input costs, earnings, tax, loan repayment, savings and cash balance. The input and output prices are used as exogeneous variables for the time being. The component also simulates the transfer of income among classes through labor, land rent and interest costs.

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8. Accounting: This component keeps track of the performance variables and summarizes them by enterprise and/or by season or year in order to show a total figure for the Thana as a whole. It provides additional information for consideration that is not available from other components. In addition to the performance variables such as output, income, employment, consumption, it provides the value that is added to agriculture and non-agriculture pursuits, storage, cash balance, investment, input demand and other related information.

The model designed on the basis of disaggregation introduces flexibility which permits the model to incorporate independent characteristics of all classes. The model generates aggregate patterns of input and output for each class which provide the basis for observing and comparing interclass performance trends. The performance criteria selected for this purpose are expressed by class as totals, and on a per farm and per capita basis. The selected performance measures fall under the following main areas:

1. Production - crops by variety - (in maunds),
2. Earnings - gross farm income and disposable income (in Taka),
3. Consumption - of rice by quantity and calories,
4. Employment - total labor and hired labor.

In addition, other variables such as value added by agriculture and by family, food inventory, liquidity, etc. are also measured by class.

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So far as the input requirement is concerned, the use of physical inputs by class is observed only in total terms.

To estimate the changes in performances due to policy changes, the model is subjected to exogenous stimulation by several policy variables. In a simulation model, practically any number of policy variables can be accommodated, but for our experimental purpose we shall limit them to a few, such as

(1) Land reform: A land ceiling of a specified size with excess land distributed among marginal or landless farmers. The proposed land ceiling would be lower than the current 33.3 acres.

(2) Desubsidization of input prices: Present subsidies on technological inputs, e.g., fertilizer, irrigation, etc. would be lowered.

(3) Tax: A land tax would be imposed per unit of land or agricultural income tax would be imposed on annual taxable income.

(4) Development of new varieties: Seeds for higher yielding crops would be made available to farmers.

(5) Cooperativization: A membership drive would be conducted so as to bring a large number of farmers under the cooperative organization.

(6) Population control: A general policy would be implemented to lower population growth.

In order to observe the dynamic effects of the policy changes, the model will run to a time horizon, of 8 years, or from 1974 to 1981, inclusive. Consequences in 1981 due to policy changes will be compared to the 1981 version of the status quo situation, in which the strategy of agricultural transformation is continued as at present.

Summary

In this chapter a conceptual framework to analyze effects of policies in the context of integrated rural development is developed. It has been pointed out that rural development objectives are multiple in number and interrelated in nature. Because of trade-offs existing among them the pursuit of solitary objectives, leaving others unconsidered, often leads to incongruity in goal achievement.

For achieving agricultural transformation in Bangladesh, technological change is indeed crucially needed. But as much as technological change is necessary to induce transformation in traditional subsistence agriculture it is not sufficient. Behavioral and institutional changes are also required to accommodate technological change. In a free economy the transformation is automatically achieved through the market by exchanges of demanders and suppliers. However, in developing countries it is unlikely that the market alone will be able to effectuate all such changes and induce a transformation without some alternative arrangements.

Distributive effects that result from agricultural transformation are inherently due to initial structural conditions of the environment, to the method of implementing changes and to the manner in which inputs are combined. Their solutions entail administrative and institutional policy interventions for regulating the transformation.

There is no clear cut methodology available that can readily be prescribed. Considering the institutional environment of less developed countries, it is argued that the organizational approach provides a means both for the infusion of technological, behavioral and institutional inputs in combination, and for regulating them through policies or otherwise. In this regard the role of intermediate level organizations has been found worthy of consideration. An intermediate level organization provides maximum integration and interaction of the change inputs, which is the basis of integrated rural development.

Planning policies aimed at achieving multiple objectives are methodologically problematic due to the absence of an interpersonally valid common denominator, of a method to determine the optimum order sequence, and of decision making rules for choosing the best policy. These fundamental difficulties extenuate further when dynamic analyses are sought. This study seeks to cope with these problems through the simultaneous achievement of single objectives among participants disaggregated according to their homogeneous characteristics, and by examining the attainment sequentially along the time path.

The systems analysis method has been used to describe the complex interacting linkages in the integrated rural development system. Based on the closed regional system structure defined by the Comilla approach, the study shows, in a conceptual way how integrated rural development works and how policies can be effectively applied to the system. The system analysis framework thus can be used to measure dynamic performances of disaggregated participant classes. The systems approach also provides scope for decentralized

Thana policy planning, and for deriving and testing ideas for the modification and improvement of the Comilla approach.

The policy analysis framework has been developed on the basis of a systems analytical model of integrated rural development. The model structure has been designed with eight components or building blocks and their linkages. The output variables that define performances of the system participants, and policies that are considered useful to attack problems of agricultural growth and distributive inequalities are indicated, along with their impact points in the system. In the next chapter the mathematical structure of the model, which is based on the conceptual framework of this chapter, is presented.

PART B: THE SYSTEM SIMULATION MODEL

CHAPTER IV

THE MODEL DESCRIPTION

Scope of the Model

The mathematical structure of the model is described in this chapter, but before it is presented we would like to point out its scope vis-a-vis the gross structure presented in Chapter III.[1] The structure discussed therein is that of the total model conceptualized for the Integrated Rural Development System. But due to the limitation of resources it has not been possible to operationalize the total model. Instead, we undertook to develop structural equations for the blocks designated by bold lines in Figure 3, page 64. It is expected that if explicit representation of the remainder of the total model is attempted at a later date, the present work can be fitted to the other sections in order to operationalize the complete model.

The structural equations presented here involve several components of the gross structure shown in Figure 3. These components are: Farm, Production, Consumption, Income and Accounting. The components which have not been included in the present work are organization, modernization, and the Allocating Decisions. These components are undeniably crucial for the system as a whole because, through

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[1]The computer program of the model is given in the Appendix.

their decision making roles, they can make other components dependent and can thereby change the outcome of the system. To circumvent the difficulties that crop up in leaving them out of the present work we resorted to alternative means. Firstly, critical information that would be obtained as output of the excluded components to serve as inputs to the included components is provided exogenously in this work. In generating exogenous data for this purpose, an attempt has been made to obtain information that is as realistic as possible. Reliable sources have been sought out, but intuitive guesstimates have sometimes been made. Secondly, those alternative decisions that could have an impact upon system performances have been examined through model sensitivity tests; during these tests the model was subjected to several alternate situations that could arise due to differing outputs of the omitted components. This methodology provided the basis on which the omitted components have been involved in the present work. Although these methods cannot fully substitute for a modelling of the complicated interactions which actually take place between the omitted and the included components in the real world, the approach has allowed operationalization of a model.

As indicated earlier, the model is essentially developed for a small geographical region as identified by the administrative boundary of Thana. Except for a few variables, i.e. prices, interest rates, input supplies, the system being modelled has been, for all practical purposes, considered as closed. The rural population of the area has been disaggregated into eight classes (i = 1,8) according to membership or nonmembership in cooperatives and the size of land holdings. Farmers retain their independent decision making functions but have been considered as a group in each of the classes. For this model only the rice crop has been studied. Although a number of crops are grown in Bangladesh, by far the major crop is rice (in Comilla Thana, for example 95 percent of the cropping intensity is specified by rice production) and the new technology presently being expounded is mainly for this crop. The presently available strains of rice varieties are grouped under two crops (j = 1,2); improved varieties (HYV) e.g. IR5, IR8, IR-20, Pajam, Mala, Chandina; and local varieties e.g. Dharial. Dhalishaitta, Boro, Latishail, Nigershail. Rice crops are grown in three rice growing seasons (n = 1,3) - Boro, Aus and Amon. In Boro season cultivation of rice, especially the HYV are greatly dependent upon mechanical irrigation facilities; in other seasons occasional irrigation might be useful at the planting or harvesting stages, but this is not presently done. In view of this a provision has been made in the model for including methods of irrigation (K = 1,2), but it was not used due to the paucity of data. Thus, the model has been made flexible in at least two aspects -- methods of irrigation and number of crops -- so that it can accommodate these aspects later as data become available.

Notions of the availability, forms, and constraints of data have been reflected in the forms of various equations. Care has been taken to demand as little exogenous data as possible, and to use data which are for the most part already available. In many cases, however, roundabout means of derivation in structuring the equations could not be avoided. Although such roundabout derivations have increased number of equations or iterations, they have not caused us to deviate from central purposes of the model. As and when the data situation improves, the model can be simplified by eliminating the roundabout derivation.

Detailed Model Description

Farm Component:

The Farm Component generates data for the eight population classes, including their land holdings, their institutional membership, and their agricultural labor supplies. It also generates allocation of land area for seasonal cultivation and for crop varieties. The two other characteristics that have been incorporated in the farm component are interclass transfers and dynamic growth of the class variables. The farm component generates data for four categories of farmers according to the size of their land holdings (i.e. 0-1 acres, 1-3 acres, 3-5 acres and 5 acres and over), and it then disaggregates the data for each of these categories into two 'sub' classes according to institutional affiliation with cooperatives (i.e. members, and non-members).

The institutional membership data is generated by the following equation:

$$(1)\quad MEMB_m(t) = \text{Min}\ (FFM_m(PPFM_m(t) + RTM_m(t)), C1.FFM_m)$$

where

$MEMB$ = members of cooperative institution (number)

FFM = total farm families in the category (number)

PPFM = initial proportion of farm families who are members (dimensionless)

RTM = proportion of new farmers (net) joining the cooperatives each year (dimensionless)

C1 = maximum proportion of farmers expected to be in the cooperatives (dimensionless)

m = land holding category (m = 1,4)

t = time

The total number of farm families in the Thana is assumed not to change during the run duration.[2] Also it is assumed that a member in the cooperative organization represents one family. The minimum function has been introduced in the equation to prevent it from blowing up in situations that may result due to linear growth. The linear growth parameter RTM may be a little unrealistic but it is accepted so as to simplify the dynamic growth.

The non-member data, NMEMB, are then obtained as:

(2) $$NMEMB_m(t) = FFM_m - MEMB_m(t) .$$

The total population, POPN, in each of the four land holding categories is generated for each year by the following equation:

(3) $$POPN_m(t) = POPN_m74 \cdot (EXP\ (GRT\ .\ T))$$

---

[2]This assumption was made for several reasons. Firstly, the joint family system still existing in the rural areas absorbs the population increase within the families. Secondly, the formation of nuclear families is slow and would be insignificant within the time period with which we are concerned. Thirdly, there is great paucity of data on growth of rural families.

where

GRT = intrinsic rate of natural increase in population (persons/year)

$POPN_m74$ = initial population in 1974

EXP = exponential

T = year

This provides a basis for calculating family sizes for each category of farmers as:

$$AVFSZ_m(t) = POPN_m(t)/FFM_m \tag{4}$$

where

$AVFSZ$ = average size of family (persons).

Since the number of farm families in each category (FFM) does not change, and since migration into or out of the Thana is assumed to be negligible, the average family size (AVFSZ) will vary only due to the changes in POPN, the total Thana population. It has also been assumed that during the run period of 8 years there is no transfer of farmers or population from one land holding category to another. The population represented by each land holding category of cooperative members can then be calculated as:

$$POPNM_m(t) = MEMB_m(t) \cdot AVFSZ_m(t) \tag{5}$$

and

$$POPNN_m(t) = POPN_m(t) - POPNM_m(t) \tag{6}$$

where

POPNM = population represented by farmers holding membership in cooperatives (persons);

POPNN = population of non-members (persons).

Given the land area possessed by the farm families of respective categories it is possible to calculate their average land holdings. The land area possessed by members and non-members can then easily be obtained as:

(7) $$AVLND_m(t) = LND_m(t)/FFM_m$$

(8) $$LNDM_m(t) = MEMB_m(t) \cdot AVLND_m(t)$$

(9) $$LNDN_m(t) = LND_m(t) - LNDM_m(t)$$

where

LND = total land area in possession of the land holding category (acres);

LNDM = land area in possession of members in the landholding category (acres);

LNDN = land area in possession of non-members in theland holding category (acres);

AVLND = average area of land possessed (acres).

While account has been made through the above equations of possessed land transferred from one class to another along with the transferees, it is also logical to do so for the land which is under share cropping. In this case, there is a transfer of land from one category of farmers to another only for cultivation, the ownership is retained by the owning category for which it receives a share of the output from the category which cultivates the land. To determine the amount of sharecropped land (either taken or given by the category) in question, the following equation is devised:

(10) $$SHRLND_m(t) = GAMMA_m \cdot PRPSH \cdot (1. + RTSH.T) \quad TOTLND$$

where

SHRLND = total amount of (net) land under sharecropping in a category (acres);

PRPSH = proportion of total land in the region under sharecropping (dimensionless);

RTSH = the yearly rate of change of PRPSH

T = year

TOTLND = total cultivable land in the region (acres)

GAMMA = the proportion of total sharecropped land in the region received or given by the category (dimensionless)

In this equation the parameter GAMMA, whose values and signs are given exogenously takes the crucial role of distributing the sharecropped area to any particular class while signifying its ownership rights. The GAMMA is given a positive sign for a group that takes land for sharecropping and a negative sign to the group that lends out. Its values and signs are so determined that total area of sharecropping land lent out in the region must always be equal to that taken in by the sharecroppers. The following equations then determine the area of sharecropped land in possession of members and non-members:

(11) $AVSHR_m(t) = SHRLND_m(t)/FFM_m(t)$

(12) $ARSHM_m(t) = AVSHR_m(t) \cdot MEMB_m(t)$

(13) $ARSHN_m(t) = AVSHR_m(t) \cdot NMEMB_m(t)$

where

AVSHR = average area of sharecropped land taken in or given out by a category (acres)

ARSHM = area of sharecropped land taken in or given out by member class of the category (acres)

ARSHN = area of sharecropped land taken in or given out by non-member class of the category (acres)

Once the farm families, population and population of the four categories are disaggregated into member-non-member classes, as above the variable names and subscripts are changed so that they designate eight sub-classes. The 'm' subscript is converted to 'i' subscript in the following manner:

Land Holding (acres)	0-1		1-3		3-5		> 5	
Subscript m	1		2		3		4	
Institutional Affiliation	Memb	Non-Memb	Memb	Non-Memb	Memb	Non-Memb	Memb	Non-Memb
Subscript i	1	2	3	4	5	6	7	8

Accordingly the changed variables are named as:

Variables	
Under m Subscript	Under i Subscript
$MEMB_m$	FAM_i, i = 1, 3, 5, 7
$NMEMB_m$	FAM_i, i = 2, 4, 6, 8
$POPNM_m$	$POPN_i$, i = 1, 3, 5, 7
$POPNN_m$	$POPN_i$, i = 2, 4, 6, 8
$LNDM_m$	$LAND_i$, i = 1, 3, 5, 7
$LNDN_m$	$LAND_i$, i = 2, 4, 6, 8
$ARSH_m$	$ARSD_i$, i = 1, 3, 5, 7
$ARSHN_m$	$ARSD_i$, i = 2, 4, 6, 8

This completes the dynamic process of interclass transfer within a group of the specified variables. It hardly needs any mention that except for $ARSD_i$ all variables are non-negative. ARSD retains the sign of GAMMA in the way as stated and is added to the owned land of the class to determine the total land available to it for cultivation so that[3]

(14) $$AVAR_i(t) = LAND_i(t) + ARSD_i(t)$$

where

AVAR = total land available to ith class for cultivation (acres)

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[3]The equation defining this must always hold $\Sigma_{i=1}^{8} ARSD_i(t) = 0$ so that $\Sigma_i AVAR_i(t) = \Sigma_i LAND_i(t) = TOTLND$.

In other words, $AVAR_i(t) > LAND_i(t)$ is for the class that takes in land for sharecropping while for lending class $AVAR_i(t) < LAND_i(t)$. It must be mentioned that after the transfer the elements always assume all characteristics of the class into which they are transferred.

To generate data for land seasonally allocated to rice cultivation the following equation has been devised:[4]

$$\text{(15)} \quad ARC_{in}(t) = \text{Min}\ ((PPARC_{in}(t),\ C2_{in}(t)),\ AVAR_i(t))$$

where

ARC = area allocated to seasonal rice cultivation (acres);

PPARC = proportion of total cultivable area that is under rice cultivation (dimensionless);

C2 = maximum proportion of total cultivable area that could be brought under rice cultivation during the run period (dimensionless);

i = farmer classes according to size of land holding (1, 8);

n = cropping seasons (1, 3).

The variable PPARC depicts the dynamic change of seasonal acreages in the run period and is obtained as:

$$\text{(16)} \quad PPARC_{in}(t) = PPA_{in}(t)\ (1 + RTA_{in}(t) \cdot T)$$

---

[2]The minimum function in eqn. (15) is true if PPARC is increasing or remains constant in the run period. If PPARC is decreasing due to negative RTA, as has been observed in the Aus season in Comilla Thana, the minimum function has to be replaced by a maximum one and C_2 must be defined as the minimum proportion of land under seasonal rice cultivation.

where

PPA = initial proportion of total cultivated land allocated to seasonal rice cultivation (dimensionless);

RTA = the rate of change in the proportion (PPA)

and T = year

In fact, the parameter RTA indicates the shift in acreages that is taking place over the years. Whether it is positive or negative depends upon government policies, farmers decisions, weather, etc. as determined in the allocative decision making component. For the present the parameter is determined from a linear extrapolation of the past trends.

The total land area allocated to seasonal rice cultivation (by eqn. (15)) is again divided into the acreages under different rice varieties. The area put under HYV cultivation is given by:

$$(17) \qquad ARA_{i,2,n}(t) = \text{Min}\ ((PPHYV_{in}(t),\ C3_{in}(t)) \cdot ARC_{in}(t))$$

where

$ARA_{i,2,n}$ = area put under HYV rice crops cultivation by ith class in nth season (acres)

PPHYV = proportion of rice land area put under HYV (dimensionless);

C3 = maximum proportion of rice land area that may be put under HYV (dimensionless).

The variable PPHYV is determined in the same way as PPARC, i.e.

(18) $$PPHYV_{in}(t) = PPH_{in}(t)\ (1 + RTH_{in}(t) \cdot T)$$

where

PPH = proportion of total rice area allocated to HYV;

RTH = rate of change in PPH,

and T = year.

While the same assumptions remain true for RTH as have been stated before for RTA and symbolises the dynamic change in cultivation of HYV due to modernization in agricultural production. The land area under the local rice variety is simply given by:

(19) $$ARA_{i,1,n}(t) = ARC_{in}(t) - ARA_{i2n}(t)$$

as the remaining seasonal rice cultivation area after allocating land to HYV cultivation.

The agricultural labor force is determined by the proportion of population involved in agricultural production activities. This method of determination, though crude, is much simpler than a derivation through the whole process of disaggregating the population by class, sex, age and sector for which data are scarcely available. Until such data are available the following equation is expected to provide an adequate estimate of the agricultural labor force:

(20) $$AGLAB_i(t) = POPN_i(t) \cdot PPAL$$

where

AGLAB = agricultural labor available in the class (persons)

PPAL = proportion of population engaged in agricultural labor (dimensionless).

The value of PPAL is assumed to be the same for all classes. It may be possible that a smaller proportion of the larger land holding population than of the small land holding population engage in agricultural work, but sufficient data is not available as yet. However, the fact that the larger land holding class puts in less working days than the small land holding class is taken into account in the following equation for generating total family labor available in each class.

(21) $$FAMLAB_i(t) = AGLAB_i(t) \cdot PPYRW_i$$

where

FAMLAB = family labor available for agricultural production activities (mandays/year)

PPYRW = days spent in agricultural work (days/year)

Production Component[3]

The activities in the Production Component are grouped under three categories:

(a) Crop production which generates yield rates and output production and distribution;

(b) Crop input which computes inputs used, including labor in the production process; and

(c) Cost accounting which keeps track of production expenses.

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[3]The mathematical structures defined in this component involve two time variables - Season (n = 1,3) and DT (= .02 yr). Some equations are solved for the season only and others for every time element DT in the season.

Crop Production Subcomponent.

To generate the yield rates of different crop varieties we have used fertilizer response functions. Fertilizer was chosen as an independent variable to determine yield because yields of the rice crop varieties introduced under the new technology depend more on chemical fertilizer than on any other single input. Moreover, a large variation in the rice yield is ascribed to variation in the doses of nitrogen as contained in Urea. The fertilizer response function used in this model is of the non-linear quadratic form, $y = a + bx + cx^2$ so that the yield rates are given by

$$(22)\ YLDFA_{ijn}(t) = A_{jn} + B_{jn} \cdot FERTA_{ijn}(t) + C_{jn} \cdot FERTA_{ijn}{}^{2}(t)$$

where

YLDFA = yield rate of rice varieties determined from the response function (mds/acre)

FERTA = chemical fertilizer allocated in terms of Urea and in fixed proportion (2:3:1) to triple superphosphate and Muriate of Potash (mds/acre)

A, B, C = coefficients of the fertilizer response function

i = classes of farmers (i = 1, 8)

j = crop varieties (j = 1, 2)

n = cropping seasons (n = 1, 3).

The allocation of FERTA depends upon the availability of inputs including capital and credit, cropping pattern in the area, price elasticity, motivation, etc. and is to be determined by the allocative decision making component. Since that component is yet to be modelled, we provided the fertilizer level exogenously from the available data on actual level of use by farmers. In so doing we observed that fertilizer use data is generally expressed variety-wise in seasonal averages but is not disaggregated by classes. To obtain fertilizer use by classes, an index was constructed that gives a pattern of fertilizer use vis-a-vis the average dose used in the region. The following equation then disaggregates the fertilizer use by classes:

(23) $$FERTA_{ijn}(t) = AVFET_{jn}(t) \cdot FINDX_i$$

where

AVFET = average dose of Urea used in the Thana in fixed proportion (2:3:1) to TSP and MP (mds/acre);

FINDX = index of fertilizer use by the classes determined exogenously conforming to their allocation characteristics (dimensionless).

To incorporate any change that might occur in the use of average dose due to price change, availability, motivation, etc. the variable AVFET is linked to a change-parameter so that

(24) $$AVFET_{jn}(t) = FET_{jn}(t)\ (1 + RTFU_{jn}(t))$$

where

FET = initial average dose of Urea use (mds/acre)

RTFU = rate of change in FET.

The YLDFA is further adjusted to the loss of yield due to processing, handling, etc. in harvesting, threshing and storing operations as well as in milling the paddy into rice. Also, the yield is adjusted to weather conditions such as flood, droughts, cyclone so that the final rice yield is obtained as

(25) $\quad YLDA_{ijn}(t) = YLDFA_{ijn}(t)\ (1 - PPLOSS) \cdot WI_n$

where

YLDA = adjusted rice yield (mds/acre)

PPLOSS = proportion of yield lost in processing and milling (dimensionless)

WI = weather index derived from past experience.

It is as difficult to project weather conditions from the past experience as to forecast the occurrance and timing of natural hazards. Furthermore, variation in the timing of planting and harvesting might lead to different crop maturation time and in different weather periods having differing effects on yield rates. Instead of recognizing all these aspects separately they have been incorporated into one index that expresses the seasonal weather in terms of normal conditions necessary for crop growing. If evidence establishes a reason for expecting a departure from normal conditions, the index can be set accordingly.

The seasonal output of a crop variety for a class of farmers is then generated by the equation:

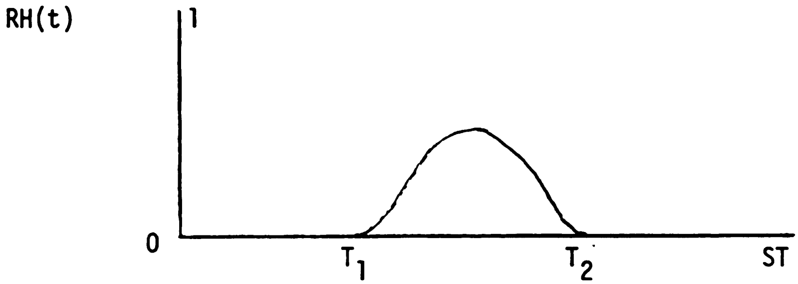
(26) $\quad OUTPUT_{ijn}(t) = ARA_{ijn}(t) \cdot YLFA_{ijn}(t)$

where

OUTPUT = rice production (mds)

ARA = land area under rice cultivation (acres).

The output is harvested at different points of time during the harvesting period and has significant implications upon labor demand as well as on employment, storage, market price and sales. Output is distributed over the harvesting period by a mathematical function called SEAVAL which generates a symmetrical curve RH depicting the harvest rate between start of harvest time, T_1 and the end of harvest at T_2.[4] The SEAVAL function is generated in such a way as to make the area under the RH curve between T_1 and T_2 equal to the output and equal to zero elsewhere,



so that the harvest rate becomes:

$$(27) \qquad RH_{ijn}(t) = OUTPUT_{ijn}(t) \cdot SEAVAL \quad (T_1, T_2, ST)$$

The class which cultivates land under sharecropping (net) is required to give a portion of the output to the class which lends out (net) the land. Therefore, available output for consumption purposes is reduced for the class which cultivates the borrowed land while it is increased for the class which lends it. To take account of this

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[4]The mathematical function SEAVAL is derived as

$SEAVAL(t) = D \cdot (1. - \text{Cos } (W \cdot t)$

where $D = 1/(T_2 - T_1)$

and $W = 6.28319 * D.$

fact the sharecropped land area llocated to seasonal rice cultivation is distributed into the acreages under different varieties. The sharecropped area put under HYV is then obtained as

(28) $$ARSH_{i,2,n}(t) = PPHYV_{in}(t) \cdot ARSH_{in}(t);$$

and that under local variety as

(29) $$ARSH_{i,1,n}(t) = ARSD_i(t) - ARSH_{i,2,n}(t).$$

where

$ARSH_{i,2,n}$ = sharecropped area cultivated by ith class in nth season under HYV rice crop (acres)

$ARSH_{i,1,n}$ = sharecropped area cultivated by ith class in nth season under local variety (acres)

The cultivated land area which is owned then is given by

(30) $$AROW_{ijn}(t) = ARA_{ijn}(t) - ARSH_{ijn}(t)$$

where

AROW = area owned cultivated (acres).

The land area from which output is received by the farmers is then expressed as

(31) $$AROR_{ijn}(t) = AROW_{ijn}(t) - ALPHA \cdot ARSH_{ijn}(t)$$

where

AROR = area from which output is received (acres)

ALPHA = proportion of output to be received by the sharecroppers.

Note that the sign of ARSD is positive for the class which cultivates the sharecropped land and negative for the class that lends it.

Secondly, a class coefficient BETA is computed as

$$(32) \qquad BETA_{ijn}(t) = AROR_{ijn}(t)/ARA_{ijn}(t)$$

so that BETA (dimensionless) determines the quantity of output obtained after the harvest to be received by the class for consumption purposes. For the class which takes land from another class for cultivation, the value of BETA is less than unity while for the class which lends out land, BETA is greater than 1.[5] Therefore, the available output given by

$$(33) \qquad AVLOPT_{ijn}(t) = BETA_{ijn}(t) \cdot RH_{ijn}(t)$$

where

AVLOPT = total rice output available to the class for consumption (mds.)

would be smaller than the OUTPUT produced if ARSH > 0 and would be greater than that if ARSH < 0. Since groups with large farms satisfy the earlier condition their output would be higher than what their cultivated land produces, and the reverse would be the case for small farmers who satisfy the latter condition.

The cumulative totals of seasonal production and output available to ith class are obtained from the following integral approximation equations:

$$(34) \qquad SOPT_{ijn}(t) = SOPT_{ijn}(t - DT) + DT \cdot RH_{ijn}(t)$$

---

[5]With $\alpha > 0$ and ARSH > 0 for small farmers BETA = AROR/ARA is < 1, while for large farmers ARSH < 0 so that BETA = AROR/ARA is > 1.

(35) $$SAVLO_{ijn}(t) = SAVLO_{ijn}(t - DT) + DT \cdot AVLOPT_{ijn}(t)$$

where

SOPT = seasonal output produced (mds.)

SAVLO = seasonal output available to producers (mds.)

Crop Inputs

The chemical fertilizer used in the production of the crop variety in the nth season by the ith class is obtained from the equation

(36) $$FERT_{ijn}(t) = ARA_{ijn}(t) \cdot FERTA_{ijn}(t)$$

where

FERT = fertilizer used, in terms of Urea (mds./acre).

Since other kinds of chemical fertilizer besides Urea are used in a (2:3:1) proportion, their amounts can be easily calculated accordingly. Similarly the total amount of seed used is obtained as:

(37) $$SEED_{ijn}(t) = ARA_{ijn}(t) \cdot SEEDA_{ijn}(t)$$

where

SEED = total seed used (mds.);

SEEDA = seed used per acre (mds.).

To generate the human labor required to the crop production, the cultivation process is divided into two mutually exclusive segments - pre-harvest period and harvest period. The pre-harvest labor required is computed as:[6]

[6]The divisor NDT is used in the equation to transform the stock variable PVLA into flow.

(38) $PVL_{ijn}(A) = ARA_{ijn}(A) \cdot PVLA_{jn}(A)/NDT_{jn}$

where

PVL = labor required in pre-harvest related work (mandays/year)

PVLA = pre-harvest labor required per acre (mandays)

NDT = length of time from the start of season until the beginning of harvest (year).

The labor required in the harvest period is computed by using the harvest rate, RH so that

(39) $HVL_{ijn}(t) = HVLPOU_{jn}(t) \cdot RH_{ijn}(t)$

where

HVL = labor required in harvest related work (mandays/year)

HVLPOU = harvest labor required per unit of output (mandays/md.).

The total human labor required in the crop enterprise is the sum of pre-harvest labor and harvest labor,[7]

(40) $LAB_{ijn}(t) = LAB_{ijn}(t - DT) + DT \cdot (PVL_{ijn}(t) + HVL_{ijn}(t))$

and the total human labor used per acre is obtained as

(41) $LABA_{ijn}(t) = LAB_{ijn}(t)/ARA_{ijn}(t)$

where

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[7]Eqn. (40) is the numerical approximation of the integral equation,

$$LAB_{ijn}(t) = \int_{T_2}^{T_1} PVL_{ijn}(x)dx + \int_{T_1}^{T_2} HVL_{ijn}(x)dx.$$

We have used this form of approximation for the integral equations throughout.

LAB = total labor required (mandays)

$LABA$ = labor required per acre (mandays/acre)

DT = time variable (.02 year).

Not all of this labor is provided by the farmers as family labor; in fact some of it is hired from outside the families. The labor supplied by the family depends upon the agricultural labor available within the family beyond which the requirement has to be met through hiring of labor. The total family labor available in the class has been estimated by the equation (21).

However, as has been empirically observed, certain characteristics in the production processes impose maximum limits up to which family labor can be used and beyond which the required labor has to be hired even though the family labor for the season remains in excess. Under these assumptions, and also assuming that family labor is used uniformly over the period irrespective of the crop variety, the per acre family labor available for use by the class is obtained by the following equation:

(42) $$FLABA_{in}(t) = \text{Min}\ (FAMLAB_i(t)/ARA_{in}(t),\ U2_i(t))$$

where

$FLABA_{in}$ = per acre family labor used by ith class in nth season (mandays/year);

ARA_{in} = total area under cultivation in nth season by ith class (acre);

$U2_i$ = maximum amount of family labor that can be used by the ith class in per acre crop production (mandays/year).

The total family labor available for use by the class for production of a crop variety is given by

(43) $$FLAB_{ijn}(t) = FLABA_{in}(t) \cdot ARA_{ijn}(t).$$

In order to get an estimate of hired labor used at any time, the labor required in excess of family labor is computed for both pre-harvest and harvest periods by the following equations:

(44) $$PLH_{ijn}(t) = \text{Max}\ ((PVL_{ijn}(t) - FLAB_{ijn}(t)),\ 0)$$

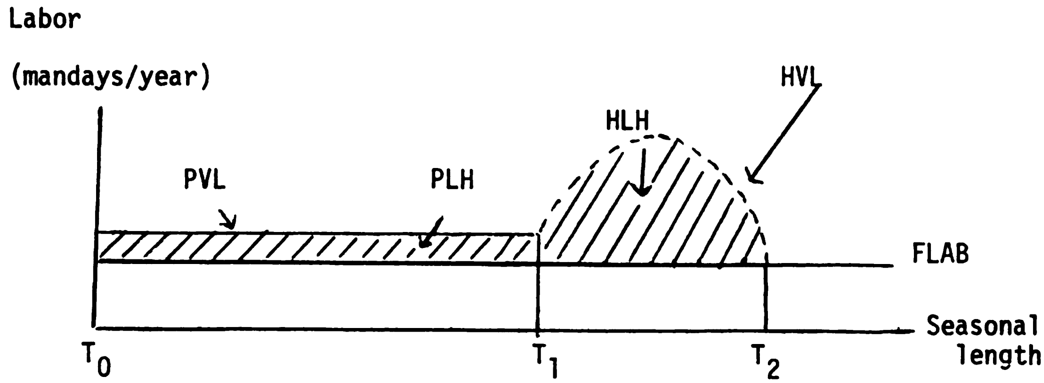
(45) $$HLH_{ijn}(t) = \text{Max}\ ((HVL_{ijn}(t) - FLAB_{ijn}(t)),\ 0)$$

where

PLH = hired labor used in pre-harvest related work (mandays/year)

HLH = hired labor used in harvest related work (mandays/year).

The maximum functions are introduced to make the equations non-zero so that only the positive differences between PVL and FLAB, and between HVL and FLAB, are measured to obtain the extent of hired labor use.



Family labor used by the class at any time is obtained as

(46) $FMLAB_{in}(t) = (PVL_{ijn}(t) + HVL_{ijn}(t)) - (PLH_{ijn}(t) + HLH_{ijn}(t))$

where

FMLAB = family labor used (mandays/year).

The total hired labor required in both segments of pre-harvest and harvest periods are given as respective integrals of eqn. (44) and eqn. (45) as

(47) $PVLH_{ijn}(t) = PVLH_{ijn}(t - DT) + DT \cdot PLH_{ijn}(t)$

(48) $HVLH_{ijn}(t) = HVLH_{ijn}(t - DT) + DT \cdot HLH_{ijn}(t)$

where

PVLH = total hired labor used in pre-harvest related work (mandays)

HVLH = total hired labor used in harvest related work (mandays)

The total hired labor used by the class during the season for growing a crop variety SHLAB, is given by

(49) $SHLAB_{ijn}(t) = PVLH_{ijn}(t) + HVLH_{ijn}(t)$

and that for both crop varieties SLABH, is given by

(50) $SLABH_{in}(t) = \sum_{j=1}^{2} SHLAB_{ijn}(t)$.

Assuming that the region is closed i.e., that there is no in or out migration of agricultural labor, the hired labor is employed from the classes of farmers who are land poor and have surplus family labor to offer for wages. In general, land rich farmers do not offer themselves as wage labor and it is the first four classes of farmers who provide the wage labor. The distribution of wage labor among these classes is made through a weight, PPWL, established on the basis of surplus labor that each of the four classes has after meeting the family labor requirement for their crop production. Therefore,

$$(51) \qquad PPWL_i(t) = WLAB_i(t)/TWLAB(t)$$

$$(52) \qquad WLAB_i(t) = FAMLAB_i(t) - \sum_{j=1}^{2} FLAB_{ijn}(t)$$

and

$$(53) \qquad TWLAB(t) = \sum_{i=1}^{4} WLAB_i(t)$$

where

PPWL = proportion of wage labor that can be employed from the class (dimensionless);

WLAB = surplus labor of first four classes after meeting crop labor requirement (mandays/year) (i = 1, 4)

TWLAB = total surplus labor of first four classes (mandays/year).

To determine the amount of wage labor that each class provides, the hired labor used by all classes is pooled for all time periods first and then is distributed among the wage labor classes (i.e. i = 1, 4) according to the weight $PPWL_i$.

At any time t, hired labor used by any particular class is the sum of that required for all crops in either pre-harvest work or in harvest work so that

$$(54) \qquad APVL_{in}(t) = \sum_{j=1}^{2} PLH_{ijn}(t)$$

and

(55) $$AHVL_{in}(t) = \sum_{j}^{2} HLH_{ijn}(t)$$

where

APVL = hired labor required for both crop varieties in pre-harvest related work (mandays/year),

AHVL = hired labor required for both crop varieties in harvest related work (mandays/year).

The total hired labor used by the classes at any time t is then given by

(56) $$DHLAB(t) = \sum_{i=1}^{8} (APVL_{in}(t) + AHVL_{in}(t))$$

where

DHLAB = total hired labor pooled (mandays/year).

The wage labor provided by the respective class at any time t is computed as

(57) $$LHLAB_i(t) = DHLAB(t) \cdot PPWL_i(t)$$

where

LHLAB = wage labor employment of the class (mandays/year).

$LHLAB_i(t)$ is summed over the seasonal time length to obtain the amount of wage labor that the class provided is given by the following equation:

(58) $$SLHLAB_{in}(t) = SLHLAB_{in}(t - DT) + DT \cdot LHLAB_{in}(t)$$

where

SLHLAB = total wage labor employment (mandays).

Similarly, the amount of family labor in the season spent by the class is obtained as

(59) $$SFMLAB_{in}(t) = SFMLAB_{in}(t - DT) + DT \cdot FMLAB_{in}(t)$$

where

SFMLAB = total family labor spent in the seasonal crop production (mandays).

Finally, the sum of family labor and wage labor gives the total employment of the class labor so that

(60) $$SLAB_{in}(t) = SFMLAB_{in}(t) + SLHLAB_{in}(t)$$

where

$SLAB_{in}(t)$ = total seasonal employment of labor (mandays).

Cost Accounting

The expenses incurred in crop production for variable inputs are accounted under two categories according to where the inputs originate, (i) non-agricultural sector or (ii) the agricultural sector. The expenses are categorized in this way in order to reflect the value added concept. Also, only cash expenses are considered in conformity to the farmers' notion in determining costs of production. In fact, many of the owned inputs that farmers utilize in the crop enterprise have zero opportunity costs, but earn a value only when they are used on the farm. Further, due to the capital constraints in subsistence agriculture case expenses are strictly regarded as costs, and any return over cash expenses is considered as earning for the fixed and variable input received by the family.

The cash expenses incurred for inputs excluding credit originating in the non-agricultural sector are added in the following equation:

$$(61)\quad XCSNAG_{ijn}(t) = (XFERT_{ijn}(t) + XIRG_{ijn}(t) + XPLT_{ijn}(t) + XOTH_{ijn}(t))/NDTS_{jn}(t)$$

where

XCSNAG = cash expenses incurred on non-agricultural sector inputs (Taka/year),

XFERT = cash expenses on chemical fertilizer (TK),

XIRG = cash expenses on mechanical irrigation (TK),

XPLT = cash expenses on plant protection (TK),

XOTH = cash expenses or other inputs related to power, i.e., tractor, thresher, bullock power, etc. (TK),

NDTS = time length of crop season used to convert stock variable into a flow (year).

The derivations of the components of XCSNAG are given below:

$$(62)\quad XFERT_{ijn}(t) = FERTA_{ijn}(t) \cdot PRF_{in}(t) \cdot ARA_{ijn}(t)$$

$$(63)\quad XIRG_{ijn}(t) = PPIR_{jn}(t) \cdot PRI_{in}(t) \cdot ARA_{ijn}(t)$$

$$(64)\quad XPLT_{ijn}(t) = PPLT_{jn}(t) \cdot CPLTA_{ijn}(t) \cdot ARA_{ijn}(t)$$

$$(65)\quad XOTH_{ijn}(t) = COTHA_{ijn}(t) \cdot ARA_{ijn}(t)$$

where

PRF = a composite price of chemical fertilizers (TK/md),

PRI = price of irrigated water (TK/acre),

PPIR = proportion of land under mechanical irrigation,

PPLT = proportion of land in which plant protection measures are used,

PLT = cost of plant protection (TK/acre),

COTHA = cost of services of other inputs (TK/acre).

Similarly, the cash expenses due to agricultural sector inputs are calculated as:

$$(66) \qquad XCSAG_{ijn}(t) = ((XRENT_{ijn}(t) + XSEED_{ijn}(t))/NDTS_{jn}(t)) + XHLAB_{ijn}(t)$$

where

XCSAG = cash expenses of agricultural sector inputs (TK/year),

XRENT = cash expenses on rented land (TK),

XSEED = cash expenses on seed (TK),

XHLAB = cash expenses on hired labor (TK/year).

The components of XCSAG are derived as

$$(67) \qquad XRENT_{ijn}(t) = PPRENT_{ijn}(t) \cdot ARA_{ijn}(t) \cdot RENTP_{ijn}(t)$$

$$(68) \qquad XSEED_{ijn}(t) = SEEDA_{jn}(t) \cdot PRS_{jn}(t) \cdot ARA_{ijn}(t)$$

$$(69) \qquad XHLAB_{ijn}(t) = (PLH_{ijn}(t) + HLH_{ijn}(t)) \cdot WGRT_{n}(t)$$

where

PPRENT = proportion of land rented,

RENTP = rental cost (TK/acre),

SEEDA = seed used (md/acre),

PRS = price of seed (TK/md),

WGRT = wage rate of hired labor (TK/mandays).

The expenses on agricultural credit, which could have been a component of XCSNAG, are determined from the amount of total cash expenses that is borrowed by the farmers to lessen the cash outlay needed. It is assumed that cooperative members can borrow agricultural credit from the institutional sources in a larger proportion and at a lower rate of interest than the non-members, who would have to look to non-institutional sources.[8] Under this assumption the cost of agricultural credit is calculated as

$$(70) \quad XCRED_{ijn}(t) = D1_i(t)\ (XCSNAG_{ijn}(t) + XCSAG_{ijn}(t)) \cdot RTINT_i(t)$$

where

XCRED = cash expenses on agricultural credit (TK/year),

D1 = proportion of total expenses borrowed by the class,

RTINT = interest rate charged (TK).

Tot total cash cost incurred at any time t in producing a crop variety is therefore,

$$(71) \quad CSHCST_{ijn}(t) = XCSNAG_{ijn}(t) + XCSAG_{ijn}(t) + XCRED_{ijn}(t)$$

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[8]It is also assumed, for the time being, that agricultural credit is available from both sources at the respective rates of interest.

where

CSHCST = cash expenses incurred on variable inputs (TK/year).

Integrating over time the total cash cost TCSHCST made on a crop variety is obtained as

(72) $$TCSHCST_{ijn}(t) = TCSHCST_{ijn}(t - DT) + DT \cdot CSHCST_{ijn}(t).$$

The agricultural credit is then added to XCSNAG to determine the cash cost expended on inputs originating in the non-agricultural sector XNAG at any time t so that

(73) $$XNAG_{ijn}(t) = XCSNAG_{ijn}(t) + XCRED_{ijn}(t)$$

and the cumulative total case cost incurred on these inputs is obtained by integrating XNAG as

(74) $$TXNAG_{ijn}(t) = TXNAG_{ijn}(t - DT) + DT \cdot [XNAG_{ijn}(t)]$$

where XNAG and TXNAG is given in units of TK.

The amount of agricultural credit used at any time is obtained as

(75) $$ACREDIT_{ijn}(t) = CRED_{ijn}(t)/RTINT_{i}(t)$$

and the total amount is cumulated over time by the following equation as

(76) $$CREDIT_{ijn}(t) = CREDIT_{ijn}(t - DT) + DT \cdot ACREDIT_{ijn}(t)$$

where

ACREDIT = agricultural credit used (TK/year) at any time

CREDIT = total agricultural credit used (TK).

Consumption

This component deals with consumption, storage, sales, purchase and nutritional intake of the produce by different classes of farmers. In a subsistence rural sector food consumption is generally met by production on the farm for which produce is stored. A large enough stock is retained to meet the consumption needs of the farmers until the next harvest. The excess over the consumption requirement is the marketable surplus, which is sold. If, however, the food stock is insufficient to meet the consumption demand, the farmers would first try to stretch the available stock by reducing the consumption rate and thereby the nutritional intake. They would buy food grains only when the stock is at an end or insufficient to carry them through to the next harvest. On the other hand, the need for cash money would have an impact on the selling and buying process. The whole process therefore has significance, particularly in subsistence agriculture, in determining the income, health and financial status of the farmers.

For consumption purposes it is not the output produced, but the output available to farmers after meeting the sharing commitments that is of importance. Also, varietal differences would be of little signficance in pooling the rice together so that

$$(77) \qquad AVLOCON_i(t) = \sum_{j=1}^{2} AVLOPT_{ijn}(t)$$

where

AVLOCON = available rice output for consumption (mds/year).

The consumption need of rice at any time t is determined by the equation

(78) $CONS_i(t) = PCCONS_i(t) \cdot POPN_i(t)$

where

CONS = consumption need fo the class (mds/year)

PCCONS = per capita consumption (mds/year)

POPN = population of the class (persons)

The per capita consumption (PCCONS) is determined in terms of nutritional intake effected by the size of the actual stock. General estimates of normal consumption of rice are available from various nutritional studies (GOP, 1966; Chen, 1974). It is understood that farmers will maintain about the normal level of consumption as long as the available stock is sufficient to carry them through to the next harvest time. If, however, the actual stock level falls below the desired stock level based on the present consumption level, it would be natural for farmers to cut down their consumption level to a minimum and stretch the supply of the existing food stock. This notion has been maintained in determining the per capita rice consumption by the following equation:[9]

(79) $PCCCONS_i(t) = FN1.F1.RNUTN_i(t)$

where

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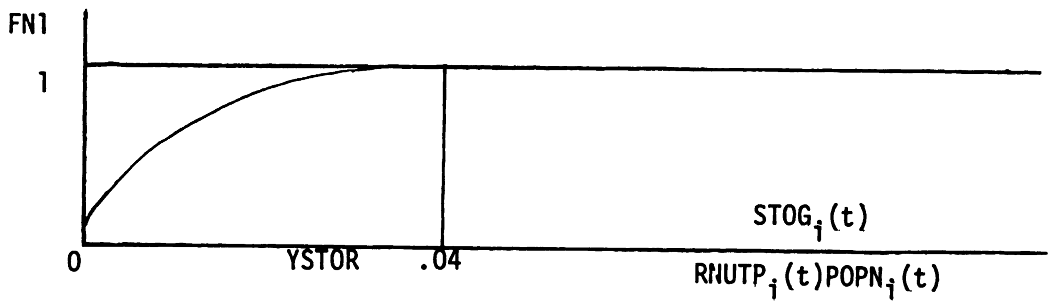
[9]It is similar to that derived by T.J. Manetsch (1975) in the Survival model.

RNUTN = normal nutritional intake from rice in grain equivalent term (mds/person/year)

FN1 = a function (≥ 0) that regulates the consumption level

F1 = a constant used for defining the bounds of FN1.

The function FN1, whose form is shown below, determines the rate at which consumption level will be maintained given the stock level (STOG) and the normal nutritional requirement (RNUTP).



FN1 is generated by the variable $STOG_i(t)/RNUTP_i(t) \cdot POPN_i(t)$ which has units in years and represents the portion of a year that the available food stock will last at consumption level equal to the normal required levels. The parameter YSTOR is the normal stock level of food grains measured in years of consumption. Let us say that the farmers wish to have at least two weeks of food supply in the stock, which specifies YSTOR = .04. As long as the available food stock lasts more than YSTOR there would not be any cutback in the consumption level. But when it falls below YSTOR, the consumption level will be affected by the rate given by FN1. Simultaneously, a move will be generated among the farmers to increase the stock to the level of at least YSTOR either through purchase or otherwise.

The desired stock level that farmers would wish to maintain is determined on the basis of consumption level and the time period remaining till the next harvest. This is the quantity that is kept aside for home consumption as well as for seed. It is determined by the following equations:[10]

(80) $DSTOG_i(t) = DSTOG_i(t - DT) + DER\ (DSTOGU_i(t) - DSTOG_i(t))$

(81) $DSTOGU_i(t) = FN2F2\ RNUTP_i(t) \cdot POPN_i(t)\ (TTSH + STING)$
$+ QSEED_{ijn}(t))$

where

DSTOG = desired stock level (mds/year)

DSTOGU = unlagged version of desired stock level (md/year)

DER = a smoothening delay factor,

RNUTP = normal nutritional requirement in grain equivalent (mds/year)

TTSH = time remaining before the next harvest starts (year)

STINC = a grace time required after the next harvest starts before grain is available for consumption

QSEED = quantity of grain set aside for seed purpose for use in the next cropping season (mds/year)

FN2 = a function of price that indicates the willingness to reduce food intakes when prices are high

F2 = a boundary constant for FN2.

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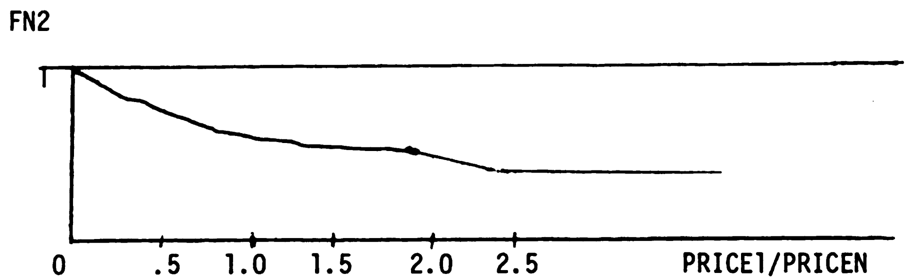
[10] Cf. Korean Agricultural Sector Analysis, p. 136 (Rossmiller, 1972).

DSTOG is the lagged version of DSTOGU which determines the desired stock needed to meet consumption and seed requirement of farmers. It is lagged in order to simulate a realistic situation in which the farmers make decisions over the time period. The function FN2 introduces the effect of higher grain price (PRICE1) compared to normal price level (PRICEN) under which it is desirable to cut down the storage level.



The actual level of grain stock at a given time t is determined by the following equation:

$$(82) \quad STOG_i(t) = STOG_i(t - DT) + DT\ (AVLOCON_i(t) + PURCH_i(t) - CONS_i(t) - SALES_i(t))$$

where

STOG = actual stock level (mds)

PURCH = purchase of food grains (mds/year)

SALES = sales of food grains (mds/year)

In other words, foodstock level is changing continually due to an interaction among the incoming and the outgoing flows of stock. While the available output and consumption variables (AVLOCON and

CONS) are already determined independent of foodstock (STOG), the sales and purchase operations necessarily depend upon the level of STOG. In general, the farmer would sell if there is excess stock over his family's consumptive needs. These sales are farmers' source of cash money for buying non-farm food and non-food goods, for repaying debts, or for investing elsewhere. The sale may be made just after the harvest or can be delayed until good prices are obtained. If, however, there is large amount of debt to be repayed and the farmers are insistently pressed by the creditors, they may have to sell the produce early without waiting for good prices. Worse yet, they may have to sell from their desired stock if selling of the excess stock does not cover the required repayment. The sales pattern would reflect a combination of these two situations so that

$$(83) \quad SALES_i(t) = \max\,(FN3.F3(STOG_i(t) - DSTOG_i(t)),\ 0) + \max\,(FN4.F4(STOG_i(t) - YSTOCK_i(t)),\ 0)$$

$$(84) \quad YSTOCK_i(t) = K1.RNUTP_i(t) \cdot POPN_i(t)$$

where

YSTPCK = desired level of food stock needed for a minimum time period (mds/year)

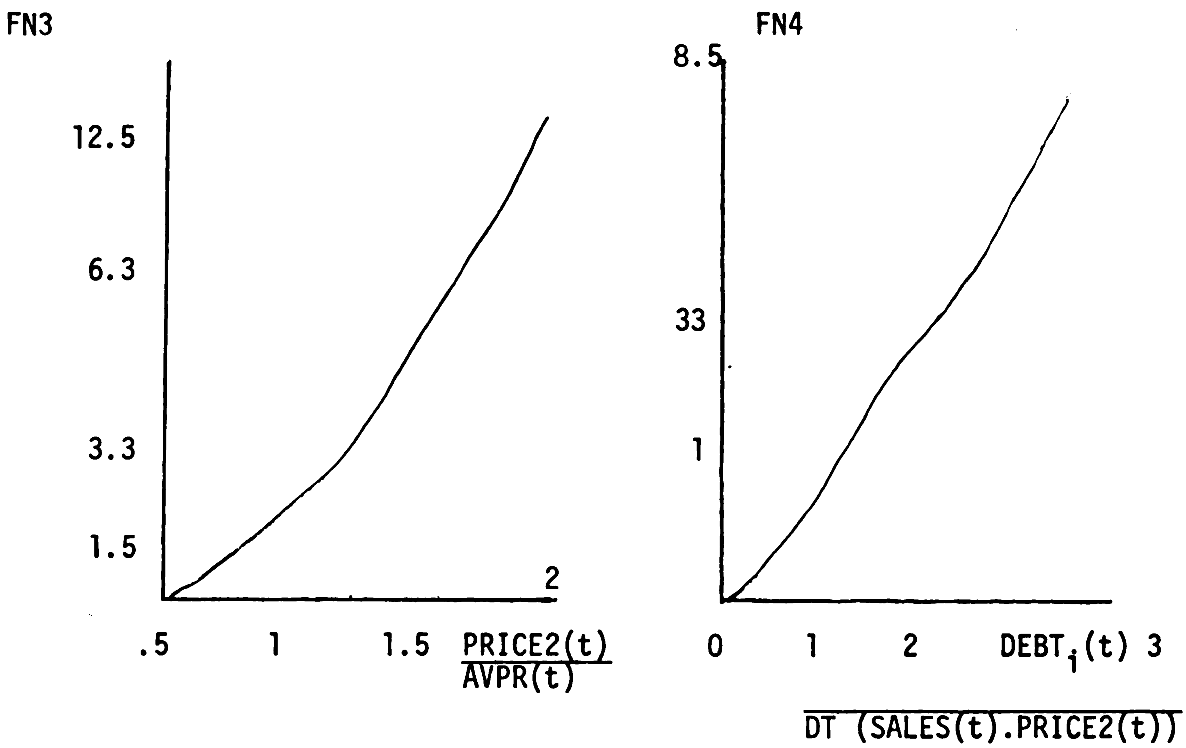
K1 = a time parameter indicating the minimum period for which food must be kept (usually YSTOR - K1) (year)

FN3 = a function of market prices that influence the sale

FN4 = a function that hastens the sale due to debt service need

F3, F4 = bound defining constants for FN3 and FN4 respectively.

The first part of equation (83) determines the rate of sales of the marketable surplus as influenced by market prices, while the second part represents that due to the emergency need for debt servicing. Together they determine the rate at which the stock is reduced through sales under the influences of FN3 and FN4. In generating the values for FN3 and FN4 certain assumptions are made about the reactions of farmers in their produce disposal rates. In determining FN3 it is assumed that when the ratio of selling price (PRICE2) to seasonal average market (AVPR) price is low, farmers would wait



longer to dispose of the stock. If the selljng price reaches the average price they may decide to dispose of the total surplus stock in about 16 weeks time because another harvest would be available after that period. If, however, the prices are as high as double the market average price they may dispose of the stock in about four

weeks. Similarly, for FN4 it is assumed that when the debt becomes larger than the amount of cash obtained from normal sale, they would hasten to sell from the desired stock.

When the actual stock level has fallen below the required stock level, purchases have to be made to bring it back to the desired level. The quantity to purchase is simply the difference between the two stock levels so that

$$\text{(85)} \qquad PURCH_i(t) = \max\left(FN5\left(DSTOG_i(t) - STOG_i(t)\right), 0\right)$$

where

FN5 = a function of price, income and other variables which influence purchase (currently taken as a constant).

The function FN5 depends on several factors e.g. purchase price, income, cash balance, etc. It does not impede or restrict the purchase if it is needed but is so determined as to replenish the stock before the next harvest is available. By taking its value as constant we assume that shortages in consumption stock level are always made up through purchases, no matter what the price or income level is, and that expenses are met either from the cash balance or through borrowing.

Income Component

The income component primarily performs financial accounting of the different cash transactions that are made by the classes. To begin with, the cash inflow from the crop enterprise is generated by the sales of products so that

(86) $CSHREV_i(t) = SALES_i(t) \cdot PRICE1_n(t)$

where

CSHREV = cash revenue received through sales of produce (Tk/year)

PRICE1 = selling price of produce (Tk/md)

Besides rice crop enterprises, earnings are also received from other sources. The case flows of other incomes are estimated as the sum of all incomes received from various sources so that

(87) $OTHIN_i(t) = (ERENT_i(t) + OCPIN_i(t) + ONFIN_i(t))/NDTS_n(t)$

and

(88) $WAGE_i(t) = LHLAB_i(t)WGRT_n(t)$

where

OTHIN = income received from other enterprises (TK/year)

ERENT = cash income earned from renting out land (TK)

OCPIN = cash income from other cash crops cost (TK)

ONFIN = income from non-agricultural sources (TK)

WAGE = wages earned through hiring out labor (TK/year)

WGRT = wage rate (TK/day).

The various components of OTHIN are determined in the following manner:

(89) $ERENT_i(t) = RLAND_{in}(t) \cdot RENTA_n(t)$

(90) $OCPIN_i(t) = AROCP_{in}(t) \cdot OCPFT_n(t)$

(91) $AROCP_{in}(t) = AROC_n \cdot ARC_{in}(t)$

$ONFIN_i(t)$ = an estimate of non-farm income currently taken as zero (TK)

where

RLAND = area of land rented out (acre)

RENTA = average rates of rent (TK/acre)

AROCP = land area under other cash crops (acres)

AROC = proportion of land under other case crops vis-a-vis area under rice cultivation (dimensionless)

OCPFT = average cash profit from cash crops (TK)

For lack of diaaggregated data and also for brevity, values of ONFIN, AROC and OCPFT are exogeneously given from estimates.

The cumulative totals of OTHIN and WAGE are given by the following equations:

(92) $$TOTHIN_i(t) = TOTHIN_i(t - DT) + NDTS_{in} \cdot OTHIN_i(t)$$

(93) $$TWAGE_i(t) = TWAGE_{in}(t - DT) + DT \cdot WAGE_i(t)$$

The total cash flow earned by the class at any time t is the sum of all incomes generated from different sources so that

(94) $$CSHIN_i(t) = CSHREV_i(t) + OTHIN_i(t) + WAGE_i(t)$$

where

CSHIN = total cash income (TK/year).

By deducting the case expenses paid for crop production repayment of loan and taxes from CSHIN, whatever is left is taken as the disposable income, so that

(95) $DISPIN_i(t) = CSHIN_i(t) - CCSHCST_i(t) - PPI_i(t) - XTAX_i(t)$

and cumulative total of disposable income is obtained as

(96) $TDISP_i(t) = TDISP_i(t - DT) + DT.DISPIN_i(t)$

where

TDISP = total yearly disposable income (TK)

DISPIN = disposable income (TK/year)

CCSHCST = total cash cost in crop production (i.e. $\sum_{j=1}^{2} CSHCST_{ijn}(t)$) (TK/year)

PPI = repayment of principal and interest (TK/year)

XTAX = payment of tax (TK/year)

Taxes considered here are of two kinds -agricultural land tax and agricultural income tax. Agricultural land tax is imposed on estimated gross profit received from per unit of land while agricultural income tax is imposed on farmers' annual earned income in excess of a certain amount of earning. The total tax payment is, therefore, determined as

(97) $XTAX_i(t) = RTX \cdot MAX\ (0., (PFERNG_i(t) - TXFLOR))$
$+ RTL \cdot TVADFAM_i(t)$

where

RTX = agricultural income tax rate (taken as constant proportion)

RTL = agricultural land tax rate (taken as constant proportion)

PFERNG = per family yearly earning (TK/year)

TXFLOR = income earning ceiling in excess of which income tax is imposed (TK/year)

TVADFAM = yearly gross profit earned from crops cultivated (TK/year)

The first part of right hand side equation calculates agricultural income tax while the last calculates agricultural land tax. The equation remains valid even when only one kind of taxation or none is imposed depending on the values of RTX and RTL.

The cash expenses needed for consumption purposes are met from the disposable income while the non-cash consumption expenses, of which foodgrain is the major item, are assumed to be met from the farm produce. The cash consumption expenses are incurred for buying foodgrains as well as food and non-food items.

The expenses on foodgrains are simply given by

$$(98) \qquad FDCST_i(t) = PURCH_i(t) \text{ PRICE 2 } (t)$$

and the other food and non-food expenses are estimated by the equation

$$(99) \qquad OCONX_i(t) = PPC_i(t) \cdot DISPIN_i(t)/PRINDX(t)$$

where

FDCST = cash expenses on foodgrains (TK/year)

PRICE 2 = buying price of foodgrains (TK/md)

OCONX = other consumption expenditures (TK/year)

PPC = proportion of disposable income spent on other consumption items (dimensionless)

PRINDX = an index of consumption goods prices.

The total cash consumption expenses are obtained as the sum of all above expenditures so that

$$(100) \quad CONEX_i(t) = FDCST_i(t) + ONCONX_i(t)$$

and the residual of disposable income after meeting cash consumption expenses is termed as savings so that

$$(101) \quad SAVING_i(t) = DISPIN_i(t) - CONEX_i(t).$$

Total savings accumulated over time is obtained by integrating the above equation as

$$(102) \quad TSAVING_i(t) = TSAVING_i(t - DT) + DT.SAVING_i(t)\ .$$

The variable SAVING can, however, be positive or negative depending upon the extent of DISPIN and/or CONEX. The residual constitutes the cash balance which reduces if saving is negative, i.e. if the cash expenses are higher than the disposable income. To augment the cash balance, which must always be positive (≥ 0) by definition, farmers will have to borrow or sell land. Assuming that farmers will not sell land right away but will try to borrow money from every source, institutional or non-institutional, depending on the credit availability, the cash balance fund then is the accumulation of cash money obtained from all sources and is given by

$$(103) \quad CASBAL_i(t) = CASBAL_i(t- DT) + DT[SAVING_i(t) + ACREDIT_i(t)] + BORROW_i(t)$$

where

CASBAL = cash balance (TK)

ACREDIT = total agricultural credit taken for crop production purpose (TK/year)

The variable BORROW is the amount of money needed to make cash balance always positive. In other words, whenever CASBAL becomes low , there must be a borrowing and so

$$(104) \qquad BORROW_i(t) = -CASBAL_i(t)$$

if and only if CASBAL is negative.

Borrowing and repayment is a continuous process and the debt is built up over time, constituting the part of the loan that is non-repayed. The amount of debt is obtained as

$$(105) \qquad DEBT_i(t) = DEBT_i(t - DT) + BORROW_i(t) + DT[RTINT_i(t) \cdot DEBT_i(t) - PRI_i(t) + ACREDIT_i(t)]$$

where

DEBT = total debt due (TK)

RTINT = rate of interest charged (TK/year)

At any time t the loans are made in two ways, by ACREDIT for agricultural production purpose and BORROW for replenishing the cash balance, while the variable DEBT signifies the class's indebtedness. The total borrowing that the class makes over time is cumulated as

$$(106) \qquad LOAN_i(t) = LOAN_i(t - DT) + BORROW_i(t) + DT \cdot ACREDIT_i(t)$$

which reflects the class's extent of borrowing. However, the repayment is made on the basis of outstanding unpaid debts. The repayment schedule depends on farmers' decisions, cash availability, extent of debt, etc. Presently it is determined as

$$(108) \quad PPI_i(t) = G3 \cdot DEBT_i(t)[1 + RTINT_i(t)]$$

G3 = a function of indebtedness, income and cash balance that influences the repayment schedule. (Currently taken as a constant.)[11]

The rate of interest RTINT varies with the class's institutional affiliation. It is assumed that the members would be charged a lower rate of interest by the institutional sources, while non-members have to seek the loan from non-institutional sources who would charge a higher rate.

Accounting Component

The accounting of the system outputs and computations for performance criteria are done in this component. Accounting is done for two time periods: season and year. In general, yearly accounting is used to obtain values for the performance criteria while seasonal accounting provides information that is useful for decisions as well as for keeping track of the performances. Besides obtaining disaggregated values of the indicators by classes and crops, aggregated

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[11] When G3 is taken as equal to 1, it means that the debt service schedule is one year; if G3 = 2, the schedule is six months, and so on.

values are also obtained for the region as a whole by summing across the classes and the crops.

The seasonal output production of a crop variety is given by

$$(108) \qquad SPRDV_{jn}(t) = \sum_{i}^{8} SOPT_{ijn}(t)$$

and the total production of rice in the region is

$$(109) \qquad SPRD_{n}(t) = \sum_{j}^{2} SPRDV_{jn}(t)$$

where

SOPT = cumulative seasonal output of a variety by a class (mds.)

SPRDV = total output of a crop variety (mds.)

SPRD = total production in the Thana (mds.)

all of which were computed earlier. The output produced by the class similarly is given by

$$(110) \qquad SPRNEW_{in}(t) = \sum_{j}^{2} SOPT_{ijn}(t)$$

while the quantity of produce received by the class is given by

$$(111) \qquad SPRDL_{in}(t) = \sum_{j}^{2} SAVLO_{ijn}(t)$$

where SAVLO is the summation of output available to producers.

The seasonal uses of chemical fertilizer is simply given by [12]

$$(112) \qquad SFERT_{n}(t) = \sum_{i}^{8} \sum_{j}^{2} 3FERT_{ijn}(t)$$

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[12] Since FERT is expressed in terms of Urea and other kinds of chemical fertilizers are used in 2:3:1 proportion. The total amount of chemical fertilizers used in terms of Urea amount is 3FERT.

and that of seed by variety is

$$(113) \quad SSEEDV_{jn}(t) = \sum_{i}^{8} SSEED_{ijn}(t)$$

The seasonal family and hired labor use and total employment have been computed by class in the production component. In this component the seasonal accumulation of these variables is done in the following manner:

$$(114) \quad SHDLAB_n(t) = \sum_{i=1}^{8} SLABH_{in}(t)$$

$$(115) \quad TFMLAB_n(t) = \sum_{i}^{8} SFMLAB_{in}(t)$$

$$(116) \quad TLHLAB_n(t) = \sum_{i}^{8} SLHLAB_{in}(t)$$

and

$$(117) \quad TLAB_n(t) = \sum_{i}^{8} SLAB_{in}(t)$$

where

SHDLAB = total seasonal hired labor used (mandays)

TFMLAB = total seasonal family labor used (mandays)

TLHLAB = total seasonal wage labor employed (mandays)

TLAB = total seasonal employment (mandays)

The seasonal totals of labor use, as given above, are obtained by summing their outputs over the cropping seasons from beginning to end. It may be of interest to note the distribution of labor use patterns by month, or by some other time period, in order to enquire into the peak labor demand and the extent of employment. To obtain such a time profile of labor use the following accounting equations have been introduced. For any time period p (expressed in terms of DT), the total hired labor used in harvest work is obtained as

$$(118) \quad EMOH_{ijp}(t) = EMOH_{ijp}(t - DT) + DT[HLH_{ijn}(t)]$$

and that in pre-harvest work is given by

$$(119) \quad EMOP_{ijp}(t) = EMOP_{ijp}(t - DT) + DT[PLH_{ijn}(t)] \ .$$

The total hired labor used is therefore the sum of the above two equations so that

$$(120) \quad EMO_{ijp}(t) = EMOP_{ijp}(t) + EMOH_{ijp}(t)$$

where

EMO = total hired labor used in crop production in the time period (mandays)

EMOP = total hired labor used in pre-harvest work (mandays)

EMOH = total hired labor used in harvest work (mandays)

The total hired labor used by the class is then

$$(121) \quad HIRMO_{ip}(t) = \sum_{j}^{2} EMO_{ijp}(t),$$

obtained by adding hired labor used in all crop varieties.

The family labor and wage labor used are given respectively as

$$(122) \quad GMO_{ip}(t) = GMO_{ip}(t - DT) + DT[FMLAB_{i}(t)]$$

$$(123) \quad WAGMO_{ip}(t) = WAGMO_{ip}(t - DT) + DT[LHLAB_{i}(t)]$$

where

GMO = total family labor used for all crop varieties (mandays)

WAGMO = total wage labor used (mandays)

and FMLAB, LHLAB are as defined earlier.

Finally, the total employment EMPMO provided by the crop production to a class in any time period, p, is simply obtained as

(124) $$EMPMO_{ip}(t) = WAGMO_{ip}(t) + GMO_{ip}(t)$$

where EMPMO is expressed in units of mandays.

In addition, the seasonal hired labor and total labor use are disaggregated by variety so that they are obtained as:

(125) $$SHLABF_{1n}(t) = \sum_{i}^{8} SHLAB_{i1n}(t)$$

(126) $$SHLABS_{2n}(t) = \sum_{i}^{8} SHLAB_{i2n}(t)$$

and

(127) $$SHLABE_{jn}(t) = \sum_{i}^{8} LAB_{ijn}(t)$$

where

SHLABF = total seasonal hired labor used in local varieties (mandays)

SHLABS = total seasonal hired labor used in HYV (mandays)

SHLABE = total seasonal labor used in each variety (mandays)

The consumption of produce is accumulated for the season is given by:

(128) $$TCONS_{ijn}(t) = TCONS_{ijn}(t - DT) + DT \cdot CONS_{ijn}(t)$$

and the seasonal consumption by class is obtained as:

$$\text{(129)} \qquad SCONSL_{in}(t) = \sum_{j}^{2} TCONS_{ijn}(t)$$

The seasonal consumption of rice for all classes is then simply,

$$\text{(130)} \qquad SCONS_{n}(t) = \sum_{i}^{8} SCONSL_{in}(t)$$

where

SCONSL = seasonal consumption by classes (mds.)

SCONS = seasonal consumption in the Thanas (mds.)

Similarly the sales and purchases of produce are cumulated for the season so that:

$$\text{(131)} \qquad SSALES_{in}(t) = SSALES_{in}(t - DT) + DT \cdot SALES_{in}(t)$$

and

$$\text{(132)} \qquad SSPURCH_{in}(t) = SSPURCH_{in}(t - DT) + DT \cdot PURCH_{in}(t)$$

and the seasonal sales and purchases of rice by class are given by

$$\text{(133)} \qquad TSALES_{in}(t) = \sum_{i}^{2} SSALES_{in}(t)$$

and

$$\text{(134)} \qquad TPURCH_{in}(t) = \sum_{j}^{2} SSPURCH_{in}(t)$$

In the Income Component the financial transactions have been computed for determining cash inflows and outflows. In this component some economic accounting has been made regarding costs and returns of crop enterprises so as to reflect their economic performances.

The value of output produced by the class in a given season is determined by the equation

(135) $\quad VOUTPUT_{ijn}(t) = AVPR_{jn}(t) \cdot OUTPUT_{ijn}(t)$

where

VOUTPUT = gross value of produced output (Taka)

AVPR = average price prevailing during the season (Tk/md)

To determine the profits earned from the crop enterprises, total cash costs are deducted from the gross value of output so that

(136) $\quad PROFITA_{ijn}(t) = (VOUTPUT_{ijn}(t) - TCSHCST_{ijn}(t))/ARA_{ijn}(t)$

where

PROFITA = gross return per acre from the crop enterprise (TK/acre)

The cost per acre in the cropping enterprise is determined simply by

(137) $\quad COSTCC_{ijn}(t) = TCSHCST_{ijn}(t)/ARA_{ijn}(t)$

where

COSTCC = cash cost expended in the crop (TK/acre)

An aggregated figure for cost incurred in a crop variety is also obtained as

(138) $\quad COSTA_{jn}(t) = \sum_{i}^{8} TCSHCST/\sum_{i}^{8} ARA_{ijn}(t)$

and similarly that for return is given by

(139) $\quad RETURN_{jn}(t) = \sum_{i}^{8} VADFAM_{ijn}(t)/\Sigma\ ARA_{ijn}(t)$

where

COST = average cash cost in the seasonal crop enterprise (TK/acre)

RETURN = average gross return over COST in the seasonal crop enterprise (TK/acre)

The return over cash costs actually includes values of family provided inputs e.g., labor, land, materials, capital and management services, as well as pure profit. As such the return over cash costs represents the value added by family and the numerator of the equation is the total value added by family for the class as a whole so that

(140) $$VADFAM_{ijn}(t) = BETA.VOUTPUT_{ijn}(t) - TCSHCST_{ijn}(t)$$

The VADFAM is regarded as the class earning from the seasonal crop enterprise. However, from an economic point of view it is also necessary to estimate how much of a lift the agricultural sector has received from the crop enterprises. The valued added by agriculture is defined as the return over cash costs incurred due to inputs originating in non-agricultural sector so that

(141) $$VADAG_{ijn}(t) = VOUTPUT_{ijn}(t) - TXNAG_{ijn}(t)$$

where

VADAG = value added by agriculture (TK)

TXNAG = total case cost of non-agricultural sector inputs (TK)

The value added by agriculture and by the family are computed seasonally so that they may be summed over the seasons to obtain yearly indicators. They are expressed both by class and by variety so that for the class,

(142) $$VADADUM_{in}(t) = \sum_{j}^{2} VADAG_{ijn}(t)$$

(143) $$VADFDUM_{in}(t) = \sum_{j}^{2} VADFAM_{ijn}(t)$$

and for the varieties,

(144) $$CVADAG_{jn}(t) = \sum_{i}^{8} VADAG_{ijn}(t)$$

(145) $$CVADFAM_{jn}(t) = \sum_{i}^{8} VADFAM_{ijn}(t)$$

where

VADADUM = class seasonal value added by agriculture (TK)

VADFDUM = class seasonal value added by family (TK)

CVADAG = variety seasonal value added by agriculture (TK)

CVADFAM = variety seasonal value added by family (TK)

The seasonal total of value added by agriculture and by family are given respectively by

(146) $$SVADAG_{n}(t) = \sum_{j}^{2} CVADAG_{jn}(t)$$

(147) $$SVADFAM_{n}(t) = \sum_{j}^{2} CVADFAM_{jn}(t)$$

Yearly Accounting

In this sub-component the system outputs are obtained in the form of yearly variables and are transformed into some measurable indicators that serve as performance criteria of the disaggregated classes. The yearly variables are derived either through summation of the seasonal variables through accumulation (integration) of the fine time variables (i.e. DT) and are transformed to indicators by

simple aggregation. While there are many output variables present in the model, only a few of them have been considered to serve as performance criteria that are relevant to our purpose.

The yearly variables are computed as

(148) $$TPRDL_i(t) = \sum_{n}^{3} SPRDL_{in}(t)$$

(149) $$TPRDV_j(t) = \sum_{n}^{3} SPRDV_{jn}(t)$$

(150) $$TPRD_j(t) = \sum_{n}^{3} SPRD_{jn}(t)$$

where

TPRDL = yearly available output by classes (mds.)

TPRDV = yearly production by varieties (mds.)

TPRD = total yearly production of rice in the Thanas (mds.)

The yearly per capita output available to a given class is

(151) $$PCPRDL_i(t) = TPRDL_i(t)/POPN_i(t)$$

The total yearly requirements of chemical fertilizer and seed[13] are simply given by

(152) $$TFERT(t) = \sum_{n}^{3} SFERT_n(t)$$

and

(153) $$TSEEDV_j(t) = \sum_{n}^{3} SSEEDV_{jn}(t)$$

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[13]Seed requirements expressed here in terms of rice weight. To get paddy weight multiply by the ratio $\frac{40}{27}$.

where

TFERT = total chemical fertilizer required in the year (mds.)

TSEEDV = total seed requirement by variety (mds.)

The yearly accounting of family labor used in cropping enterprises, wage labor offered and total employment are given by classes by the following equations:

(154) $$YFMLAB_i(t) = \sum_{n}^{3} TFMLAB_{in}(t)$$

(155) $$YLHLAB_i(t) = \sum_{n}^{3} TLHLAB_{in}(t)$$

(156) $$YLAB_i(t) = \sum_{n}^{3} TLAB_{in}(t)$$

where

YFMLAB - total yearly family labor used (mandays)

YLHLAB = total yearly wage labor employed (mandays)

YLAB = total yearly employment of human labor (mandays)

The extent of labor use in agriculture is given by the ratio of human labor employment in crop cultivation and available family labor so that

(157) $$RTEMPL_i(t) = YLAB_i(t)/FAMLAB_i(t)$$

where

RTEMPL = proportion of available labor use in agriculture

The yearly total consumption of rice by different classes is given by

(158) $$TTCONSL_i(t) = \sum_{n}^{3} SCONSL_{in}(t)$$

while that for the Thana is obtained as

(159) $$TTCONS(t) = \sum_{n}^{3} SCONS_n(t)$$

where

TTCONSL = yearly total consumption of rice by classes (mds.)

TTCONS = yearly total consumption of rice for the region (mds.)

The classwise per capita consumption is then computed yearly as

(160) $$PCCONY_i(t) = TTCONSL_i(t)/POPN_i(t)$$

and daily as

(161) $$PCCOND_i(t) = PCCONY_i(t)\ K4$$

where

PCCONY = yearly per capita consumption of rice (mds./year)

PCCOND = per capita consumption of rice per day (oz/day)

and K4 = conversion ratio from mds/year to ounce/day.

To obtain nutritional intake from rice the PCCOND is again converted into nutritional units as

(162) $$CALPDA_i(t) = PCCOND_i(t) \cdot K5$$

where

CALPDA = nutritional value received from rice (calories/day)

K5 = conversion ratio.

The $TPRDL_i$ denotes the total foodgrain received by the class while TTCONSL denotes total foodgrain needed for consumption. The marketable surplus is determined as the difference between them so that

$$(163)\qquad PFSURP_i(t) = (TPRDL_i(t) - TTCONSL_i(t))/FAM_i(t))$$

where

PFSURP = yearly marketable surplus of food grain per family (mds.)

In general, sales of foodgrain would be made if PFSURP is positive and purchase would occur when PFSURP is negative. However, since the actual sales and purchases would be determined by the interaction of many variables at each time period, they may be different than the marketable surplus expressed by PFSURP. In order to observe such patterns we have also obtained the yearly sales and purchase quantities by

$$(164)\qquad PFSALES_i(t) = YSALES_i(t)/FAM_i(t)$$

and

$$PFPURCH_i(t) = YPURCH_i(t)/FAM_i(t)$$

where

PFSALES = yearly sales of foodgrains per family (mds.)

PFPURCH = yearly purchase of foodgrains per family (mds.)

YSALES = classwise yearly sales of foodgrains (mds.)

YPURCH = classwise yearly purchase (mds.)

the yearly totals of sales and purchases being obtained as

$$(165)\qquad YSALES_i(t) = \sum_{n}^{3} TSALES_{in}(t)$$

$$(166)\qquad YPURCH_i(t) = \sum_{n}^{3} TPURCH_{in}(t)$$

The value added by agriculture and by family are calculated both for the classes and for the varieties for analytical purposes. For the classes they are given by

$$\text{(167)} \qquad TVADAG_i(t) = \sum_{n}^{3} VADADUM_{in}(t)$$

$$\text{(168)} \qquad TVADFAM_i(t) = \sum_{n}^{3} VADFDUM_{in}(t)$$

and for the varieties they are

$$\text{(169)} \qquad VVADAG_j(t) = \sum_{n}^{3} CVADAG_{jn}(t)$$

$$\text{(170)} \qquad VVADFAM_j(t) = \sum_{n}^{3} CVADFAM_{jn}(t)$$

where

TVADAG = classwise value added by agriculture (TK)

TVADFAM = classwise value added by family (TK)

VVADAG = varietywise value added by agriculture (TK)

VVADFAM = varietywise value added by family (TK)

The total yearly value added in the Thana by agriculture and by family are respectively given as

$$\text{(171)} \qquad YVADAG(t) = \sum_{n}^{3} SVADAG_n(t)$$

$$\text{(172)} \qquad YVADFAM(t) = \sum_{n}^{3} SVADFAM_n(t)$$

Of particular interest to us is to find the farmers' yearly earning in the Thana. The classwise yearly earning is obtained by adding farmers' total incomes from all sources so that

$$\text{(173)} \qquad ERNG_i(t) = TVADFAM_i(t) + TWAGE_i(t) + FAM_i(t)$$

The yearly per capita and per family earning is therefore obtained as

(174) $$PCERNG_i(t) = ERNG_i(t)/POPN_i(t)$$

(175) $$PFERNG_i(t) = ERNG_i(t)/FAM_i(t)$$

which serves as income indicators for the classes.

Other financial indicators are obtained for classes as

(176) $$PFINC_i(t) = TDISP_i(t)/FAM_i(t)$$

(177) $$PFSCBL_i(t) = CASBAL_i(t)/FAM_i(t)$$

(178) $$PFDBT_i(t) = DEBT_i(t)/FAM_i(t)$$

(179) $$PFLOAN_i(t) = LOAN_i(t)/FAM_i(t)$$

(180) $$PFSVG_i(t) = TSAVING_i(t)/FAM_i(t)$$

(181) $$PFCRDT_i(t) = CREDIT_i(t)/FAM_i(t)$$

(182) $$PFTAX_i(t) = XTAX_i(t)/FAM_i(t)$$

where

PFINC = yearly per family dsiposable income (TK)

PFCSBL = per family cash balance at year end (TK)

PFDBT = per family indebtedness at year end (TK)

PFLOAN = per family loan taken during the year (TK)

PFSVG = per family cumulative savings (TK)

PFCRDT = per family yearly agricultural credit (TK)

PFTAX = per family yearly tax paid (TK)

Aggregate total agricultural credit (TCREDIT), loan (TLOAN), and tax (TTAX) are obtained by simply summing respective class totals so that

(183) $$TCREDIT = \sum_i CREDIT_i(t)$$

(184) $$TLOAN = \sum_i LOAN_i(t)$$

(185) $$TTAX = \sum_i XTAX_i(t)$$

all being expressed in Taka unit.

Estimating Changes in the Price Variables

It is obvious that the region for which the model is constructed is too small to have power in setting different input and output prices. As such prices are exogenously given to the model on the basis of national averages. While the model can be initialized with existing price data, it also needs price data for the projection period. The projection of future prices in itself is a difficult task, requiring a great deal of information and work, and is marred with uncertainty. The present work is not well suited to an endeavor in this area, and indeed, such an undertaking would constitute a deviation from our main concerns. However, in order to satisfy the demands of the present study we have introduced some simple equations to estimate dynamic changes of future prices so that the estimating equations provide at least a basis for our purpose.

The general mechanism involved in this method is to linearly increase base prices at a certain rate of change determined from either the past trend, from indications of government's future price policies, or from intuitive guesses. It is to be understood that in Bangladesh, input and output prices are determined by the government's intervention either through its control over the supplies or through its price policies. This does not, however, mean that market prices are always stable, especially when goods are in short supply and the markets are in distant rural areas. However, this mechanism is seen as a means to control violent fluctuations in the prices and is accepted as the basis upon which dynamic changes are projected.

The base product price is determiend by the following equation:

$$AVPR_j(t) = AVPRZEO_j(t)[1 + RTPR_j * T] \tag{186}$$

where

AVPR = average price of the product to prevail (TK/md)

AVPRZEO = the base average price in the beginning of projection (TK/md)

RTPR = rate of change of product price (dimensionless)

T = time variable.

The value of RTPR, which represents a combined change effect on product price due to normal inflation, demand-supply disequilibrium, etc. is determined exogenously. As expressed by the above equation, the average price would be linearly increasing at a rate given by RTPR which would be sufficiently stable. The fluctuation that occurs in the market price is taken to be due to the seasonal variation. It has been observed that the price remains higher than the average price before harvest starts, while it comes down after the harvest period as the commodity supply increases. Using the past trend of seasonal price variation an index is constructed which provides a pattern of price fluctuation. The market price is determined as

$$\text{(187)} \qquad PRICE1_j(t) = AVPR_j(t) \cdot SINDX$$

where

PRICE1 = buying price of the commodity (TK/md)

SINDX = seasonal index by month (dimensionless)

The market price PRICE1 is actually a price at which the commodity can be purchased. It is assumed that the selling price of a commodity would be marked down by as much as 10 percent, so that farmers' farmgate price of the commodity is

$$\text{(188)} \qquad PRICE2_j(t) = 0{\cdot}9\ PRICE1_j(t)$$

where

PRICE2 = selling price of commodity (TK/md).

On the input side, the price of seed is determined from the average product price existing in the beginning of the season as

$$\text{(189)} \qquad PRS_j(t) = K6 * AVPR_j(t)$$

where

PRS = price of seed (TK/md)

K6 = mark-up proportion (taken as constant).

Since AVPR is the price of rice and PRS is that of paddy, the constant K6 takes care of the conversion as well.

The wage rate of labor is also determined in the same way so that

(190) $$WGRT(t) = WGRTZEO(t)\ [1 + RTW * T]$$

where

WGRT = labor wage rate (TK/day)

RTW = rate of change in wage rate

WGRTZEO = initial wage rate at the base period (TK/day)

T = time variable.

The prices of inputs which are controlled by the government, e.g., fertilizer, irrigation, plant protection chemicals, etc. are expected to be more stable. Generally the government fixes the price levels of these inputs in one year and keeps it unchanged for long periods until it is refixed again. When the procurement price becomes higher, the government pays subsidies with a view to keeping the input prices low for the farmers. Assuming that the present prices will be refixed at some point of time during the run period in order to cope with the international inflationary pressure, the future prices of fertilizer and irrigation are estimated as

(191) $$PRF_i(t) = PRF_i(t)\ [1 + RTF * DVAR1]$$

and

(192) $$PRI_i(t) = PRI(t)\ [1 + RTI * DVAR2]$$

where

PRF = combined fertilizer price expressed in terms of crop in proportion of 2:3:1:2 for Urea, TSP, M.O. and oilcake (TK/md)

PRS = irrigation water charge (TK/acre)

RTF = rate of change in fertilizer price

RTI = rate of change in irrigation change

DVAR1, DVAR2 = dummy year at whcih the prices are refixed

The step function form of the above equation depicts the change only for the time when the prices are refixed and remains constant during the run period.

The prices of other inputs including the interest rate are given exogenously at the initiation of the run and are kept constant for the duration. This has been done under the assumption that either their prices will remain unchanged or that even if they change, the effect on the farmers will not be appreciable, since these are minor inputs with minimal use.

A Note on Data Usage

Data used in the model fall under three general groups: 1) behavioral system parameters, 2) technological coefficients and 3) initial conditions. The system parameters define the behavioral characteristics of the system; the more accurate they are, the better the model structure represents the real system. Technological coefficients provide information about the state of technology involved in the system. The initial conditions are the initial values that are given to the model to start the first cycle of computations. Most of the system parameters and technological coefficients are kept constant during a simulation run, under the assumption that they are unlikely to change within such a brief time. Those which are expected to change have been expressed as variables with the initial values given and the nature of dynamic changes defined by equations. For many of the variables the values are endogenously determined from the exogenous variables through interconnections.

Data for these parameters, coefficients, and initial conditions are made available from primary surveys conducted by Comilla Academy, from secondary published sources, and from tertiary data worked out from the primary and secondary sources. For values which are not up-to-date or available at all, guesstimates have been made. Experts' opinions and the author's personal experience were called upon to check the accuracy of such guesstimates but they could not be authenticated. Nevertheless, it should be understood that the data base is weak, and has been employed tentatively in order to operate the model.

Insofar as this study is concerned, the accuracy of results has not been the primary issue of concern; the main issue has been the viability of the model. Accurate results would depend upon the availability of accurate data, which has not been assured. It is anticipated that the model would serve its purpose if it proved to be workable and effective. Data requirements can be fulfilled in the field eventually after the model is found to be worthwhile.

Data used for operationalizing the model are contained in the computer program given in the Appendix. Further refinement and timing of the model as well as of data has been pursued in the course of the validation tests conducted in the next chapter.

CHAPTER V

MODEL VALIDATION AND TESTS OF SENSITIVITY

Introduction

The computer simulation model, as presented in the last chapter, has been subjected to various tests to ascertain its validity. The basic idea behind conducting such tests is to examine how well the model simulates the interacting complex behavior of the real system that it is supposed to represent. Model building work by itself is an iterative process of testing, refining, tuning and validating (Manetsch et al., 1971). Such a process is ongoing as long as the model is in use, and even after it is implemented, so as to include new information derived from the system and so as to sharpen the model structure to make it represent reality more accurately. Tests of the model, as described in this chapter, are intended to evaluate its consistency and workability. The model was subjected to these tests in order to establish confidence in its ability before it is used, in the next chapter, to simulate the consequences of policy decisions.

Even though validation of the model is important for establishing its credibility, this is by far the most difficult of all tests. The simulation model projects output values for an unknown future which cannot be verified by reference to empirical information.

In some cases, even past time series data are not available for comparison. The difficulty of model validation is all the more apparent when new situations, for which little knowledge is presently available, are being explored in the simulation. The validation tests of verification and viability, in such a case, have to be based upon whatever information is available, and on intuitive judgement. The guiding principles, then, rest on some objective tests of the model, e.g. its logical consistency (both internal and external), clarity and workability (Johnson, 1972; Johnson and Zerby, 1973). The consistency test examines whether the model matches established analytic conceptions and bears a logical relationship with their past, present and future attainments. The ambiguity or vagueness of the model is checked through a clarity test, while a workability test checks the viability of the model and its usefulness for the solution of practical problems. The clarity and workability tests by themselves also entail a check on the internal and external consistency of the model.

The methods by which these tests have been carried out are indicated below. Due to the problems mentioned above, the methods used were primarily intuition and judgement drawn from experience and common sense. The methods used were more eclectic than selective. They were not of a deterministic sort.

The first method of validation employed was to compare the model structure and the behavior it simulates with the real system. Experts who have intimate knowledge of Comilla and Bangladesh were consulted to obtain their intuitive judgements about the degree to which the structure of the model represented reality. In this respect the author's personal work experience gained through long association with the system was very useful. The author also availed himself of direct consultations with experts on the systems simulation approach. The viability of the present model is largely the consequence of this pooling of the intuition, knowledge, and experience of many experts at M.S.U.

A second method employed for model validation was to compare simulation outputs with historical information, in those instances in which it was available, or with similar conditions. For this purpose, published sources of secondary data were particularly helpful in tracking time series.

Finally, sensitivity tests were conducted to identify model parameters which carried more than or less than proportional changes in the output values when the parameters values were changed. The objective of such sensitivity tests is twofold: to validate the internal consistency of the model, and to pinpoint input variables and parameters for which the data needs improvement.

General Validation

In pursuance of the general validation of the model a number of consistency and workability checks of which a few are mentioned here, have been made with the model results to determine if the model equations are able to simulate the real system behavior effectively. The primary means adopted for this purpose has been either internally cross checking the output results obtained from various equations or comparing them with data obtained from externally available sources.

In cases where mathematical identities exist between two or more sets of equations their results were checked to see if the identities held. For example, equation (27) defines, for any time t, a harvest rate, $RH_{ijn}(t)$, via a mathematical function SEAVAL which distributes the total output produced over the entire harvest period. If SEAVAL is working correctly, the cumulative total of harvested output during the season or year must be equal to the product of cultivated acreage and the corresponding yield rates, as expressed in the equation

$$\int_{T_1}^{T_2} RH_{ijn}(X)dX = ARA_{ijn} * XLDA_{ijn}$$

for any season or year.

In Table V.1 the numerical results obtained from both equations are shown. It has been found that except for integration error the identity relationship is well satisfied.

Besides generating data the FARM component is involved in the two crticially important functions of dealing with inter-class transfers within the farmer categories, and with sharecropped land allocation between the categories. Inasmuch as modelling of these functions mathematically was important but complicated, checks were conducted to make sure that the model equations were working consistently. In a situation of inter-class transfer, a nonmember farmer of a particular land holding category leaves his own class and joins the member class. In doing so, he moves with his land and family members which therefore affects a number of interrelated variables in the component. The equations (1) to (13) are devised so as to capture this process of transfer. Their ability to do so has been checked through the results

Table V.1: Consistency Check on Production Equations

Season	Crop Variety	Crop output (in mds.) determined by[1] $\int_{T_1}^{T_2} RH_{ijn}(X)dx$	$ARA_{ijn}*YLDA_{ijn}$
BORO	LOC	2302.4	2299.5
	HYV	218955.8	218998.1
	Sub total	221258.2	221297.6
AUS	LOC	13762.4	13766.5
	HYV	34354.7	34367.7
	Sub total	48117.1	48124.2
AMON	LOC	59624.1	59614.2
	HYV	123812.8	123811.5
	Sub total	183436.9	183425.7
	Year total	452812.2	452847.5

[1]Production figures are shown for one class only in 1975 as an example.

shown in Table V.2. A test run (Run 1) generates the class data for families (FAM), population (POPN) and land under possession (LAND) in a reference year. Run No. 1 was made without any transfer while another test run (Run No. 2) was made with transfer by giving a value to the rate of change in membership parameter (RTM) in equation (1). Comparing the results of the two runs, it has been found that for identical totals for the reference year, Run 2 was able to effect transfers of all the variables in question from one class to the other.

The inclusion of share cropped land in the FARM component of the model complicates the allocation further as it involves inter-category transfer over and above the normal process of dynamic inter-class transfers. A thorough check has to be made to make sure that the model equations adequately represented the whole process of land allocation. Conceptually the following identities must hold in order to make the allocating equations of share cropped land correct.

(1) $$\sum_{i=1}^{8} ARSD_i = 0$$

(2) $$\sum_{i=1}^{8} ARA_i = \sum_{i=1}^{8} AROR_i = \sum_{i=1}^{8} AROW_i$$

(3) $$\sum_{i=1}^{8} AVLOPT_i = \sum_{i=1}^{8} OUTPUT_i$$

(4) $$AROW_i = ARA_i - ARSD_i$$

The model results for the one season shown as an example in Table V.3 confirm that the identity conditions are satisfied. It has also been observed, but not shown here, that the conditions remain

Table V.2: Consistency Check with Inter-class Transfer Variables

		Test Run No. 1 (with no inter-class transfer)			Test Run No. 2 (with inter-class transfer)		
Class No.	Institutional Affiliation	FAM (families)	POPN (persons)	LAND (acres)	FAM (families)	POPN (persons)	LAND (acres)
1	Member	1664	14475	499	1697	14765	509
2	Non-member	11648	101327	3494	11615	101037	3484
Sub-total		13312	115802	3993	13312	115802	3993
3	Member	6743	58699	8762	6945	60460	9025
4	Non-member	4495	39133	5841	4293	37372	5578
Sub-total		11238	97832	14603	11238	97832	14603
5	Member	1785	15851	6606	1839	16326	6804
6	Non-member	1241	11015	4590	1187	10540	4392
Sub-total		3026	26866	11196	3026	26866	11196
7	Member	883	7857	5382	918	8171	5597
8	Non-member	541	4816	3295	506	4502	3083
Sub-total		1424	12673	8680	1424	12673	8680
	Member	29000	96882	21249	11399	99722	21935
	Non-member	17924	156291	17223	17601	153451	16537
TOTAL		29000	253173	38472	29000	253173	38472

satisfied in a similar manner in every season throughout the run period even when dynamic changes are introduced.

A more intricate check involving several equations has been made in Table V.4 with the food grain inventory. Conceptually an accounting identity exists between the yearly inflow of the inventory and the outflow so that

$$STOG_i(t-1) + TPRDL_i(t) + TPURCH_i(t) = TCONS_i(t) + TSALES_i(t) + STOG(t)$$

that is the sum of foodgrain from last year's stock, plus this year's produce and purchase should be equal to foodgrain consumption this year, plus produce sold and the remaining stock. If any of the equations involved in generating the output is inconsistent, the inventory would be unbalanced.

Table V.4: Consistency Check on Inventory[1]

Inflow			Outflow		
Source	Variable	Quantity (in mds)	Source	Variable	Quantity (in mds)
Last year's stock brought forward	STOG	65239	This year's consumption	TCONS	65757
This year's production	TPRDL	291107	This year's sales	STOG	68886
This year's purchase	TPURCH	3577	Year end stock	STOG	68886
TOTAL		359923			359923

[1]Inventory figures shown are of one class of farmers for one year.

Table V.5: Comparison of Data Generated by the Model Equations with Data Obtained from Other Sources

	Model generated data (1974)			Data from other sources[a] (1974)		
	Boro	Aus	Amon	Boro	Aus	Amon
Area (in acres)						
LOC	421	8518	19701	398	8558	20572
HYV	14521	8201	16078	14497	8143	15361
Total	14942	16719	35779	14895	16701	35883
Cash Cost of Production (TK/acre)						
LOC	826	443	461	NA	NA	590[c]
HYV	1064	809	750	840[b]	NA	823
Human Labor Used (mandays/acre)						
LOC	46	42	45	47[b]	NA	48[c]
HYV	72	68	64	69[b]	NA	63[c]
Rice Yield rate (mandays/acre)						
LOC	15.12	12.55	13.18	12.55	13.75	14.29
LYV	30.82	26.93	26.88	30.93	30.15	24.49

[a]Area and rice yield data compiled from Seasonal Crop Surveys by Rezaul Karim: Production of HYV and LV Rice in Comilla Thana. (mimeo), BARD, Comilla (1975).

[b]Boro Labor figures are for 1967 from Anwarul Hoque: Costs and Returns - A Study of Irrigated Winter Crops, BARD, Comilla (1968); production cost figure is for 1973, from Rezaul Karim: Boro Crop Survey 1972-73, BARD, Comilla, 1973.

[c]Cash Cost of Amon of 1974 is from M. Shahjahan, Costs and Returns - A Study of Transplanted Amon Paddy, BARD, Comilla (1975).

NA - Not available

The farm component also allocates land under seasonal cultivation and under different varieties while the production component computes the cost of production, human labor use and the yield rates. Various controlling parameters of the equations are given values as derived from the real system so that the equations can realistically simulate the system. In Table V.5 some data generated by the models are shown for comparison with data obtained from other sources. The comparison has been made only for the initial year since data for later years are not available from any source.

While many such checks have been made during the process of validation, only a few are mentioned here as examples. These are shown here to establish a preliminary credibility in the model before more rigorous tests are described in the next section.

Analysis of Sensitivity Tests on Aggregate Performance Criteria

In this section some results of the sensitivity tests made on the model are presented. The purpose of undertaking this analysis has been indicated above. More specifically, sensitivity test analysis performs at least three functions. It helps in understanding the behavior of the model and in checking its logical consistencies as a part of model validation. It also helps in indicating possible policy directions and implications. Lastly, it can usefully indicate which specific data elements, measured at what level of accuracy, will be crucial to the performance of the model.[1]

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[1] Data used in this study are to be found in the computer program given in the Appendix.

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Though it might have been desirable, ideally, to carry out a sensitivity test on each and every input variable or parameter included in the model, so as to observe the impact of each of these on all the output variables, such a task would have been voluminous. Moreover, many input variables or parameters may have an impact upon only a few of the output variables. With these considerations in mind, our approach was to conduct sensitivity tests only on a few exemplary cases which we thought to be of importance. The sensitivity test method employed was to vary the parameter values by an amount subjectively determined beforehand and to observe the changes that resulted in the performance variables selected. In order to estimate the full effect of each input variable or parameter upon the output, each run was made with an alteration in a single input or parameter. When more than one parameter was tested, the output variables were separated completely so that they were not affected by more than one source. Comparisons of changes in the performance variables were made against the base run values which had been obtained from the model when run with initial values. However, intuitive feelings rather than strict rules were followed to evaluate the degree of sensitivity observed.

In Table V.6 results of 21 sensitivity tests made are indicated. The performance criteria selected for the analysis are total production (TPRD), total consumption (TCONS), total employment (TEMP), value added to family (VADFAM), value added to agriculture (VADAG), and per capita earning (PCERNG). These are all annual aggregate values for the region as a whole indicating performance in the final

Table V.6: Results of Sensitivity Tests with Some Selected Parameters

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	Performance Criteria: TPRD[a]	TCONS[b]	TEMP[c]	VADFAM[d]	VADAG[e]	PCERNG[f]
						Base Run Value in 1981					
						1.723 mil. mds.	0.943 mil. mds.	4.456 million mandays	137.8 mil. Taka	163.8 mil. Taka	542 Taka
						Percent Departure from Base Run Value					
2	Proportion of total farmers in the respective land holding categories joining the coops, every year.										
	Cat.1(0-1 acres)	RTM1	.02	0.)							
	Cat.2(1-3 acres)	RTM2	.02	0.)							
	Cat.3(3-5 acres)	RTM3	.02	0.)		-2.70	-0.24	-2.12	-2.61	-2.50	-2.58
	Cat.4(5 acres or more)	RTM4	.02	0.)							
3	Intrinsic rate of population growth per year	GRT	.03	.0245		0.	-3.15	0.	0.	0.	0.
4	Land owned by farmer category:										
	1(0-1 acres)	LND_1	3993	5483)	acres	0.55	1.35	0.65	0.58	0.49	0.56
	4(over 5 acres)	LND_4	8680	7190)							

Table V.6 (continued)

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
5	Rate of change in the proportion of land share cropping	RTSH	-.002	-.005		-.02	-.01	-.02	-.07	0.	-.02
6	Proportion of land under share cropped	PRPSH	.05	.10		0.71	0.57	0.75	0.87	0.61	0.74
	Rate of change in the proportion of land under share-cropping	RTSH	-.002	-.005							
7	Rate of change in the proportion of total land utilized:										
	Boro season	RTA_{ij1}	.03	.06		2.26	0.2	1.89	1.96	1.95	2.03
	Aus season	RTA_{ij2}	-.01	-.02							
8	Rate of change in the proportion of land under HYV:										
	Aus season	RTH_{ij2}	.05	.075		4.98	0.27	2.50	4.86	4.70	4.78
	Amon season	RTH_{ij3}	.06	.10							

Table V.6 (continued)

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
9	Rate of change in the average quantity of fertilizer used for:										
	Local variety	$RTFV_1$	0	-.3							
	HYV	$RTFV_2$	0	-.3		-3.42	-0.27	-1.30	-2.10	-1.95	-2.03
	Change effected in year after the initial	$RTIM_1$	0	1.							
		$RTIM_2$	0	1.							
10	Fertilizer use index of different classes (i = 1,8)	$FINDX_i$	1.4								
			0.6								
			1.6								
			0.7	1.8		4.39	.62	1.70	2.10	2.20	2.21
			1.6								
			0.7								
			1.3								
			0.6								
11	Fertilizer response function coefficient (J = 1,2; n = 1,3)	A_{jn}									
		11	18.18	21.82							
		21	40.89	49.07							
		12	18.18	21.82							
		22	34.90	41.88	mds.	17.08	1.45	6.5	21.99	19.96	19.93
		13	18.01	21.61							
		23	34.90	41.88							

Table V.6 (continued

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
12	Labor required in pre-harvest related work (j = 1,2; n = 1,3)	$PVLA_{jn}$									
		11	30.	24							
		21	44.	35.2							
		12	28.	22.4							
		22	40.	36							
		13	28.	22.4							
		23	40.	36.							
	Labor required in harvest related work (j = 1,2; n = 1,3)	$HVLPOV_{jn}$			man days	0.	0.	-12.77	3.48	0.18	0.18
		11	1.2	1.08							
		21	1.1	0.94							
		12	1.3	1.17							
		22	0.9	0.81							
		13	0.9	0.81							
		23	1.0	0.9							
13	Maximum family labor that can be used in crop production by different classes (i = 1,8)	U_{2i}									
		1	75.	120.							
		2	75.	120.							
		3	75.	120.							
		4	75.	120.							
		5	45.	75.	man days/ years	0.	0.	1.38	4.57	0.24	0.26
		6	45.	75.							
		7	45.	45.							
		8	45.	45.							

Table V.6 (continued)

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
14	Proportion of agricultural labor employed as wage labor in different classes (i = 1,4)	$PPWL_i$				0.	0.	0.	0.	0.	0.
		1	.08	.15							
		2	.50	.75							
		3	.29	.05							
		4	.13	.05							
15	Run 13 and Run 14 Combined					0.	0.	1.38	4.57	0.24	0.26
16	Rate of change of fertilizer price	RTF	0.	.50		0.	0.	0.	-5.01	-4.15	-4.06
	Rate of change of mechanical irrigation charge	RT1	0.	.30							
	Year when effective	KVARF	0.	2.							
		KVARI	0.	2.							
17	Run 9 and Run 16 Combined					-3.42	-0.27	-1.30	-5.8	-5.13	-5.17

Table V.6 (continued)

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
18	Rate of change in the product price of rice Local variety HYV variety Rate of change in the wage rate	 $RTPR_1$ $RTPR_2$ RTW	 0. 0. 0.	 .05 .05 .06		0.	.01	0.	42.53	42.80	42.25
19	Rate of taxation on earned income (i = 5,8)	RTX_i	0.	.15		0.	0.	0.	0.	0.	0.
20	Value of FN1 regulating consumption level	VALFN1	.75 .85 .95 1.00	0. .85 .95 1.0		0.	-21.0	0.	0.	0.	0.
21	Weather index for given seasons: Amon in 4th year Aus in 8th year	 WI(3) WI(2)	 1. 1.	 .70 .85		-3.02	-.31	-1.09	-4.00	-3.54	-3.51

Table V.6 (continued)

Run No.	Test Parameter Definition	Parameter Name	Base Run Value	Test Run Value	Unit	TPRD	TCONS	TEMP	VADFAM	VADAG	PCERNG
22	Fine time interval in simulation	DT	.02	.01		0.	0.44	-2.03	0.51	0.06	.04

[a]TPRD = Total Rice Production

[b]TCONS = Total Rice Consumption

[c]TEMP = Total Employment

[d]VADFAM = Value Added by Family

[e]VADAG = Value Added to Agriculture

[f]PCERNG = Per Capita Income Earning

year of the 8-year run period. The differences between test run values in that year and the base run values have been expressed in the Table in terms of percentages; the sign shows the direction of departure of the test run from the base run.

The sensitivity of the membership growth rate parameter is examined in Run 2. While the base run assumes a constant increase of 2 percent net membership per year,[2] it may be the case that there will not be any further increase in membership if membership has reached a plateau. Such a situation would arise if farmers manifested a lack of interest or confidence in the cooperative institution. There would be shortfall in almost all of the performance criteria if such a leveling off of membership was not taken into account.

The results of run 1 show that total production and some of the related performance criteria are sensitive to the membership growth rate. Members characteristically produce more than non-members and a reduction in membership would be expected to lower the total production. The higher production in the class of cooperative members results from the fact that, because of their motivation and training, members (a) achieve more cropping intensity in land, (b) allocate more land to high yielding varieties and (c) get comparatively higher per acre yield than non-members. In fact, the test results also reflect the impact of the institutional factor upon the performance

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[2]A slow rate of membership growth has been assumed because the cooperative organization has passed through its early growth phase and by now cooperative membership is reaching a plateau. The simulation run starts at the upper asymptotic point of the S-shaped membership growth curve where the slope is low.

criteria as achieved through a better allocation of resources to improved agriculture. As such, the base run assumes an unequal adoption of improved agriculture and resource allocation which can be modified if the evidence shows otherwise. If the adoption of improved practices by non-members seems to be faster than for members (as might be the case if non-members were seeking to catch up with members) by the end of the run period the shortfall would probably be reduced. Then the role of the institutional factor would decline and the variable could show insensitivity. On the other hand, if the growth rate of membership is fast, the membership characteristics as stated above inherently would increase production, in which case the variable would again record sensitivity.

In Run 3 the intrinsic rate of population growth is decreased to 2.45% from 3% in the base run so that there was a 15% reduction in population growth. Such a reduction in population growth could be achieved if vigorous family planning education were conducted. The variable, however, is only sensitive in relationship to total consumption, which declines. A reverse effect would be expected if the population grew faster than is assumed in the base run.

In Run 4 a test has been carried out with the land variable by shifting about 3.9% to total land from the large farmer category (over 5 acres) to the land poor category (less than 1 acre). This test is specially directed to observe the effects of land redistribution in the region. The test variable has shown insensitivity in relation to almost all of the overall performance criteria, although their values were all non-negative. The reason for such behavior is that as long as the cropping intensity and crop yields in the shifted land are maintained at the same levels, then total production is unaffected by who it is that owns the land. Positive changes in the total production and its related performance criteria resulted due to the higher cropping intensity and/or higher yield rate of the group which acquires the land. Since land is intensively cultivated in this region, the positive effects on the performances are minimal. If the distributed land had been fallow (i.e. zero cropping intensity) the effects would be appreciable.

Run No. 5 was made with a slightly higher rate of negative change in the share cropping land in order to see how the performance criteria would be influenced if land owners, discovering the benefits of improved agriculture, decided to reduce their share cropping. The test results show insensitivity of the variable. This happens because the land withdrawn from sharecropping is then cultivated by the owners themselves and therefore does not remain fallow. The slight change that takes place reflects the productive characteristics of share croppers. This aspect is more clearly observed in Run 6 where land under sharecropping is raised from 5% to 10% with a similar rate of change in the proportion (RTSH) as is in Run 5. Run 6 also confirms the insensitivity of the sharecropping variable.

In Run 7 the land under Boro cultivation increases at a faster rate than in the base run, mainly due to the greater availability of irrigation facilities. However, since almost all of the Boro land is cultivated under HYV which, due to a longer maturation time, encroach upon the Aus season, an increase in Boro cultivation will have a negative effect upon Aus season acreage. In fact, it is estimated that by the end of the run year the land under Boro increased by 10.3% over the base run, then the Aus crop would decline by 8.7%, thereby leaving a resultant yearly increase of 1.3% in the cropped area.

The test shows that the reallocation of land is somewhat sensitive in relation to all performance criteria, for it increases cropping acreage on the one hand and increases the yield rate on the other due to a change in the cropping pattern in favor of HYV. This provides an indication that increasing Boro cultivation, even at the cost of decreasing Aus crop acreage, would be worthwhile. However, no such scope exists in increasing Amon crop acreage which is presently at the maximum cultivation level.

But there does exist a possibility of changing the cropping pattern both in the Aus and in the Amon season. In Run 8 slightly higher rates of change in the proportions of land allocated under HYV in Aus and Amon are accepted in conducting the test. All performance criteria are found to be quite sensitive to these changes. Unsurprisingly, the total production and the per capita earning variable increase rapidly and new employment is created. This happens because the higher rate of change in the cropping pattern brings 77% of the combined Aus and Amon land under HYV at the end of the run, instead of 64% as obtained in the base run. Therefore, 18% more land is cultivated under HYV in these seasons, which increased the total production by 5%.

Run 9 has been singled out to test the sensitivity of changes in fertilizer use patterns among the farmers. In the base run it was assumed that the average fertilizer dose presently adopted by the farmers will not change during the run period while in test Run 9 the average dose was reduced by 30% after the first year of the run. The test was made to examine the effect upon the performance criteria of a reduction in fertilizer use, caused either by a fertilizer price increase, scarcity, or behavioral change in the allocation of inputs. It has been observed that all performances criteria are affected by such a reduction. The variable affects production and earning, and to a lesser extent consumption and employment. The reason is that although reduction in fertilizer use will have an impact upon consumption and employment, due to reduced production, the minimum levels of consumption and employment will still be maintained.

Earlier while discussing Run 1 it was indicated that non-members might adopt improved agriculture at a faster rate now in order to achieve the level demonstrated by the cooperative members. If this happens, then there would be no difference in the use of fertilizer dose by the two groups of farmers. The Run 10 results show that total performance would be affected by such farmer behavior. Although the variable expresses the behavioral pattern of farmers, it is the physical input of fertilizer that makes the impact.

In Run 11 a parallel upward shift to the fertilizer response functions is tested by introducing a 20% increase in the constant terms. It envisages a new seed variety that would give higher yield than the present strains.[3] Since it is not possible to project any

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[3]Already Bangladesh Rice Research Institute has brought out several hybrid rice varieties, e.g. BR-3 and BR-4, that show higher yields than the presently available HYV.

marginal productivity estimate of those future varieties, the test has been made with the assumption that 20% higher yield will be obtained from the new varieties at the same level of fertilizer dose and other inputs. The test shows that total production would increase by 17% and value added by agriculture by 20%, at present prices. As production would increase, so would value added to family and per capita earning. There would be comparatively less impact upon employment and much less consumption.

Run 12 is conducted with reduced labor use, both in pre-harvest and harvest work, which may occur due to the introduction of labor saving mechanical devises or an increase in labor efficiency. In the test run the variables are found to be sensitive in relation to total employment in the region, which decreases. Total production or consumption may not be affected and the variables may be insensitive to overall per capita earning criteria of the region.[4] In general, the reduction in labor will be primarily aimed at decreasing the use of hired labor and thereby minimizing the cash cost of production and increasing the value added to family. On the other hand, earning from wages would decline in the region so that there would not be any perceptable change in the overall per capita earning (although there will be an effect upon class earnings).

Run 13 tests the inpact of a higher availability of family labor in the first six classes of farmers -- those holding up to 5

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[4]For brevity the model has not been geared to consider the comparative marginal loss or return to production by reduced labor and mechanical devices. It is, however, assumed that reduction of labor beyond a certain limit would affect production. However, the test values are maintained well within such a limit.

acres of land. It is assumed that the lower the land holding, the higher would be the availability of family labor per acre, and that therefore farmers holding little land would try to minimize the need for hired labor by using more family labor. The results show that farmers would thereby increase their value added to family. There may also be a slight increase in total employment. But overall per capita earning would not be affected, because a decrease in hired labor use would reduce wages for some classes and cut costs for other classes.

Runs 14 and 16 are tested with a readjusted proportion of wage labor employability; they will be discussed later as their effects are significant for class performances rather than for regional aggregates.

Run 16 assumes a higher cost of inputs than the base run. The price of fertilizer is increased by 50%, which would be equivalent to the price level if the present subsidy were lifted. Similarly, the irrigation charge is also raised by 40%. Assuming that the farmers have been fully motivated to adopt improved agriculture, the use of these kinds of inputs is inelastic, so there would be no effect on production or employment. The effects, however, would be felt in the reduction of value added and of per capita earning, since the total cost of cultivation would increase. In other words, an input price increase would be sensitive only in relation to the monetary aspect of agriculture, rather than physical production.

Whether the assumption of inelasticity is valid or not is difficult to prove at this time. No study is known to have been made in this area to determine the price elasticity of demand for fertilizer.

The assumption of inelasticity has been made by reasoning that such a price increase is tantamount to a reduction of about 10% in gross profit per acre. When institutional credit is still available to cover the increased cost, there would be little tendency to reduce the quantity of input use.

But it might still be argued that in subsistence agriculture an input price increase would influence farmers to be cautious about input allocation. To examine this situation Run 16 was made with an elasticity of -.4, considered as the extreme limit of elasticity. The results show that all performances would then be affected by an input price increase. Physical production falls due to a reduced use of fertilizer, and value added variables decline due to the combined effects of increased costs and reduced production.

Constant increases in the output price level and wage rate are sensitive in relation to value added and per capita earning, as is shown by the results of Run 18. It is believed that increased profitability due to output price increases would induce farmers to adopt improved agriculture at a faster rate and to utilize a greater amount of modern inputs so that their production increases. Modelling such responses that would occur in the allocating component has not been included in the present model.

The results of Run 19 and Run 20, which involve respectively the tax variables and the functional value of the consumption level regulator, show insensitivity in relation to almost all performances. The need for these runs will be fully apparent in the next section; however, a little discussion here on Run 20 is relevant. In the base run the lowest value of FNI has been fixed at 0.75, so that the consumption level would not fall below 75% of the normal grain intake even if the available grain level in storage falls below this limit during any period. Flexibility, due to the availability of unlimited credit for buying the deficit grain, has been allowed. In other words, the complete non-availability of food, if not malnutrition, was ruled out. In Run 20 this condition is withdrawn and the consumption level is forced to adjust to the storage level. The result shows high sensitivity since total consumption declines by about 20%. This indicated to us that the assumption made in the base run in this respect is quite weak, and needs modification in the policy runs.

While all previous test runs were made with normal weather conditions, Run 21 was carried out by subjecting the Thana to flood in the Amon season in the 4th year of the run, and to drought in the Aus season in the 8th year. The results shown, however, reflected only the effect on the Aus season in the final year. The indicated decline of all performances due to bad weather is not altogether unexpected. However it is difficult to pinpoint deterministically in the model when such a weather condition will occur. Therefore the test shows, at best, sensitivity of the weather variable in relation to the performances in the region.

Finally, test Run 22 is made with changes in DT. It is insensitive in relation to all but employment. Since labor use is calculated by DT it also affects the seasonal labor use profile by month, although the extent is quite low.

Analysis of Sensitivity Tests on Class Performance Criteria

When test results are observed at the aggregate level they do not reveal much about the effects on particular classes. In aggregate analysis it is generally assumed that there are no significant differences among classes of farmers; that these classes maintain equal and uniform characteristics. That this is not so in reality is the reason why a disaggregative analysis has been attempted in this study. In fact, when the test effects are analyzed at the individual class levels, a far more illuminating and interesting set of effects comes to light. In rural development planning it is as desirable to bring this information into focus as it is difficult to do so because of its complexity and voluminousness. In this section a disaggregative analysis is attempted, though in a simplistic manner, in order to grasp the distributive effects of the sensitivity tests.

Tables V.7a through Table V.7i present the results only of those test runs that are considered significant to class performances. The class performance criteria selected for the analysis are: per capita available output (PCPRDL), per capita consumption (PCCONY), per family surplus food (PFSURP), total class employment (TEMPL), per family earning (PFERNG), per family disposable income (PFINC), per family loan taken during the year (PFLOAN) and per family total savings (PFSVG). Except for PFSVG, which is cumulative, all performance criteria are expressed in annual figures. The base run values in Table V.7a are presented in absolute figures, while the test run values in Table V.7b through Table V.7i are shown in terms of percentage departures from the base run.[5]

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[5]Test runs are the same as those given in Table V.6.

The class performance criteria values of 1981 obtained from the base run are presented in Table V.7a. These values, though they are not to be considered exact due to the stated data limitations, nonetheless provide a clear picture of the classic economic condition. Per capita food availability varies among the classes, the near landless class (0-1 acre) being in deficit, while the rest of the farmers are in surplus. The larger the farm landholding, the higher is the per capita food surplus, the higher is income, and, as it accumulates over the years, the higher also is savings. Although the Thana food production shows an aggregate surplus, about 46% of the farmers in the Thana are actually in a situation of food deficit. To subsist they have to buy food. The earning power of these deficit farmers is meagre. Since they do not have surplus food to sell, they have to depend primarily upon their wages for money to buy food. These wage earnings, however, are not sufficient. Their disposable income, therefore, is constantly negative and they borrow continually. The result is that over the years they accumulate a heavy debt.[6]

The income gaps among the classes of farmers are clearly visible. Even between members and non-members of the same land holding category there exists some gap, apparently because of the difference in production level. Any change in these income distribution

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[6]The cumulative negative savings in PFSVG is slightly unrealistic because of the two assumptions made in the base run on credit availability and food consumption level. The minimum food consumption level is assumed to be 75% of the normal food intake, and to maintain that level unlimited consumption credit is assumed to be available. These assumptions have been made to restrict extreme malnutrition due to hunger, even though they translate into considerable credit costs.

Table V.7a: Base Run Values in 1981

Class Definition	No.	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (Tk/yr)	PFINC (Tk/yr)	PFLOAN (Tk/yr)	PFSVG (Tk)
0-1 acres									
Member	1	2.52	2.89	- 3.87	296660	3119	- 1489	2248	-10254
Non-member	2	1.33	2.66	-13.79	1681461	2135	-16667	14335	-53104
1-3 acres									
Member	3	7.02	3.32	38.60	1423474	6816	2798	881	9199
Non-member	4	4.37	3.21	12.14	592101	4691	1216	252	852
3-5 acres									
Member	5	16.51	3.88	134.21	207869	14017	8220	2175	38327
Non-member	6	10.95	3.77	76.31	76988	9508	4769	671	23518
5 acres & over									
Member	7	22.67	4.06	198.24	131144	20308	14200	2601	68273
Non-member	8	17.27	4.00	141.33	46131	15708	10762	931	60478

gaps will result, however, from non-marginal changes in the individual class performances resulting from system parameter or behavioral changes.

Test analyses have been conducted so as to examine the impacts of changes of the selected variables upon class performances.

Although the test variable land (LND) (in Run 4) has shown insensitivity in relation to aggregate performance criteria, it is found to be highly sensitive in relation to performances of the affected classes. For near landless classes 1 and 2 among whom land is distributed, per capita production increases, as does earning and disposable income. As a result borrowing and negative savings of classes 1 and 2 decrease substantially. A reverse effect is observed in the performance of classes 7 and 8, from whom land is taken away. Their income shows a decline, but the comparative loss is less than the gain that accrues to the near landless class. Due to the higher efficiency of member farmers in class 1 (i.e. higher cropping intensity, improved cropping pattern and higher yield rate), this class comes to have a surplus in food, and so improves its income more than the non-member farmers in class 2, who still maintains a deficit in per capita food production. The extent of gain in these classes depends, however, on the volume of land redistributed. On the whole only those classes that are directly involved by the land redistribution are affected and one class gains at a cost to another.

The variable RTA, which indicates the rate of change of land under cultivation (in Run 7) affects class performances less than the changing variable RTH that defines rate of change of land under HYV

Table V.7b: Sensitivity Tests on Performances of Class 1.
Percent Departure from Base Run Values of 1981

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	31.46	3.81	184.5	4.56	21.48	14.82	-81.18	77.20
7	RTA	5.16	N	26.61	2.09	3.33	29.95	-15.30	11.47
8	RTH	3.97	N	22.48	3.21	3.82	21.76	-11.74	8.20
11	A	17.06	2.08	98.19	8.00	17.70	140.97	-76.11	72.83
12	PVLA HVLPOU	0	0	0	-15.67	-3.72	-32.16	16.64	-16.30
15	U2 PPWL	0	0	0	41.19	16.77	152.25	-77.67	77.34
17	RTF RTI RTFU	-3.57	N	-21.71	-1.59	-5.07	-40.23	21.57	-19.01
18	RTPR RTW	0	0	0	0	43.06	23.77	6.81	-3.82
19	RTX	0	0	0	0	0	0	0	0
20	VALFNI	0	-24.91	195.61	0	0	159.57	-40.93	95.89
21	WI	-3.17	N	-18.60	-1.32	-3.46	-14.84	9,07	-7.43

N = Negligible

Table V.7c: Sensitivity Tests on Performances of Class 2.
Percent Departure from Base Run Values of 1981

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	33.21	3.38	26.18	3.06	17.70	24.50	-24.04	23.77
7	RTA	4.51	N	3.63	2.03	3.18	2.92	- 3.04	2.56
8	RTH	5.26	N	3.63	3.43	4.54	4.13	- 3.15	2.56
11	A	18.45	1.88	14.14	8.56	16.81	23.30	-31.99	22.03
12	PVLA HVLPOU	0	0	0	-16.80	-6.93	-9.31	8.09	-8.10
15	U2 PPWL	0	0	0	19.29	10.73	25.16	-10.88	10.84
17	RTF RTI RTFU	-2.26	N	-1.96	-1.70	-3.51	-4.26	3.94	-3.43
18	RTPR RTW	0	0	0	0	43.47	-13.55	16.58	-12.35
19	RTX	0	0	0	0	0	0	0	0
20	VALFNI	0	-33.83	67.88	0	0	79.66	-76.61	73.18
21	WI	-3.01	N	-2.90	-1.41	-2.76	-3.05	2.92	-2.58

N = Negligible

Table V.7d: Sensitivity Tests on Performances of Class 3.
Percent Departure from Base Run Values of 1981.

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	0	0	0	N	N	0	0	0
7	RTA	0.85	N	4.17	1.72	2.00	4.93	2.27	9.94
8	RTH	3.99	N	7.64	2.25	3.89	8.43	2.95	7.37
11	A	16.67	1.20	30.52	5.83	19.56	42.60	4.30	71.40
12	PVLA HVLPOU	0	0	0	-11.44	0.60	4.65	-9.08	6.47
15	U2 PPWL	0	0	0	-28.17	-6.21	-9.87	-14.98	-14.96
17	RTF RTI RTFU	-3.85	N	-7.10	-1.16	-6.12	-15.80	3.52	-22.02
18	RTPR RTW	0	0	0	0	42.68	59.51	19.52	41.09
19	RTX	0	0	0	0	0	0	0	0
20	VALFNI	0	-15.96	14.25	0	0	17.37	0	39.65
21	WI	-1.28	N	-2.25	-1.02	-1.76	-2.89	-0.45	-7.13

N = Negligible

Table V.7e: Sensitivity Tests on Performances of Class 4.
Percent Departure from Base Run Values of 1981.

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	0	0	0	N	N	0	0	0
7	RTA	2.52	N	7.58	1.89	1.98	5.18	3.17	13.32
8	RTH	5.72	N	20.26	2.49	5.27	24.75	3.97	90.25
11	A	18.08	1.56	63.43	6.62	19.85	74.51	5.56	765.25
12	PVLA HVLPOU	0	0	0	-13.05	- .60	0.74	-9.92	0
15	U2 PPWL	0	0	0	-29.85	-8.44	-26.65	-18.24	-288.03
17	RTF RTI RTFU	-2.52	N	-9.47	-1.31	-4.07	-14.56	2.78	-118.19
18	RTPR RTW	0	0	0	0	42.10	61.84	24.21	47.88
19	RTX	0	0	0	0	0	0	0	0
20	VALFNI	0	-18.68	51.89	0	0	50.25	0	563.6
21	WI	-2.06	N	-10.87	-1.12	-3.62	-10.53	-0.79	-88.50

N = Negligible

Table V.7f: Sensitivity Tests on Performances of Class 5.
Percent Departure from Base Run Values of 1981

Run No.	Test Parameter	PCRPDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	0	0	0	N	N	0	0	0
7	RTA	3.03	N	3.01	3.05	3.83	3.66	3.58	2.54
8	RTH	5.33	N	6.92	-0.57	5.27	8.33	3.95	4.97
11	A	16.47	0.52	21.41	0	21.36	37.30	4.13	39.58
12	PVLA HVLPOU	0	0	0	0	3.29	7.99	-8.00	8.53
15	U2 PPWL	0	0	0	66.67	3.82	9.26	-9.29	9.83
17	RTF RTI RTFU	-3.69	0	-4.77	0	-5.97	-12.04	2.02	-6.92
18	RTPR RTW	0	0	0	0	40.88	47.33	27.11	27.79
19	RTX	0	0	0	0	0	-13.98	0	-12.78
20	VALFNI	0	-5.93	1.86	0	0	3.30	0	3.46
21	WI	-5.09	N	-4.76	0	-4.98	-10.57	-0.88	-5.40

N = Negligible

Table V.7g: Sensitivity Tests on Performances of Class 6. Percent Departure from Base Run Values of 1981.

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	0	0	0	N	N	0	0	0
7	RTA	0.73	N	1.18	0.70	0.51	-0.90	1.34	0.12
8	RTH	6.03	N	9.11	-0.61	6.11	12.33	3.73	7.43
11	A	17.99	0.80	26.90	0	22.72	45.36	4.92	54.44
12	PVLA HVLPOU	0	0	0	0	3.55	9.10	-9.09	11.16
15	U2 PPWL	0	0	0	66.67	4.36	11.18	-11.18	13.54
17	RTF RTI RTFU	-2.74	N	-4.09	0	-4.32	-10.72	1.49	-9.51
18	RTPR RTW	0	0	0	0	40.88	47.33	27.12	27.79
19	RTX	0	0	0	0	0	-13.98	0	-12.78
20	VALFNI	0	-11.14	5.84	0	0	10.23	0	12.33
21	WI	-3.74	N	-5.50	0	-4.76	-12.08	-0.89	-8.42

N = Negligible

Table V.7h: Sensitivity Tests on Performances of Class 7.
Percent Departure from Base Run Values of 1981.

Run No.	Test Parameter	PCRPDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	-18.46	-0.98	-22.24	-20.80	-17.71	-22.67	-20.80	-23.33
7	RTA	0.79	N	1.00	0.97	-.66	0.65	1.26	0.35
8	RTH	5.96	N	7.17	-0.64	5.77	7.83	4.38	4.65
11	A	16.85	0.49	20.43	0	20.87	30.92	4.42	31.70
12	PVLA HVLPOU	0	0	0	0	2-80	5.71	-8.23	5.96
15	U2 PPWL	0	0	0	0	0	0	0	0
17	RTF RTI RTFU	-3.62	N	-4.37	0	-5.21	-8.11	1.31	-7.29
18	RTPR RTW		0		0	40.82	45.89	25.11	26.93
19	RTX	0	0	0	0	0	-14.55	0	-13.22
20	VALFNI	0	-3.69	0.82	0	0	1.31	0	1.28
21	WI	-4.59	N	-5.55	0	-5.73	-9.54	-1.11	-4.53

N = Negligible

Table V.7i: Sensitivity Tests on Performances of Class 8.
Percent Departure from Base Run Values of 1981.

Run No.	Test Parameter	PCPRDL (mds/yr)	PCCONY (mds/yr)	PFSURP (mds/yr)	TEMPL (mandays/yr)	PFERNG (tk/yr)	PFINC (tk/yr)	PFLOAN (tk/yr)	PFSVG (tk)
4	LND	-18.03	-1.25	-23.09	-20.80	-17.18	-23.26	-20.84	-24.61
7	RTA	-0.12	N	-0.14	N	-0.24	-0.70	0.32	-0.41
8	RTH	5.85	N	7.55	-0.62	5.82	8.56	3.76	4.84
11	A	18.18	1.00	23.41	0	22.22	33.53	5.05	35.54
12	PVLA HVLPOU	0	0	0	0	3.04	5.69	-9.34	6.24
15	U2 PPWL	0	0	0	0	0	0	0	0
16	RTF RTI RTFU	-2.49	N	-3.19	0	-3.62	-5.64	1.07	-5.03
18	RTPR RTW	0	0	0	0	40.02	43.03	27.82	23.98
19	RTX	0	0	0	0	0	-13.82	0	-12.55
20	VALFNI	0	-6.00	1.83	9	9	2.71	0	2.57
21	WI	-4.34	N	-5.53	0	-5.32	-8.85	-1.18	-5.02

N = Negligible

(in Run 8). This is so because of the limited capacity of RTA, as discussed earlier, which puts a constraint on increases in the cropping area. The capacity to change cropping pattern is greater for RTH than for RTA. RTA is much less sensitive in relation to classes 6 to 8 than in relation to classes 1 through 5 because of the higher cropping intensity of the latter classes. On the other hand, higher production due to the transfer of more land under HYV (in Run 8) helps to better the income criteria of all classes. The wage earning classes (1 through 4) are helped by increased employment as much as by the increase of food availability; these factors have a positive impact on their income performances. Still, the sensitivity of RTH is higher for performances of member classes, and the larger the farm the greater is the impact.

The fertilizer response function coefficient A (in Run 11) is highly sensitive in relation to performance criteria of all classes, in the same way as was observed in the case of the total performances. Since this variable is related to changes in the production function, the change in production and income is uniform for all classes. The extent of impact depends upon the amount of land under cultivation so the large farmers get more absolute benefit than the small farmers. A positive change in the variable A tends to minimize the deficit of near landless farmers, which helps to better their financial condition without putting any stress on other classes.

Reduction of labor use through the variables PVLA and HVLPOU (in Run 12) affects the employment performances of wage earning classes 1 through 4 which provide hired labor. Since reduction in labor use is primarily directed towards reducing use of hired labor, the employment performances of the non-wage-earning classes 5 through 8 are not changed. As earnings from wages are reduced, the income of the wage labor classes, aminly the near landless classes 1 and 2 which provide most of the hired labor, declines, while that of labor hiring classes increases due to wage cost saving. The variables are therefore sensitive for all classes -- classes 1 through 4 which experience changes in the direction to which the variables are changed and classes 5 through 8 that experience it in the opposite direction. However, if the reduction of labor use comes about mainly through the use of mechanical devices and not through labor efficiency, there would be a cost which would reduce the amount of saving by the labor hiring classes. In such a case, income performances of the labor hiring classes would remain more or less unchanged. Despite sensitivity of the effect on income performances of the various classes, the regional totals are little affected since labor variables affect income transfers within the system.

The variables U2 and PPWL (in Run 15), also dealing with labor use, have earlier shown insensitivity in relation to total performances. The test is made with increased use of family labor (U2) which would tend to reduce hired labor use. The parameter PPWL that distributes the wage labor employment among the wage earning classes 1 through 4 proportionally according to labor availability is modified so that the near landless classes get a greater share of the employment. The use of these two variables in the test resulted in increased family labor use, and in reallocation of the reduced hired labor use among the wage earning classes. When effects on class performance are considered the variables are found to be sensitive. The wage savings from higher family labor use help to reduce the cost of cultivation and to increase income, but have a negative effect on the employment and income of the wage earning class. On the other hand, concentration of hired labor employment on classes 1 and 2, as defined by the values of PPWL, reduces hired labor employment in classes 3 and 4. As an employment allocating parameter, PPWL has no effect whatsoever on total performance criteria, but it is of importance with respect to class income performances. It has also been observed that the variable is sensitive since it affects income performances, and a misplaced weighting could lead to changes in them. This has been shown by test results in which a heavy concentration of hired labor employment in classes 1 and 2 has increased their income by reducing that of classes 3 and 4. As a result, it is believed that the value of PPWL, which is short of being accurately specified either in the base run or in the test run, has to be determined precisely.

The input price increase (RTF, RTI), together with a decrease in fertilizer use (RTFU), affects production and income criteria of all classes (in Run 17). The income performances are decreased by a combination of factors: decreased production due to lower doses of fertilizer, decreased employment due to lowered production, and increased cost.

In the absence of a discriminatory price increase, all class performances are affected in proportion to their input use and in the direction in which prices are changed. The parameters involved in this test are more sensitive to performances of those classes, particularily those of the members who use modern inputs more than others.

On the other hand, output price increased (in Run 18) significantly help those classes which have marketable surpluses to increase their income, and put pressure on those who are indeficit, because the increased cost of food purchases out weighs the increased earning from higher wages. The larger farmers who have larger surplus food stocks get bigger profits and accumulate more savings. The variable therefore is highly sensitive for income performances of all classes. The tax variable (in Run 19), however, affects incomes of only classes 5 through 8 whose disposable income has been taxed. As a result income performances of the first 4 classes remain steady while those of the last 4 classes decline.

The test with parameter VALFNI (in Run 20) indicates some significant effects on the class income performances. When the forced restriction on minimum per capita consumption level is withdrawn, letting it fall if needed instead of maintaining it at 75% of normal intake as assumed, the simulation allows people to go to a low level of food consumption for a short period while stocks are low and are being replenished. This drastically cuts down the class total consumption and reduces the extent of purchase as well as the credit needed for the class. As a result debt accumulation slows down, which reduces the depletion of disposable income. The variable has been observed to be highly sensitive among those farmers having less than 3 acres of land, especially among the food deficit classes. The sensitivity of the variable is low among the large land holding classes. In this run extreme malnutrition and human misery due to hunger are allowed although in the income performances these conditions are not reflected.

The effects on income performances of the weather variable (in Run 21) are experienced by all classes. The more severe the weather condition, the greater its effect. Loss of production due to weather causes a loss of disposable income and a higher credit requirement, which in turn depletes savings.

Having analyzed the impacts of different variables upon class performances, we proceed to isolate those variables that are most sensitive, and that are useful in reducing disparities in income among the classes. The reduction of income gaps can be attained in several ways, e.g. by generating larger income increases for low income classes compared to high income classes, by lowering the income level of high income classes while maintaining a steady improvement of the level of low income classes, or even by redistributing income. In testing the income effects of different variables, it is therefore necessary to examine both the direction and the degree to which changes in income occur.

Besides the parameters VALFNI, U2 and PPWL, which are useful mainly in model tuning, all others are relevant for policy analysis. The parameter A, which indicates increasing production capacity, is found to be effective in increasing incomes of all classes. Although it helps to reduce food deficits and therefore the debts of the near landless class, higher production helps larger farmers more and so widens the overall disparity. The same is true in the case of RTPR, which by increasing the output price helps the surplus farmers more then the deficit ones. Both are highly sensitive and operate upon the income performances of all classes in degrees higher than for other variables. The land allocation parameters, RTA and RTH, also initiate the same directional change in the incomes of all classes, but the degree depends on the adoption characteristic of the classes. If members and small land holders are given more favor than others they would be able to generate comparatively higher income. Any negative change in labor variables such as PVLA or HVLPOU depresses the income of smaller land holders while it increases the income of the rest with the result that the income gap widens. The effects of input price increased (RTF, RTI) are depressing for all classes, and although there is some reduction in the income, the degree of the income change is much less proportionately than the degree of the price change. However, if input use (RTFU) maintains a negative price elasticity the possible effect upon the income performances of members classes would be larger and therefore would increase disparity. The tax variable RTX has a potentiality for reducing disparity because it reduces incomes of the larger landholders without affecting the incomes of smaller ones. Lastly, the redistribution of land resources is a means to activate income transfer from larger to smaller farmers and thereby to reduce the income gap. However, it has an impact upon the income performance only of those classes which are affected by the change.

Summary

The major concerns in this chapter were (i) to operationalize the model, (ii) to validate the results of the model equations, (iii) to test the sensitivity of model parameters and (iv) to gain ideas from the tests about policy variables useful for problem solution. The tests provided a basis for establishing model credibility as well as ideas for improving the model. Crucial parameters were also identified through these tests.

To simulate the economy operating under present conditions a base run was conducted with all system parameters and variables derived from the system. Despite data limitations, which affect the precision of the results, the base run adequately simulated the trend of the economy and provided consistent model results. The test runs were conducted as much to examine the stability of the model as to isolate variables that effect model results due to their variation. So far as the system parameter DT is concerned, it is found to be stable. However, VALFNI seemed to be unrealistic if the minimum level is fixed at 0.75 rather than at a much lower level such as 0. Similarly PPWL needs to be readjusted so that more concentration is put on classes 1 and 2, instead of giving a proportional weight on the basis of labor availability. However both VALFNI and PPWL worked perfectly well under present assumptions.

While system parameters state the stability of the model, the behavioral variables indicate the nature of flexibility in the economic system. Some of these variables were tested in order to obtain ideas about the extent to which the system can be redirected toward specific goals. The institutional characteristics contained in the membership and its growth (RTM), if considered in isolation from other variables, have only a slight influence on economic trends. Increasing cropping intensity (RTA), allocation of more land to HYV (RTH), use of higher fertilizer doses (RTFU and FINDX) -- all of which are sensitive variables -- are assumed to derive from the institutional drive. It has also been observed that new high yielding strains of HYV (A) are a highly effective means of increasing production, income and employment. The improved practices involved in each of these variables help increase employment slightly, but the use of labor saving devices cuts it down. On the side of consumption, almost all of the variables are insensitive except the population growth rate (GRT).

Many of the test parameters which were found to be slightly sensitive or insensitive in relation to total performances criteria show opposite results when class performances are considered and vice versa. This finding supported our contention regarding the need for disaggregative analysis in order to observe income distribution effects. On a disaggregated basis it was possible to isolate variables which could be used in forming policy alternatives. Most of the variables examined in the tests are conventional in the sense that they are generally used as policy tools. However it has been observed that under the present pattern of resource distribution the scope for a drastic reduction of the income disparity gap is limited unless discriminatory policies are adopted.

PART C: MODEL APPLICATION

CHAPTER VI

POLICY EXPERIMENTS

The system simulation model developed so far is now ready for use in policy experimentation. Several policy alternatives have been identified which, though they may or may not be adopted by policy-makers, are conventionally thought of as means of achieving agricultural development objectives. It needs to be stated again that the results presented here must be considered tentative rather than conclusive, for the model output values, may be inexact due to stated weaknesses in the data. Neither has an objective cost analysis of undertaking the defined policies been completed. The sociopolitical feasibility of these policies has not been reviewed. It should be understood that issues such as these are so important in their own right that they can only be dealt with effectively in separate studies. The present study, therefore, should be thought of as an analytical exercise which projects the economic consequences that may result from policy actions.

Policy Alternatives Designed for Experimentation

Ten policy alternatives in all have been identified for the experiment. The simulation run for a particular policy is made by providing input values for relevant variables in the model. Although in simulation it is possible as well as useful to experiment with various values of the policy input variable, due to resource limitations in this study only a single value was selected. The selection of the input value for each policy, however, was made on the basis of realistic guesstimation, so that policies were not drawn overly optimistically, and so that alternatives were identified that have a close affinity to the situation in which the model is applied.

Alternative I: Status Quo Policy

This is essentially the continuation of what is presently being pursued. The basic tenets of this policy are contained in the conditions of the base run, as described in the previous chapter.

Alternative IIA: Policy Concerning Technological Change

In this policy the irrigation program is expanded so that more land could be brought under Boro crop cultivation. Specifically, the policy is aimed at increasing Boro cultivation at the rate of 6 percent per year instead of 3 percent per year as in the status quo policy. The reduction in acreage of the Aus crop as a result of Boro acreage expansion is held down by making irrigation available early in the season, and by introducing a new short duration crop seed. In addition, better varieties of seeds would be made available by research, so that the crop yield in Boro and Amon seasons, but not in Aus, is expected to increase at least 20 percent above the yield of the presently available HYV. The new seeds would be 10 percent more responsive to fertilizer.

Alternative IIB: Policy Concerning Behavioral Change

Extension programs will be effectively geared up so that the farmers' adoption of modern practices increases. The impact of this policy is that the cultivation of HYV increases by 8 percent per year in Aus season and by 10 percent per year in Amon season, instead of by 5 and 6 percent respectively in the status quo policy.

It is also expected that by the third year of the program farmers would average a 30 percent higher rate of fertilizer than at present. The adoption rate of increased fertilizer dose will be steeper in the case of non-members, since they would be strongly motivated in an effort to catch up with the members. In addition, an effective family planning program would be institutionalized in the Extension program, with the intention of lowering the population growth rate by 10 percent per year.

Alternative IIC: Policy Concerning Institutional Change

Through the impetus of the Integrated Rural Development Program, cooperative institutions would be mobilized to increase their membership at a faster rate than is presently projected. The target is to cover about 70 percent of all farmers under the program by the end of the 8-year run period, as against 44 percent for the status quo policy. Also, it is assumed that under this policy a concerted effort would be made by the relevant organizational structures (e.g., IRDP, TCCA, TTDC) to provide adequate training, education, services, and supplies to the new entrants, so that the average performance of cooperative members would be maintained at least at the present level.

While the distribution of credit and of modern inputs will be institutionalized to a greater extent around the cooperatives, it is very likely that the government would want to reduce input price subsidies on fertilizer and mechanical irrigation. The price of fertilizer and irrigation would then increase. It is estimated that there will be a 50 percent increase in chemical fertilizer price and a 30 percent increase in the mechanical irrigation charge rate beginning in the third year of the run period. To make this policy effective, it is assumed that the government will be prepared to extend necessary agricultural credit and to keep the output price stabilized. The underlying credit and output policies therefore would follow without intervention.

Alternative III: A Combined Policy Package

This will be a broad-based policy package involving policy inputs of all of the three alternatives IIA, IIB, and IIC. This could be termed an Integrated Agricultural Development policy. A wide range of interactive policies would be undertaken so that the impact would result from their unification.

Alternative IV: Policy Concerning Preferential Treatment

This policy is essentially a modified form of policy alternative III. Policy alternative IV is more biased towards small farmers. In defining alternatives IIA through IIC and alternative III, it was assumed that there would be no discrimination in input distribution (either technological, behavioral, or institutional) among different classes of farmers. So far as the availability or prices of inputs are concerned, in other words, those policies would not discriminate between members and non members of the cooperative organization. The cooperative organization would thus be identified more as a group which forms in order to obtain better facilities and better dissemination of information, rather than to obtain lower input prices and preferential access to inputs.

In policy alternative IV, however, a definite bias is introduced in favor of the small land holding classes centering around the cooperatives. Irrigation facilities are supplied only through the cooperatives, so that land under Boro cultivation increases by a yearly rate of 8 percent for classes 1, 3, and 5 and by 4 percent for class 7. For classes 2, 4, 6, and 8, which cannot be left out of any cooperative irrigation program due to inherent field problems, the increase would be limited to 2 percent per year. The distribution of fertilizer also favors the cooperatives, and is controlled so that the increase of the average fertilizer dose is 30 percent for members and 10 percent for non-members. The price increases of these inputs also follows a discriminatory policy, so that cooperative members pay lower input prices than the rest of the farmers. The input price subsidy program would be revised so that the prices of fertilizers distributed through the cooperatives would increase by 20 percent against a 50 percent increase in the open market. Since members already pay lower irrigation charges than non-members, a flat increase in these charges of 30 percent would effectively be a discriminatory price hike.

This preferential policy may provide incentives to the non-members to join the cooperatives. At this stage of the development of the model no special credence has been given to this possibility instead, the pattern of membership growth under policy alternative IV has been made identical to that under alternative III.

Alternative V: Policy Concerning Taxation and Employment

With the dual purpose of raising government income for development expenditures and reducing income disparity among rural classes, it may be useful to impose some form of agricultural taxation. Since various forms of taxation are available, each having inherent merits and demerits in collection as well as in enforcement, it is difficult to ascertain at this point which form should be preferred to others. (Actually a series of simulations could be conducted with different forms of taxation to ascertain their respective impact.) For our purpose it would not matter which form of taxation is decided upon, so we shall arbitrarily identify it to be an agricultural income tax imposed upon farmers possessing more than 3 acres of land at the rate of 15 percent on their annual family earned income in excess of 6000 taka. The taxation policy would be combined with the policy package of alternative III.

A large part of the collected tax fund is expected to be utilized for land and water development in the area, primarily through a rural works program. Besides capital investment, the works program would create possibilities for generating seasonal labor employment, and for channelling a portion of the tax fund (in the form of wages or food for work instead of outright doles or relief) to the landless or near-landless classes. It is estimated that through this program temporary non-farm employment would be created to the extent of 0.2 million man-days per year.

Alternative VA: Policy Concerning More Stringent Taxation

The content of this policy would be the same as for alternative V, but the taxation schedule would be more stringent. While the rate of agricultural income tax would remain the same, the tax floor would be lowered from 6000 taka to 4800 taka in annual earned income. Furthermore, the agricultural land tax, which currently is in abeyance, would be reimposed on all cultivable land (irrespective of the size of land holding) at a rate equivalent to 10 percent of the estimated gross profit earned per acre of land. In effect all farmers, including small farmers, would be liable to pay the agricultural land tax, while only those farmers who possess more than 3 acres would also pay the agricultural income tax. On the other hand, as the additional tax fund builds up, land and water development would be further intensified under the rural works program. Seasonal employment opportunities in the area would double so that 0.4 million man-days of temporary jobs would be created per year.

Alternative VI: Policy Concerning Land Reform

To mitigate the insurmountable problems of landless or near-landless farmers, it may be thought desirable to redistribute land holdings by lowering the present ceiling from 33.3 acres. Apart from the political and administrative problems that may result from any attempt to enforce such a policy of land reform, there is a lack of general consensus about what new ceiling would be effective. On the other hand, even if a seemingly radical reform is proposed with a land ceiling of 10 acres, in many regions such as Comilla where only a handful of farmers possess that much land, even a 10-acre ceiling would have little consequence. In order to obtain significant results from a simulated land reform, a policy is simulated with the ceiling at 5 acres. This policy will be launched simultaneously with the combined policy package given by alternative III.

Alternative VII: Policy Concerning Migration

As has been pointed out in Chapter IV, the model has been constructed as a closed one so that there is no net in or out migration. However, as population pressure upon the economy increased and/or as the development of sectors other than agriculture gains momemtum, a rise in outmigration would be a likely phenomenon. The first aim of the policy would be to relocate the migrating families to areas where government reclaimed land is available, to places where industrial or manufacturing jobs are being created, or to countries which could be persuaded to allow immigration. To examine the impact of the policy on the area concerned, it is assumed that during the whole 8-year run period, 10 percent of all landless families, and 5 percent of the population in all other landed classes would in effect outmigrate under this policy. No land transaction, within or among the classes, has been assumed for this policy, so patterns of land holding would not be affected.

The policy alternatives described in Table VI.1 are primarily intended for simulating the economic consequences that would be imposed upon the system participants. Governmental costs of administering these policies were not estimated, nor have the political and

Table VI.1: Summary of Policy Runs

Run No.	Alternative Policy Sets	Policy Ingredients
1	I. Status Quo	All base run conditions[1]
2	IIA. Technological Change	(i) More irrigation (ii) Better HYV seeds
3	IIB. Behavioral Change	(i) Higher adoption of HYV (ii) Increased use of fertilizer (iii) Increased use of family planning
4	IIC. Institutional Change	(i) Faster growth of co-operative membership (ii) Desubsidization of input price
5	III. Integrated Agricultural Development	(i) All conditions of runs 2 through 4 included
6	IV. Preferential Input Prices and Distribution	All run 5 conditions modified for discriminatory preference
7	V. Taxation and Employment	(i) Agricultural income tax imposed on run 5 conditions (ii) Non-farm employment increased
8	VA. More Stringent Taxation	(i) Agricultural land tax added to run 5 and income tax floor modified (ii) Non-farm employment created in run 5 doubled
9	VI. Land Reform	A land redistribution from large land holders to landless class is added to run 5
10	VII. Migration	Planned migration is added to run 5.

[1]After modifications made on the basis of sensitivity test results.

administrative difficulties of imposing these policies been fully explored in this study. Although we tried, in defining the policies, to be as realistic as possible, it is probable that some of the alternatives would have greater practical limitations than others. Alternative policies IIA through IIC and III are more feasible but costlier than the rest. Alternative policies IV through VII are institutional in nature and would put a heavy strain on administrative enforcement. Because of their greater stringency, it is less likely that they would be adopted as they are specified if at all. These issues of implementation can be settled elsewhere. The simulation results presented in the next section indicate the consequences that would result from these alternative policies.

Simulated Policy Results

As has been indicated before, performance variables contained in the model are numerous in number. It is possible to obtain simulated values of the performances for (i) classes, (ii) crop variables, (iii) seasons, and (iv) years in detailed form. Understandably it is difficult to assimilate such a voluminous amount of information in a single study report. This is not, however, to be considered as a disadvantage or a waste; instead it shows the powerful capability of the computer simulation model to generate the multitude of information that may be demanded for decentralized Thana level planning. Considering the objectives of the present study, analysis of the simulation results has been limited to a few selected performance variables that are relevant to (a) production, (b) employment,

(c) consumption, and (d) income. Further, instead of tracing the total time path of performance variables in each simulation run, an inter-temporal analysis is made by focusing on the performance variables in the eighth year of each run.

Production

The simulated impacts of policy alternatives on rice production in the year 1981 are shown in Table VI.2. Under the status quo policy (Run 1) total production in the region increases by about 17 percent over that of the base year (1974). The production increase of a little over 2 percent per year, however, falls short of coping with the 3 percent per year population growth. This perspective shows that although the present policy, encompassing as it does modern agricultural and institutional innovations, is considered a long-awaited step towards self-sufficiency in food, it does not provide scope for complacency. Alternative policies that can assure higher food production therefore should be sought.

The introduction of more technological changes in the form of expanded irrigation and better seed varieties (at rates specified in alternative IIA) would cause an increase of rice production of about 38 percent by 1981 (Run 2). Behavioral changes or institutional changes, as specified under alternatives IIB and IIC respectively (Runs 3 and 4), would, when pursued independently, each cause an increase in total production of about 29 percent, which would put production almost at par with population growth. When all these changes are integrated under a combined policy package in alternative III

Table VI.2: 1981 Production Impacts of Policy Alternatives

Run No.	Policy Alternative	Aggregate: Total Rice Production (Thous. mds.)	Aggregate: Per Capita Production (mds.)	Per Capita Yearly Rice Production (mds) in Class							
Base Year		1474	6.00	2.71	1.44	7.48	4.77	18.05	12.08	25.06	19.23
1	I	1724 (17.0)	5.69 (-5.2)	2.52 (-7.0)	1.33 (-7.6)	7.02 (-6.2)	4.38 (-8.2)	16.51 (-8.5)	10.95 (-9.4)	26.67 (-9.5)	17.27 (-10.2)
2	IIA	2031 (37.8)	6.70 (11.7)	3.05 (12.5)	1.61 (11.8)	8.37 (11.9)	5.12 (7.8)	19.54 (8.25)	12.55 (3.9)	26.05 (4.0)	19.54 (1.6)
3	IIB	1899 (28.8)	6.40 (6.7)	2.8 (3.3)	1.52 (5.6)	7.78 (4.0)	5.06 (6.1)	18.36 (1.7)	12.71 (5.2)	25.61 (2.2)	19.96 (3.8)
4	IIC	1896 (28.6)	6.25 (4.2)	2.47 (-8.9)	1.34 (-6.9)	7.09 (-5.2)	4.34 (-6.9)	16.36 (-8.2)	11.09 (-8.2)	22.74 (-9.3)	17.19 (-10.6)
5	III	2472 (67.7)	8.33 (38.8)	3.32 (22.5)	1.85 (28.5)	9.43 (26.1)	5.89 (23.5)	22.02 (22.0)	14.86 (23.0)	29.76 (18.8)	22.60 (17.5)
6	IV	2476 (68.0)	8.34 (39.0)	3.34 (23.2)	1.72 (19.4)	9.48 (26.7)	5.41 (13.4)	22.81 (26.4)	13.85 (14.7)	29.31 (17.1)	21.38 (11.2)
7	V	2472 (67.7)	8.33 (38.8)	3.32 (22.5)	1.85 (28.5)	9.43 (26.1)	5.89 (23.5)	22.02 (22.0)	14.86 (28.0)	29.76 (18.8)	22.60 (17.5)
8	VA	2472 (67.7)	8.33 (38.8)	3.32 (22.5)	1.85 (28.5)	9.43 (26.1)	5.89 (23.5)	22.03 (22.0)	14.86 (28.0)	29.76 (18.8)	22.60 (17.5)
9	VI	2486 (68.7)	8.37 (39.5)	4.36 (60.9)	2.46 (70.8)	9.43 (26.1)	5.89 (23.5)	22.02 (22.0)	14.86 (28.0)	24.24 (-3.1)	18.51 (-3.7)
10	VII	2472 (67.7)	8.98 (49.7)	3.69 (36.2)	2.06 (43.1)	9.93 (32.8)	6.20 (30.0)	23.18 (28.0)	15.64 (29.5)	31.33 (25.0)	23.79 (23.7)

Figures in parentheses are percentage changes from respective base year values.

(Run 5), the resultant impact on the total rice production by 1981 shows a substantial increase of about 68 percent, or a rate of increase of 8.5 percent per year. The aggregate per capita food availability increases by 39 percent over the base year despite a 21 percent increase in population during the period.

Policy alternatives IV through VII, which are elaborations of alternative III, have no marked additional impact on total rice production (Runs 6 to Run 10). With the exception of alternative VII (Run 10), the aggregate per capita production also shows a trend similar to alternative III. The increase in aggregate per capita production for alternative VII, as compared to alternative III, is due to the 11 percent decrease in the expected population caused by migration. The impacts of a preferential policy and of land reform (Runs 6 and 9) have been observed to be insignificant so far as total rice production or per capita food availability is concerned.

When disaggregated by classes, the impacts of policy alternatives on rice production show a clearer but sometimes different picture. In general, it emerges that the land poor classes (Classes 1, 2, and 3) under whatever policy alternative is chosen invariably obtain much less per capita production than the aggregate statistic suggests. The cooperative members in all land holding categories obtain higher per capita production than non-members in the same category, and the farmers with the largest land holdings always obtain about 9 to 15 times more than the corresponding group of farmers with the smallest land holdings. As far as per capita production is concerned, none of the alternative policies except alternative VI could

effectively reduce the inter-class disparity in production. In fact, since production is land dependent and inputs are mostly divisible, the alternative policies present farmers of all classes with opportunities to increase their production in proportion to their land holding.

The per capita production in 1981 under a status quo policy (Run 1) shows a decline in all classes. A similar declining trend, though at a less steep rate, is observed in the case of alternative IIC (Run 4), under which total production at first showed a larger increase than alternative I due to the higher growth of institutional membership. This indicates that changes in institutional factors alone would not sustain production at the base year level, but at most can reduce the rate of decline. That population growth is a critical factor in counteracting production increase is clearly apparent when the impacts of alternatives IIB and IIC are compared (Runs 3 and 4). Although total production is at about the same level under both alternatives, alternative IIB includes a policy ingredient for reducing the population growth rate. Alternative IIB shows a higher per capita food availability than alternative IIC. When population decreases as under alternative VII (Run 10), in which migration has been considered, the per capita food availability shows a significantly higher level than in alternative III.

Under combined policy alternative III (Run 5) the per capita food production of all classes increases substantially in comparison to the status quo policy of alternative I. Though proportional increases for the classes remain the same, the absolute quantity of increase is greater among the large land holding classes than among the small ones. It is apparent that integrated changes in technology, behavior, and institutions have the potential of widening the production gaps between the classes. None of the remaining alternatives IV through VA can better this trend. The policy of discrimination as in alternative IV (Run 6) is more favorable to cooperative members, so that their per capita production increases above that of the non-members. However, under alternative VI land redistribution causes larger farmers (Classes 7 and 8) to produce less while smaller farmers (Classes 1 and 2) obtain higher production. As a result, the smaller farmers have higher per capita production than in alternative III, although total production in both the alternatives remains almost the same. This clearly shows how small farmers may gain from land reform. A land reform policy also has the potential of reducing the production gap.

Land allocation and crop yield rates, under different policy alternatives, are shown in Table VI.3. It should be noted that the increase in production under the status quo policy of alternative I (Run 1) is not caused by changes in the varietal yield rate as much as by changes in land allocation and in the cropping pattern. During the run period, land cultivation in Boro season increases every year, while increasingly more land is transferred to high yielding variety (HYV) rice crops in all seasons. The increase in cultivated land, however, was minimal (5 percent), in comparison to the 34 percent change of cropping pattern in favor of the high yielding varieties. The 50 percent yield difference for the high yielding varieties

Table VI.3: 1981 Acreages and Yield Rates Under Policy Alternatives

Run No.	Policy Alternative	Area Cultivated (Acres) All Seasons Total	All Seasons HYV	All Seasons Loc	Boro HYV	Boro Loc	Aus HYV	Aus Loc	Amon HYV	Amon Loc	Rice Yield Rate (mds.) Boro HYV	Boro Loc	Aus HYV	Aus Loc	Amon HYV	Amon Loc
Base Year		67440	38800	28640	14521	421	8201	8518	16078	19701	30.82	15.12	26.93	12.55	26.88	13.18
1	I	70574 (4.6)	52093 (34.3)	18421 (-35.7)	18930 (30.4)	193 (-54.2)	10354 (26.3)	5258 (-38.3)	22809 (41.9)	12970 (-34.2)	30.94	15.17	27.09	12.55	27.04	13.23
2	IIA	72703 (7.8)	54260 (3.98)	18143 (-35.8)	21097 (45.3)	215 (-49.0)	10354 (26.3)	5258 (-38.3)	22809 (41.9)	12970 (-34.2)	36.71	15.14	27.09	12.58	32.21	13.23
3	IIB	70513 (4.6)	58553 (50.9)	11960 (-58.2)	18930 (30.4)	193 (-54.2)	12025 (46.6)	3586 (-57.9)	27598 (71.7)	8181 (-58.5)	30.94	15.17	28.02	13.06	28.02	14.01
4	IIC	74798 (10.9)	57212 (47.5)	17586 (-38.6)	22956 (58.1)	233 (-44.7)	10698 (40.5)	5132 (-39.8)	23558 (46.5)	12221 (-38.0)	31.28	15.40	27.57	12.72	27.54	13.51
5	III	77224 (14.5)	66286 (70.8)	10938 (-61.8)	25358 (74.6)	257 (-39.0)	12425 (51.5)	3405 (-60.1)	28503 (77.3)	7276 (-63.1)	39.65	17.32	28.20	13.23	33.41	14.33
6	IV	77243 (14.6)	55305 (70.9)	10938	25377 (74.8)	257 (-39.0)	12425 (51.5)	3405 (-60.1)	28503 (77.3)	7276 (-63.1)	39.87	17.70	27.94	13.30	33.75	14.39
7	V	77224 (14.5)	66286 (70.8)	10938 (-61.8)	25358 (74.6)	257 (-39.0)	12425 (51.5)	3405 (-60.1)	2850- (77.3)	7276 (-63.1)	39.65	17.32	28.20	13.23	33.91	14.33
8	VA	77224 (14.5)	66286 (70.8)	19938 (-61.8)	25358 (74.6)	257 (-39.0)	12425 (51.5)	3405 (-60.1)	28503 (77.3)	7276 (-63.1)	39.65	17.32	28.20	13.23	33.91	14.23
9	VI	77705 (15.2)	66646 (71.8)	11059 (-61.4)	25944 (78.7)	263 (-37.5)	12307 (50.0)	3412 (-60.5)	28395 (76.6)	7384 (-62.6)	29.40	17.26	28.16	13.21	33.87	14.29
10	VII	77224 (14.5)	66286 (70.8)	10938 (-61.8)	25358 (74.6)	257 (-39.0)	12425 (51.5)	3405 (-60.1)	28503 (77.3)	7276 (-63.1)	39.65	17.32	28.20	13.23	33.91	14.33

Figures in parentheses are percentage departure from respective base year values.

substantially in increased production under alternative I. In alternatives IIA, IIB, and IIC these processes have been further intensified in various ways, while in alternative policy III all of them have been put together in combination. The resulting impacts of total land allocation, cropping pattern, and HYV yield rate together helped increase production under alternative III. Alternatives IV, V, VA and VII have similar ingredients as in alternative III and so their consequences upon production are no different than that under alternative III.

Employment and Input Demand

A major concern in rural development policy formulation has been the generation of employment for rural people, particularly for the landless or near-landless class of farmers. Since the industrial sector is at an infant stage in Bangladesh, it has a limited capability for rapid expansion to absorb many of these rural poor. The creation of a substantial number of industrial sector jobs, moreover, can be quite costly. The agricultural sector, on the other hand, is thought of as having good possibilities for large-scale employment generation. Within the rural sector, food crop production has a direct relationship with the ancillary household as well as commercial employment, but these side effects have not been taken into account at this stage. It should be understood that with the exception of crop production the ripple effects of policy alternatives concerning employment have been neglected in this study.

Despite substantial modernization efforts under the status quo policy, alternative I (Run 1), the aggregate total man-days of

Table VI.4: Agricultural Employment Impacts of Policy Alternatives in 1981

Run No.	Policy Alternative	Aggregate Total Ag. Employment (Thous. mandays)	Hired labor (Thous. mandays)	Total ag. employment by landholding category (Thous. mandays) 1	2	3	4
Base Year		3892	1560	1465	1773	496	157
1	I	4342 (11.6)	1800 (15.4)	1647 (12.4)	2007 (13.2)	525 (5.8)	163 (3.8)
2	IIA	4726 (21.5)	2089 (23.9)	1857 (16.8)	2153 (21.4)	549 (10.7)	168 (7.0)
3	IIB	4559 (17.2)	1983 (27.1)	1773 (21.0)	2092 (18.6)	529 (6.7)	164 (4.5)
4	IIC	4694 (20.6)	1961 (25.7)	1770 (20.8)	2185 (23.2)	568 (14.5)	170 (8.3)
5	III	5394 (38.6)	2523 (61.7)	2170 (48.1)	2448 (38.1)	599 (20.8)	177 (12.7)
6	IV	5398 (38.7)	2529 (62.1)	2161 (47.5)	2447 (38.0)	618 (24.6)	173 (10.2)
7	V	5594 (43.8)	2723 (74.5)	2296 (56.7)	2522 (42.2)	599 (20.8)	177 (12.7)
8	VA	5794 (48.9)	2923 (87.4)	2421 (65.3)	2596 (46.4)	599 (20.8)	177 (12.7)
9	VI	5427 (39.5)	2424 (55.5)	2265 (54.6)	2421 (36.5)	599 (20.8)	141 (-1.9)
10	VII	5394 (38.6)	2523 (61.7)	2141 (46.1)	2477 (39.6)	599 (20.8)	177 (12.7)

Figures in parentheses are percentage departures from respective base year values.

agricultural employment in 1981 increases by less than 12 percent, or at the rate of about 1.5 percent per year (Table VI.4). The rate of increase almost doubles when seed-irrigation technology is further improved under alternative policy IIA (Run 2). Even under policies of faster behavioral or institutional change, alternative IIB or IIC (Run 3 or 4), the employment is higher than it is under the status quo policy. In alternative policy III with an integrated policy combining technological, behavioral, and institutional changes, the aggregate agricultural employment increases by almost 5 percent per year, or 39 percent by 1981 (Run 5). This represents slightly more employment of labor than is possible under policy alternative IV of preference, or under alternative VI of land reform (Runs 6 and 9). Beyond this, use of agricultural labor can be further increased through non-farm employment as has been indicated by alternatives V and VA (Runs 7 and 8), the extent of added employment depending upon the policies concerned.

Overall employment consists of both family labor and hired labor. The impact of various policy alternatives on hired labor deserves special consideration, because of the income deriving from the wages of agricultural laborers. Under the status quo policy (alternative I), the estimated total number of mandays of hired labor would increase by about 15 per cent in 1981 (Run 1). The increase would be four times higher under the integrated policy alternatives III and IV (Runs 5 and 6). Since the beneficiaries of this increased demand for hired labor are the wage laborers of land category 1 and 2 (Classes 1 through 4), their employment opportunities would increase substantially if policies III or IV were adopted. However, if land reform is tagged onto the integrated policy hired labor employment would show a declining trend (Run 9). This would happen because the demand for hired labor is primarily generated by the large land holding category of farmers, so a reduction of farm size directly affects the demand for labor.

Under a land reform policy employment among category 1 farmers would increase due to the availability of extra land, which would open up opportunities for employing more of their labor than what would have been demanded by classes 7 and 8 farmers if the land were not redistributed. The employment of classes 7 and 8, on the other hand, would decline as family labor could not be utilized due to the reduction of farm size, and that of category 2 would decrease due to the fall of hired labor demand. Policy alternatives V and VA (Runs 8 and 9) create additional opportunities for employing the hired labor of classes 1 through 4 farmers, which greatly improves their employment situation.

At this stage it is useful to point out some undercurrents that might be found in the labor use pattern. As the intensity of modernization and the concomitant need for labor increases, the likely tendency of the farmers would be to increase their marginal labor efficiencies and to increase their use of family labor in crop production activities.

The effects of improved labor efficiency would be reflected in the total mandays of employment, while the effects of greater use of family labor would show up only in hired labor employment. Neither effect is expected to cause any substantial reduction in total labor use. Another likely trend would be an increase in the use of labor saving devices. Though some of these devices would be essential and fixed complements to the adoption of new agricultural technology, there might be some interest among the large farmers in substituting machines for labor in order to reduce their wage bill. How far this substitution effect would materialize would greatly depend upon the labor wage rate and the cost of mechanization, and therefore these variables should be carefully considered. If the drive for mechanization is thwarted by allowing only the complementary form of devices, it is expected that even under such resulting structural changes labor employment would substantially increase.

Despite the increasing agricultural labor demand resulting from some of the policy alternatives, the unemployment situation does not improve greatly. In fact, the increase in employment would be far less than the increase in the labor supply itself. The labor supply, which already is in great surplus, would further increase due to the net rise of the labor force in the near future.[2] Assuming that 35 percent of the population is in the agricultural labor force and that each laborer is willing to offer 300 days (landless class) to 200 days

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[2] The male population in the 8-15 year age cohort which will enter into the labor force (16-70 years) during the run period is larger in number than those in the 62-70 year age group who will leave it. The net result therefore would be an increase in the labor force every year. Even if population growth decreases substantially from now on, the projected increase in the labor force during the run period would not be affected.

Table VI.5: Labor Use Impacts of Policy Alternatives (in 1981)

Run No.	Policy Alternative	Labor use rate per laborer per year in class 1	2	3	4	5	6	7	8
Base Year		0.14	0.12	0.24	0.20	0.27	0.21	0.19	0.16
1	I	0.13	0.11	0.22	0.18	0.23	0.11	0.16	0.13
2	IIA	0.14	0.12	0.23	0.19	0.24	0.18	0.17	0.14
3	IIB	0.14	0.12	0.23	0.19	0.24	0.18	0.17	0.14
4	IIC	0.13	0.12	0.22	0.18	0.23	0.17	0.16	0.13
5	III	0.17	0.15	0.26	0.22	0.25	0.18	0.17	0.14
6	IV	0.17	0.15	0.26	0.21	0.26	0.18	0.17	0.14
7	V	0.17	0.16	0.26	0.22	0.25	0.15	0.17	0.14
8	VA	0.18	0.17	0.27	0.23	0.25	0.18	0.17	0.14
9	VI	0.18	0.15	0.25	0.21	0.25	0.18	0.14	0.11
10	VII	0.18	0.16	0.27	0.23	0.26	0.19	0.18	0.15

(large land holding class) of work a year, it can be seen from Table VI.5 that only 14 to 27 percent of the available labor would actually be utilized in food crop production. Since non-food crop production is minimal in this area, it is reasonable to expect it to have only an insignificant influence on labor use. It is therefore clear that agriculture, which offers the largest scope for labor use in the rural sector, could absorb less than a quarter of the total labor available. The labor use rates shown in Table VI.5 are the proportion of available labor mandays per year which are actually absorbed in employment in comparison to the base year. The labor use rate declines by the end of the run under the status quo policy, because of the growth of population. The downward trend in labor use is stalled by policy alternatives IIA and IIB, but these policies do not reverse the decline from the base year. Labor use rates improve slightly under policy alternatives III through VII, especially among small farmers. Even the non-farm employment opportunities created under policy alternatives V and VA have little impact in increasing the labor use rates, since their extent is nominal compared to the amount of surplus labor. Incidentally, migration shows an impact similar to the creation of employment (Runs 7, 8 and 10), but nonetheless the problem of unemployment remains unsolved.

The yearly demand for inputs shows an increasing trend (Table VI.6) under all policy alternatives that directly pursue production increases. Under the status quo policy (Run 1) the demand for HYV seeds is expected to increase by about one-third above the base year, but as the transformation intensifies demand for HYV seeds increases

Table VI.6: Agricultural Input Demand under Policy Alternatives (in 1981)

Run No.	Policy Alternative	HYV Seed (mds)	Chemical Fertilizer (Thous. mds.)	Ag. Credit (mill. Taka)	Institutional Ag. Credit (mill. Taka)		Agricultural Credit Demand Per Family by Class						
						1	2	3	4	5	6	7	8
Base Year		9700	136.3	9.488	7.102	201	50	601	166	808	518	1204	877
1	I	13023 (34.2)	174.7 (28.2)	11.113 (17.1)	8.902 (25.3)	227	55	684	182	936	558	1301	931
2	IIA	13565 (39.8)	182.1 (33.6)	12.092 (27.4)	9.666 (36.1)	254	63	742	201	1024	598	1388	982
3	IIB	14638 (50.9)	804.3 (123.3)	13.688 (43.7)	10.934 (53.9)	283	68	850	238	1141	675	1532	1080
4	IIC	14303 (47.5)	216.6 (58.9)	15.685 (65.3)	14.746 (107.6)	269	63	834	202	1065	617	1450	982
5	III	16572 (70.8)	380.8 (179.4)	21.573 (127.4)	20.241 (185.0)	384	92	1152	28.9	1097	832	1886	1047
6	IV	16576 (70.9)	405.9 (198.8)	20.220 (113.1)	19.073 (168.5)	358	78	1076	242	1459	723	1758	1120
7	V	16572 (70.8)	380.8 (179.4)	21.573 (127.4)	20.241 (185.0)	384	92	1152	289	1497	832	1886	1247
8	VA	16572 (70.8)	380.8 (179.4)	21.573 (127.4)	20.241 (185.0)	389	82	1152	289	1497	832	1886	1247
9	VI	16661 (71.8)	379.7 (178.6)	21.618 (127.8)	20.024 (181.9)	495	118	1152	289	1497	832	1494	987
10	VII	16572 (70.8)	380.8 (179.4)	21.573 (127.4)	20.239 (184.9)	426	102	1152	289	1497	832	1886	1247

Figures in parentheses are departures from respective base year values.

further. The demand for HYV seeds under alternative III (Run 5), is twice as much as that under alternative I, while under alternatives IV and VI (Runs 6 and 9) it is slightly higher.

The demand for chemical fertilizer and agricultural credit shows a steep increasing trend. For example, if the agricultural transformation proceeds as intended by integrated policy alternative III (Run 5) the demand for chemical fertilizer is expected to rise by 180 percent over the base year, and agricultural credit demand by 127 percent. Since most of the agricultural credit is to be supplied through institutional channels, the demand for institutional credit shows an increase of 185 percent under this policy. Under alternative IV (Run 6) of preferential input prices and distribution, the demand for institutional credit might be slightly less than under non-preferential alternative III, but the demand for fertilizer is greater. The rest of the policies follow a trend more or less similar to alternative III. All these impacts show the impressive increase in the demand for inputs that would result from launching agricultural transformation policies. Whether such demand could be met is a different question; the simulation makes it clear that to achieve production performances as shown in Table VI.2 the respective input demands must be met.

Another factor that influences the sharp increase in agricultural credit is the rise of institutional membership in cooperatives. Cooperative members are entitled to avail themselves of institutional credit and use more credit than non-members. As a result of the increased intensity of agricultural transformation the demand for credit rises more among the members, since they use a higher quantity of

modern inputs the do non-members. The institutional change under policy alternative IIC (Run 4) drives the membership up, and with it the demand for institutional credit. However, under a constrained credit situation it is expected that demand may not be fully met. How far this could affect production performance as well as membership growth is not clear at this stage.

Consumption

The impact of policy alternatives on home consumption and on the consumption surplus of rice -- the two forms of output disposal considered in this study -- are presented in Table VI. 7 and Table VI.9 respectively. The total consumption of rice under the status quo policy of alternative 1 (Run 1) rises by about 17 percent over rice consumption in the base year as a result of population growth. But the corresponding aggregate per capita consumption shows a decline. As production under alternative policies IIA, IIB or IIC increases more or less at par with population growth the declining trend of per capita consumption is stalled. The aggregate per capita consumption trends are maintained at the base year level under any of these policy situations. In other words, just to maintain the present level of consumption the status quo policy has to be changed in favor of either alternative IIA, IIB or IIC so as to stimulate production. That increased production gives rise to increased consumption is evident from the rise of aggregate per capita consumption under alternatives III through VII. The highest per capita as well as total consumption is recorded under the land reform alternative VI (Run 9) indicating that

Table VI.7: Consumption Impact of Policy Alternatives (in 1981)

Run No.	Policy Alternative	Aggregate Rice Consumption Total (Thous. mds.)	Per Capita (mds)	Yearly Per Capita Rice Consumption by Class (mds)							
Base Year		6.50	2.57	2.30	1.88	2.91	2.74	3.76	3.47	4.00	3.92
1	I	760 (16.9)	2.51 (-2.3)	2.22	1.80	2.85	2.66	3.71	3.43	3.95	3.84
2	IIA	783 (20.5)	2.55 (0.3)	2.29	1.91	2.88	2.75	3.76	3.54	3.99	3.90
3	IIB	765 (17.7)	2.58 (.08)	2.26	1.88	2.91	2.78	3.77	3.53	3.99	3.94
4	IIC	974 (19.1)	2.55 (-1.8)	2.19	1.81	2.86	2.65	3.11	3.48	3.95	3.82
5	III	797 (22.6)	2.08 (4.3)	2.32	1.98	2.95	2.82	3.82	3.68	4.04	3.97
6	IV	791 (21.7)	2.86 (3.5)	2.32	1.93	2.95	2.74	3.83	3.61	4.04	3.95
7	V	797 (22.6)	2.18 (4.3)	2.32	1.98	2.95	2.82	3.82	3.68	4.04	3.97
8	VA	797 (22.6)	2.68 (4.3)	2.32	1.98	2.95	2.82	3.82	3.68	4.04	3.97
9	VI	822 (26.3)	2.77 (7.8)	2.50	2.18	2.95	2.82	3.82	3.68	3.97	3.87
10	VII	756 (16.3)	2.15 (7.0)	2.39	2.06	2.98	2.85	3.85	3.71	4.06	3.99

Figures in parentheses are percentage departures from respective base year values.

farmers receiving land would augment their consumption when more food becomes available. Nonetheless, the per capita yearly consumption levels of between 2.55 mds and 2.77 mds recorded under these alternatives fall far short of expected normal intakes.

The aggregate per capita yearly consumption level figures estimated in column 4 of Table VI.7 are sharply in contrast to the national averages of normal intake requirement estimated by other sources (GOP, 1966). Chen (1974) discounted the generally quoted level of more than 15 oz/day as an over estimate and suggested a compromise figure of 14.5 oz/day or 4.0 mds/year. Our figures came out below Chen's estimate mainly because of methodological reasons. Firstly, our aggregates were calculated for the average person, regardless of age or sex. Secondly, yearly figures arrived at through incorporating the simulated effects of food stocks, sales and purchases (see Chapter IV). Therefore the yearly accumulation took account of both the reduced consumption period before harvest and of the normal food intake after the harvest. Thirdly, the consumption patterns have been calculated first on a disaggregated basis by class so as to incorporate income effects on consumption. All these methodological influences should increase the accuracy of the per capita consumption levels calculated by class. The aggregate consumption figures shown in column 4 were calculated on the basis of these disaggregated class figures.

However it must be noted that the rice consumption levels presented in Table VI.7 are probably underestimates because of the restrictive assumptions made about income. In this study incomes received from crop production and agricultural wages have been considered, while that from off-farm sources (e.g. service, trade, and other non-agricultural occupation) have been neglected. Although scope of incomes earning from off-farm sources are expected to be small, in actuality it is not zero and may possibly increase as development proceeds. Such incomes would be used for consumption buying and so it is expected that rice consumption level would be higher than that shown in Table VI.7.

While the general trends of per capita consumption by classes under alternative policies are similar to the aggregate trends, consumption levels among the classes vary greatly. Classes 1 through 4 consume substantially less then classes 5 through 8, while class 2 maintains a critically low consumption level. If the normal intake requirement of rice is considered as 4 mds/year then only classes 5 through 8 are found to be close to this level, while all others fall far below it. In the extreme case of class 2 rice consumption is 52 percent short of the normal intake level. None of the alternative policies seems to change this pattern much. The severity of the situation may be made clearer by Table VI.8, which presents per capita daily consumption of rice by weight and by caloric value for the different classes. The consumption levels of classes 1 and 2, especially, are so low as to suggest the existence of extreme malnutrition and of periodic starvation. Even deaths from total starvation are not ruled out for some people in these classes. None of the conventional policies mentioned here seems to solve the problem; the best that these policies can accomplish is to slow the deterioration of consumption.

Table VI.8: Per Capita Daily Consumption Under the Policy Alternatives (in 1981)

Run No.	Policy Alternative	Per Capita Daily Rice Consumption in Class (oz/day)[1] 1	2	3	4	5	6	7	8
Base Year		8.32 (842)	6.79 (687)	10.51 (1063)	9.91 (1002)	13.61 (1377)	12.63 (1276)	14.98 (1465)	14.18 (1435)
1	I	9.01 (811)	6.51 (659)	10.30 (1042)	9.63 (975)	13.41 (1357)	12.41 (1256)	14.28 (1445)	13.89 (1406)
2	IIA	8.28 (83-)	6.91 (700)	10.42 (1054)	9.93 (1005)	13.57 (1373)	12.79 (1293)	14.48 (1460)	14.11 (1428)
3	IIB	8.18 (828)	6.81 (690)	10.51 (1064)	9.86 (998)	13.65 (1381)	12.77 (1292)	14.44 (1461)	14.24 (1441)
4	IIC	7.93 (802)	6.53 (661)	10.32 (1045)	9.57 (909)	13.42 (1358)	12.57 (1272)	14.30 (1447)	13.83 (1400)
5	III	8.38 (848)	7.16 (725)	10.68 (1081)	10.18 (1031)	13.83 (1399)	13.31 (1347)	14.62 (1479)	14.37 (1454)
6	IV	8.39 (849)	7.00 (708)	10.66 (1079)	9.92 (1004)	13.84 (1401)	13.06 (1322)	14.61 (1479)	14.29 (1447)
7	V	8.38 (848)	7.16 (725)	10.68 (1081)	10.18 (1031)	13.83 (1399)	13.31 (1347)	14.62 (1479)	14.37 (1454)
8	VA	8.38 (848)	7.16 (725)	10.68 (1081)	10.18 (1031)	13.83 (1399)	13.31 (1347)	14.62 (1479)	14.37 (1454)
9	VI	9.05 (915)	7.88 (798)	10.68 (1081)	10.18 (1031)	13.83 (1399)	13.31 (1347)	14.37 (1454)	13.98 (1415)
10	VII	8.66 (876)	7.44 (753)	10.76 (1089)	10.32 (1044)	13.92 (1408)	13.42 (1358)	14.67 (1484)	14.43 (1460)

[1]Caloric values are given in parentheses.

Production that is left over after meeting consumption requirements is taken as surplus that can be marketed or bartered for cash or in kind. This surplus is considered as the margin from which investment as well as improvements in the standard of living derive. While consumption intake indicates the basic economic condition of the villagers, the consumption surplus informs us about their financial well being. The surplus output generates capital required to meet the expenses of goods and services needed for consumption and production that are not available within the farm family.[3] As modernization in agriculture intensifies, the need for cash capital further increases. Even subsistence farming should be considered as a business enterprise which needs to be financially solvent. An output deficit causes a farmer to incur financial losses and heavy debts that may ultimately lead him to disinvest. On the other hand, investment in modern inputs and the improvement of the economic conditions of the subsistence farmers is dependent upon the extent to which surplus output can be generated.

The impact of alternative policies on the food surplus is shown in Table VI.9. The aggregate per family surplus output under alternative I (Run 1) increases slightly from that of the base year though

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[3] The output surplus which often results from a critical reduction in the consumption level for the small farmer classes may at first glance seems unrealistic, but it should be pointed out that crop production costs, debt service and other necessary food and non-food consumption expenses come from this source.

Table VI.9: Output Surplus under Policy Alternatives (in 1981)

Run No.	Policy Alternative	Surplus rice (mds.)			Per family surplus of rice in class (in mds.)							
		Total	Per Capita	Per Family	1	2	3	4	5	6	7	8
Base Year		956	3.38	24.5	3.22	-3.87	38.89	17.43	124.39	75.27	183.99	134.34
1	I	963	3.18	33.2	3.18	-4.88	43.53	17.84	136.03	79.92	199.44	143.07
2	IIA	1247	4.12	43.0	7.88	-3.15	57.16	24.75	167.85	95.76	235.03	166.63
3	IIB	1134	3.82	39.1	5.51	-3.69	49.71	23.77	151.78	95.52	225.56	167.19
4	IIC	1122	3.70	38.7	2.85	-4.88	44.13	17.60	136.57	80.89	200.12	142.44
5	III	1675	5.64	57.8	10.21	-1.34	66.08	31.33	189.44	116.31	288.33	194.32
6	IV	1685	5.68	55.1	10.41	-2.19	66.68	27.17	197.38	106.38	253.95	181.84
7	V	1675	5.64	57.8	10.21	-1.34	66.08	31.33	189.44	116.31	268.33	194.32
8	VA	1675	5.64	57.8	10.21	-1.34	66.08	31.33	18.44	116.31	268.33	194.32
9	VI	1663	5.60	57.3	18.93	2.82	66.08	31.33	189.44	116.31	211.43	152.77
10	VII	1716	6.24	62.0	13.17	- .03	67.38	32.41	191.18	117.91	270.31	196.23

it actually decreases if measured in per capita terms.[4] While surplus output under policy alternatives IIA through IIC (Run 2 to Run 4) are higher than the status quo policy, the highest surplus outputs are generated from the combined policy package alternative III (Run 5) its ancilliaries-alternatives IV through VII (Run 5 to Run 10). Any of these policies, would generate twice as much per family surplus output as the status quo policy.

Differences in per family surplus output between classes 1 and classes 7 and 8 are found to be very wide. Class 2, in fact, incurs a deficit which means that even to maintain the lowest possible consumption level (as observed in Table VI.8), the class has to depend upon food outside of its productive capacity. All classes of cooperative members have higher surplus output levels than do nonmembers of the same land holding category, and the difference between respective levels is substantial. Classes 3, 5, 6, 7 and 8 have a much higher per family surplus than the aggregate statistic indicates.

Under the status quo the per family surplus of classes 1 and 2 decreases while that of all other classes shows an increase. Their surplus situation is slightly better under alternatives IIA and IIB but no improvement takes place under alternative IIC. The output deficit of class 2 is almost eliminated under alternative III, while

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[4] The performance variable is expressed in per family rather than per capita terms on the understanding that financial decisions are made by a farmer for the household as a unit and not for a member of that unit. Although members in the family increase due to population growth the family unit is considered unchanged and so the variable does not reflect effects of population increases.

class 1 triples its surpluses. It is interesting to note that the deficit situation of class 2 does not improve as much under discriminatory policy alternative IV (Run 6) which seems more favorable to cooperative members. Classes 1 and 2 both get a boost from land reform alternative VI under which class 2 develops a surplus for the first time (Run 9).

A conspicuous impact of the production increasing policies is to widen the difference in surplus among the classes. The absolute increase is always much greater among larger land holders than among smaller land holders. The widening difference seems to lessen slightly only under alternative VI when land is redistributed. It is not, however, surprising to find that production oriented policies favor the owners of larger land resources (Run 9), or that population reduction (Run 10) betters the surplus situation of all classes.

Income Earning and Distribution

Simulated values of aggregate incomes generated by the alternative policies are presented in Table VI.10 while per capita incomes by classes are shown in Table VI.11. Under the status quo policy alternative (Run 1), the value added to agriculture in the region grows at a yearly rate of about 2 percent and so does the value added by families. That such a rate of growth is incompatible with the population increase in maintaining even the base year income level is exemplified by the falling aggregate per capita earning under alternative I. Alternative IIC (Run 4) shows a similar trend. Policy IIB (Run 3), under which both value added by agriculture and value added

Table VI.10: Aggregate Income Impacts of Policy Alternatives (in 1981)

Run No.	Policy Alternative	Value Added by Agriculture (mill. Taka)	Value Added by Family (mill. Taka)	Aggregate Per Capita Earning (Taka)
Base Year		142.9	128.2	581
1	I	165.0 (15.5)	148.4 (15.8)	546 (-6.0)
2	IIA	197.3 (88.1)	178.3 (39.1)	653 (12.4)
3	IIB	175.3 (22.7)	157.2 (22.6)	593 (2.1)
4	IIC	172.1 (20.4)	154.1 (20.2)	570 (-1.6)
5	III	218.1 (52.6)	195.5 (52.5)	738 (27.0)
6	IV	223.4 (56.3)	200.9 (56.7)	759 (30.6)
7	V	218.1 (52.6)	195.5 (52.5)	744 (28.1)
8	VA	218.1 (52.6)	195.5 (52.5)	749 (28.9)
9	VI	219.3 (53.3)	197.5 (54.1)	743 (27.9)
10	VII	218.1 (52.6)	195.5 (52.5)	796 (37.0)

Figures in parentheses are percentage changes from base year values.

by family grow at about 3 percent per year simultaneously with a reduction in population growth, possibly can maintain a constant per capita earning level. However, a 4.5 percent per year increase in the value added under alternative policy IIA (Run 2) with no reduction in the population growth rate would help increase the per capita earning only by about 1.5 percent per year.

Under policy alternative III(Run 5) value added by agriculture and value added by family increases more than three times as much as under alternative I, so that by 1981 the increase is 53 percent over the base year. This increase results from the continued effects of technological, behavioral and institutional changes brought into the system through policy alternative III. A look into the marginal analysis reveals that total cash operating cost of production (the difference between the value added by agriculture and the value added by family) increases by 7.9 million taka between the base year and 1981. During that period the value added by agriculture increases by 75.2 million taka and the value added by family increases by 67.3 million taka. This substantial marginal return has caused aggregate per capita earning to rise by 27 percent during the period (Run 5).

The value added by agriculture and by family remain almost equal under policy alternatives V through VII (Run 7 to Run 10). However, under alternative IV, where a discriminatory input distribution policy is pursued, the increases seem higher (Run 6). This incidentally exposes a rather different picture than what has been observed so far. The policy showed a lack of effect in increasing production or employment significantly compared to alternative III. It now appears that a

Table VI.11: Earnings Under Policy Alternatives (in 1981)

Run No.	Policy Alternative	Aggregate Per Capita Earning	PerCapita Yearly Earning (Taka) in Class							
			1	2	3	4	5	6	7	8
Base Year		581	314	204	711	490	1552	1060	2140	1648
1	I	546	290	187	664	448	1407	953	1924	1474
2	IIA	653	351	224	805	528	1701	1109	2256	1698
3	IIB	593	313	209	705	501	1494	1075	2112	1676
4	IIC	570	280	190	638	438	1341	938	1860	1440
5	III	738	364	253	821	575	1724	1229	2396	1879
6	IV	759	373	246	848	547	1831	1175	2411	1810
7	V	744	371	260	827	580	1724	1229	2396	1879
8	VA	749	378	268	833	586	1724	1229	2396	1879
9	VI	743	446	303	821	575	1729	1229	1971	1585
10	VII	796	402	279	866	607	1815	1294	2522	1978

discriminatory policy might actually improve imcome conditions, both in terms of value added and per capita earning, although it may not improve the production or employment outcomes of the non-discriminated policy alternative III. Under policy alternative VII (Run 10) though the value added would not be any different than alternative III, the per capita earning would show an increase due to population reduction.

The impacts of different policy alternatives on classwise per capita earning (Table VI.11) and per family disposable income (Table VI.12) follow the same general trend as observed in the case of aggregate incomes above. Particularly revealing in these Tables, however, are the differing income levels of different classes of farmers. As expected, the larger the land holding the higher is the imcome level, and the cooperative members earn higher incomes than non-members of the same landholding category. Comparatively, per capita earnings of classes 7 and 8 are 6 to 8 times as much as classes 1 and 2. Even thoush the class per capita earnings show an increasing trend induced by the policy alternatives, in general, the earning gaps amoung them show no tendency toward closing. For example, under alternative III (Run 5) per capita earnings of classes 1 and 2 rise by about 50 taka during the run period while those of classes 7 and 8 increase by more than 200 taka. Thus, the earning gaps between classes may widen due to integrated agricultural development efforts. However, the intended impact of policy alternative III was to increase production and income. Distributional issues were addressed by other policy alternatives. The discriminatory input distribution policy under alternative IV (Run 5) shows an impact of this sort. Cooperative members increase their per capita earning faster under policy alternative IV than under alternative III. Those who are not members of the cooperatives, on the other hand, increase their per capita earnings less under alternative IV than under alternative III. Alternative IV does not help to reduce the earning gap, but rather it widens it in a different manner due to the distributory bias towards the group of farmers who are members of cooperatives. Distributory impacts, however, are more pronounced in alternative V and VA (Runs 7 and 8) under which income earnings of only classes 1 through 4 increase due to non-farm employment, and in alternative VI (Run 9) under which classes 1 and 2 receive higher earnings while those of classes 7 and 8 decline. Population migration under alternative VII (Run 10) increases per capita earning for all classes but has no significant effect on distribution.

A more in depth picture of the economic condition of farmers under the impact of various policies is obtained by considering disposable income statistics (Table VI.12) instead of income earnings. Since disposable income has been defined here in terms of cash flows, it supposedly indicates the farmers' financial solvancy in maintaining their consumptive as well as their investment or disinvestment needs[5]. The financial condition of class 2 farmers is already in deficit in the base year, and it substantially worsens under the status quo policy

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[5] Earning is defined as the return of output values over cash cost, plus incomes received from wages and other agricultural sources. Disposable income is defined as the balance of cash income received from crop sales, wages and other non-rice crops by deducting cash costs of production, repayment of loans and tax payments.

Table VI.12: Disposable Cash Income Under Policy Alternatives (in 1981)

Run No.	Policy Alternative	Per Family Disposable Cash Income in Class (TK) 1	2	3	4	5	6	7	8
	Base Year	560	- 602	2636	1398	8117	4613	12237	8523
1	I	754	-4871	2915	1557	8812	4808	13165	8908
2	IIA	1237	-2592	4182	2201	11599	6127	16280	10957
3	IIB	816	-4075	2853	1855	9105	5528	14320	10293
4	IIC	617	-5194	2502	1238	8009	4247	12415	7836
5	II	1111	-1826	3590	2047	10891	6221	16618	11040
6	IV	1224	-1969	3941	1984	12048	6023	16905	10648
7	V	1184	-995	3642	2103	8231	4853	13880	8958
8	VA	1005	-1535	2460	1227	7377	3089	11307	6814
9	VI	1542	503	3571	2029	10891	6221	13045	8692
10	VII	1333	-132	3724	2157	11064	6373	16820	11233

(Run 1). What happens is that the yearly income earning does not meet the staple food and production cost needs of the class, so they have to borrow. over time their debt piles up to a substantial amount. Most of the policies help improve their deteriorating disposable income conditions. However, only a very few can change from a deficit to a surplus. The impacts of policies III and IV (Runs 5 and 6) cut the deficit that would have been accumulated under alternative I by two-thirds. Policy alternatives V and VA (Runs 7 and 8) improve the situation further, depending upon the non-farm income opportunities created. The per family disposable income of class 2 increases substantially under alternative V of land reform (Run 9) or alternative VII of migration (Run 10) to levels which are sufficient to meet consumption and production expenses without incurring deficits.

The distributory difference in per family disposable income between the lowest and the highest income levels is more pronounced than what has been observed in the case of per capita earning (Table VI.11). Under policy alternative I,Class 7 earns 17 times as much disposable income as class 1, and 8 times as much as class 4 (it would be much higher if class 2 is considered). Even under alternative III when there is a proportionally equal increase in the respective classwise incomes (Run 5), or under alternative IV when there is discriminatory increases in incomes of members (Run 7), this ratio still remains more or less the same. Only under alternatives V through VI does this ratio change.

Under alternative 8 (Run 7) classes 5 through 8 pay taxes on their earned income which brings down their disposable income by about 1300 taka to 2800 taka from alternative III levels. Stiffer taxation in the form of a lowered earned income tax floor and higher rates on cultivated land could lower disposable income further, as is shown by alternative VA (Run 8). Classes 1 through 4 on the other hand, increase their disposable income level through added non-farm income generated under alternative V (Run 7). As a result of simultaneous taxation and employment the income gaps among all classes show a tendency to be reduced under alternative V. However, under alternative VA this reduction is smaller because of the now discriminatory land tax. In fact, despite doubling employment wage earning opportunities, the income levels of classes 1 through 4 fall below alternative III. Under alternative policy VI (Run 9) of land redistribution the disposable income of classes 1 and 2 increases to levels higher than can be obtained under any other policy. Land reform causes the disposable income of classes 7 and 8 to decline. It is interesting to note that land redistribution results in a greater reduction of the income of the large landowners than does income taxation under alternative V.

To further examine the issue of income distribution Gini Ratios have been calculated on the annual income earnings given by different policy alternatives (Table VI.13). The Gini Ratio is an aggregate measure; it is generally used to indicate the degree of equality (or inequality) in a distribution. Despite its aggregative bias and its inherent limitation for reflecting changes in absolute income earnings within the system[6] the Gini Ratio has been used here to obtain a general picture of the income distribution impacts of the policy alternatives.

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[6]See Riemenschneider (1976) for a discussion on the limitations of Gini Ratios.

Table VI.13: Distribution of Income Earning and Families in Classes (1981)

Run No.	Policy Alternative	Gini Ratio	Percentage of Total Families in Class								Percentage of Farmers as Coop Members
			1	2	3	4	5	6	7	8	
	Base Year	.3446	5.7	40.2	23.3	15.5	6.2	4.3	1.1	1.9	36.35
1	I	.3390									
2	IIA	.3327	5.5	39.4	26.5	12.2	7.0	3.4	3.5	1.4	43.5
3	IIB	.3359									
4	IIC	.3565									
5	III	.3544									
6	IV	.3543	9.8	36.1	36.8	1.9	9.9	0.5	4.7	0.2	61.2
7	V	.3514									
8	VA	.3464									
9	VI	.2941									
10	VII	.3367	9.2	34.1	38.6	3.0	10.4	0.5	4.9	0.3	63.1

The base year (1974) Gini Ratio of income earning in this area has been found to be 0.3446[7]. Far more interesting is the trend shown by alternative I under which the Gini Ratio falls to 0.3390 in 1981. In other words, equality of income distribution as observed by this measure proves an improving trend, which leads us to suspect the concern expressed earlier about the trend of increasing inequality. That concern, it seems that, resulted mainly from the declining trend of absolute income, rather than from the inequality of the distribution as such. Alternatives IIA or IIB improve the equality in the distribution as compared to alternative I. Under alternative IIC, however, the increased inequality as expressed by the Gini Ratio is primarily a result of the desubsidization of input prices which reduces absolute income. Thus it is evident that lifting subsidies from input prices would affect both absolute income as well as the equality of the distribution. Since all the policy alternatives III through VII include this policy ingredient they are similarly affected, as can be observed from their respective Gini Ratios.

For this reason it would be inappropriate to compare Gini Ratios of the alternatives III through VII with the ratio for alternative I or for the base year. Nevertheless, if we argue only about the resulting distribution effect, not about its causation, it is obvious that inequality will increase under policy alternative III as compared to the base year. Although the equality of the distribution improves under policy alternatives

[7] According to Blair (1974) the Gini Ratio of income earning in Bangladesh in 1966-67 was 0.379. Following his argument it is expected that for Comilla Thana the ratio would be lower.

VI does a big change in the situation occur; the Gini Ratio for a land reform policy shows greater equality than is attained by any of the other policy alternatives, including the present policy.

However, the Gini Ratios have not adequately described the internal movement of farmers from a lower income level to a higher income level. Considering the fact that cooperative members get higher income than non-members, it has been observed that due to the growth of membership from 38 percent of the farmers to 44 percent during the 8-year period under alternative I, at least 6 percent of the farmers obtain higher imcomes by the transfer. Similarly, under alternative III, 23 percent of the farmers who transferred from being non-members to being members receive higher incomes than they would have obtained if they had not joined the cooperatives. All of the joiners were benefitted in two ways - by the policy impact on the agricultural transformation, and by acquiring the characteristics of members. A close look at the percentage breakdown of the families under different policy alternatives further shows that 18 percent of the farmers holding under 3 acres of land are benefitted in this way under alternatives III through VI. Similarly, of course, 7 percent of the large farmers were also benefitted.

We might also point out that if Gini Ratios were calculated using disposable income instead of earnings they would have revealed clearer information.[8] Such Gini Ratios would have shown the effects of tax deductions from earnings, whereby the disposable incomes of large farmers

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[8] The existence of negative disposable income creates problems for calculating such Gini Ratios. See Riemenschneider (1976) p. 16.

were brought down in order to attain equality. The Gini Ratios presented here, therefore, do not show the full effects of policy alternatives V and VA.

Policy Implications

In this section simulated impacts of the experimental policy alternatives analyzed above are summarized and their implications further explored.

The simulation experiment provided many insights into the dynamic consequences of alternative strategies relating to production, employment, consumption and income of farmers in a region. Particularly illuminating was the information about the long run consequences of continuing the present policy and the necessity of searching for better alternatives. It should be borne in mind that the present policy has been considered a revolutionary step in stagnant economic situation; the measures embodied in the base run representing present policy have increased agricultural growth and have bettered economic conditions in the rural areas. Nonetheless, the results of the simulation experiment conducted in this study show that although agricultural growth would continue if the present policy is maintained, in the long run the policy would not offset population growth. Despite increased total production, employment income due to the status quo policy, all show a decline in per capita terms primarily for the reason that population growth out paces the present rate of agricultural growth. In consequence, a continual deterioration of economic conditions in the rural sector is forseen. While the pinch will be felt by all classes of farmers, its impact on the 46 percent of near-landless farmers will be severe. Their per capita food availability from farming and their per capita income, which are already at precariously low levels, will decrease further. In order to survive they will either have to go deeply into debt, which would ultimately lead them to disinvest and become landless, or they will have to be supported by a huge relief dole (a yearly amount of 50 million taka for this region alone), mostly from government or donor finances. On the other hand, large land holders would still maintain a production surplus and their savings would continually grow. The fact is that it is not yearly income as such which shows the diverging trend; it is rather the accumulated savings which makes the gap widen between classes of farmers (Table VI.14).

The cooperative members, through their characteristic adoption of modern agricultural innovations, produce conspicuously larger output. In consequence, production, employment and income of the region and of the cooperative members increased. The performance differences between the members and non-members in the same land holding category are considered not as disparities as such but rather the margin of incentives provided to overcome the land constraint through technological and institutional means. Since participation in the cooperatives is not overly restrictive, any such differences emanating from the system actually serve as an inducement to join it. However, it has been observed that participation in the cooperatives under the present policy is not increasing as expected. In the 8-year run period the cooperative membership rises from 38 percent in the base year to only 44 percent by 1981. Therefore, it hardly could be said that the institutional structure responded fully to the present policy or that its fruits are widely shared.

Table VI.14: Cumulative Savings Under Policy Alternatives (1981)

Policy Alternative	Per Family Cumulative Savings (Taka) by Landholding Category 1	2	3	4
Base Year	-736	546	2452	4322
I	-15567	8882	35544	58852
IIA	-10024	14194	45261	71091
IIB	-13887	9284	36914	63076
IIC	-15610	8015	35278	58793
III	-8340	13494	46034	75210
IV	-8454	14831	49286	76370
V	-6368	13796	39508	63745
VA	-7394	9315	31452	52479
VI	-2562	13401	46034	58764
VII	-4175	14377	47047	76240

In sum, the general concerns expressed at the outset of the study about the effects of the present policy are not altogether untrue. The dynamic analysis clearly shows that long run trends of the present policy are not adequate for maintaining the status quo. As such several suggested policy alternatives were simulated in order to estimate their comparitive consequences.

The policy alternatives involve infusion of more technological changes (alternative IIA). Behavioral changes (alternative IIB) and institutional changes (alternative IIC) as separate policies as well as in combination (alternative III). Technological changes introduced through alternative IIA are primarily production oriented. Provision of better seed and irrigation facilities expand the cultivated acreages and increase the cropping intensity on the one hand, while on the other they cause an upward shift of the production function resulting in an increase of crop yield. Together these factors increase aggregate production as well as profitability, and therefore aggregate income. In alternative IIB and IIC, however, the increase in production comes from changes in the resource allocation behavior and managerial characteristics of the farmers. In alternative IIB, land allocation behavior is changed towards a new cropping pattern in which HYV crops are more favored, while at the same time increasing the tendency to use more modern inputs such as fertilizers. In alternative IIC training and education are provided through the cooperatives to achieve better managerial capabilities that helped in increasing production. A decrease in subsidies on input prices would cause an increase in the costs of production, thereby decreasing income (Table VI.15).

Table VI.15: Crop Profitability under Policy Alternatives

Run No.	Policy Alternative	Crop Variety	Per Acre Return over Cash Operating Costs in Crop Seasons (Taka)		
			Boro	Aus	Amon
1	I	LOC	1112	1170	1237
		HYV	2533	2312	2370
2	IIA	LOC	1108	1170	1237
		HYV	3122	2311	2895
3	IIB	LOC	1205	1196	1293
		HYV	2603	2299	2362
4	IIC	LOC	972	1154	1236
		HYV	2376	2242	2306
5	III	LOC	1010	1168	1278
		HYV	3000	2135	2785
6	IV	LOC	1107	1192	1304
		HYV	3122	2177	2835
7	V	LOC	1010	1168	1278
		HYV	3000	2135	2785
8	VA	LOC	1010	1168	1278
		HYV	3000	2135	2785
9	VI	LOC	1010	1179	1285
		HYV	3002	2153	2796
10	VII				

From the results of these policy simulation experiments it appears that technological changes are by far the most important factor in productivity growth. Varietal improvement and irrigation expansion can increase production at a faster rate than can increasing fertilizer dose or improving managerial capabilities. Similar effects on employment and income by the respective structural changes are also observed. When technological changes are introduced through alternative IIA, or for that matter, through any of the other kinds of changes given by the respective policy alternatives, it is actually impossible to maintain the ceteris paribus condition. In fact, the imposition of structural change of one kind would produce a demand for the other two because of their complementary interrelationship. To hold them constant would be a wasteful restriction on full capacity utilization of the transformation. Conversely, a combination of all the changes in a policy package such as alternative III would consummate the interactions and result in a larger marginal productivity. In other words, the new meta-production function defined by the interacting technological, behavioral and institutional variables through changes under the integrated policy alternative becomes superior to that defined under alternative IIA, IIB or IIC. Production, imployment and incomes under alternative III, therefore, attain higher levels than they do under any other policy both in aggregate and class terms.

A closer look at the performance variables for different classes of farmers under policy alternative III shows great improvement compared to the status quo policy of alternative I. The declining trend of performance in per capita terms as observed in alternative I is stated in alternative III; in fact they showed an increasing trend due to productivity growth and population reduction. Whether growth rates of the performance variables could be further increased by changing policy input levels and how long such an increasing trend would continue before leveling off or even starting to decline has not been fully explored in these simulation runs. However, it has been clearly observed that the new levels of production, employment and incomes of all classes generated by alternative policy III are much higher than could be attained under the status quo policy.

The distributional impacts of the agricultural growth policy planned under alternative III, or any part of it (alternatives IIA, IIB and IIC) need to be examined closely. The resulting higher levels of performances would help farmers, especially the small ones, to minimize their deficits and thereby to alleviate extreme poverty conditions. Also, due to the institutional structure of the cooperatives more farmers would move from lower levels of performance to the higher levels obtained by members in the land holding category. Sixty one percent of farmers will be involved in such a distribution pattern as against 44 percent in alternative I. In fact between the base year and the end of the run period 23 percent additional farmers who made such transfers are directly benefitted by this policy. From these considerations it appears that as the organization expands concurrently with agricultural growth, benefits are spread among a larger mass of the participants. In other words, the impact of growth is widely distributed rather than being limited only to large land holders or to some other such small group.

From this point of view, it appears that the organizational approach has an inherent capability to attain and to diffuse favorable impacts of agricultural growth policies. However, under alternative III performance disparities among the land holding categories of farmers show a further widening, possibly more than would occur under alternative I. In fact, it has been observed that the larger farmers' income increases at a higher rate than the small farmers' income. It therefore seems plausible that inequality looms large in the growth oriented policies. Such a conclusion, though not at variance with findings elsewhere, strengthens the view that the answer to inequality lies more in the realm of institutional policy approaches. But institutional policies do not seem to help reduce income inequality when introduced without concurrent growth oriented policies, for without growth equality does not resolve the issue of general poverty. As such, it is all the more reasonable to expect that additional institutional policy approaches would be attached to the production oriented policy of alternative III.

Several policies that are thought to be relevant in limiting disparities were simulated. The policies that have been experimented with in this study are preferential policy to small farmers (alternative IV), taxation and employment at different levels of stringency (alternatives V and VA) and land redistribution (alternative VI). Since population was found to be a very important factor in welfare measurement, a policy of rural migration was also considered. In general, all these policies are institutional in nature and are aimed primarily at attaining more equal income distribution.

Under the preferential policy alternative IV, cooperative members receive a greater amount of inputs and at a lesser price. As a result they obtain not only higher output but also higher profit and disposable income. Although the policy appears to discriminate against the 39 percent of the farmers who are non-members, (36 percent of whom are both non-members and landless or near landless) the effective discrimination is actually against only 3 percent of all farmers. Thus, the income disparities between members and non-members have turned out to be of lesser importance than those among the members. In that respect alternative IV would do the least to reduce the disparity gap; it might acutally widen the gap.

The disparity problem emerges as a crucial issue when the lowest income strata are considered. 46 percent of the farmers who are landless or near landless fall in this category, earning as little as 1/10 of the highest income level. Being near landless their main source of earning is wages from hired labor. policy alternatives V and VA are aimed at reducing the disparity gap by increasing the non-farm income of the lowest strata through employment creation, while lowering the disposable income of the highest strata through taxation. The simulated results show the policy effectively working to reduce the gap. The more stringent the policies the more improvement would be made in reducing the disparity gaps.

The rationale for taxation, however, goes beyond tackling the issue of income disparities. Land and water development, for example, is necessary for all landed farmers. If farmers developed land and water resources by their own efforts, their expenditures would stimulate the rural economy and generate income opportunities for the landless laborers. The aim of the rural works program is the same as this except that it is initiated by the government instead of by the farmers, who show reluctance to undertake such project themselves. Under alternative V, the revenues received from the agricultural income tax is about 9 million taka, which could be rechanneled into the economy through rural developement programs. If a land tax is imposed at the same time it would generate 34 million taka. Even if the imposition of a land tax upon farmers having less than 1 acre is considered punitive and a less stringent tax schedule devised, the generated tax fund would lie somewhere between 9 million and 34 million taka, which could be reinvested in the region in some for or another (Table VI.16).

The other alternative for dealing with the dual problem of increasing income for near landless farmers and of decreasing disparity is through land reform. The present ceiling of land ownership (33.3 acres) is ineffective in regions where the largest farms are no more than 10 acres in size. If a radical land reform could be made that would bring down the ceiling to 5 acres, as is assumed in alternative VI, and if the appropriated land is distributed among the landless, there is a possibility of improving the situation. In fact, this alternative shows better performances than all others for the lowest income category. It is interesting to observe that alternative V could be slightly adjusted so as to provide the same level of class performances as alternative VI. In other words, a fiscal policy might serve as well as land reform in readjusting the performance levels. However, this study has not emphasized the investigation of the impact of respective policies on decision making for land allocation and for resource distribution, and therefore the question of whether production will change has not been fully resolved.

Table VI.16: Taxes and Income Under Policy Alternatives V and VA (1981)

Class	Policy Alternative V (agricultural income tax)				Policy Alternative VA (agricultural income and land tax)			
	Per Family							
	Tax (Taka)	Earning (Taka)	Tax deducted disposable income (Taka)	Realizable tax from class (thous. taka)	Tax (Taka)	Earning (Taka)	Tax deducted disposable income (Taka)	Realizable tax from class (thous. taka)
1	0	3784	1184	0	269	3857	1005	716
2	0	2656	-995	0	154	2732	-1535	1641
3	0	8444	3642	0	1235	8497	2460	13183
4	0	5919	2103	0	932	5976	1227	523
5	1670	17947	9231	4771	3536	17497	7377	10102
6	1221	12796	4853	207	2796	12796	3089	474
7	2737	24993	13880	3703	5311	24993	11307	7184
8	2082	19601	8958	148	4226	19601	6814	301
Total Realizable Tax:				8,830				34,125

Alternative VII clearly indicates the impact of population. If population could migrate, the pressure would be reduced and performances would attain better levels. It is, however, understood that at the national level this policy poses no solution if people migrate from one part of the country to another, which in fact is happening presently. Without the prospect of emigration it would be hard to attain any favorable result at the national level. So far as the region is concerned, any shift towards out migration would result in better per capita distribution.

In sum, different institutional policies would work differently towards reducing income disparities. The preferential input distribution policy should increase incomes of cooperative members of all landholding categories, primarily as a result of input subsidies by the government. Yet although the preferential policy will help small farmers to increase their income, it does not help to reduce the disparity gap. A government initiated job creation program would increase nonfarm incomes of agricultural laborers. The more nonfarm income is generated the better the economic condition of small farmers and the smaller is the disparity gap. A further reduction of the gap is possible through taxation, and the more stringent is the tax schedule the smaller the gap. Land redistribution could achieve the same objective as taxation and imployment, and might even do better. Migration, on the other hand, would reduce the excess labor supply and consumption, and would increase the income of particular classes. None of these policies, however, would assure perfect equality or even drastically reduce inequality. Moreover, each policy has to be weighed not only according to its capacity to reduce disparity, but also according to its inherent socio-political and administrative costs.

At this stage it needs to be mentioned that a string of assumptions have been made in conducting the simulation experiments. First, the weather condition has been assumed normal throughout the 8-year run period. For Bangladesh this is too rigid an assumption since one out of every five years there is a drought or a flood. Although natural vagaries would affect all performances they would do so irrespective of policy alternatives and therefore comparative policy patterns would remain unchanged.

The second and third assumptions relate to output price and agricultural credit policies. The policy runs are conducted on the basis of an output price value given by government fixed guaranteed price levels. Any violent fluctuation beyond normal seasonal variations has not been accounted for, nor has any declining or increasing price trend over the run period been considered. Beyond difficulties of projecting such price levels under uncertain conditions, there has been the expectation that the government through its various mechanisms (e.g., stockpiling, stock releasing, import and export of rice, and even fixing prices of substitute food products accordingly) would effectively maintain the guaranteed price levels in the market. If rice price levels could not be maintained at the levels considered here the income figures would change. So would the relative profitability which may result in smaller changes than are projected under policy alternative III.

In the area of credit policy, it has been assumed that the total volume of credit (in kind or in cash) required by the member farmers in stipulated proportions of production costs (e.g., 40 percent for small farmers and 20 percent for large farmers) will be supplied throughout the run period. In other words, total credit demand will be met even when it steeply increases over the years.

However, a more probable situation would call for a credit constraint resulting in a decrease in credit availability. The effect would be to either force an increase of self financing by farmers from savings, in which case their income will further increase, or to force a reduction in input use, which would decrease production. In this study implications arising from such a situation have not been fully explored.

The increase of employment under alternative III can be achieved if a definite policy against labor displacing mechanization is effected. It is assumed that there would be steadfast opposition by the government to allowing labor displacing machines, but not towards those forms of implements that complement the agricultural transformation.

It was mentioned at the outset that the simulated policies were arbitrarily designed, considering their relevancy and usefulness in tackling problems of a certain region and its agro-economic characteristics. In this spirit, we have not attempted an exhaustive treatment of all possible policy alternatives that might be considered, nor have we conducted simulation experiments with different possible levels of input values for particular policies, though such experiments would have given insights about the degree of intensity with which a policy should be pursued. Also, no attempt has been made to estimate either financial or socio-political costs of pursuing the policy alternatives. As such the policy impacts examined here are primarily concenrned with consequences at the grass roots.

One particular aspect that has not be adequately looked into is the dynamic impact of savings on the transformation of the landholding structure and on inflation. In the model itself no net change in landholding has been assumed during the run period. Thus, the numbers of farmers within a specific landholding category would remain constant, although they might transfer from one institutional class to another. It may, however, be possible that due to deteriorating economic conditions the rate of disinvestment may greatly increase among the lowest income category while the highest income category would buy land as their savings accumulate. In effect, a structural transformation in landholding may ensue as a result of rapid agricultural transformation so that large farms will tend to become larger while small ones will become smaller.

On the other hand, the accumulation of untapped savings in rural areas may generate an inflationary tendency. It is also likely that channeling a huge amount of agricultural credit and rural works program funds into the economy may fuel the inflation. For all these reasons it may be necessary to devise an adequate fiscal policy to combat the situation. Primarily, it would be worthwhile to consider a rural savings program or a rural investment policy under the aegis of cooperatives. For simulating the impacts of these policies it is, however, necessary to extend the model to incorporate the organizational component, and this has not been done in this study. Also for the reasons stated above it was not possible to simulate effects of a more radical and socialized policy, e.g., cooperative farming or land collectivism. It seems possible, however, that this could be done if the system loops were closed by the inclusion of an organizational component.

Finally, the simulation experiment entails general implications about regional policy planning. The experiment shows that policies can be finely tuned to the need and extent of a homogeneous region such as a thana with reasonably detailed feedback analysis. Based upon such information as would come out of such analysis, long term regional prospective plans can be drawn up, implemented, and their impacts monitored. Although this simulation embodies an essentially decentralized policy planning mechanism, in fact it could serve the purposes of central planning effectively because of its firm roots in the region.

Before concluding this chapter we would like to review the implications of the various policy alternatives in the light of rural development objectives. It has been indicated earlier (in Chapter III) that objectives can be set singly or collectively in terms of agricultural growth and equity related to production, employment, consumption and income in the region. When the objective function contains only one objective the policy strategy and the method for decision making are fairly straightforward and unencumbered by complexity. However, in reality none of the objectives by themselves are less important than any of the others; or to look at the matter the other way, emphasizing just one objective for policy attention while leaving the rest aside does not solve rural development problems. The truth of this latter observation has been amply demonstrated by the results obtained from this study. As such, it is imperative that before policy action is undertaken the multiple objective function be clearly defined, so as to avoid conflict among objectives and so as to determine the stress priority which should be given to each objective. Since different policies interact in different ways and attain different levels of performance of individual objectives within the objective function, it is also necessary that the goals should be described according to their importance and requirements before policy strategies are sought. In that search for policies capable of achieving the desired goals, the consequences and implications of the alternative strategies as presented in this study should be helpful (Table VI.17).

By now it may be apparent that we have tried to present policy impacts on production, employment, consumption, income, distribution and equity objectively, but have carefully refrained from ranking the policies according to their suitability. We have not recommended any particular policy. This position is taken for various reasons discussed earlier (in Chapter III). The clarification and ranking of goals should precede the ranking of strategies. It is the decision maker, in any event, who weighs goals on the basis of the socio-economic and political climate. Secondly, the social, political, financial and administrative costs of the various alternatives have not been calculated in this study. No ranking can be done until such information on costs as well as benefits is available. Third, the model might require sharpening. Further validation and data improvements in order to increase the credibility of the policy results. For all these reasons we have limited ourselves to the present role of presenting information to help decision makers, rather than imposing a decision upon them. In fact, the thrust of our whole approach of introducing the systems simulation technique into the domain of economic analysis has been to facilitate the decision making process, not to duplicate it.

Table VI.17. Impacts of Policy Alternatives on Aggregate Performances in 1981

Alternatives	Production (Thous. mds.)	Consumption (Thous. mds.)	Employment (Thous. mandays)	Vaue Added by Family (mil. Taka)	Per Capita Earning (Taka)
Base Year	1474	650	3892	142.9	581
I	1724	760	4342	165.0	546
IIa	2031	783	4726	1983	653
IIb	1899	765	4559	175.3	593
IIc	1896	774	4694	172.1	570
III	2472	797	5394	218.1	788
IV	2476	791	5398	228.4	759
V	2472	797	5594	218.1	744
VA	2472	797	5794	218.1	749
VI	2486	822	5427	219.3	743
VII	2472	756	5394	218.1	796

CHAPTER VII

SUMMARY AND CONCLUSION

Summary

This study has emerged from a concern about the structural change effects of the agricultural transformation presently being undertaken in Bangladesh. The combination of new technology in agricultural production and institutional innovations in cooperative organization has undoubtedly caused agricultural growth in the country. In the attempt to become self-sufficient the goal of agricultural development was predominantly that of increasing production. Equity of income distribution was left out of the goal function as a minor issue. With the agricultural transformation, however, the concomitant problem of inequity increasingly came to the surface, and policy makers in Bangladesh are presently searching for suitable alternative rural development strategies to alleviate it. The present study was launched to examine possible economic consequences with respect to both growth and equity of alternative policies on the rural economy.

We have argued that the concern of policy analysis for growth and equity should be matched by a new analytic perspective because of the advent of the Integrated Rural Development System. The integration of technological, behavioral and institutional changes through the initiatives of intermediate level organizations has created a new system for development. Little is presently known about the interactions within the new system but they must be fully understood if policy analysis in this new context is to be effective. Furthermore, when the nature of the policy objective function changes from that of a function with a single objective of growth to a function that includes equity considerations, the inherent trade-offs involved in policy choices make decision making difficult, and policy planning and evaluation analytically challenging. The complexity of the problem increases further when a dynamic analysis of long term policy effects is sought. Effective policy planning is therefore restricted by an inadequate understanding of system interactions and by deficiencies in analytic methodology.

In this study the systems analytic approach was used to describe the integrated rural development system and the interrelationship within it. In order to generate the dynamic effects of alternative policies a computer simulation model was constructed. After testing the model for validity and after testing the variables for sensitivity, an implementation experiment was conducted with ten policy alternatives.

Although a conceptual version of the integrated rural development system model was presented, complete operationalization of all of its components was not possible due to resource limitations. Mathematical models of five out of a total of eight components were constructed; these five components cover the farm, production, consumption, income and accounting components of the total system. The farm population of the region (where the integrated rural development system was assumed to operate in a closed loop) was disaggregated into eight classes according to levels of landholding and cooperative membership. The farm component generated data for population, land holdings, institutional membership and agricultural labor supplies, along with dynamic changes and interclass transfers for these variables. It also generated seasonal land allocation to each variety of rice crop. The production component generated crop yield rates, output production, and the use of inputs including human labor and the cost of production. Output disposal, consumption and inventory operations were modeled in the consumption component. The income component maintained a financial accounting of the case transactions made by the different classes, e.g. revenue, expenses, credit, debt, repayment, savings, and cash balance. The accounting component primarily kept track of the system output and performance criteria on a seasonal and yearly basis. In particular, the output of the accounting component generated the information used in the policy analysis.

The systems simulation model was then subjected to various means of viability testing. The model was operationalized on the computer with initial data selected from the real system. The output provided by the structural equations was intuitively appraised, cross checked and in some cases compared with secondary information. The validation process included consistency checks and tests of sensitivity. The 21 sensitivity test runs, made with various variables of the model, provided a great deal of information on validity, some of which was used to refine the model. The tests also provided a basis for understanding the nature of the impact of various policy alternatives.

To test the impact of 10 alternative policies including the one presently pursued, a simulation experiment was designed. The 10 policies were selected so that they would represent a wide range of technological and institutional ingredients which might realistically be selected in the simultaneous pursuit of growth and equity. Each alternative policy was closely examined according to its impact on production, employment, consumption and income performance, both in aggregate terms and in terms of class distribution. By examining intertemporal changes in each classes performances under different policies, and by comparing these results with performances of other classes, it was possible to evaluate consequences of the policies and to explore their implications. Although the results were considered tentative, they provided many useful perspectives for planners and decision makers. The study thus introduced a new approach to policy planning and evaluation in the area of rural development, this approach may have applicability in developing countries in general and in Bangladesh in particular.

Conclusions

In this section major conclusions derived from various areas of the study are presented. The conclusions cover areas such as conceptualization of the policy analysis framework, construction of the systems simulation model, and policy simulation experiments.

Limitations of the study, areas in which improvements and extension of the model are called for, and directions for further research are mentioned in the next section.

a) Rural development objectives are multiple in number and interrelated in nature. Long run incongruity in achievement generally results from omitting or slighting certain objectives at the time of goal formulation. To avoid such a conflict all objectives important to rural life should be considered in the objective function.

b) Structural changes resulting from agricultural transformation are non-spurious and necessary for rural development. Structural changes can be brought about through the propagation of a combination of technological, behavioral and institutional inputs whose integration and interaction are effected in the integrated rural development system. In the process of propagating these inputs, it is necessary to have control over their manipulation in order to attain the goals of the multiple objective function. Policy direction is needed for such purposes.

c) A rapid and viable agricultural transformation can be attained through the intermediate level organization approach. Technological, behavioral and institutional changes can be effectively integrated and introduced for better performances. The impacts of integrated changes are far more impressive than are those caused by only one kind of change. It is possible that the introduction of only one kind of change may even be ineffective because of its inherent interdependence with another.

d) Distributive problems arise mainly from the initial structural conditions, from the process of implementing the transportation, and from the inflexibilities of the institutional system in accommodating changes. Solutions to such problems are to be found in the realm of institutional policy. Before a policy change is implemented, though, its long term consequences should be examined, and its implications for the multiple goals of rural development should be explored.

e) The formulation of rural development policies should be based on a clear understanding of the integrated rural development system. The mechanisms of that system, however, are new, imperfectly understood, and complex. The systems analysis approach makes an in depth understanding of its complex interrelationships possible by dividing the system into building blocks and tracking the linkages within and among them. Mathematical representation of the interactions is both precise and thorough, and provides scope to capture the interplay of efforts in the integrated development process.

f) While it is desirable to examine the long run effects of policies relative to policy goals, it is difficult analytically to model all the dynamic interactions. The difficulty is compounded for a system which has just come into existence and whose interactions are still emerging and imperfectly understood. A computer simulation technique that describes dynamic interactions along a sequential time path helps overcome this difficulty. It has been found particularly suitable for exploring a system which itself is in an experimental stage but the technique may require future modification to more accurately reflect reality.

g) Disaggregation, whether by class, crop varieties, regions or structural changes, has been found to be a very useful way of generating information. It provides a basis for comparing performances of different disaggregated units and evaluating policy impacts on them more closely. This technique cuts across the aggregation bias by identifying the otherwise hidden perfromances of disaggregated units. As a result, decision makers can focus on the important considerations.

h) Though the jurisdiction of an intermediate level organization -- the Thana -- conditioned the definition of the system, the regional approach was found to have methodological merit as well. In a way, the Thana is a disaggregated unit of the country. The system is close enough to the grassroots so that micro-elements could be studied in detail. At the same time this level is close enough to the macro level so that the impact of policies could be delineated. The mini-macro level, as we may call it, provided an adequate basis for effective policy formulation and analysis. This leads to the conclusion that rural development planning can be decentralized at the Thana level, where local policies and plans can be set according to the needs and problems of the area. In effect, the implementation and monitoring of national plans can be perceived from this mini-macro level, and in a much better manner. Analytically, a closed system in a small area is found to be much simpler to handle than the total country. On the other hand, the aggregation of such a disaggregated system is easier to achieve than the other way around.

i) Although aggregate production, employment and income will continue to grow under the present policy, they will show a long run decline in per capita terms. This happens because agricultural growth falls behind the present rate of population growth. Therefore, to maintain present per capita performance it is necessary that the present policy be changed in favor of further agricultural growth.

j) In fact, the effect of the present rate of population growth was found to severely limit the impact of even a high agricultural growth rate. As such, it is urgently important that an effective population policy be imposed in order to reduce the pressure on the rural sector.

k) Higher agricultural growth can be obtained through a combined policy package such as alternative III. Under this policy, in the eight year period aggregate production of the Thana can be increased by 68 percent, aggregate employment by 39 percent and aggregate income earning by 53 percent compared to the base year. Comparable results for the present policy are increases of 17 percent, 12 percent, and 16 percent, respectively. (With a higher level of input supply, the performance of both the present policy and of the growth oriented combined policy package could be improved.)

l) The demand for physical inputs under production oriented policy alternatives will continually increase. By 1981 the demand for HYV seed may double, and that for chemical fertilizer and institutional credit may treble, depending upon the nature and extent of the policies adopted. To sustain the agricultural growth envisaged such demands for inputs must be met.

m) Although the area is developing a surplus in rice production, the rice consumption of classes holding little land is below the normal intake requirement. However, the consumption levels in this study are considered underestimates due to the exclusion from the simulation of off-farm incomes. On the other hand, the simulation suggests that the improvement of the consumption levels of these classes requires off-farm income opportunities through the provision of employment or doles.

n) Despite increases in agricultural labor demand resulting from the agricultural transformation the unemployment situation will not greatly improve. In fact, in the long run the increases in labor supply will outweigh the increases in labor demand. Although agriculture provides the largest scope for labor use, it is able to absorb less than a quarter of the total available labor. Employment creation is necessary to generate non-farm incomes for the landless and near-landless class, who are found to be in a distressed condition that deteriorates in the long run. Unless employment opportunities are created within and beyond the agricultural sector through public or private means the condition of these classes of farmers will further deteriorate.

o) The disparity gap between classes of farmers in terms of production, and income is observable. The larger the land holding, the higher is the level of production and income. Cooperative members show better performances than non-members of the same land holding category, almost attaining the level of performances of non-members in the nect higher land holding category. The impact of the agricultural transformation adds to the disparity as well as providing incentives. Additionally, it has been observed that the disparity gap in income among classes of farmers widens as the pace of agricultural transformation accelerates.

p) Equity should be considered to be as important a goal of rural development as growth, but equity without growth, or vice versa, would constitute a less meaningful strategy for rural development. To attain equity it is necessary to pursue institutional policies that help to reduce the disparity gaps without decelerating agricultural growth. This can be done by increasing the incomes of the lower land holding category, while simultaneously constraining or reducing the incomes of the farmers in the higher land holding category. The policy of agricultural taxation with employment creation and the policy of land reform possess such characteristics. Both of these policies intervene in the system in order to divert resources from larger farmers to smaller ones. However, in land reform, it may be difficult to determine the appropriate land holding ceiling that would be effective for reaching the distributional objective. Such a problem is less severe in determining an appropriate tax schedule and in fact taxation and employment creation may achieve almost the same effects as land reform without heavy socio-political stress.

q) Different institutional policies have differing impacts on aggregate performances. Land reform may increase aggregate production and employment but its impact on aggregate income will be insignificant. Under the taxation and employment generating policy aggregate employment and income will increase but not aggregate production. Aggregate income under the policy of preferential input price and distribution will be affected but its impact on aggregate production and employment will be insignificant. The policy of orderly out-migration will have an impact only on the per capita income. With such varying performances the choice of policy thus depends upon the choice of goals by decision matters.

Need for Improvement and Direction for Use of the Model

Many of the limitations of this study have emanated from the paucity of data. The most important limitation is the non-availability of non-farm income and non-rice crop data. While aggregate estimates of such information might possibly be made, the difficulties arise in disaggregating them classwise. Similar problems arise in determining the proportions of total land under cultivation, under high yielding varieties and under sharecropping, in determining the rate of changes in these proportions, and in determining the fertilizer doses used for different crops, the proportion of labor used for hiring out and such values of the variables. The accuracy of all of these disaggregated data is important, since the model has been shown to be sensitive to variation in these variables. Although data on these general subjects is usually collected by relevant agencies or institutions, it is reported in aggregate forms. By obtaining the primary data from the collecting institutions the disaggregated information could be compiled as needed. Otherwise, it might be necessary to launch a small scale sample survey in the area for obtaining such data.

Improvement in data by itself will improve model performance. However, the model also needs to be refined in certain other areas. First, except for the production function most of the dynamic growth functions used in the model are of a linear form, primarily because data was insufficient to indicate non linearity. As data becomes available the linear growth functions should be revised to non-linear forms in order to introduce more realism into the model. Second, a few aspects of the system were inadequately considered. These include cash rent, non-farm income, non-rice and non-food crop production, demand and supply of credit, animal power and other inputs. Modeling of these aspects of the system should be refined. Third, price projection, particularly of output, needs further improvement. Instead of fixing the average prices from the government support-price level, prices should be made dependent on the market. Price fluctuations due to the interaction of the demand for and supply of outputs will have an impact on the incomes of farmers. Demand and supply need to be properly projected within the model.

Another important limitation of the model, and the most important requirement for future research, lies in the area of the resource allocation decisions and the organization of farmers. In fact, without the inclusion of these factors in the model the representation of the integrated rural development system remains incomplete and its effectiveness is less than fully determined. With their inclusion the system loop would close accounting for the feedbacks resulting from relative profitabilities, adoption of agricultural transformation, savings and credit generation, etc. From this point of view the present model is a foundation upon which new components should be attached. However, the present model has been designed with enough flexibility so that it can be easily extended to include these missing components without any major change.

Last, but not least, social, educational and health aspects of development must be included in the system. Once the loop of the systems model is closed through the addition of allocation decision making and organization, these aspects can be attached to the model. This would undoubtedly make the system model complex, but it would provide a more meaningful representation of the real system as well as a powerful tool for intermediate level policy planning.

For future work on this model it is advisable that those areas should be selected which have high payoff and priorities over other parts. In this context it might be suggested that the model should be refined before it is extended to include other components. For example, credit, non-rice food and non-food consumption, agricultural investments, etc. should be included. If extension of the model is intended, the high payoff components would be modernization and organization, the inclusion of which would practically close the system loop. Further work in these areas would greatly improve the effectiveness of the model so far as integrated rural development policy planning and evaluation are concerned.

No matter whether these extensions are made or not, the system simulation model in its present form or in an improved version can be applied for other Thanas of the country. Primarily, this would involve the replacement of present data by local data; however, certain characteristics of the new area, if different than those modeled here, may call for the revision of some equations. If the model's workability in different Thanas is found suitable, it can be utilized in generating information for all Thanas. The subsequent task would be to develop a national aggregate model enveloping the Thana models.

The model can be used at least in two ways: for national policy planning and for decentralized Thana development planning. In national policy planning the model can be used for selecting adequate policies by studying their long term consequences and implications. For that purpose any typical Thana (not necessarily Comilla) can be selected as a sample whose relevant data would be fed into the computer model for generating required information. Since the Bangladesh Planning Commission is primarily responsible for policy planning, it is expected that this work would be carried out by them.

For Thana development planning it would be advisable for a coordinating institution such as IRDP which has access to computer facilities to assist the Thana planning organization to run the computer model, to analyze the output and to develop a plan. A beginning in this direction could be made by experimenting in Comilla Thana, which has in the past pioneered such experimental work. Supervision of the experiment could be entrusted to the Bangladesh Academy for Rural Development which, if the venture is found suitable, can make recommendations for replication by IRDP. Through such an experimental process the viability of Thana development planning would be tested and the usefulness of the model as a tool could be verified.

APPENDIX

COMPUTER PROGRAM

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      PROGRAM MAIN(INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT)
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCRCPER,T1(3,2,1),WGPT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPF(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4   ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOFT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),        TCSHOST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAG(3,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON /ALLO/ POP(4),FFM(4),LND(4),AVLND(4),AFAS(3,1),LAND(3),
     2   POP74(4),PPARC(3,8),PPHYV(3,8),APC(3,8),ARSH(8,2,1),PPFM(4)
      COMMON/SEABLOC / NJ2,NDTS(3,2),PPAL,VOUTPUT(8,2,1),XCPED(8,2,1)
     2   ,PRI(8),PRF(8),TXNAG(8,2,1),PRINDX,XNAG(8,2,1)
      COMMON/PROBLOC/HVLPCU(3,2),PVLA(3,2),AHVL (8),APVL(8),RH(8,2,1),
     2            HVL(8,2,1),PVL(8,2,1),U1,EMCH(8,2,1),EMOP(8,2,1),
     3             SLHLAB(8),SFMLAB(8),SLAB(8),EMO(8,2,1),WAGMO(8),
     4          GMO(8),EMPMO(8),HIFMO(8)
      COMMON / FFNBLOC/ SPROL(3,8),SCONSL(3,8),SPROV(3,2),SHLABF(3,2),
     2           SSEEDV(3,2),SPRD(3),SFERT(3),SCONS(3),COSTA(2),PAF(8),
     3      CPRNEW(3,8),VADFAM(8,2,1),VADAG(8,2,1),
     4          CVADFAM(3,2),CVADAG(3,2),SVADAG(3),SVADFAM(3),
     5          PROFITA(3,2,1),COSTCC(3,2,1),VADFDUM(3,8),VADADUM(3,8),
     6          LABA(8,2,1) ,TPURCH(3,8),TSALES(3,8)
      COMMON/ YRBLOC/ TPROL(8),TTCONSL(8),TPROV(2),THLABV(2),TTCONS,
     2          TSEEDV(2),PCOSIN(8),TFERT    ,PCSVG(8),PFSVG(8),PCOSBL(8),
     3          PFCSBL(8),PFDBT(8),PCPRDL(8),TPRD,PCINC(8),TVADFAM(8),
     4          TVADAG(8),VVADFAM(2),VVADAG(2),YVADFAM,YVADAG,PCCONY(8),
     5          PCCOND(8),CALPDA(8),PFSURP(8),PFLOAN(8),ERNG(8),
     6          FCERNG(8),YPURCH(8),YSALES(8),PFERNG(8)
      COMMON/CONBLOC/STOG(8,1),CONS(8,1),DSTOG(8,1),DSTOGU(8,1),
     2 RNUTN(8,1),RNUTP(8,1),STINC,DER,K1
      COMMON /INCO / BORROW(8),FPI(8),SAVING(8),CSHCST(8,2,1),
     2          CSHIN(8),PRICE1(2),PRICE2(2),XTAX(8),PPC(8),CCSHCST(8),
     3          CSHREV(8),FDIST(8),XHLAB(8,2,1),XCSAG(8,2,1),DISPIN(8),
     4          CCONX(8),CONEX(8),ACREDIT(8)
      COMMON /HAR/ NSTOP,FLAGPH,NTHAR(2)
      COMMON/ADD/PFCSIN(8),TPSURP(8),PFINC(8)
      COMMON/ TEMP / SEEDC(8),YLDA(8,2,1),YLDFA(8,2,1),SSEED(8)
      COMMON/3/ TDISP(8),TERNG,TLOAN,TCREDIT,CREDIT(8),PFCRDT(8)
      DIMENSION INT(8)
      DIMENSION PREDVAR(15),PRIDVAR(15)
      DIMENSION NAMVAR(41)
      DIMENSION SHLABF(3),SHLABS(3),SLABH(8,3),SHDLAB(3)
      DIMENSION TLHLAB(3,8),TFMLAB(3,8),TLAB(3,8),YLHLAB(8),YFMLAB(8),
     2YLAB(8),YLABH(8)
      DIMENSION RTEMPL(8),PETAX(8)
      REAL LAB,LHLAB,NDT,NDTS
      REAL LOAN
      REAL LARA
      REAL K1
      DATA NVAR /41 /
C           FOR SUBROUTINE NAMELIST---CONTROL PARAMETERS
      DATA NAMVAR / 3HDUR,      2HDT,       6HDETPRT, 6HSELPRT, 6HBEGPRT,
     +     6HPRTCHG,6HPRTVL1,6HPRTVL2,3HDSS, 5HALPHA,
     2     3HRTF,     3HRTI,      3HRTW,      5HRTPR1,   5HRTPR2,   6HPRICEN,
     4     5HPPFM1,5HPPFM2,5HPPFM3,5HPPFM4,4HRTM1,4HRTM2,4HRTM3,4HRTM4,
     5     3HGRT, 5HRTIM1, 5HRTIM2, 4HRTF1, 4HRTF2, 2HF1, 2HF2, 2HF3,
     +   2HF4,  2HF5,   4HRTIN,   5HKVARF, 5HKVARI, 5HPRPSH, 4HRTSH ,
     +    6HTXFLOR, 3HRTX   /
C           NCROP= NUMBER OF CROPS=2
C           LOW YIELD + HIGH YIELD
C           NCLS= NUMBER OF CLASSES=8
C           NIRG= IRRIGATED OR NON-IRRIGATED (CURRENTLY THIS IS A GENER-
C           ALITY NOT USED)
C           NIRG=1.
      DATA NCROP,NCLS,NIRG / 2,8,1/
      DATA GRT, PPAL,U1,STINC,K1 /.03, .35, 1., .04, .04 /
      DATA INT/1,2,3,4,5,6,7,8 /
      DATA F CST/8*0. /
      DATA PREDVAR/ 15*0. /
      DATA PRIDVAR/ 15*0. /
C           SAPV ST START(T1) AND END(T2) BY SEASON AND CROP
      DATA ((T1(N,J,1),J=1,2),N=1,3) / .24,.32,.55,.63,.88,.92 /
      DATA ((T2(N,J,1),J=1,2),N=1,3) / .32,.43,.64,.63,.96,1.0 /
C           TIME OF SEASON ENDING

      DATA SEAS / .36,.66,1.0 /
      DATA ((NDTS(N,J),N=1,3),J=1,2)/.36,.30,.34,.40,.26,.32/
C           NUMBER OF DT BETWEEN BEGIN SEASON AND BEGIN HARVEST
      DATA ((NDT(N,J,1),N=1,3),J=1,2) / .24,.27,.22,.32,.20,.26 /
      DATA POP74/ 112330.,9941.,26072.,12295. /
      NCROPS=NCROP-1
      READ 900,NRUN
C                    BEGIN RUN LOOP
      DO 800 IRUN=1,NRUN
C                    CONTROL PARAMETERS
      DUR=5.     $     DT=.02            DSS=.3
      DUP = 0.
      BEGPRT=.1     $     PRTVL1=.095        $        PRTVL2=1.     $     PRTCHG=10.
      RTIM1=0.
      RTIM2=0.
      SELPRT=1.     $     DETPRT=0.
      ALPHA=.07
      RTF=0.     $     RTI=0.     $     RTW=0.          RTPR1=0.     $     RTPR2=0.
      GRT = .03
      PRICEN=120.
      PPFM1=0.125     $     PPFM2=0.50     $     PPFM3=0.59     $     PPFM4=.32
      PRPSH=.05     $     RTSH=-.002
      RTM1=.02
      RTM2=.02
      RTM3=.02
      RTF1=0.     $     RTF2=0.
      RTM4=.02
      F1=1.
      F2=1.
      F3=1.
      F4=1.
      F5=1.
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      RTIN=0.08
      KVARF=15
      KVARI=15
      TXFLOR=6000.
      FTX=0.
C                INITIALIZING DATA
      FLAGPR = 0.
      PRF(1)=175.  $  PRF(2)=175.  $ PRF(3)=175.  $ PRF(4)=175.
      PRF(5)=175.  $  PRF(6)=175.  $ PRF(7)=175.  $ PRF(8)=175.
      PRI(1)=200.  $  PRI(2)=300.  $  PRI(3)=200.  $  PRI(4)=300.
      PRI(5)=200.  $  PRI(6)=300.  $  PRI(7)=200.  $  PRI(8)=300.
C               INITIAL DATA FOR STATE VARIABLES IN SUBROUT
      STOG(1,1)=13165.  $  STOG(2,1)=39757.  $  STOG(3,1)=70605.
      STOG(4,1)=46745.  $  STOG(5,1)=19751.  $  STOG(6,1)=15519.
      STOG(7,1)=10305.  $  STOG(8,1)=6912.
      CONS(1,1)=788.    $    CONS(2,1)=5955.    $  CONS(3,1)=4170.
      CONS(4,1)=2761.   $    CONS(5,1)=1197.    $     CONS(6,1)=941.
      CONS(7,1)=620.    $      CONS(8,1)=413.
      DSTOG  (1,1)=13659. $DSTOG  (2,1)=103125.  $  DSTOG  (3,1)=59407.
      DSTOG  (4,1)=39332.  $  DSTOG  (5,1)=15184.  $  DSTOG  (6,1)=11931.
      DSTOG  (7,1)=7674. $DSTOG  (8,1)=5116.
      DSTOGU(1,1)=13659. $DSTOGU(2,1)=103125.  $  DSTOGU(3,1)=59407.
      DSTOGU(4,1)=39332.  $   DSTOGU(5,1)=15184.  $  DSTOGU(6,1)=11931.
      DSTOGU(7,1)=7674. $DSTOGU(8,1)=5116.
      KYEAR=1    $   DVAR1=PRFDVAR(KYEAR)            DVAR2=PRIDVAR(KYEAR)
C                SUBROUTINES PRODUC AND SEASO
      DO 10 I=1,NCLS
      WAGMO(I)=0.   $    GMO(I)=0.
      TWAGE(I)=0.   $    WAGE(I)=0.    $    TOTHIN(I)=0.
      DO 10 J=1,NCROP
      DO 10 K=1,NIRG
      HVL(I,J,K)=0.   $  PVL(I,J,K)=0.   $  HVLH(I,J,K)=0.
      FH(I,J,K)=0.
      PVLH(I,J,K)=0.   $  SOPT(I,J,K)=0.   $   SAVLO(I,J)=0.
      AVLCPT(I,J,K)=0.  $    LAB(I,J,K)=0.
      HLH(I,J,K)=0.        $    PLH(I,J,K)=0.
      EMOH(I,J,K)=0.    $   EMOP(I,J,K)=0.
      SLHLAB(I)=0.
      SFHLAB(I)=0.
      LHLAB(I)=0.
   10 CONTINUE
C               SUBROUTINES CONSUMP AND INCOM
      ITAX=0.
      DO 41 I=1,NCLS
      PURCH(I,1)=0.
      SALES(I,1)=.001
      TCONS(I,1)=0.
      SSALES(I,1)=0.
      SPURCH(I,1)=0.

      BORROW(I)=0.   $  PPI(I)=0.
      TCSHIN(I)=0.   $  TSAVING(I)=0.   $  DEBT(I)=0.   $  SAVING(I)=0.
      TCISP(I)=0.
      ACREDIT(I)=0.      $     CSHIN(I)=0.
      LOAN(I)=0.
      CASBAL(I)=0.001
      XTAX(I)=0.
      PFTAX(I)=0.
      CREDIT(I)=0.
      PHC(I)=.4
      DO 41 J=1,NCROP
      DO 41 K=1,NIRG
      CSHCST(I,J,K)=0.      $    TCSHCST(I,J,K)=0.
      TXWAG(I,J,K)=0.      $   XWAG(I,J,K)=0.
      XCRED(I,J,K)=0.
   41 CONTINUE
      NOWHAR(1)=1    $    NOWHAR(2)=1
       NSTOP=0
      WRITE(2,931)NFUN
      CALL NAMLST(NAMVAR,NVAR,ERROR)
      IF(ERROR.NE.0.)GO TO 300
      DER=DT/DSS
      PRIDVAR(KVARI)=1.
      PRFDVAR(KVARF)=1.
C               NUMBER OF ITERATIONS
      NITER= DUR/DT+.000000001
      FLAGHY(1)=0.
      ST=0.   $  T=0.     $  TONE=1.0000000001    $   NOWS=1
      PRTIME=BEGPRT      $       PRTVL=PRTVL1
      PPFM(1)=PPFM1*(1.+RTM1*T)     $    PPFM(2)=PPFM2*(1.+RTM2*T)
      PPFM(3)=PPFM3*(1.+RTM3*T)     $    PPFM(4)=PPFM4*(1.+RTM4*T)
      DO 202 M=1,4
  202 POP(M)= POP74(M)*EXP(GPT*T)
C               ORIGINAL ALLOCATION OF LAND AREAS
      CALL ALLOC
C               SEASONAL COMPUTATIONS
      NJ2=1
      CALL SEASO
C               BEGIN TIME LOOP
      FLAGHY(1)=1.
      DO 200 NTQ=1,NITER
      IF(T.LT..01) GO TO 61
17    CONTINUE
      T=T+DT     $     ST=ST+DT
C               CHECK FOR END OF YEAR
      IF(ST.GT.TONE) ST=DT
C                          CALL SUBROUTINES
      CALL PRODUC
      CALL CONSUMP
      CALL INCOM
C               CHECK FOR END OF SEASON
      IF(ST.GE.SEAS(NOWS)-.0000001) GO TO 25
      GO TO 28
   25 KJ=1
C               SEASONAL STORAGE OF VALUES FOR CROP NO. 1 (KJ=1)
      CALL PRINSTO
C               INCREASE SEASON (ONLY USED FOR CROP NO. 1)
      NOWS=NOWS+1
      IF(NOWS.GT.3)NOWS=1
C               NEXT SEASON*S LAND ALLOCATION
      CALL ALLOC
C               NEXT SEASON*S SEASONAL COMPUTATION
      NJ2=1     $    CALL SEASO
C               CHECK FOR END OF HARVEST,BY CROP
   28 CALL HARCHK
      IF(T.LT.PRTIME) GO TO 92
      IF(T.GT.PRTCHG) PRTVL=PRTVL2
      PRTIME=T+PRTVL
      IF(SELPRT.EQ.0.) GO TO 92
C                LABOR PROFILE (MONTHLY)
      PRINT 990,T
      PRINT 995, (INT(I),I=1,8)
      PRINT 996, (HIRMO(I),I=1,8),(WAGMO(I),I=1,8)
      PRINT 997, (EMPMO(I),I=1,8)
      DO 91 I=1,NCLS
      WAGMO(I)=0.    $    GMO(I)=0.
      DO 91 J=1,NCROP
      EMOH(I,J,1)=0.    $    EMOP(I,J,1)=0.
   91 CONTINUE
   92 CONTINUE
C               PRINTING FLAG
```

```
      IF(FLAGPR.LT.1.) GO TO 200
      SHLABF(NOWS)=0.    $    SHLABS(NOWS)=0.
      SHOLAB(NOWS)=0.
C               FERTILIZER AMOUNT REPRTED = TOTAL CHEMICAL (2:3:1)
      SFERT(NOWS)=3.*SFERT(NOWS)
      DO   80   I=1,NCLS
      SLABH(I,NOWS)=SHLAB1(I)+SHLAB(I,2,1)
      SHOLAB(NOWS)=SHOLAB(NOWS)+SLABH(I,NOWS)
      SHLABF(NOWS)=SHLABF(NOWS)+SHLAB1(I)
      SHLABS(NOWS) =SHLABS(NOWS)+SHLAB(I,2,1)
      SHLAB(I,2,1)=0.    $   HVLH(I,2,1)=0.    $    PVLH(I,2,1)=0.
      TLHLAB(NOWS,I)=SLHLAB(I)
      TFMLAB(NOWS,I)=SFMLAB(I)
      TLAB(NOWS,I)=SLAB(I)
      SLHLAB(I)=0.    $    SFMLAB(I)=0.
   80 CONTINUE
      PRINT 925,NOWS,(INT(I),I=1,8)
      PRINT 910,  (SPRNEW(NOWS,I), I=1,NCLS)
      PRINT 926,  (SPROL(NOWS,I),I=1,NCLS),(SCONSL(NOWS,I),I=1,NCLS)
      PRINT 928,  (PAR(I)      ,I=1,NCLS),TARA(1,1),(AFA(I,2,1),I=1,NCLS),
     2            TAFA(2,1)
      PRINT 951,(SLABH(I,NOWS),I=1,NCLS),SHOLAB(NOWS)
      PRINT 960,  (TLHLAB(NOWS,I),I=1,NCLS)
      PRINT 961,  (TFMLAB(NOWS,I),I=1,NCLS)
      PRINT 962,  (TLAB(NOWS,I),I=1,NCLS)
      PRINT 940,  ((PROFITA(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 941,  ((COSTCC(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 942,  ((LABA(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 943,  (TPURCH(NOWS,I),I=1,NCLS)
      PRINT 944,  (TSALES(NOWS,I),I=1,NCLS)
      PRINT 945,  (STOG(I,1),I=1,NCLS)
      PRINT 850,  (SSEEDC(I),I=1,NCLS)
  850 FORMAT(* SEED USED-PLANTING*,2X,8F12.2)
      PRINT 935
      DO 101 J=1,NCROP
  101 PRINT 936, J,SPROV(NOWS,J),SHLABE(NOWS,J),SSEEDV(NOWS,J),
     2    CVADAG(NOWS,J),CVADFAM(NOWS,J),COSTA(J)
      PRINT 937, SPRD(NOWS),SVADAG(NOWS),SVADFAM(NOWS),SFERT(NOWS)
      IF(NOWS.NE.3) GO TO 60
      KYEAR=KYEAR+1
      DVAR1=PRFDVAR(KYEAR)
      DVAR2=PRIDVAR(KYEAR)
      PRICEN=AVPR(1,1)
      CALL YEARLY
      DO 120 I=1,NCLS
      PRI(I)=PRI(I)*(1.+RTI*DVAR2)
      PRF(I)=PRF(I)*(1.+RTF*DVAR1)
      YLHLAB(I)=0.    $    YFMLAB(I)=0.    $    YLAB(I)=0.
      YLABH(I)=0.
      DO 120 L=1,3
      YLABH(I)=YLABH(I)+SLABH(I,NOWS)
      YLHLAB(I)=YLHLAB(I)+TLHLAB(L,I)
      YFMLAB(I)=YFMLAB(I)+TFMLAB(L,I)
  120 YLAB(I)=YLAB(I)+TLAB(L,I)
      TEMPL=0.    $    TWGLB=0.
      DO 121 I=1,NCLS
      TEMPL=TEMPL+YLAB(I)
      RTEMPL(I)=YLAB(I)/FAMLAB(I)
  121 TWGLB=TWGLB+YLHLAB(I)
      TYEAR=T+1973.
      PRINT 970,  TYEAR,(INT(I),I=1,8)
      PRINT 971,  (TPPOL(I),I=1,NCLS),TPRD,(PCPPOL(I),I=1,NCLS)
      PRINT 951,  (YLABH(I),I=1,NCLS)
      PRINT 960,  (YLHLAB(I),I=1,NCLS),TWGLB
      PRINT 961,  (YFMLAB(I),I=1,NCLS)
      PRINT 962,  (YLAB(I),I=1,NCLS),TEMPL
      PRINT 963,  (RTEMPL(I),I=1,NCLS)
      PRINT 973,  (TTCONSL(I),I=1,NCLS),TTCONS
      PRINT 977,  (PFCSIN(I),I=1,NCLS),(PCSVG(I),I=1,NCLS)
      PRINT 978,  (PFSVG(I),I=1,NCLS),(PCCDBL(I),I=1,NCLS)
      PRINT 979,  (PFCDBL(I),I=1,NCLS),(PFDBT(I),I=1,NCLS)
      PRINT 964,  (PCERNG(I),I=1,NCLS)
      PRINT 981,  (PFERNG(I),I=1,NCLS)
      PRINT 983,  (PCINC(I),I=1,NCLS),(PFINC(I),I=1,NCLS)
      PRINT 965,  (PCCSIN(I),I=1,NCLS),(PFLOAN(I),I=1,NCLS),TLOAN
      PRINT 948,  (PFCRDT(I),I=1,NCLS),TCREDIT
      PRINT 966,  (PCCONY(I),I=1,NCLS),(PCCOND(I),I=1,NCLS)
      PRINT 967,  (CALPOA(I),I=1,NCLS),(PFSURP(I),I=1,NCLS)
      PRINT 968,  (TVADFAM(I),I=1,NCLS),YVADFAM
      PRINT 969,  (TVADAG(I),I=1,NCLS),YVADAG
      PRINT 974,  (YSALES(I),I=1,NCLS),(YPURCH(I),I=1,NCLS)

      PRINT 991,  (ERNG(I),I=1,NCLS),TERNG
      PRINT 998,  (XTAX(I),I=1,NCLS),TTAX
      PRINT 999,  (PFTAX(I),I=1,NCLS)
      PRINT 435
      DO 105 J=1,NCROP
  105 PRINT 936,  J,TPROV(J),THLABV(J),TSEEDV(J),VVADAG(J),VVADFAM(J)
      PRINT 937,  TPRD,YVADAG,YVADFAM,TFERT
      PPFM(1)=PPFM1*(1.+RTM1*T)    $    PPFM(2)=PPFM2*(1.+RTM2*T)
      PPFM(3)=PPFM3*(1.+RTM3*T)    $    PPFM(4)=PPFM4*(1.+RTM4*T)
      DO 201 M=1,4
  201 POP(M)= POP74(M)*EXP(GRT*T)
      NOWS=NSTOR
      TTAX=0.
      DO 91 I=1,NCLS
      IF (I.LE.4) GO TO 82
      IF(I.GT.4) GO TO 83
   82 XTAX(I)=0.1*TVADFAM(I)
   83 XTAX(I)=RTX*AMAX1(0.,(PFERNG(I)-TXFLOR))*FAM(I)+0.1*TVADFAM(I)
      PFTAX(I)=XTAX(I)/FAM(I)
   91 TTAX=TTAX+XTAX(I)
      CALL ALLOC
      NJ2=1
      CALL SEASO
   60 CONTINUE
C             RESET CURRENT SEASON(SEE HAFCHK)
      NOWS=NSTOR
      FLAGPR = 0.
      DO 20 I=1,NCLS
C             NEXT SEASON:S LAND AREA FOR CROP 2
   20 ARA(I,2,1)=ARAS(I,1)
      NJ2=2    $    CALL SEASO
61    PRINT 721,NOWS,T,(INT(I),I=1,8)
      PRINT 722,  (ARC(NOWS,I),I=1,8)
      PRINT 723,  (PPHYV(NOWS,I),I=1,NCLS)
      PRINT 724,  (PPAFC(NOWS,I),I=1,NCLS)
      PRINT 725,  (FAM(I),I=1,NCLS)
      PRINT 726,  (LAND(I),I=1,NCLS)
      PRINT 727,  (POPN(I),I=1,NCLS)
      PRINT 728,  ((FERTA(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 731,  ((YLDA(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 732,  ((YLDFA(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 733,  ((OUTPUT(I,J,1),I=1,NCLS),J=1,NCROP)
      PRINT 729,  (PRI(I),I=1,NCLS)
      PRINT 730,  WGRT,     (AVPP(J,1),J=1,NCROP)
      PRINT 735,  (PRF(I),I=1,NCLS)
      IF(T.LT..01) GO TO 17
  200 CONTINUE
  500 CONTINUE
```

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900 FORMAT(I2)
901 FORMAT(37H1NON-DEFAULT PARAMETER VALUES FOR RUN,I2)
925 FORMAT(1H0,*SEASON NUMBER*,I3,/,18X,8(10X,I2),8X,*TOTAL*)
910 FORMAT(* TOTAL PRODUCTION*,4X,8F12.0)
926 FORMAT(1H ,*AVAILABLE OUTPUT*,4X,8F12.0,/,1H ,*TOTAL CONSUMPTION*,
   2          3X,8F12.0)
928 FORMAT(1H ,*LAND AREA CROP 1*,4X,9F12.0,/,1H ,
   2         *LAND AREA CROP 2*,4X,9F12.0)
935 FORMAT(1H0,* VALUES BY CROP*,/,25X,3(* TOTAL*,9X),2(* VALUE*,9X),
   2      * CASH COST*,/,23X,* PRODUCTION*,6X,* LABOR*,9X,* SEED*,
   3      8X,*ADDED AG*,6X,* ADDED FAM*,7X,* PER ACRE*,
   4      4X,* FERTILIZER*)
936 FORMAT(1H ,5X,I1,14X,3F13.0,5X,2E13.4,F13.2)
937 FORMAT(1H ,3X,* TOTAL*,11X,F13.0,26X,5X,2E13.4,13X,F13.0)
940 FORMAT(* PROFIT/ACRE(LOCAL)*,2X,8F12.2,/,* PROFIT/ACRE(HYV)*,
   2      4X,8F12.2)
941 FORMAT(* COST/ACRE(LOCAL)*,4X,8F12.2,/,* COST/ACRE(HYV)*,
   2      6X,8F12.2)
942 FORMAT(* LABOR/ACRE(LOCAL)*,3X,8F12.2,/,* LABOR/ACRE(HYV)*,5X,
   2      8F12.2)
943 FORMAT(* PURCHASES OF RICE*,3X,8F12.2)
944 FORMAT(* SALES OF RICE*,7X,8F12.2)
945   FORMAT(* STOCK*,15X,8F12.2)
951 FORMAT(* HIRED LABOR*,9X,9F12.0)
946 FORMAT(* PER FAM AG.CREDIT*,2X,9F12.0)
960 FORMAT (* WAGE LABOR*,10X,9F12.0)
961 FORMAT(* FAMILY LABOR*,8X,8F12.0)
962 FORMAT (* TOTAL EMPLOYMENT*,4X,9F12.0)
963 FORMAT(* LABOR USE RATE *,4X,8F12.2)
964 FORMAT(* PER CAP EARNING*,5X,8F12.2)
965 FORMAT(* PER CAP CASH INC*,4X,8F12.3,/,* PER FAM LOAN TAKEN*,
   2        1X,9F12.0 )
966 FORMAT(* PER CAP CONS YEAR*,3X,8F12.2,/,* PER CAP CONS DAY*,

   2      4X,8F12.3)
967 FORMAT(* CALORIES PER DAY*,4X,8F12.2,/,* PER FAM SURPLUS*,
   2      5X,8F12.2)
998 FORMAT (* TAX *,14X,9F12.0 )
999 FORMAT (* PER FAM TAX *,8X,8F12.0 )
968 FORMAT(* VALUE ADDED FAMILY*,2X,9E12.4)
969 FORMAT(* VALUE ADDED AGRI*,4X,9E12.4)
970 FORMAT(1H1,* YEAR TOTALS FOR*,F5.0,/,1H0,* CLASS*,7X,8I12,5X,
   2      *TOTAL*)
971 FORMAT(* TOTAL PRODUCTION*,4X,9F12.0,/,* PER CAP PROD*,8X,8F12.3)
973   FORMAT(* CONSUMPTION*,9X,9F12.0)
974 FORMAT(* YEAR SALES*,10X,8F12.2,/,* YEAR PURCHASES*,5X,8F12.2)
977 FORMAT(* PER FAM CASH INC*,4X,8F12.2,/,* PER CAP SAVING*,6X,
   2      8F12.2)
978 FORMAT(* PER FAM SAVING*,6X,8F12.2,/,* PER CAP CASH BAL*,4X,
   2        8F12.2)
979 FORMAT(* PER FAM CASH BAL*,4X,8F12.2,/,* PER FAM DEBT*,8X,8F12.2)
981   FORMAT(* PER FAM EARNINGS*,4X,8F12.2)
983 FORMAT(* PER CAP DISPIN*,6X,8F12.2,/,* PER FAM DISPIN*,6X,8F12.2)
990 FORMAT(1H0,* LABOR PROFILE AT TIME T=*,F5.2)
991 FORMAT (* CLASS EARNINGS*,7X,9F12.0)
995 FORMAT(1H0,5X,* CLASS*,15X,8I12)
996 FORMAT(* HIRED LABOR USED*,4X,8F12.2,/,* WAGE LABOR*,
   2      10X,8F12.2)
997 FORMAT(* EMPLOYMENT*,10X,8F12.2)
721   FORMAT(*1SEASONAL VALUES,  SEASON NUMBER*,I3,*  TIME =*,   F5.2,/,
   2       *0      CLASS*,8X,8I12)
722   FORMAT(*0ARC*,17X,8F12.2)
723   FORMAT(*0PPHYV*,15X,8F12.2)
724   FORMAT(*0PPARC*,15X,8F12.2)
725   FORMAT(*0FAM*,17X,8F12.2)
726   FORMAT(*0LAND*,16X,8F12.2)
727   FORMAT(*0POPN*,16X,8F12.0)
728   FORMAT(*0FERTA CROP 1*,8X,8F12.2,/,*0FERTA CROP 2*,8X,8F12.2)
729   FORMAT(*0PRI*,17X,8F12.2)
730   FORMAT (*0WGRT= *,F12.2,*AVPR1 = *,F12.2,* AVPR2 = *,F12.2)
735   FORMAT (*0PRF*,17X,8F12.2)
731   FORMAT(*0YLDA CROP 1*,9X,8F12.2,/,*0YLDA CROP 2*,9X,8F12.2)
732   FORMAT(*0YLDFA CROP 1*,8X,8F12.2,/,*0YLDFA CROP2*,8X,8F12.2)
733   FORMAT(*0OUTPUT CROP 1*,7X,8F12.2,/,*0OUTPUT CROP 2*,7X,8F12 .2)
      END
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      SUBROUTINE SEASO
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPPT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),        TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON /ALLO/ POP(4),FFM(4),LND(4),AVLND(4),AFAS(8,1),LAND(8),
     2    POP74(4),PPARC(3,8),PPHYV(3,8),ARC(3,8),ARSH(8,2,1),PPFM(4)
      COMMON/SEABLOC / NJ2,NDTS(3,2),PPAL,VOUTPUT(8,2,1),XSEED(8,2,1)
     2     ,PRI(8),PRF(8),TXNAG(8,2,1),PRINDX,XNAG(8,2,1)
      COMMON/ TEMP / SEEDC(8),YLDA(8,2,1),YLDFA(8,2,1),SSEEDC(8)
      DIMENSION A(3,2),B(3,2),C(3,2),AVPRZEO(2),FINDX(8),FET(3,2),WI(3),
     2     PRS(2),RLAND(8),AROC(3),PPYRW(8),PPRENT(8,2,1),
     3     AGLAB(8),PPIR(3,2),PPLT(3,2),CPLTA(8,2,1),COTHA(8,2,1),
     4     FLABA(8),ONFIN(8),AROW(8,2,1),
     5     AROR(8,2,1),XFERT(8,2,1),XIRG(8,2,1),XOTH(8,2,1),
     6     XRENT(8,2,1),XSEED(8,2,1),ERENT(8),OCPIN(8),AROCP(8),
     7     XPLT(8,2,1), SEEDA(3,2) ,U2(8),AVFET(3,2)
      REAL LAB,LHLAB,NOTS,K5
C          SEASONAL FERTILIZE-YIELD COEFFICIENT
      DATA ((A(N,J),J=1,2),N=1,3)/ 18.19,40.89,18.18,34.90,18.01,34.90/
      DATA ((B(N,J),J=1,2),N=1,3) / 5.49,6.20,5.49,10.73,10.40,10.73 /
      DATA ((C(N,J),J=1,2),N=1,3) / -.26,-.60,-.26,-3.25,-3.65,-3.25 /
      DATA  SEEDA / 6*.25 /
      DATA WGRTZEO,AVPRZEO / 8.,120.,110. /

      DATA FINDX / 1.4,.6,1.6,.7,1.6,.7,1.3,.6 /
C          SEASONAL FERTILIZER AMOUNT
      DATA ((FET(N,J),J=1,2),N=1,3) /.73,.92,.19,.77,.22,.74 /
      DATA RLAND,ONFIN / 16*0. /
      DATA CPLTA,PPRENT / 16*25.,16*0. /
      DATA ((COTHA(I,J,1),I=1,8),J=1,2) / 8*100.,8*125. /
      DATA((PPIR(N,J),J=1,2),N=1,3) / 1.,1.,4*0. /
      DATA((PPLT(N,J),J=1,2),N=1,3) / 6*1. /
      DATA PPLOSS,WI / .35,3*1.0 /
      DATA PPYRW/2(300.),2(240.),2(220.),2(200.) /
      DATA OCPFT,AROC/500., .1, .05,  0. /
      DATA RENTP,RENTA / 2*0. /
      DATA U2 /2(240.),2(150.),2(90.),2(45.) /
      K6=1.2
      RTFU1=0.   $  RTFU2=0.
      IF(T.GE.RTIM1) RTFU1=RTF1
      IF(T.GE.RTIM2) RTFU2=RTF2
      AVFET(NOWS,1)=FET(NOWS,1)*(1.+RTFU1)
      AVFET(NOWS,2)=FET(NOWS,2)*(1.+RTFU2)
C          TOTAL AREA BY CROP
      DO 25 I=1, NCLS
C          NJ2=2 IMPLIES CROP 1 HAS ALREADY RECEIVED SEASONAL VALUES
      DO 26 J=NJ2,NCROP
      DO 26 K=1, NIRG
      IF(J.NE.2) GO TO 11
C          IF CROP 2 BEING HARVESTED,DO NOT CALCULATE
      IF(FLAGHY(K).GT.0.) GO TO 26
   11 CONTINUE
      WGRT=WGRTZEO*(1.+RTW*T)
      AVPR(1,1)= AVPRZEO(1)*(1.+RTPR1*T)
      AVPR(2,1)= AVPRZEO(2)*(1.+RTPR2*T)
      PRINDX=1.+RTIN*T
      PRS(J)= K6*AVPR(J,1)
C          FERTILIZER RATE
      FERTA(I,J,K)=AVFET(NOWS,J)*FINDX(I)
C          YIELD RATE
      YLDFA(I,J,K)=A(NOWS,J)+B(NOWS,J)*FERTA(I,J,K)+C(NOWS,J)
     2     *FERTA(I,J,K)*FERTA(I,J,K)
      YLDA(I,J,K)=YLDFA(I,J,K)*(1.-PPLOSS)*WI(NOWS)
      OUTPUT(I,J,K)=ARA(I,J,K)*YLDA(I,J,K)
C          CALCULATE PROPORTION OF OUTPUT DUE SHARECROPPERS
      AROW(I,J,K) = ARA(I,J,K)-ARSH(I,J,K)
      AROR(I,J,K) = AROW(I,J,K)+ALPHA*ARSH(I,J,K)
      BETA(I,J,K) = AROR(I,J,K)/ARA(I,J,K)
C          TOTAL FERTILIZER
      FERT(I,J,K) = ARA(I,J,K)*FERTA(I,J,K)
C          TOTAL SEED
      SSEED(I,J,K) = ARA(I,J,K)*SEEDA(J,K)
      VOUTPUT(I,J,K) = AVPR(J,K)*OUTPUT(I,J,K)
C                    NON-AGRICULTURAL COSTS
      XFERT(I,J,K) = FERTA(I,J,K)*PRF(I)*ARA(I,J,K)
      XIRG(I,J,K)=PPIR(NOWS,J)*PRI(I)*ARA(I,J,K)
      XPLT(I,J,K) =PPLT(NOWS,J)*CPLTA(I,J,K)*ARA(I,J,K)
      XOTH(I,J,K) = COTHA(I,J,K)*ARA(I,J,K)
      XCSNAG(I,J,K) = (XFERT(I,J,K)+XIRG(I,J,K)+XPLT(I,J,K)
     2     +XOTH(I,J,K))/NDTS(NOWS,J)
C                    AGRICULTURAL COSTS, EXCLUDING LABOR
C          LABOR COSTS CALCULATED IN INCOM
      XRENT(I,J,K) = PPRENT(I,J,K)*RENTP*ARA(I,J,K)
      XSEED(I,J,K) = SSEED(I,J,K)*PRS(J)
      XCSAGP(I,J,K) = ( XRENT(I,J,K)+XSEED(I,J,K))/NDTS(NOWS,J)
      AGLAB(I)=POPN(I)*PPAL
      FAMLAB(I) = AGLAB(I)*PPYRW(I)
      FLABA(I)= AMIN1(FAMLAB(I)/(ARA(I,1,1)+ARA(I,2,1)),U2(I))
      FLAB(I,J) = FLABA(I)* ARA(I,J,K)
   26 CONTINUE
      SEEDC(I)=SSEED(I,1,1)+SSEED(I,2,1)
      IF(I.GT.4) GO TO 50
      WLAB(I)=FAMLAB(I)-(FLAB(I,1)+FLAB(I,2))
   50 CONTINUE
      IF(NJ2.GT.1) GO TO 25
      AROCP(I) = AROC(NOWS)*(ARA(I,1,1)+ARA(I,2,1))
C                    OTHER INCOME
      ERENT(I) = RLAND(I)*RENTA
      OCPIN(I) = AROCP(I)*OCPFT
      OTHIN(I)= (ERENT(I)+OCPIN(I)+ONFIN(I))/NDTS(NOWS,1)
      TOTHIN(I)=TOTHIN(I)+NDTS(NOWS,1)*OTHIN(I)
   25 CONTINUE
      TWLAB=0.
      DO 55 I=1,4
   55 TWLAB= TWLAB+WLAB(I)

      DO 56  I=1,4
   56 PPWL(I)=WLAB(I)/TWLAB
      DO 57 I=5,8
   57 PPWL(I)=0.
      RETURN
      END
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      SUBROUTINE ALLOC
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),MGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),       TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON /ALLO/ POP(4),FFM(4),LND(4),AVLND(4),ARAS(8,1),LAND(8),
     2    POP74(4),PPARC(3,8),PPHYV(3,8),ARC(3,8),ARSH(8,2,1),PPFM(4)
      DIMENSION MEMB(4),C1(4),C2(3,8),C3(3,8),NMEMB(4),
     2              AVFSZ(4),POPNM(4),POPNN(4),LNDM(4),LNDN(4),
     3   PPA(3,8),RTA(3,8),PPH(3,8),RTH(3,8),SHRLND(4),AVSHR(4),ARSHM(4),
     4     ARSHN(4),ARSD(8),AVAR(8),GAMMA(4)
      REAL MEMB,NMEMB,LNDM,LNDN,LND,LAND
      DATA (FFM(M),M=1,4) / 13312.,11238.,3026.,1424. /
      DATA (LND(M),M=1,4) / 3993.,14603.,11196.,8680. /
      DATA TOTLND /38470./
      DATA (C1(M),M=1,4)/.95,.95,.95,.95  /
      DATA ((PPA(N,I),I=1,8),N=1,3) /.96,.396,.743,.22,.38,.138,.226,
     2    .11,  .80,.46,.247,.397,.568,.408,.620,.478,  8*.93    /
      DATA ((RTA(N,I),I=1,8),N=1,3) / 8*.03,   8*-.01,    8*0.0 /
      DATA ((PPH(N,I),I=1,8),N=1,3) /.968,.976,.970,.974,.972,.975,.974,
     2    .973,    .50,.46,.50,.46,.50,.46,.50,.46,    .46,.40,.46,.40,
     3    .46,.40,.46,.40 /
      DATA ((RTH(N,I),I=1,8),N=1,3) /8*.01,  8*.05,  8*.05 /
      DATA ((C2(N,I),I=1,8),N=1,3)/1.3,7*.95,   8*.8,  1.5,1.5,6*.95/
      DATA ((C3(N,I),I=1,8),N=1,3)/8*.99,  8*.8,  8*.95 /
      DATA GAMMA /.6,.4,-.2,-.8 /
      DO 20 M=1,4
      MEMB(M)=AMIN1(PPFM(M),C1(M))*FFM(M)
      NMEMB(M)=FFM(M)-MEMB(M)
      AVLND(M)=LND(M)/FFM(M)

      AVFSZ(M)=POP(M)/FFM(M)
      POPNM(M)=MEMB(M)*AVFSZ(M)
      POPNN(M)=POP(M)-POPNM(M)
      SHRLND(M)=GAMMA(M)*PRPSH*(1.+RTSH*T)*TOTLND
      AVSHR(M)=SHRLND(M)/FFM(M)
      ARSHM(M)=AVSHR(M)*MEMB(M)
      ARSHN(M)=AVSHR(M)*NMEMB(M)
      LNDM(M)=MEMB(M)*AVLND(M)
   20 LNDN(M)=LND(M)-LNDM(M)
      DO 30 MB=1,4
C       MAKE TRANSFORMATION FROM INCOME CLASSES TOSUBCLASSES
      MM=2*MB-1            $         MN=2*MB
      FAM(MM)=MEMB(MB)     $         FAM(MN)=NMEMB(MB)
      POPN(MM)=POPNM(MB)             $     POPN(MN)=POPNN(MB)
      LAND(MM)=LNDM(MB)
      LAND(MN)=LNDN(MB)
      ARSD(MM)=ARSHM(MB)
      ARSD(MN)=ARSHN(MB)
   30 CONTINUE
      DO 10 I=1,NCLS
      AVAR(I)=LAND(I)+ARSD(I)
      PPARC(NOWS,I)=PPA(NOWS,I)*(1.+RTA(NOWS,I)*T)
      IF (NOWS.EQ.2.AND.PPARC(NOWS,I).LT.0.10)  PPARC(NOWS,I)=0.1
      PPHYV(NOWS,I)=PPH(NOWS,I)*(1.+RTH(NOWS,I)*T)
      ARC(NOWS,I)=AMIN1(PPARC(NOWS,I),C2(NOWS,I))*AVAR(I)
      ARSH(I,2,1)=PPHYV(NOWS,I)*ARSD(I)
      ARSH(I,1,1)=ARSD(I)-ARSH(I,2,1)
      J=2
      NOWH=NOWHAR(J)
      DO 10 K=1,NIRG
C           DETERMINE WHETHER CURRENTLY IN HARVEST PERIOD
C           IF CROP 2 NOW IN HARVEST,SET FLAG HIGH YIELD AND STORE NEXT
C           SEASON≠S LAND ALLOCATION
      IF(ST.LE.T1(NOWH,J,K)+.0000001) GO TO 12
      IF(ST.GT.T2(NOWH,J,K)+.0000001) GO TO 12
      FLAGHY(K)=1.
      ARAS(I,K)=AMIN1(PPHYV(NOWS,I),C3(NOWS,I))*ARC(NOWS,I)
      ARA(I,1,K)=ARC(NOWS,I)-ARAS(I,K)
      GO TO 10
C           ASSIGN LAND ALLOCATION
   12 ARA(I,2,K)=AMIN1(PPHYV(NOWS,I),C3(NOWS,I))*ARC(NOWS,I)
      ARA(I,1,K)=ARC(NOWS,I)-ARA(I,2,K)
   10 CONTINUE
   80 FORMAT(1H0,* AREA ALLOC CROP1*,3X,8F12.2,/,* AREA ALLOC CROP2*,
     2     3X,8F12.2,/,* AREA STORED CROP2*,2X,8F12.2)
      RETURN
      END
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      SUBROUTINE PRODUC
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPET,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCRCPER,T1(3,2,1),WGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),          TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON/PROBLOC/HVLPOU(3,2),PVLA(3,2),AHVL(8),APVL(8),RH(8,2,1),
     2             HVL(8,2,1),PVL(8,2,1),U1,EMOH(8,2,1),EMOP(8,2,1),
     3              SLHLAB(8),SFMLAB(8),SLAB(8),EMO(8,2,1),WAGMO(8),
     4            GMO(8),EMPMO(8),HIRMO(8)
      REAL LAB,LHLAB,DHLAB,NDT
C         LABOR RATES
      DATA ((HVLPOU(N,J),N=1,3),J=1,2) / 1.2,1.1,1.3,.9,.9,1.0 /
      DATA ((PVLA(N,J),J=1,2),N=1,3) / 30.,44.,28.,40.,28.,40. /
      DHLAB=0.
      DO 40 I=1,NCLS
   40 FMLAB(I)=0.
C             RATE VARIABLES FOR TIME T
      DO 71 I=1,NCLS
      DO 70 J=1,NCROP
      DO 70 K=1,NIRG
      NOWH=NOWHAR(J)     $  T15=T1(NOWH,J,K)   $   T25=T2(NOWH,J,K)
      RH(I,J,K)= OUTPUT(I,J,K)*SEAVAL(ST,T15,T25)
      AVLOPT(I,J,K) =BETA(I,J,K)*RH(I,J,K)
      HVL(I,J,K) =                 RH(I,J,K)  *HVLPOU(NOWH,J)
      PVL(I,J,K)=PVLA(NOWH,J)*ARA(I,J,K)/NDT(NOWH,J,K)
      IF(RH(I,J,K).GT.0.001) PVL(I,J,K)=0.
      IF(ST.GE.T1(NOWS,J,K)) PVL(I,J,K)=0.
      HLH(I,J,K)=AMAX1(HVL(I,J,K)-FLAB(I,J),0.)
      PLH(I,J,K)=AMAX1(PVL(I,J,K)-FLAB(I,J),0.)
      FMLAB(I)=FMLAB(I)+(PVL(I,J,K)+HVL(I,J,K))-(PLH(I,J,K)+HLH(I,J,K))
   70 CONTINUE
      AHVL(I)=HLH(I,1,1)+HLH(I,2,1)
      APVL(I)=PLH(I,1,1)+PLH(I,2,1)
      DHLAB=DHLAB+AHVL(I)+APVL(I)
   71 CONTINUE
      DO 75 I=1,NCLS
      LHLAB(I)=DHLAB*PPWL(I)
      WAGE(I)=LHLAB(I)*WGRT
   75 CONTINUE
C             STATE VARIABLES FOR TIME T
      DO 50 I=1,NCLS
      DO 51 J=1,NCROP
      DO 51 K=1,NIRG
      SOPT(I,J,K)= SOPT(I,J,K)+DT*RH(I,J,K)
      SAVLO(I,J)=SAVLO(I,J)+DT*AVLOPT(I,J,K)
      LAB(I,J,K) = LAB(I,J,K)+DT*(HVL(I,J,K)+PVL(I,J,K))
      HVLH(I,J,K)=HVLH(I,J,K)+DT*HLH(I,J,K)
      PVLH(I,J,K)=PVLH(I,J,K)+DT*PLH(I,J,K)
      EMOH(I,J,K)=EMOH(I,J,K)+DT*HLH(I,J,K)
      EMOP(I,J,K)=EMOP(I,J,K)+DT*PLH(I,J,K)
      EMO(I,J,K)=EMOH(I,J,K)+EMOP(I,J,K)
      SHLAB(I,J,K)=HVLH(I,J,K)+PVLH(I,J,K)
   51 CONTINUE
      SLHLAB(I)=SLHLAB(I)+DT*LHLAB(I)
      SFMLAB(I)=SFMLAB(I)+DT*FMLAB(I)
      SLAB(I)=SLHLAB(I)+SFMLAB(I)
      WAGMO(I)=WAGMO(I)+DT*LHLAB(I)
      GMO(I)=GMO(I)+DT*FMLAB(I)
      EMPMO(I)=WAGMO(I)+GMO(I)
      HIRMO(I)=EMO(I,1,1)+EMO(I,2,1)
      TWAGE(I)=TWAGE(I)+DT*WAGE(I)
   50 CONTINUE
      RETURN
      END
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      SUBROUTINE CONSUMP
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),        TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(3,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NOT(3,2,1),LOAN(8),TARA(2,1)
      COMMON/CONBLOC/STOG(8,1),CONS(8,1),DSTOG(8,1),DSTOGU(8,1),
     2 RNUTN(8,1),RNUTP(8,1),STINC,DER,K1
      COMMON /INCO / BORROW(8),PPI(8),SAVING(8),CSHCST(8,2,1),
     2            CSHIN(8),PRICE1(2),PRICE2(2),XTAX(8),PPC(8),CCSHCST(8),
     3            CSHREV(8),FDCST(8),XHLAB(8,2,1),XCSAG(8,2,1),DISPIN(8),
     4            OCONX(8),CONEX(8),ACREDIT(8)
      DIMENSION QSEED(8),YSTOCK(8,1)
      REAL K1
      DIMENSION VALFN1(4),VALFN2(5),VALFN3(4),VALFN4(4),SINDX(13)
      DATA VALFN1 /.1,.85,.95,1.0 /
      DATA VALFN2/1.0,.9,.8,.7,.6/
      DATA VALFN3/1.5,3.3,6.3,12.5/
      DATA VALFN4/0.,1.,3.3,8.5/
      DATA FN5/3./
      DATA RNUTP/8*4.0/
      DATA RNUTN/2*3.5,2*3.59,2*4.04,2*4.17/
      DATA SINDX/0.88,0.92,1.00,1.01,1.02,1.02,1.00,1.08,1.14,1.08,
     2     1.00,0.93,0.88 /
      DO 60 I=1,NCLS
C                     FOR CONSUMPTION PURPOSES, LOCAL AND HIGH YIELDSUMMED
      AVLOCON= AVLOPT(I,1,1)+ AVLOPT(I,2,1)
      DO 60 J=1,NCROPER
      JP=J
      IF(J.GE.2) JP=J+1
C                 RATE VARIABLES FOR TIME T
      PRICE1(JP)= AVPR(JP,1)*TABLIE(SINDX,0.,.083,12,ST)
      PRICE2(JP)= .9*PRICE1(JP)
      XFN1 = STOG(I,JP)/(RNUTP(I,JP)*POPN(I))
      XFN2 = PRICE1(JP)/PRICEN
      XFN3 = PRICE2(JP)/AVPR(JP,1)
      XFN4= DEBT(I)/DT*SALES(I,JP)*PRICE2(JP)
      FN1 = TABLIE(VALFN1,0.,.02,3,XFN1)
      FN2=TABLIE(VALFN2,0.,.5,4,XFN2)
      FN3 = TABLIE(VALFN3,.5,.5,3,XFN3)
      FN4 = TABLIE(VALFN4,0.,1.,3,XFN4)
      PCCONS(I,JP)=RNUTN(I,JP)*FN1*F1
      CONS(I,JP)=PCCONS(I,JP)*POPN(I)
C                     CHECK TIME UNTIL NEXT HARVEST (TTSH)
      NOWH=NOWHAR(JP)
      TTSH=AMAX1(0.,T1(NOWH,JP,1)-ST)
      IF(J.GE.2) GO TO 61
      NOWH=NOWHAR(2)
      TTSH = AMIN1 (TTSH,T1(NOWH,2,1)-ST)
   61 CONTINUE
      QSEED(I)=SSEED(I,1,1)+SSEED(I,2,1)
      TEMP = RNUTP(I,JP)*POPN(I)
      DSTOGU(I,JP)=TEMP*(TTSH+STINC)*FN2*F2+QSEED(I)
      YSTOCK(I,JP) = TEMP*K1
      SALES(I,JP) = AMAX1(FN3*F3*(STOG(I,JP)-DSTOG(I,JP)),0.)+
     2              AMAX1(FN4*F4*(STOG(I,JP)-YSTOCK(I,JP)),0.)
      PURCH(I,JP)=AMAX1(FN5*F5*(DSTOG(I,JP)-STOG(I,JP)),0.)
C                 STATE VARIABLES FOR TIME T
      STOG(I,JP) = STOG(I,JP)+DT*(AVLOCON+PURCH(I,JP)-CONS(I,JP)
     2     -SALES(I,JP))
      DSTOG(I,JP)=DSTOG(I,JP)+DER*(DSTOGU(I,JP)-DSTOG(I,JP))
      TCONS(I,JP)=TCONS(I,JP)+DT*CONS(I,JP)
      SSALES(I,JP)=SSALES(I,JP)+DT*SALES(I,JP)
      SPURCH(I,JP)=SPURCH(I,JP)+DT*PURCH(I,JP)
   60 CONTINUE
      RETURN
      END
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      SUBROUTINE INCOM
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,FTM1,RTM2,RTM3,RTM4,GPT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PFWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(5,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),        TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON/SEABLOC / NJ2,NDTS(3,2),PPAL,VOUTPUT(8,2,1),XCRED(8,2,1)
     2    ,PPI(8),PPF(8),TXNAG(8,2,1),PRINDX,XNAG(8,2,1)
      COMMON /INCO / BORROW(8),PPI(8),SAVING(8),CSHCST(8,2,1),
     2          CSHIN(8),PRICE1(2),PRICE2(2),XTAX(8),PPC(8),CCSHCST(8),
     3          CSHREV(8),FDCST(8),XHLAB(8,2,1),XCSAG(8,2,1),DISPIN(8),
     4          OCONX(8),CONEX(8),ACREDIT(8)
      COMMON/B/ TDISP(8),TERNG,TLOAN,TCREDIT,CREDIT(8),PFCRDT(8)
      DIMENSION D1(8),RTINT(8)
      REAL LOAN
      DATA D1 /0.4,0.2,0.4,0.2,0.2,0.2,0.2,0.2 /
      DATA RTINT/.15,.50,.15,.50,.15,.50,.15,.50 /
      G3=1.
C             RATE VARIABLES FOR TIME T
      DO 35 I=1,NCLS
      DO 35 J=1,NCROP
      DO 35 K=1,NIRG
      XHLAB(I,J,K)=(HLH(I,J,K)+PLH(I,J,K))*WGRT
      XCSAG(I,J,K) = XCSAGP(I,J,K)+XHLAB(I,J,K)
      XCRED(I,J,K)=D1(I)*(XCSNAG(I,J,K)+XCSAGP(I,J,K)+XHLAB(I,J,K))
     2     *RTINT(I)
      CSHCST(I,J,K)=XCSNAG(I,J,K)+XCSAG(I,J,K)+XCRED(I,J,K)
      XNAG(I,J,K)=XCSNAG(I,J,K)+XCRED(I,J,K)
   35 CONTINUE
      DO 30 I=1,NCLS
      DO 32 J=1,NCROPER
      JP=J      $        IF(J.GE.2) JP=J+1
      FDCST(I)=PURCH(I,JP)*PRICE1(JP)
   32 CSHREV(I)=SALES(I,JP)*PRICE2(JP)
      ACREDIT(I)=(XCRED(I,1,1)+XCRED(I,2,1))/RTINT(I)
      CCSHCST(I)=CSHCST(I,1,1)+CSHCST(I,2,1)
      CSHIN(I)=CSHREV(I)+OTHIN(I)+WAGE(I)
      PPI(I) = G3*DEBT(I)*(1.+RTINT(I))
      DISPIN(I)=CSHIN(I)-CCSHCST(I)-XTAX(I)-PPI(I)
      OCONX(I) = PPC(I)*DISPIN(I)/PRINDX
      CONEX(I) = FDCST(I)+OCONX(I)
      SAVING(I)=DISPIN(I)-CONEX(I)
   30 CONTINUE
C             STATE VARIABLES FOR TIME T
      DO 10 I=1,NCLS
      DO 12 J=1,NCROP
      DO 12 K=1,NIRG
      TXNAG(I,J,K)=TXNAG(I,J,K)+DT*XNAG(I,J,K)
   12 TCSHCST(I,J,K)=TCSHCST(I,J,K)+DT*CSHCST(I,J,K)
      TCSHIN(I) = TCSHIN(I)+DT*CSHIN(I)
      TDISP(I)=TDISP(I)+DT*DISPIN(I)
      CASBAL(I)=CASBAL(I)+DT*(SAVING(I)+ACREDIT(I))+BORROW(I)
      IF (CASBAL(I).LT.0.) GO TO 1
      BORROW(I)=0.      $    GO TO 2
    1 BORROW(I)=-CASBAL(I)
    2 DEBT(I)=DEBT(I)+BORROW(I)+DT*(RTINT(I)*DEBT(I)-PPI(I)+ACREDIT(I))
      TSAVING(I)=TSAVING(I)+DT*SAVING(I)
      LOAN(I)=LOAN(I)+BORROW(I)+DT*ACREDIT(I)
      CREDIT(I)=CREDIT(I)+DT*ACREDIT(I)
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE HARCHK                                                 HARCHK   2
      COMMON /BLOCK/ DUR,DT,DETFRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,  HARCHK   3
     2     DSS,ALPHA,RTF,RTI,RTW,RTPRI,FTPR2,PRICEN,PPFM1,PPFM2,PPFM3,  HARCHK   4
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F HARCHK   5
     +4,F5,FTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX                       HARCH1   1
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT, HARCHK   7
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T, HARCHK   8
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1) HARCHK   9
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ, HARCHK  10
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1), HARCHK  11
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),    HARCHK  12
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),   HARCHK  13
     8     LHLAB(8),       TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,    HARCHK  14
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8), HARCHK  15
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TARA(2,1)   HARCHK  16
      COMMON /HAR/ NSTOR,FLAGPR,NTHAR(2)                                HARCHK  17
C          NUMBER OF HARVESTS PER YEAR,BY CROP                          HARCHK  18
      DATA NTHAR / 3 , 3 /                                              HARCHK  19
      DO 6 J=1,NCROP                                                    HARCHK  20
      NOWH=NOWHAR(J)                                                    HARCHK  21
      DO 6 K=1,NIRG                                                     HARCHK  22
      IF(ST.GT.T2(3,1,1)+.0001.AND.J.EQ.1) GO TO 6                      HARCH    2
C          CHECK FOR END OF HARVEST PERIOD                              HARCHK  24
      IF(T2(NOWH,J,K)-.0001.GT.ST) GO TO 6                              HARCH    3
      IF(J.NE.2) GO TO 7                                                HARCHK  25
C          FOR LOCAL VARIETY, HARVEST POINTER IS INCREMENTED            HARCHK  27
C          FOR HIGH YIELD, THE SEASONAL HIGH YIELD ALLOCATION FLAG      HARCHK  28
C          IS CHECKED. FLAGHY NE.ZERO MEANS NEW SEASON HAS STARTED.     HARCHK  29
      KJ=2                                                              HARCHK  30
      NSTOR = NOWS                                                      HARCHK  31
       NOWS=NOWS-1                                                      HARCHK  32
      IF(NOWS.LT.1) NOWS=3                                              HARCHK  33
      CALL PRINSTO                                                      HARCHK  34
C          SET PRINT FLAG,TAKE OFF HIGH YIELD FLAG                      HARCHK  35
      FLAGPR=1.  $  FLAGHY(1)=0.                                        HARCHK  36
C          IF HARVEST PERIOD OVER,CHANGE VALUE OF NOWAAP(J)             HARCHK  37
    7 NOWHAR(J)=NOWHAR(J)+1                                             HARCHK  38
      IF(NOWHAR(J).GT.NTHAR(J)) NOWHAR(J)=1                             HARCHK  39
    6 CONTINUE                                                          HARCHK  40
      RETURN                                                            HARCHK  41
      END                                                               HARCHK  42
```

```
      SUBROUTINE YEARLY
      COMMON /BLOCK/ DUR,DT,DETPRT,SELPRT,BEGPRT,PRTCHG,PRTVL1,PRTVL2,
     2    DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3    PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT,
     2    T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3    FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4   ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5    PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6    PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7    PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8    LHLAB(8),       TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9    FERTA(8,2,1),SEAS(3),FLAB(3,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1    FAM(8),SHLAB(8,2,1),SHLAB1(8),NDT(3,2,1),LOAN(8),TAPA(2,1)
      COMMON / PRNBLOC/ SPRDL(3,8),SCONSL(3,8),SPRDV(3,2),SHLABE(3,2),
     2           SSEEDV(3,2),SPRD(3),SFERT(3),SCONS(3),COSTA(2),PAR(5),
     3       SPRNEW(3,8),VADFAM(8,2,1),VADAG(8,2,1),
     4           CVADFAM(3,2),CVADAG(3,2),SVADAG(3),SVADFAM(3),
     5           PROFITA(8,2,1),COSTCC(8,2,1),VADFDUM(3,8),VADADUM(3,8),
     6           LABA(8,2,1) ,TPURCH(3,8),TSALES(3,8)
      COMMON/ YERBLOC/ TPRDL(8),TTCONSL(8),TPRDV(2),THLABV(2),TTCONS,
     2           TSEEDV(2),PCCSIN(8),TFERT   ,PCSVG(8),PFSVG(8),PCCSBL(8),
     3           PFCSBL(8),PFDBT(8),PCPRDL(8),TPRD,PCINC(8),TVADFAM(8),
     4           TVADAG(8),VVADFAM(2),VVADAG(2),YVADFAM,YVADAG,PCCONY(8),
     5           PCCOND(8),CALPDA(8),PFSURP(8),PFLOAN(8),ERNG(8),
     6           PCERNG(8),YPURCH(8),YSALES(8),PFERNG(8)
      COMMON/ADD/PFCSIN(8),TPSURP(8),PFINC(8)
      COMMON/B/ TDISP(8),TERNG,TLOAN,TCREDIT,CREDIT(8),PFCRDT(8)
      REAL LOAN
      REAL LAB,LHLAB
      REAL K4,K5
      DATA K4,K5 / 3.616,101.2 /
C                 THIS SUBROUTINE DOES YEARLY ACCOUNTING
      DO 17 I=1,NCLS
      TPRDL(I)=0.   $   TTCONSL(I)=0.   $   TVADFAM(I)=0.
      TVADAG(I)=0.   $   YPURCH(I)=0.   $   YSALES(I)=0.
   17 CONTINUE
      DO 19 J=1,NCROP
      TPRDV(J)=0.   $   THLABV(J)=0.   $   TSEEDV(J)=0.
      VVADFAM(J)=0.   $     VVADAG(J)=0.
   19 CONTINUE
      TPRD=0.   $   TFERT=0.   $   TTCONS=0.   $   YVADFAM=0.   $   YVADAG=0.
      TERNG=0.
      TLOAN=0.
      TCREDIT=0.
      DO 30 I=1,NCLS
      PCSVG(I)=TSAVING(I)/POPN(I)       $   PFSVG(I)=TSAVING(I)/FAM(I)
      PCCSBL(I)=CASBAL(I)/POPN(I)       $   PFCSBL(I)=CASBAL(I)/FAM(I)
      PCCSIN(I)=TCSHIN(I)/POPN(I)   $   PFCSIN(I)=TCSHIN(I)/FAM(I)
      PCINC(I)=TDISP(I)/POPN(I)
      PFINC(I)=TDISP(I)/FAM(I)
      PFDBT(I)=DEBT(I)/FAM(I)
      DO 31  LS=1,3
      TPRDL(I)=TPRDL(I)+SPRDL(LS,I)
      TTCONSL(I) = TTCONSL(I)+SCONSL(LS,I)

      TVADFAM(I)=TVADFAM(I)+VADFDUM(LS,I)
      TVADAG(I)=TVADAG(I)+VADADUM(LS,I)
      YPURCH(I)=YPURCH(I)+TPURCH(LS,I)
      YSALES(I)=YSALES(I)+TSALES(LS,I)
   31 CONTINUE
      PCPRDL(I)=TPRDL(I)/POPN(I)
      PCCONY(I)=TTCONSL(I)/POPN(I)
      PCCOND(I)=PCCONY(I)*K4
      CALPDA(I)=PCCOND(I)*K5
      PFSURP(I)=(TPRDL(I)-TTCONSL(I))/FAM(I)
      PFLOAN(I)=LOAN(I)/FAM(I)
      PFCRDT(I)=CREDIT(I)/FAM(I)
      ERNG(I)=TVADFAM(I)+TWAGE(I)+TOTHIN(I)
      PCERNG(I)=ERNG(I)/POPN(I)
      PFERNG(I)=ERNG(I)/FAM(I)
      TERNG=TERNG+ERNG(I)
      TLOAN=TLOAN+LOAN(I)
      TCREDIT=TCREDIT+CREDIT(I)
      TWAGE(I)=0.   $   TOTHIN(I)=0.   $   LOAN(I)=0.
      TDISP(I)=0.
      CREDIT(I)=0.
   30 CONTINUE
      DO 35 LS=1,3
      DO 33 J=1,NCROP
      TPRDV(J)=TPRDV(J)+SPRDV(LS,J)
      THLABV(J)=THLABV(J)+SHLABE(LS,J)
      TSEEDV(J)=TSEEDV(J)+SSEEDV(LS,J)
      VVADFAM(J)=VVADFAM(J)+CVADFAM(LS,J)
      VVADAG(J)=VVADAG(J)+CVADAG(LS,J)
   33 CONTINUE
      TPRD=TPRD+SPRD(LS)   $   TFERT=TFERT+SFERT(LS)
      TTCONS=TTCONS+SCONS(LS)
      YVADFAM=YVADFAM+SVADFAM(LS)
      YVADAG=YVADAG+SVADAG(LS)
   35 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PRINSTO
      COMMON /BLOCK/ DUR,DI,DETPRT,SELPRT,BEGPRT,PRTCHG,PRIVL1,PRIVL2,
     2     DSS,ALPHA,RTF,RTI,RTW,RTPR1,RTPR2,PRICEN,PPFM1,PPFM2,PPFM3,
     3     PPFM4,RTM1,RTM2,RTM3,RTM4,GRT,RTIM1,RTIM2,RTF1,RTF2,F1,F2,F3,F
     +4,F5,RTIN,KVARF,KVARI,PRPSH,RTSH,TXFLOR,RTX
      COMMON /ALLSUB/ NCLS,NCROP,NIRG,NOWHAR(2),NCROPER,T1(3,2,1),WGRT,
     2     T2(3,2,1),FLAGHY(1),ARA(8,2,1),OUTPUT(8,2,1),BETA(8,2,1),ST,T,
     3     FERT(8,2,1),SSEED(8,2,1),AVPR(2,1),XCSNAG(8,2,1),XCSAGP(8,2,1)
     4    ,OTHIN(8),FAMLAB(8),WAGE(8),PPWL(8),LAB(8,2,1),HVLH(8,2,1),KJ,
     5     PVLH(8,2,1),HLH(8,2,1),SOPT(8,2,1),SAVLO(8,2),AVLOPT(8,2,1),
     6     PURCH(8,1),SALES(8,1),TCONS(8,1),SSALES(8,1),SPURCH(8,1),
     7     PCCONS(8,1),POPN(8), WLAB(8),DEBT(8),CASBAL(8), TOTHIN(8),
     8     LHLAB(8),        TCSHCST(8,2,1),TCSHIN(8),TSAVING(8),NOWS,
     9     FERTA(8,2,1),SEAS(3),FLAB(8,2),FMLAB(8),PLH(8,2,1),TWAGE(8),
     1     FAM(8),SHLAB(8,2,1),SHLAB1(8),WDT(3,2,1),LOAN(8),TARA(2,1)
      COMMON/SEABLOC / NJ2,NDTS(3,2),PPAL,VOUTPUT(8,2,1),XCRED(8,2,1)
     2    ,PRI(8),PRF(8),TXNAG(8,2,1),PRINDX,XNAG(8,2,1)
      COMMON / PRNBLOC/ SPROL(3,8),SCONSL(3,8),SPRDV(3,2),SHLABE(3,2),
     2          SSEEDV(3,2),SPRD(3),SFERT(3),SCONS(3),COSTA(2),PAR(8),
     3       SPRNEW(3,8),VADFAM(8,2,1),VADAG(8,2,1),
     4          CVADFAM(3,2),CVADAG(3,2),SVADAG(3),SVADFAM(3),
     5          PROFITA(8,2,1),COSTCC(8,2,1),VADFDUM(3,8),VADADUM(3,8),
     6          LABA(8,2,1) ,TPURCH(3,8),TSALES(3,8)
      COMMON/ TEMP / SEEDC(8),YLDA(8,2,1),YLDFA(8,2,1),SSEEDC(8)
      REAL LAB,LABA
C           ZEROS SEASONAL VALUE,BY CROP
      SPRDV(NOWS,KJ)=0.    $    SHLABE(NOWS,KJ)=0.   $   SSEEDV(NOWS,KJ)=0.
      SCONS(NOWS)=0.    $    COSTA(KJ)=0.     $     TARA(KJ,1)=0.
      CVADFAM(NOWS,KJ)=0.    $    CVADAG(NOWS,KJ)=0.
C     SFERT SUMMED OVER CLASS AND CROP
      IF(KJ.EQ.1) SFERT(NOWS)=0.
C     TOTAL AREA,SUMMED OVER CLASSES
      DO 40 I=1,NCLS
      TARA(KJ,1) = TARA(KJ,1)+ARA(I,KJ,1)
      LABA(I,KJ,1)=LAB(I,KJ,1)/ARA(I,KJ,1)
      IF(KJ.EQ.2) GO TO 9
      SSEEDC(I)=SEEDC(I)
      SHLAB1(I)=SHLAB(I,1,1)
      SHLAB(I,1,1)=0.   $   HVLH(I,1,1)=0.   $   PVLH(I,1,1)=0.
      PAR(I)=ARA(I,1,1)
C     ZEROES SEASONAL VALUE,BY CLASS
      VADFDUM(NOWS,I)=0.     $      VADADUM(NOWS,I)=0.
      SPRNEW(NOWS,I)=0.     $     SPROL(NOWS,I)=0.
      SVADFAM(NOWS)=0.     $     SVADAG(NOWS)=0.

C                         SEASONAL PRODUCTION, LABOR, FERT,AND SEEDS
    9 SPRDV(NOWS,KJ) = SPRDV(NOWS,KJ)+SOPT(I,KJ,1)
      SHLABE(NOWS,KJ) = SHLABE(NOWS,KJ)+LAB(I,KJ,1)
      SFERT(NOWS) = SFERT(NOWS)+FERT(I,KJ,1)
      SSEEDV(NOWS,KJ) = SSEEDV(NOWS,KJ)+SSEED(I,KJ,1)
      SPRNEW(NOWS,I)=SPRNEW(NOWS,I)+SOPT(I,KJ,1)
      SPROL(NOWS,I) =  SPROL(NOWS,I)+SAVLO(I,KJ)
      VADFAM(I,KJ,1)=BETA(I,KJ,1)*VOUTPUT(I,KJ,1) - TCSHCST(I,KJ,1)
      VADAG(I,KJ,1)=VOUTPUT(I,KJ,1)-TXNAG(I,KJ,1)
      PROFITA (I,KJ,1)=(VOUTPUT(I,KJ,1) -TCSHCST(I,KJ,1)) / ARA(I,KJ,1)
      COSTCC(I,KJ,1)=TCSHCST(I,KJ,1)/ARA(I,KJ,1)
      CVADFAM(NOWS,KJ)=CVADFAM(NOWS,KJ)+VADFAM(I,KJ,1)
      CVADAG(NOWS,KJ)=CVADAG(NOWS,KJ)+VADAG(I,KJ,1)
      VADFDUM(NOWS,I)=VADFDUM(NOWS,I)+VADFAM(I,KJ,1)
      VADADUM(NOWS,I)=VADADUM(NOWS,I)+VADAG(I,KJ,1)
C                         SEASONAL CONSUMPTION AND SURPLUS
      IF(KJ.EQ.1) GO TO 10
C     DATA GIVEN BY CLASS ONLY
      SCONSL(NOWS,I) = TCONS(I,1)
      SCONS(NOWS) = SCONS(NOWS)+SCONSL(NOWS,I)
      TPURCH(NOWS,I)=SPURCH(I,1)
      TSALES(NOWS,I)=SSALES(I,1)
      TCONS(I,1)=0.    $    SSALES(I,1)=0.    $    SPURCH(I,1)=0.
   10 CONTINUE
C                         SEASONAL INCOME, PROFITS,ANDCOSTS
      COSTA(KJ) =COSTA(KJ)+TCSHCST(I,KJ,1)
   40 CONTINUE
      IF(KJ.EQ.2) GO TO 19
      SPRD(NOWS)=0.
   19 CONTINUE
      DO 21 I=1,NCLS
      SOPT(I,KJ,1)=0.    $     LAB(I,KJ,1)=0.     $     SAVLO(I,KJ)=0.
      TCSHCST(I,KJ,1)=0.
      TXNAG(I,KJ,1)=0.
   21 CONTINUE
      SPRD(NOWS) = SPRD(NOWS)+SPRDV(NOWS,KJ)
      SVADFAM(NOWS)=SVADFAM(NOWS)+CVADFAM(NOWS,KJ)
      SVADAG(NOWS)=SVADAG(NOWS)+CVADAG(NOWS,KJ)
      COSTA(KJ) = COSTA(KJ)/TARA(KJ,1)
      RETURN
      END
```

```
      SUBROUTINE NAMLST(NAMVAR, NVAR, ERROR)
      INTEGER BLANK,DOLLAR
      DIMENSION DUMMY(1),IDUMMY(1),NAMVAR(1)
      DIMENSION INT(4),LAST(4),NAME(4),VALUE(4)
      COMMON /BLOCK/ DUMMY
      EQUIVALENCE (DUMMY(1),IDUMMY(1))
      DATA BLANK,DOLLAR / 1H , 1H$ /
      ERROP=0.
10    READ(1,900) (NAME(I),INT(I),VALUE(I),LAST(I),I=1,4)
      IF(EOF(1).NE.0.)RETURN
      DO 50 I=1,4
      IF(NAME(I).EQ.BLANK)GO TO 45
      DO 30 J=1,NVAR
      IF(NAME(I).EQ.NAMVAR(J))GO TO 35
30    CONTINUE
      WRITE(2,901) NAME(I)
      ERROP = 1.
      RETURN
35    WRITE(2,902) NAME(I),VALUE(I)
      IF(INT(I).NE.BLANK)GO TO 40
      DUMMY(J) = VALUE(I)
      GO TO 45
40    IDUMMY(J) = VALUE(I)
45    IF(LAST(I).EQ.DOLLAR)RETUFN
50    CONTINUE
      GO TO 10
900   FORMAT(4(A6,1X,A1,E9.4,A1))
901   FORMAT(24H0**ERROR** VARIABLE NAME,A7,10H NOT FOUND)
902   FORMAT(1H0,A6,3H = ,E12.4)
      END
```

```
      FUNCTION SEAVAL(ST,T1,T2)
      IF(ST.LE.T1) GO TO 1
      IF(ST.GE.T2) GO TO 1
      T=ST-T1
      D=1/(T2-T1)
      W=6.28319*D
      SEAVAL=D*(1.- COS(W*T))
      GO TO 2
    1 SEAVAL=0.
    2 CONTINUE
      RETURN
      END
```

```
      FUNCTION TABLIE(VAL,SMALL,DIFF,K,DUMMY)
      DIMENSION VAL(1)
      DUM=AMIN1(AMAX1(DUMMY-SMALL,0.0),FLOAT(K)*DIFF)
      I=1.0+DUM/DIFF
      IF(I.EQ.(K+1)) I=K
      TABLIE=VAL(I)+((VAL(I+1)-VAL(I))/DIFF)*(DUM-FLOAT(I-1)*DIFF)
      RETURN
      END
```

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