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EVALUATING ALTERNATIVE SCENARIOS IN AGRICULTURAL DEVELOPMENT IN INDIA

by

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SYNOPSIS

This paper describes a current research project in national development, aimed at constructing a system dynamics model to evaluate development problems in India. The underlying premise on which the model construction is based is that the economy of India can be conveniently divided into two major sectors: those of agriculture and non-agriculture. Both these sectors are defined as being controlled by the government through the use of its own financial policies for generating investment in the development process. The investment is generated by assessing the domestic aspects of the economy and the government ability to borrow from external sources. The performance of the non-agriculture sector is, however, modelled in outline only. This limitation has been imposed since the study is basically concerned with agricultural development problems.

The agricutlure sector incorporates agricultural production, land development, irrigation, asset distribution and income distribution among wage earners, large and small farmers. The agricultural production has been split into major crop production, (rice and wheat), cash crop and livestock. The rice and wheat

production is computed from 8 different land states, each having their own yield values. These states result from permutating the two categories of farmers (large and small), the two types of land (irrigated and unirrigated) and two types of crop (rice and wheat). This configuration has facilitated the modelling of land ownership transfer and the derivation of the income and standards of living of different classes of rural population.

The model has been tested and validated by two means; one, by reproducing past behaviour (1965 to 1980) and, two, by running the model up to 1994 to check performances of the model against government projections. Initial results on policy experiments are also presented concerning growth and equity in agricultural development up to the year 2010.

INTRODUCTION

National development in general is an extremely complex subject, which has been traditionally treated in a piecemeal way, as a set of development projects or by purely economic models concerned solely with the generation and allocation of investments between development sectors, such as industry, agriculture, health, education, etc. Such economic analysis forms the core of the five-year development programmes and budgets of many third world countries. These development programmes often contain conflicting objectives, are highly optimistic and, in general, propagate the use of western style approaches to development problems. Such approaches often produce undesirable and unintentioned side-effects, which can accelerate disaster rather than prevent it. Awareness of this danger is increasing, but the development of procedures to aid its recognition are not in evidence. Development is in fact a non-linear, non-equilibrium, dynamic process, and emphasis needs to be placed on procedures which emphasize these aspects rather than the current static and empirical approaches.

The purpose of this paper is two-fold. Firstly, it is intended to demonstrate an alternative approach to piecemeal national development analysis in general and, secondly, it is intended to provide an application of that approach to a specific country. It represents an interim statement of ongoing research into the development of a system dynamics model of the Indian economy aimed at providing systemic insight into the

interaction of economic, social and political factors associated with growth. The approach is not intended as a replacement for conventional development planning. Rather it is put forward as a complimentary tool aimed at assessing the overall mode of evolution likely to result from government policy initiatives. The research builds on earlier work concerning the simulation of the national development process[1] but is oriented towards a detailed analysis of a specific sector of a particular economy.

The specific content of the paper concerns, firstly, the mode of development of the model, based on the definition of resource conversion modules and the procedures of qualitative system dynamics[2][3]. Secondly, the conversion of this model to a simulation model, involving the stages of quantification and parameterisation to represent the Indian economy (using DYSMAP)[4] is outlined. Here, emphasis has been placed on the detailed definition of the agriculture sector. The data concerning agricultural developments and for the rest of the economy have been collected from various Indian publications [5][6][7][8]. Thirdly, validation of the model and its use in policy analysis has been addressed. The model has been validated against historic data for the 15 years from 1965 to 1980 and also tested against government projections from 1980 to 1994. Finally, alternative future experiments have been conducted over the period 1980 to 2010.

DESCRIPTION OF THE MODEL

1. Overview of the model.

The Indian economy is essentially an agricultural economy. Agriculture accounts for more than 45% of the gross domestic product and nearly 70% of the total population live on agriculture or agriculture based industries. Consequently, any slight improvement in the performance of this sector, for example food output rates, employment levels and income distribution, contribute greatly towards national political and social stability. Conversely, deterioration of any one or more of these factors would be disastrous for the economy. Consequently, since the paper deals primarily with agricultural problems, the constituent parts of this sector have been considered in great detail. However, since the work is also concerned with alternative investment policies for the nation as a whole, it was felt necessary to include in the model a representation of the complete finance sector of the economy and also to have a less detailed non-agriculture sector. These model sectors are shown in Fig.1. The main circulation of finance is shown by the arrows of this diagram which represent the ultimate overall feedback process by which an attempt is made to control the total economy.

Fig.2 gives an indication of the various aspects of the economy which are represented within each of the model sectors of Fig.1. In the following sections of the paper each sector is highlighted and influence diagrams developed for the internal processes defined in each model sector.

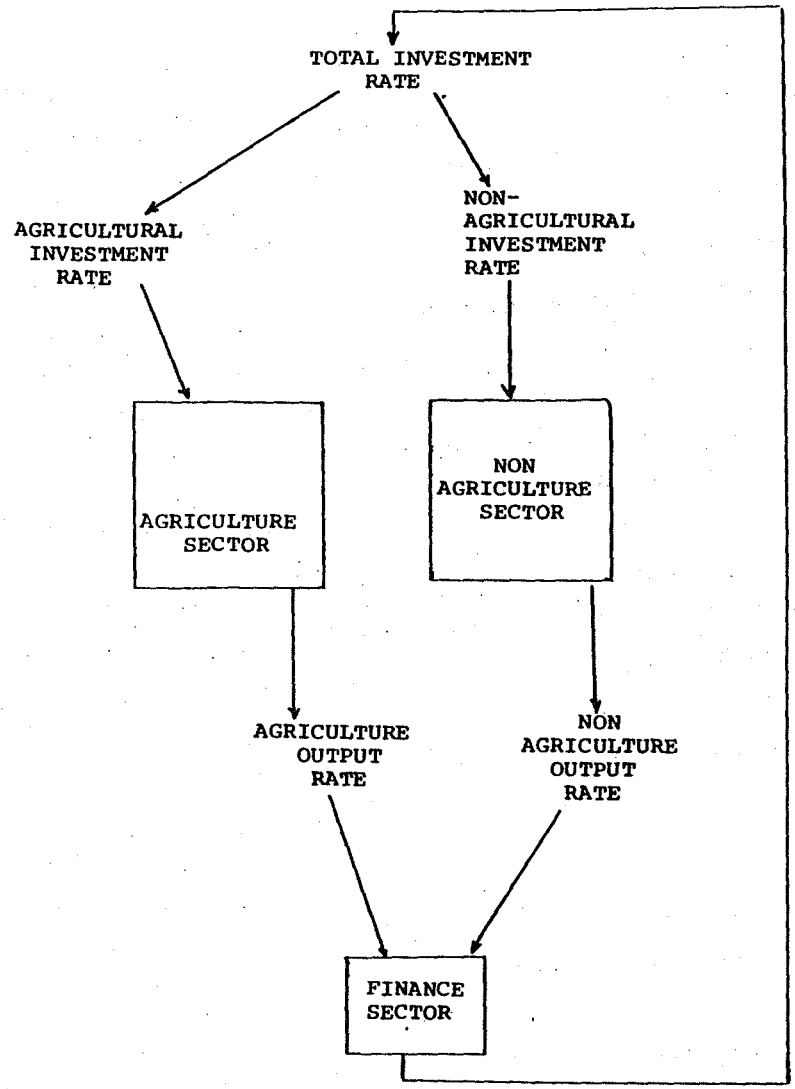


Fig.1: Blackbox relationships among the Agriculture, Non-Agriculture and Finance Sectors of the Model.

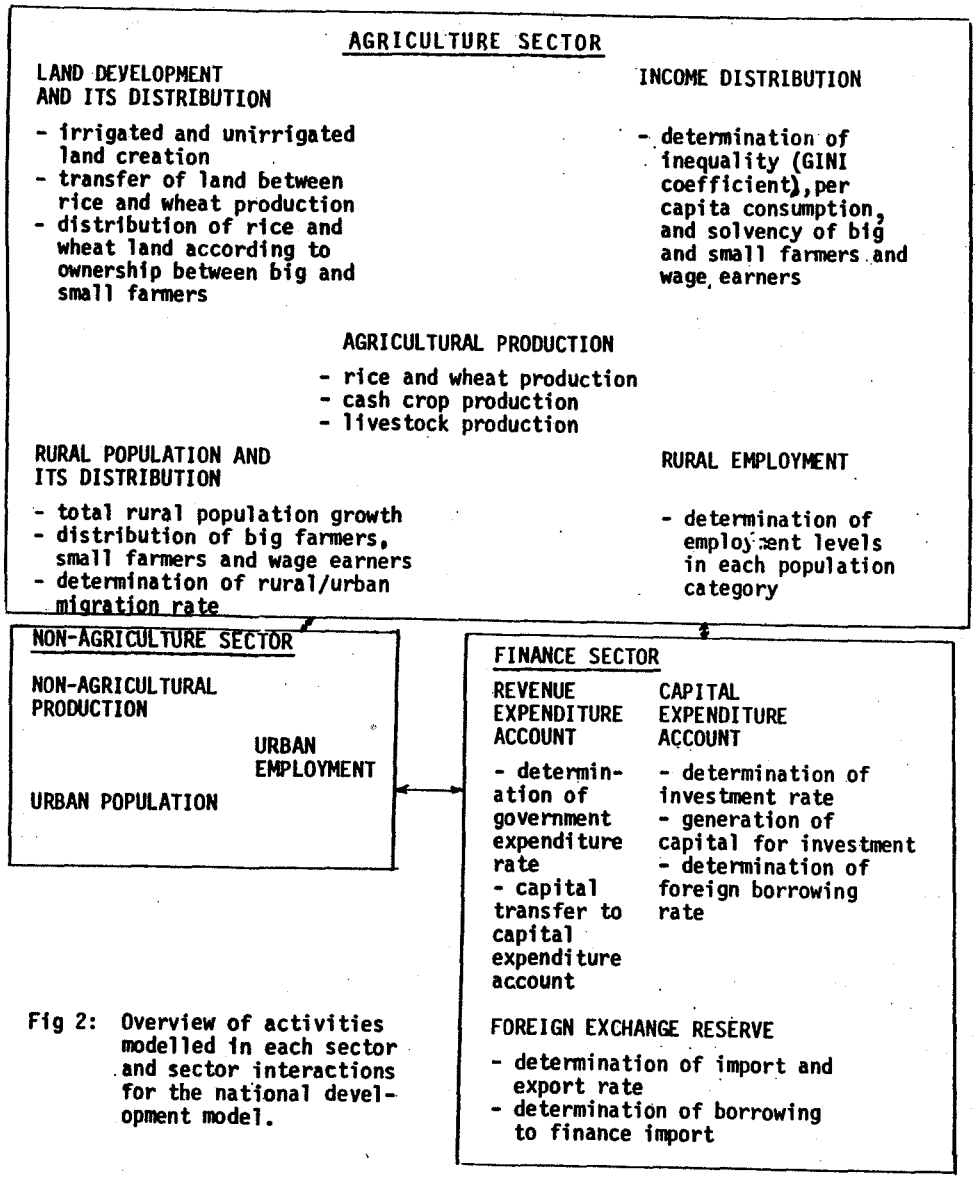


Fig 2: Overview of activities modelled in each sector and sector interactions for the national development model.

2. The Agriculture Sector.

2.1 Land development and distribution.

This sub-sector identifies the land resource as being in one of eight possible states depending on irrigation, type of crop produced (rice or wheat) and ownership (by small or big farmers). These eight states are shown in Fig.3 together with the rates which transfer them between states. In general the total land creation rate converts uncultivated land to unirrigated land and allocates this into one of four states defined by ownership and crop. Each of these four states is then converted to the irrigated state depending on the needs and capabilities of the owners. Facilities also exist in the model for the purchase of land from small farmers by the big ones and for the compulsory transfer of land from big farmers to small by government decree. Additionally land in both states of irrigation and ownership can be transferred between crops.

2.2 Agricultural Production

This sub-section of the model considers the production of food grains, for rice, wheat and other cereals (including pulses), the production of cash crops and the production of live stock. The production of rice and wheat has presently been modelled in great detail, whereas the production of other cereals has been kept as simple as possible. This is because the production of other cereals has remained more or less static for the last quarter of a century. The production of other cereals was

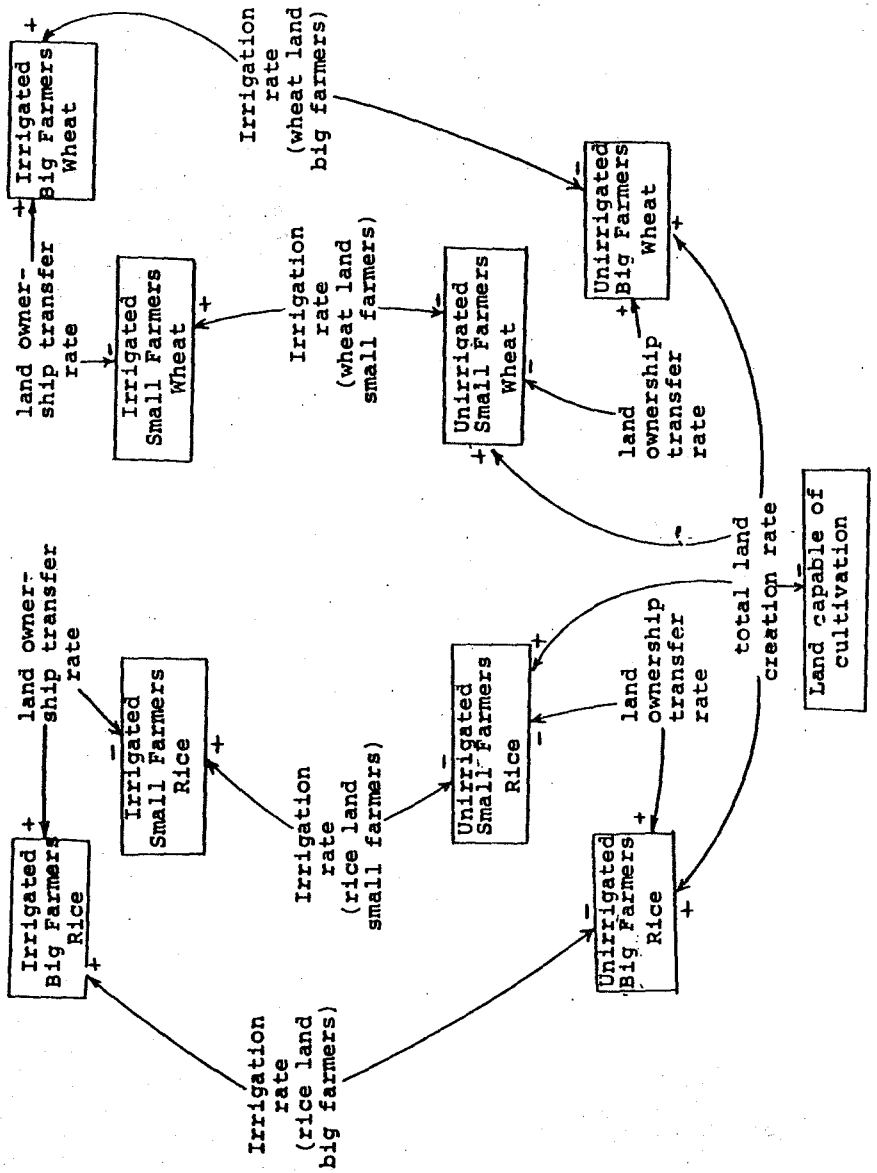


Fig. 3: Land development and distribution.

37.0 million tonnes in 1960-61 and increased merely to 41.7 million tonnes in 1981-82. Whereas, for the same time span the production of rice and wheat combinedly increased from 45.6 million tonnes to 91.3 million tonnes which is 100 per cent increase in production.

The rice and wheat production as well as other cereals production are computed in the model from land under each crop multiplied by the yield per hectare corresponding to the particular type of land. To arrive at the yield equation the fertility of the seeds used (high yielding variety (HYV) or normal), the soil condition, the input of fertilizer, the application of pesticides, and the effect of rainfall have been considered. The approach used is diagrammetically outlined in Fig.4 and will now be described.

The actual yield rate of a particular state of land is determined from the potential yield rate of that land, the use of pesticides and the rainfall situation. Potential yield rate is again determined by the base yield rate and effective fertilizer application rate. Base yield rate in the average yield from one hectare of land depending on the distribution of high yielding variety (HYV) and normal seeds, that can be achieved without the influence of any other factors and with present state of technology. It is calculated from the proportions of land under HYV seeds and normal seeds and their fertility rates.

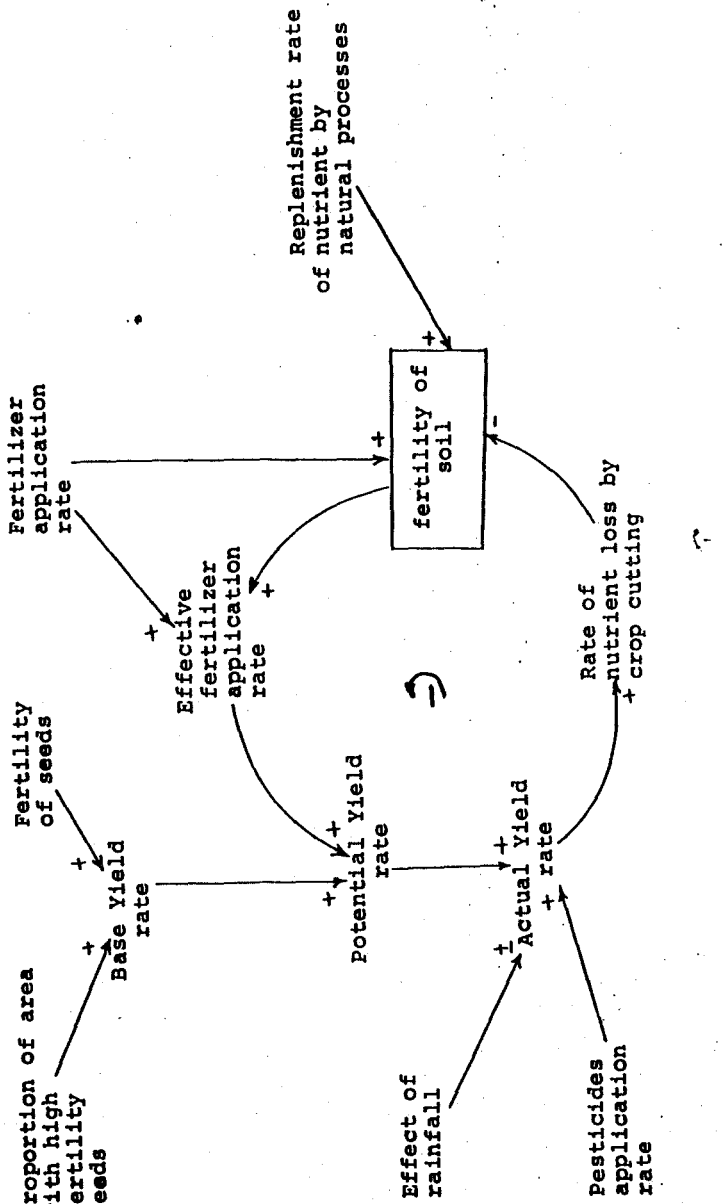


Fig. 4: Construction of the yield rates associated with the land states.

The effective fertilizer application rate which is nothing but the actual amount of nutrient left in the soil is determined by the fertilizer application rate and the fertility of the soil. It has been assumed here that the fertility of soil has a major role to play in determining the actual amount of nutrient available to the plants. If the land becomes inferior in nutrient content at any point of time some amount of fertilizer will be used to replenish the deficit and this amount of fertilizer will not be available to the plants.

The fertility of soil is determined by the balance of the amount of fertilizer put into the field and the amount of nutrient taken out of the field by way of crop cutting. Additionally, there exists the natural recovery of soil by ion exchange. The actual yield rate of big farmers' land and small farmers' land vary mainly because of unequal share of fertilizer. The sharing of fertilizer is considered to be controlled by the relative cash positions of the farmers which will be dealt with later.

The cash crop production rate has at present been made a simple function of the capital value of the crop. This in turn is considered to generate private investment and government allocation of funds commensurable with maintaining the export earning associated with this product; thus reinforcing the asset value of the crops. The production of livestock has been essentially modelled in the same way.

2.3 Income distribution

The equitable sharing of total income among different sections of the people is taken here to be one output measure of the model against which to assess the effects of alternative investment activities.

The degree of inequality in income distribution is commonly measured by the Lorenz curve and the GINI coefficient and these have been incorporated into the model. The Lorenz curve is the curve obtained by plotting the cumulative percentage of income against the cumulative percentage of population for the entire section of the population. The GINI coefficient essentially measures the deviation of the Lorenz curve from the line of equal distribution. A hypothetical Lorenz curve is presented in Fig.5.

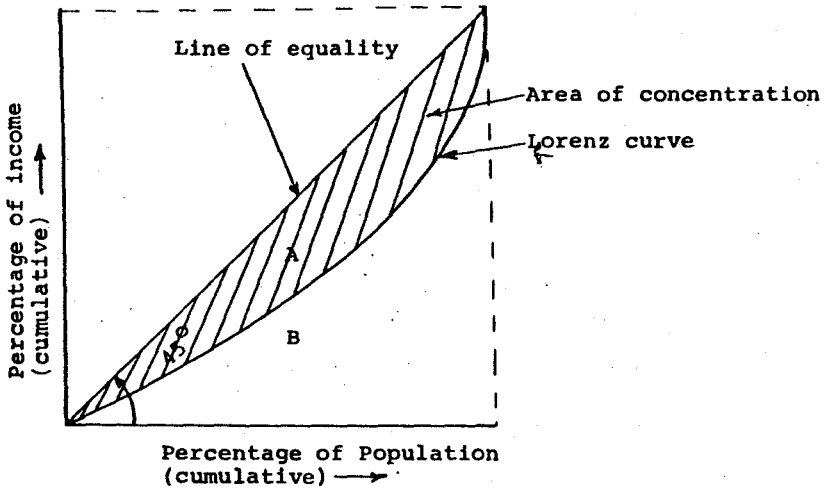


Fig 5 A Hypothetical Lorenz Curve

The line at 45° indicates perfect equality. The area between the line of equality and the Lorenz curve is designated as area of concentration and denoted by A (shaded area). The area between the Lorenz curve and the axis of percentage of population is denoted by B. The GINI coefficient is the ratio of the area of concentration (A) to the total area under the line of equality (A + B). The more the deviation of the Lorenz curve from the line of equality the more is the value of GINI coefficient and the more is the inequality in income distribution.

This ideas of the GINI coefficient is applied here to find the degree of income inequality among various sections of the rural population engaged in cultivation. For this purpose rural total population (RTP) has been divided into big farmers (BF), small farmers (SF), and wage earners (WE). The big farmers are defined as the top 5.6% rural households who own nearly 40% of the cultivated land. The rest of the rural households who own at least some amount of cultivated land are defined as small farmers. They constitute nearly 62.4% of rural households and share 60% of total cultivated land. The landless rural households which constitue nearly 32% of rural population are termed the wage earners. The income of these groups of rural people is calculated in the following manner.

Income of Big farmers (INCBF) = Revenue from Rice & Wheat production - Inputs to farm land - Wage payment

Income of Small farmers (INCSF) = Revenue from Rice & Wheat production - Inputs to farm land

Income of Wage earners (INCWE) = Wage received

and the total income of all groups (TINC) = INCBF + INCSF + INCWE.

Once the income and population of each category is determined the GINI coefficient can be calculated by the following formula.

$$GINI = 1 - \left[\frac{WE}{RTP} * \frac{INCWE}{TINC} + \frac{SF}{RTP} * \left(\frac{INCWE + INCSF}{TINC} + \frac{INCWE}{TINC}\right) + \frac{BF}{RTP} * \left(\frac{INCWE + INCSF}{TINC} + 1\right)\right]$$

The mechanism of income distribution for big farmers, small farmers and wage earners is shown in Fig.6. The cash positions of big farmers, small farmers and wage earners, which basically represent their solvency (the financial strength) are determined in the model from the balance of their income and expenditures over time. Among expenditures, the consumption expenditure rate, which is directly proportional to the size of the cash position, is common to all the three categories. The asset purchase expenditure rate is defined as special expenditure for big farmers only and represents the amount of money spent on purchasing land from small farmers. This asset purchase expenditure rate determines the land transfer rate from big farmers to small farmers as described in land distribution sub-section. Again, this land transfer rate determines the conversion of small farmers to wage earners' category. The consumption expenditure rate along with the number of persons in each category, determines per capita consumption expenditure.

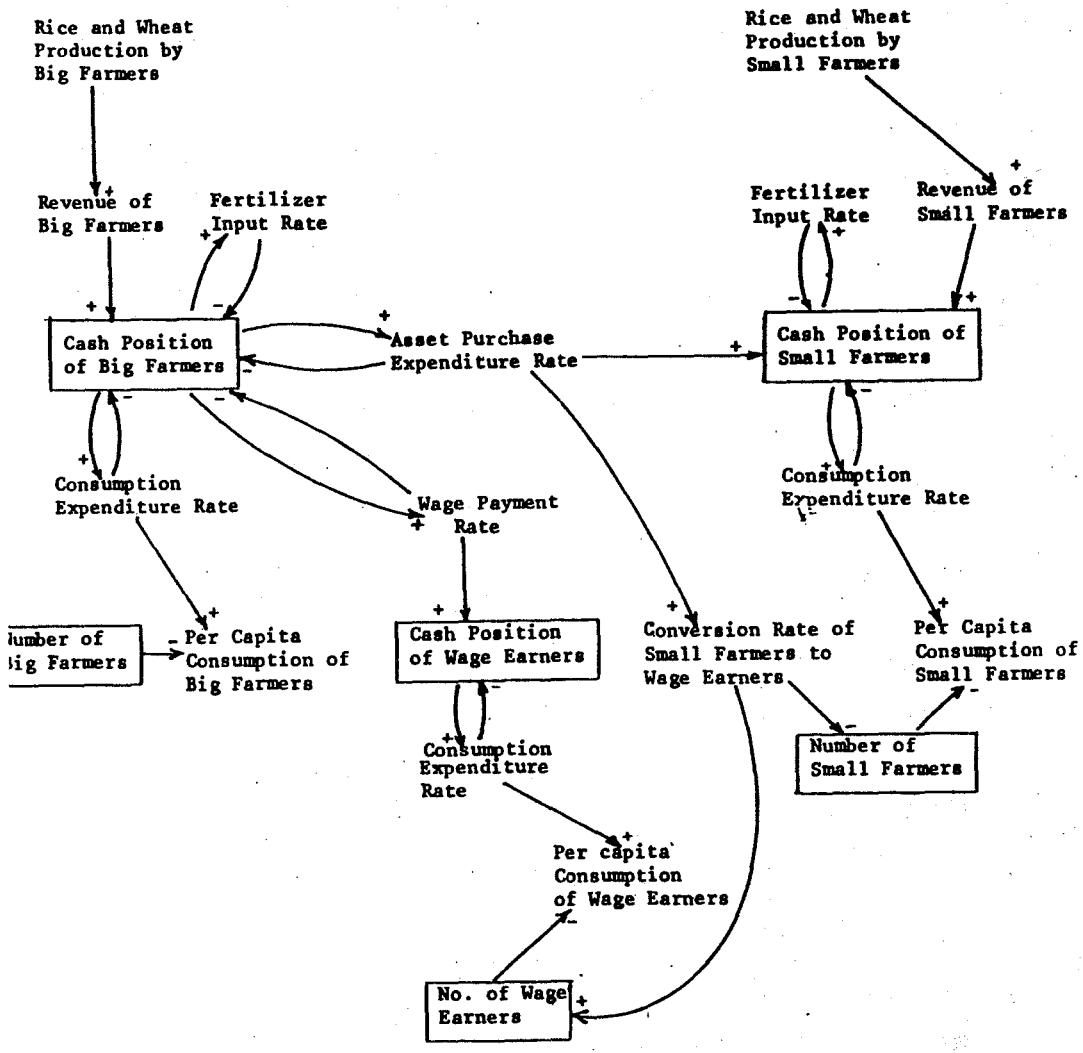
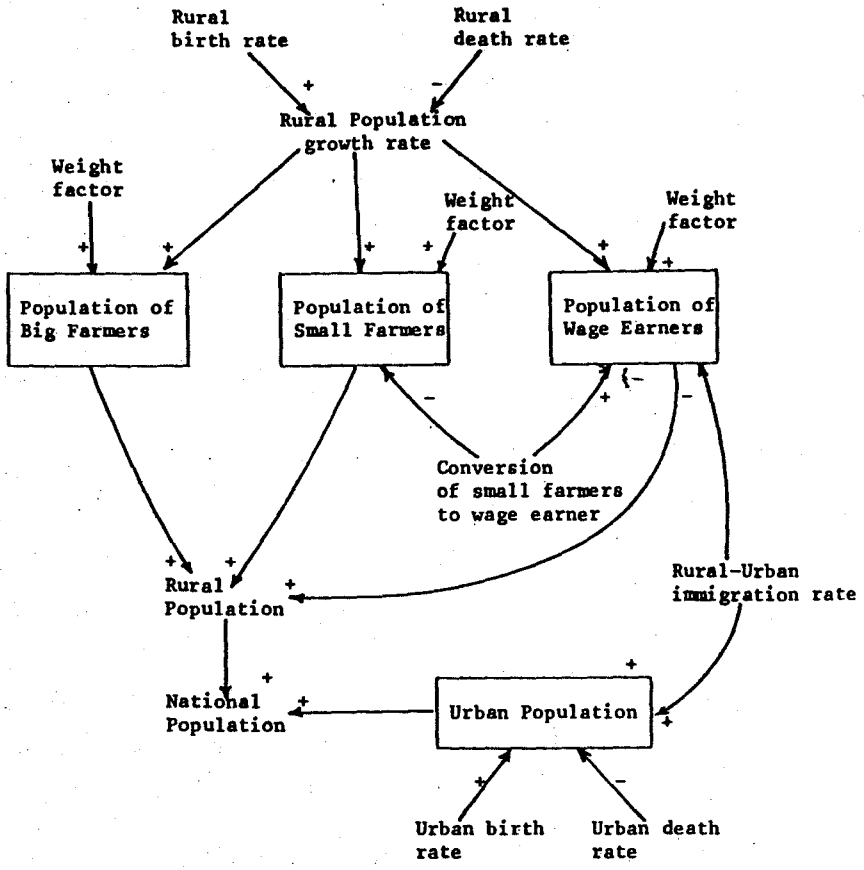


Fig.6 Influence diagram for rural income distribution

2.4 Rural Population and its distribution

Rural population distribution and its relation with the national population is modelled in Fig.7. It has been assumed

Fig. 7 Rural Population and its distribution:



that the rural as well as the urban population birth rate and death rate depend on the per capita income of these groups. Any increase in per capita income is expected to decrease both birth rate and death rate but by different amounts. Within the rural population the per capita income of big farmers differs vastly from that of wage earners and even small farmers. So suitable weighting factors are necessary to apply different growth rates (the difference between birth rate and death rate) to the population of big farmers, small farmers and wage earners. Other factors such as the conversion of small farmers to wage earners (as a result of selling out land to big farmers) and rural to urban migration have also been considered to compute the distribution of rural population. This transmigration which is related to the relative income between urban and rural population is again an important determinant associated with income distribution. The rural to urban migration rate effectively reduces the population of rural wage earners and eases the rural unemployment situation. However, it obviously puts pressure on the urban employment and economic situation.

2.5 Rural Employment.

Employment is considered as a further major output measure of the model. The employment in crop cultivation is of two types. First, is the situation of self employment in farming. The big farmers and most of the small farmers are employed in this way. The other type of employment in farming is the wage employment. Wage earners and small farmers who are available

for work in big farmers' land are hired by big farmers. The hiring or firing of labourers by big farmers is considered to be determined by the amount of money available for wage payment and the minimum amount of labour required. The employment policy by big farmers is explained clearly in Fig.8. The rural unemployment is determined by the balance of the rural work force and the total number of workers with employment in agriculture sector. The higher the rural unemployment the lower is the wage rate, which eventually increases the number of workers employed. Employment in cash crop and livestock production is related directly with capital employed and jobs per unit capital.

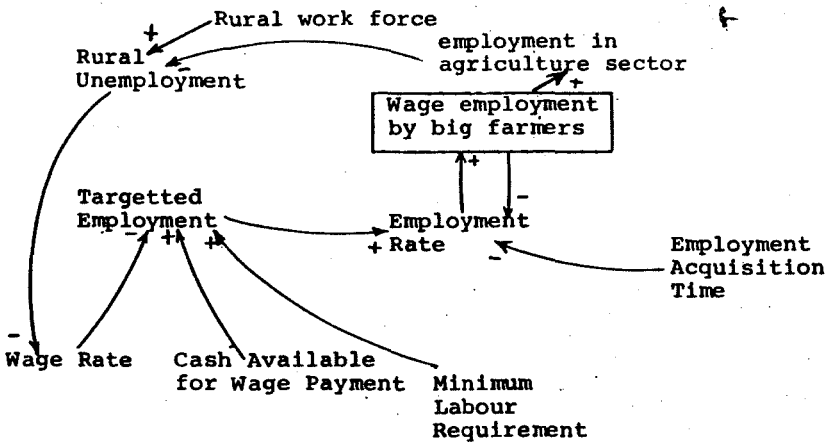


Fig. 8 Employment Mechanism of Big Farmers

3. Non-agriculture sector.

As indicated earlier, the modelling of non-agriculture sector has been left skeletonic and only those aspects which are essential and in accordance with the objective of this research have been developed. To capture the overall theme and represent the national economy as a whole it has been necessary to model non-agricultural production, urban population and urban employment in the simplest possible way.

Non-agricultural production has been determined from capital investment and the capital output ratio. Fig.9 explains the mechanism of wealth formation in this non-agriculture sector. The capital formation rate is simply the delay version of capital investment rate. Capital investment rate has two components, one is the budgetary allocation and the second is the private investment of entrepeneurs which is simply a proportion of non-agricultural production.

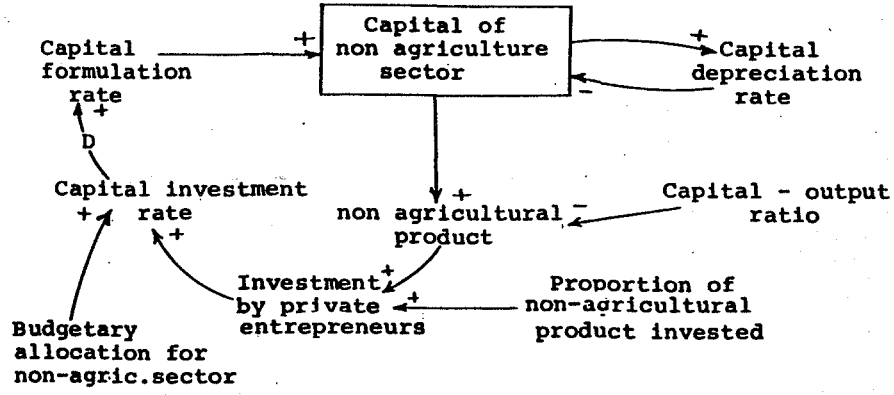


Fig. 9: Wealth generation in non-agriculture sector.

Agricultural product and non-agricultural product together make up the net domestic product.

The modelling of urban population has already been described in Fig. 7 and the urban employment is determined in the same way as is the employment associated with cash crop and live stock. Jobs per unit capital and the amount of capital employed in the non-agriculture sector, determined the urban employment. Transmigration, i.e. migration of population from rural to urban is expected to increase the urban population and deteriorate the urban employment situation. The possibility of reversal of migration, i.e. from urban to rural, has also been taken into account and has been related with the relative per capita income of rural and urban people.

4. Finance Sector.

Two types of investment need to be recognised in modelling the national finance sector. One is the budgetary investment which is controlled by government through fiscal policy. The other is the private investment by entrepreneurs. In the representation used here the target growth rate of net domestic product is considered to be the driving force used by the government as the trigger for determining the total investment rate. Total investment rate minus private investment rate results in the desired public investment rate and all government financial activities centre around how to generate this investment requirement. Fig. 10 explains the building blocks for the finance sector. The government revenue expenditure account

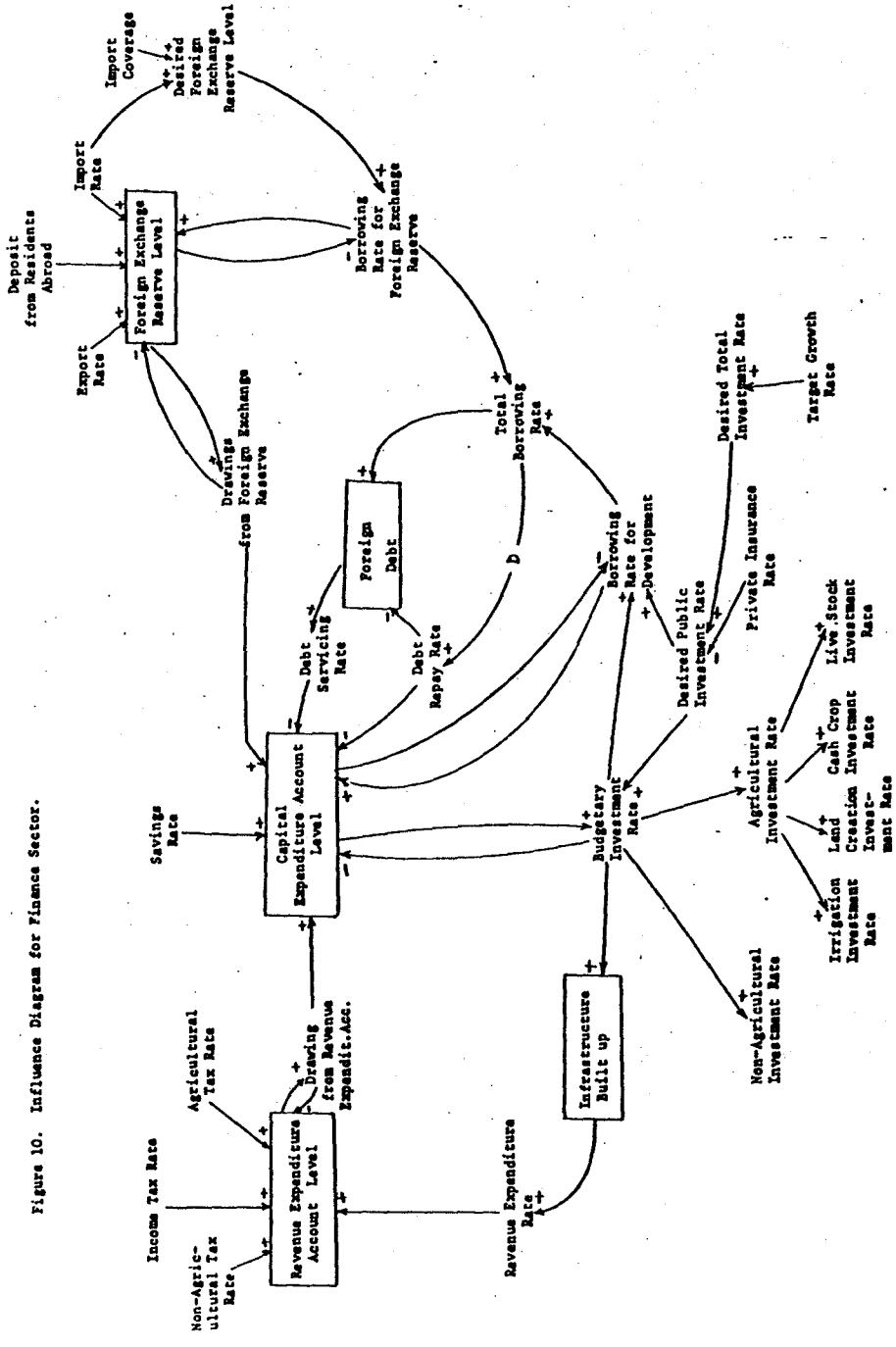


Figure 10. Influence Diagram for Finance Sector.

(which is the balance of current receipts and current expenditures) determines the performance of the government on non-development activities. If any surplus is generated in the revenue expenditure account it is transferred to capital expenditure account. The balance in the capital expenditure account is the resultant of all the economic activities to generate investment for development purposes. The inputs to the capital expenditure account are the domestic savings rate, drawings from foreign exchange reserve, drawings from the revenue expenditure account and foreign assistance for development projects. Withdrawals from this account are repayments of foreign loan and investments in development projects. Foreign exchange reserves depend on primarily export rate, import rate and the borrowing rate to finance trade deficits. The overall borrowing rate consists of borrowing for development financing and borrowing for financing trade deficits.

The actual budgetary investment rate is determined by the desired public investment rate and the position of capital expenditure account. Actual investment thus made available is then allocated between the agriculture and non-agriculture sectors, depending on the allocation policy of the government. The agricultural investment rate is again allocated among various heads of activities within the agriculture sector, namely irrigation, land creation, cash crop production and livestock production.

The foregoing influence diagram modules have been composed into a full influence diagram on which the simulation model is based. However, due to space restrictions no attempt is made to present this complex picture as it is not felt necessary for understanding of the results to be presented.

MODEL VALIDATION

The descriptive model given in the previous sections has been quantified using the DYSMAP Computer Simulation package and has been subjected to rigorous experimentation which is described in this and the following section of the paper. There are many tests that can be performed to justify the validity of system dynamic models[9][10][11]. However, the usefulness of any particular test or a set of tests depends heavily on the purposes of the model under test. In this respect, apart from structural validation, the most important validation test for a national development model is considered to be the reproduction of historical behaviour.

The ability of this model to produce the historic behaviour of the variables for which information is available, has been tested in two ways. First, the model has been tested against past data for the period 1965 to 1980. The second approach enlarges the time span and includes government projections from 1980 to 1994 as stated in the perspective plan in the Sixth Five Year Plan document[12].

1 Historic behaviour reproduction (1965-1980)

The important determinants of the development efforts, such as development in various categories of land, food grain production, net domestic product, budgetary investment rate, and government borrowing rate, have been tested against past data and the results are shown in the graphs in Fig.11(a), 11(b), 11(c) and 11(d). The behaviour of gross irrigated and unirrigated land, gross rice and wheat land, rice production, wheat production, total food grain production and net domestic product is very close to actual in terms of trend and in values. This is also ascertained by the measure in the 'goodness-of-fit' of the variables as noted in Table 1. The 'goodness-of-fit' has been measured statistically by means of the absolute errors and the percentage root-mean-square error.(11) Budgetary investment rate and total borrowing rate both show an increasing trend as in practice, but year to year variations have been considerable as shown in Table 1. Both these variables are, of course, policy variables which have been subjected to much variation over time. The modelled values have currently assumed a consistent mode of policy application which captures the average trend but obviously not its variance.

2 Model Behaviour Against Government Projections

In the Sixth Five Year Plan (1980 - 1985) document the government has set targets for 1984-85 and 1994-95 in many spheres of economic development. As a second stage of validation and in order to contrast the planned estimates with those evolved by the model, four major variables have

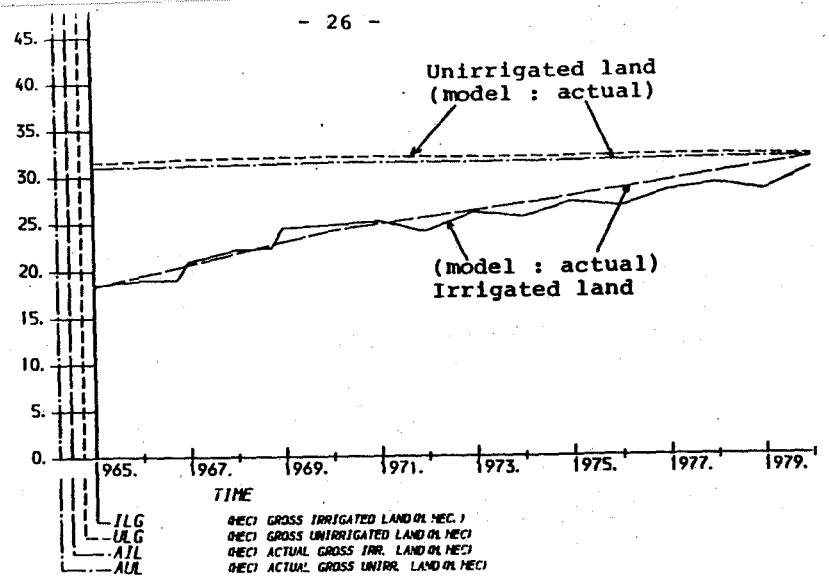


Fig 11(a) Validation Run

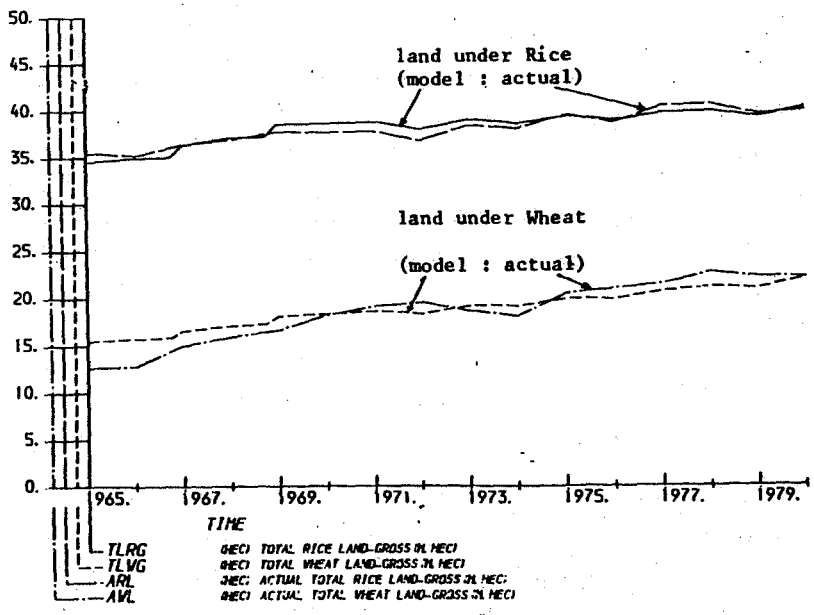


Fig 11(b) *VALIDATION RUN*

OPTM4- NATIONAL DEVELOPMENT MODEL

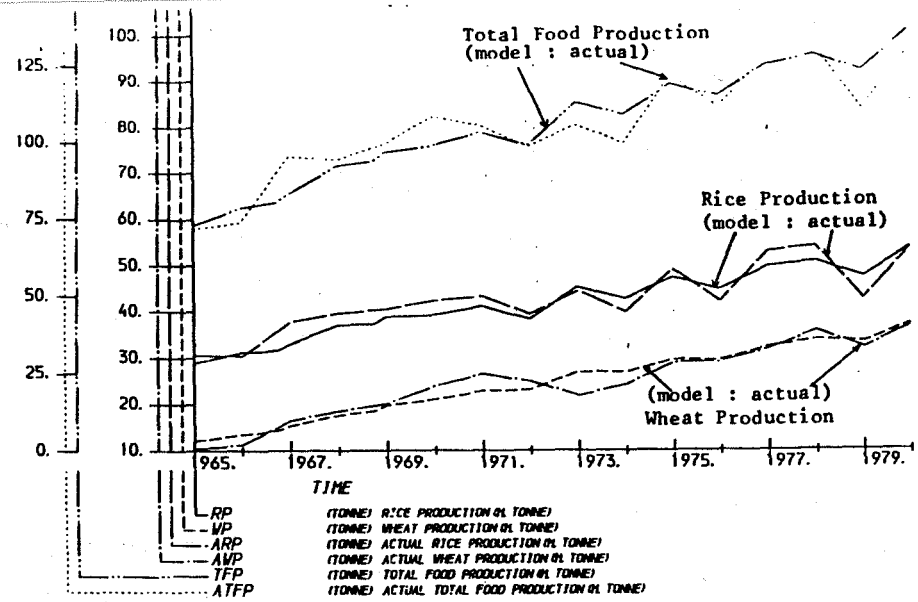


Fig 11 (c) Validation Run

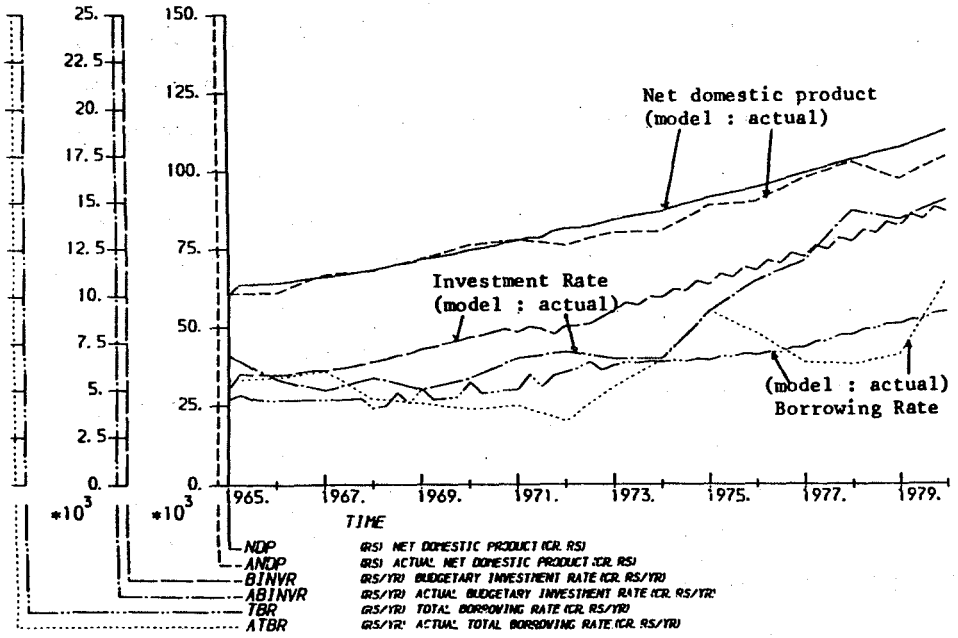


Fig 11 (d) *VALIDATION RUN*

OPTM4- NATIONAL DEVELOPMENT MODEL

Variable	mean error (unit) (a)	percentage-root-mean-square error (%) (b)
Gross Irrigated Land (ILG)	.95 M.Hec.	3.96
Gross Unirrigated Land (ULG)	.51 M.Hec.	1.69
Gross Rice Land (TLRG)	.58 M.Hec.	1.70
Gross Wheat Land (TLWG)	1.17 M.Hec.	8.27
Rice production (RP)	2.3 M.Tonne	5.39
Wheat production (WP)	1.7 M.Tonne	9.05
Total Foodgrain production (TFP)	5.1 M.Tonne	5.28
Net domestic product (NDP)	3179 Cr.Rs.	4.32
Budgetary Investment rate (BINVR)	1348 Cr.Rs.	23.26
Total Borrowing rate (TBR)	257 Cr.Rs.	23.55

Table 1: Statistical Summary of Variable Error

Note: (a) mean error = $\frac{\Sigma ABS(\text{Simulated value} - \text{Actual value})}{\text{no. of observations}}$

(b) percentage root-mean-square error

$$= 100X \sqrt{\frac{\sum\left(\frac{\text{Simulated value} - \text{Actual value}}{\text{Actual value}}\right)^2}{\text{No. of observations}}}$$

been compared with their planned values over the period until 1994; namely, total foodgrain production, population, net domestic product and budgetary investment rate. The time dependent behaviour is shown in Figs. 12(a) and 12(b). It is evident from the graphs that the simulated and planned behaviour deviates more and more as time increases with major discrepancies occurring in the 1980-85 period, i.e. during the current 5 year plan. The average growth rates for each of these four variables for past, present and future periods, are presented in Table 2 to highlight the differences. It is tentatively suggested that these results perhaps reflect the inherent optimism and piecemeal nature of the national planning process. The future projections produced by the model are entirely consistent with the actual and past simulated performance of the economy and do not indicate the potential for investment and growth suggested by the 1980-85 year plan. Actual figures for the 1980-84 growth rate are awaited to substantiate the results and the rationale for them presented here.

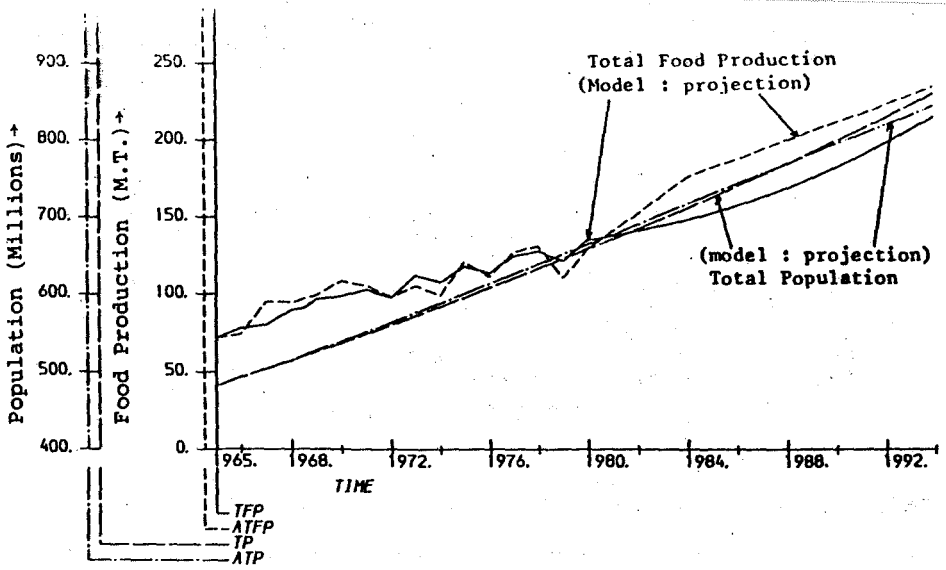


Fig 12'(a) Performance of the model against projection

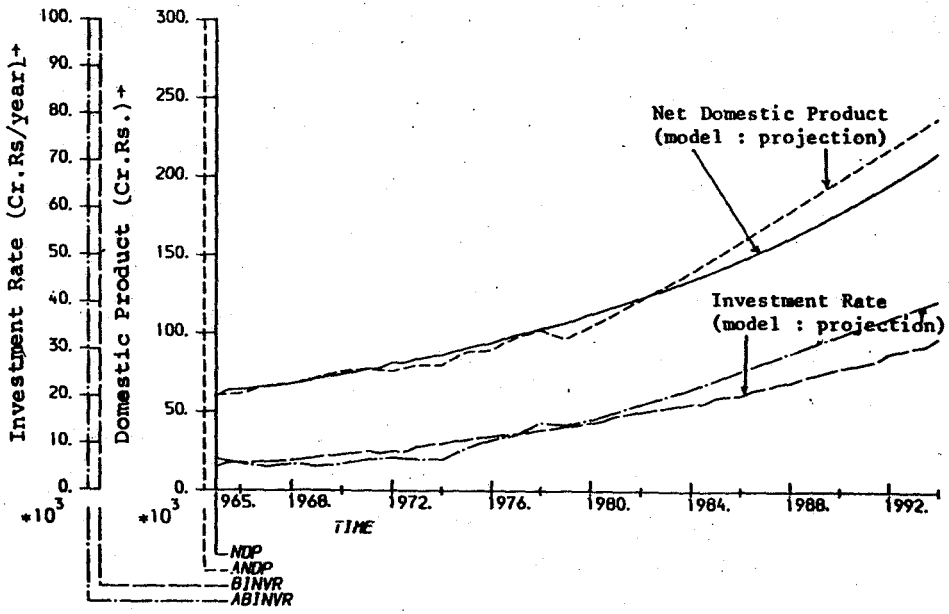


Fig 12(b) Performance of the model against projection
TEST OF PROJECTIONS IN PERSPECTIVE PLAN (1979-1994)

OPTM4A- NATIONAL DEVELOPMENT MODEL

Variable	1965 - 1980		1980 - 1985		1985 - 1994	
	Economy Growth Rate		Economy Growth Rate		Economy Growth Rate	
	ACTUAL	MODEL	government projected	model projected	government projected	model projected
Net Domestic Product (NDP)	3.66	4.26	5.2	4.52	5.5	4.86
Budgetary Investment Rate (BINVR)	5.38	7.24	9.27	6.56	6.48	5.69
Total Foodgrain Production (TFP)	3.96	4.28	7.1	2.44	2.88	3.87
Total Population (TP)	2.15	2.09	1.85	1.95	1.63	1.89

Table 2: Performance of the model in relation to past data and future projections.

POLICY ANALYSIS

The simulated performance of the economy under nine alternative development scenarios are presented and discussed here to indicate the scope of experiments possible with the developed model. These scenarios can conveniently be put into four categories. The first category represents the continuation of what may be described as present development practice and is analysed by POLICY I. The current practice in agricultural development is defined here as representing the allocation of total agricultural investment among the various activities of this sector in fixed proportions; specifically 60% in irrigation, 20% in land creation, 10% in cash crop production and 10% in livestock output.

POLICIES II to IV constitute the second category and analyse the effects of alternative agricultural investment allocation policies. The third category is composed of POLICY V and analyses the food situation resulting from a combination of intensive use of land and the introduction of two phases of new generation high yielding variety (HYV) seeds (assuming past rainfall patterns). The fourth category is designed to test various policies contributing towards the removal of income inequality of the rural population and includes POLICIES VI to IX.

Figs.13(a-d) show the major land related variables for each of the policies in the first two categories (POLICIES I to IV).

Table 3: Results of Policy Experiments (Policies I to V)

Category	Policy No.	Criterion	Food Production at 2010 AD M.Tonne	GROWTH RATES (% per year)					Remarks 1980-2010	
				Food Production	Irrigated Land	Unirrigated Land	Investment Rate	Net Domestic Product	Food Import (M.T.)	Food Export (M.T.)
1	I	Continuation of past behaviour	285	2.57	3.31	- 2.51	6.95	5.45	0	68
2	II	All agricultural investment allocated to irrigation	273	2.43	2.56 (4.70 from 1980-95 and 0.47 from 1995-2010)	-7.57 (-9.93 from 1980-95)	5.63 (6.93 from 1980-95 and 4.34 from 1995-2010)	4.89	163	80
	III	All agricultural investment allocated to land creation	218	1.67	-1.85	2.80 (4.89 from 1980-95 and 0.75 from 1995-2010)	4.84 (7.18 from 1980-97 and 1.84 from 1997-2010)	4.89	361	44
	IV	Moderate investment allocation policy: 70% of investment for irrigation and 30% for land creation	295	2.70	3.45	-2.10	6.52	5.17	0	166
3	V	Intensive cultivation, higher generation HYV seeds and repetition of past rainfall cycles	382	3.58	4.80	-1.05	7.29	5.58		

The results of the policy experiments I to V are summarised for other major variables in Table 3. Additionally, the dynamics of food production under these policies are shown in Fig 14. Fig 13(a) shows that the continuation of the past investment split between irrigation and land creation in the future (POLICY I) produces satisfactory behaviour until 2007, after which the rate of land irrigation drops very rapidly. The food production falls short of requirements at this time and the buffer stock of food starts to decrease. This result is due to the fact that the rate of land creation under the investment pattern used is too low and eventually there is no more land to irrigate. At this point agricultural investment in irrigation is diverted into non-agricultural activities. Obviously as this situation became perceived as happening in practice, corrective measures would be taken. However, the model clearly indicates the effects of the longer term constraints associated with land development and highlights the need to be cautious in determining the balance of investment between these two major functions.

In order to further develop understanding of the land development balance referred to above, three further experiments are presented concerning this issue. In Fig 13(b) the effect of diverting all agricultural investment to irrigation (POLICY II) is shown. In Fig 13(c) the opposite extreme of diverting all agricultural investment to land creation (POLICY III) is given and in Fig 13(d) the effects of splitting investment

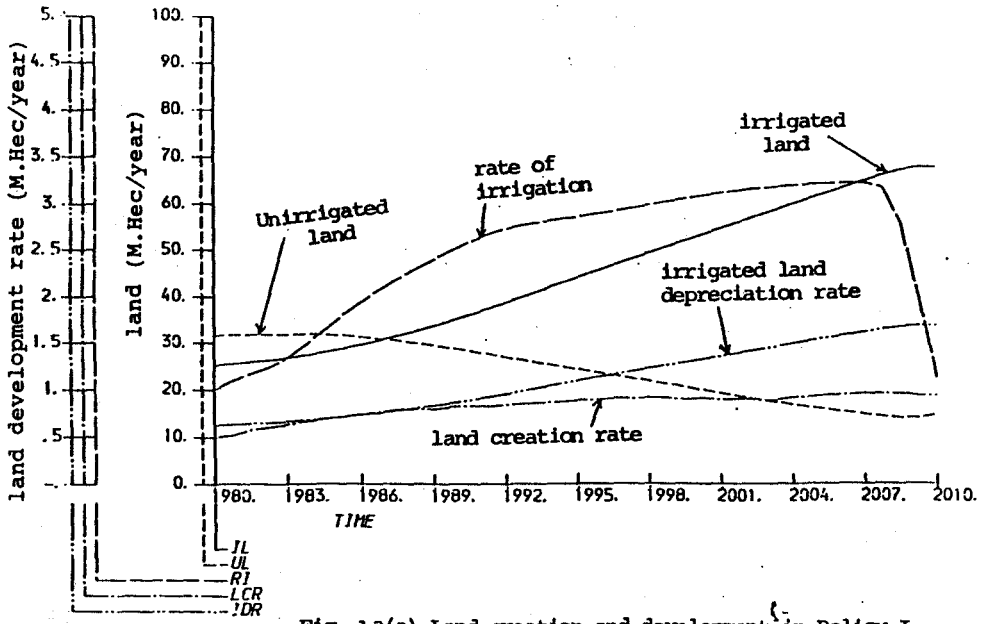


Fig. 13(a) Land creation and development in Policy I

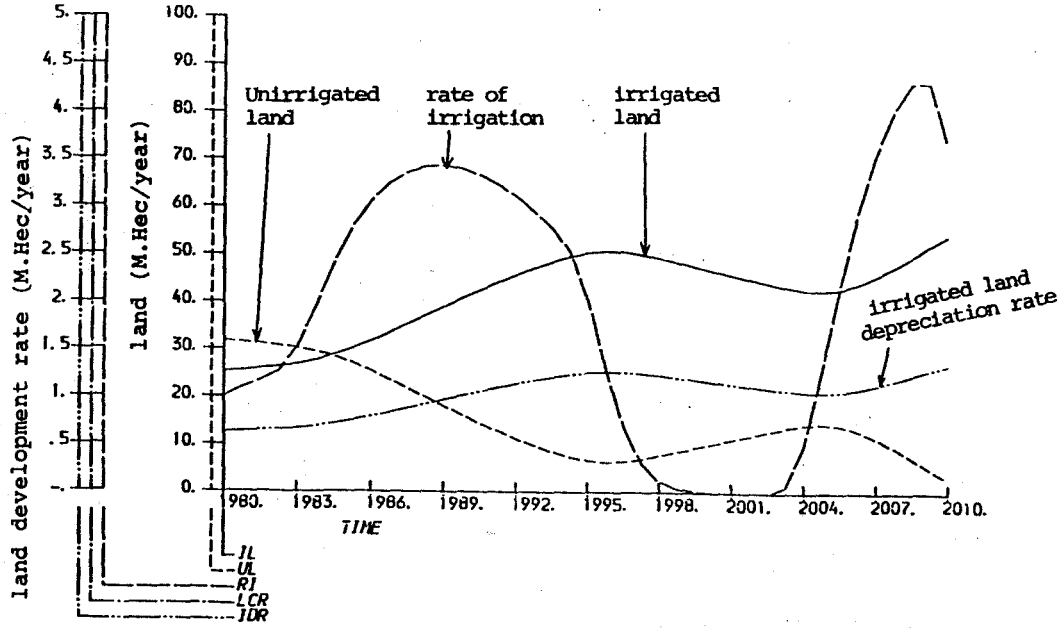


Fig. 13(b) Land Creation and development in Policy II

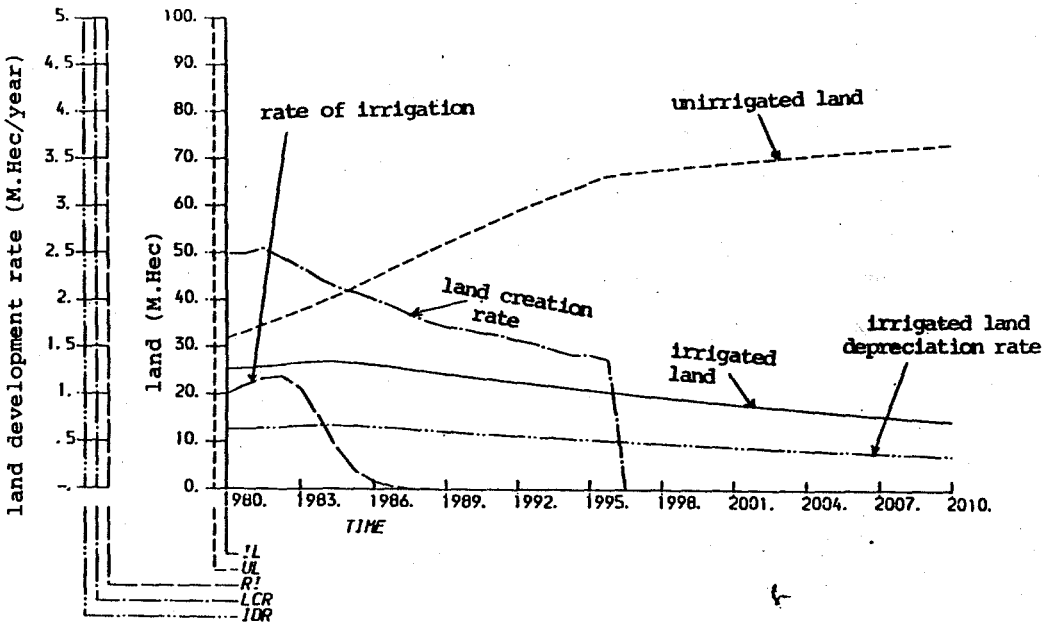


Fig. 13(c) Land Creation and development in POLICY III

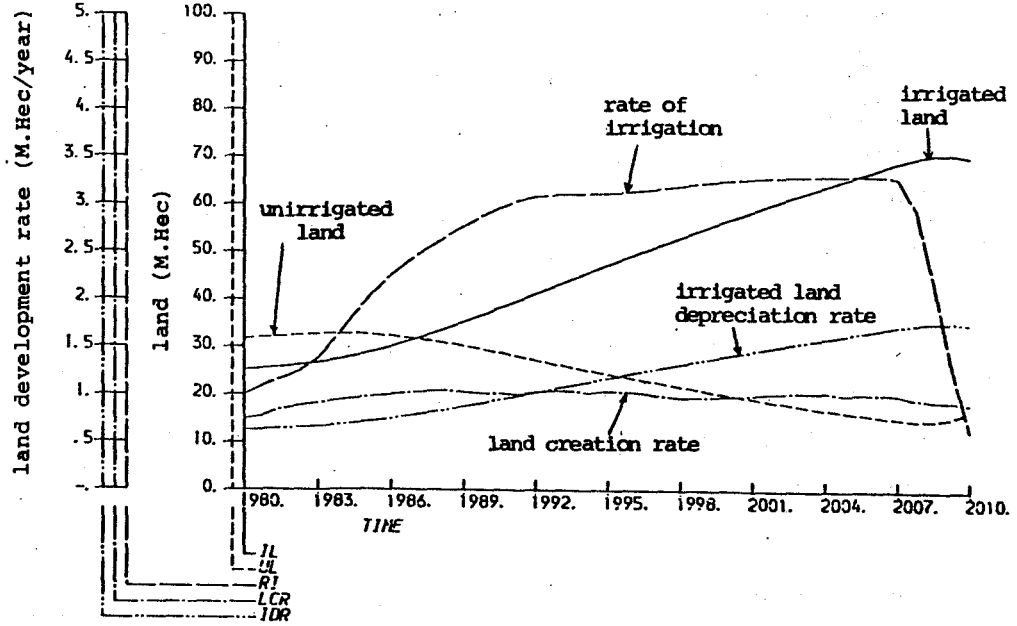


Fig. 13(d) Land Creation and development in Policy IV

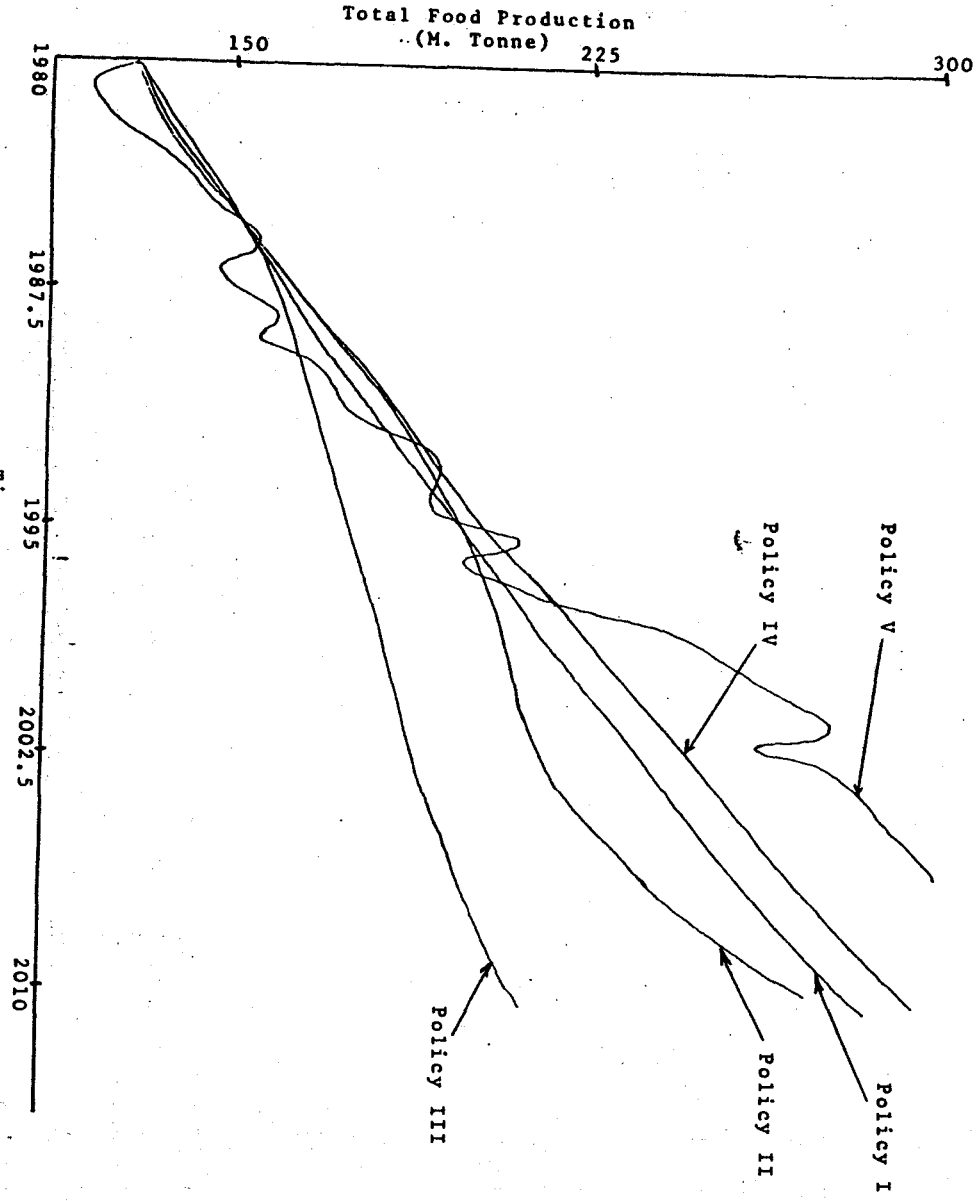


Fig 14 Dynamics of Food Production under Policies I to V.

in a 30/70 ratio between land creation and land irrigation (POLICY IV) is revealed.

The rate of irrigation and hence food production resulting from POLICY II can be seen to be very unstable (Figs 13(b) and 14). When there is no land creation taking place the rate of investment in irrigation is very high resulting in the available land being irrigated quicker. When the available land runs out the irrigation rate falls to zero and remains so until such a period when sufficient unirrigated land is accumulated by way of depreciation of irrigated land. The overall percentage growth rates in available land resources and food production can be seen in Table 3 to be significantly worse than those resulting from POLICY I. Food imports during the later periods of the simulation have been quite substantial and the effect of this is reflected in the sharp drop in the growth of investment rate to 4.34% annually during 1995-2010 compared to 6.93% annually in the previous period.

POLICY III, as might be expected, results in an even worse situation as confirmed by the figures presented in Table 3. The total waste land is converted into unirrigated land within 15 years (Fig 13(c)) and there is no further development in land later on. Although the amount of unirrigated land increases, the amount of irrigated land virtually begins to decrease. Since the productivity from unirrigated land is much less than that from irrigated land, the total food pro-

duction remained alarmingly at low level (Fig 14).

The food situation in POLICY IV is the best among these four policies. There is no import of food and the export has been of the order of 166 million tonnes throughout the period. But the performance of this policy against POLICY I in respect to growth in investment and domestic product is poorer. This is mainly because of the neglect of cash crop and livestock production which is a substantial part of agricultural production.

The major alternative way to increase food production other than increasing land is, of course, to increase the yield of the land and the results of a policy (POLICY V) to preliminarily view this issue are presented in Table 3 under category 3. The purpose is to provide an overall quantification of the effects of a policy of more intensive land use combined with the use of two phases of new generation high yielding variety (HYV) seeds. This situation reveals the best performance of the economy over all experiments presented here both in terms of food production and in investment growth. Food production increases at a rate of 3.58 per cent per year and the investment rate at 7.29 per cent, resulting in an improved rate of growth.

The experiments conducted in categories 1, 2 and 3 have been mainly concerned with food situation and overall growth of the economy. However, equity, which is an important con-

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sideration besides growth in the development process, needs to be studied carefully. Here, POLICIES VI to IX are presented as demonstrations of how the model can be used to quantify the dynamics of income inequality in the rural population resulting from government actions. POLICY VI concerns the effect of the imposition of an upper limit for land ownership (a land ceiling) in 1981 of 4 hectares per household. Here, it is assumed that any land in excess of 4 hectares per household is transferred from the big farmers and is distributed among landless labourers (termed here as wage earners). POLICY VII concerns the provision of a 50% subsidy on fertilizer for small farmers and POLICY VIII examines the imposition of a minimum wage rate of Rs 8 per day. POLICY IX represents the combination of POLICIES VI, VII and VIII. Graphs are presented of a selection of variables from each policy and Table 4 summarises the overall growth and equity measures from each.

Fig 15(a) (corresponding to POLICY I) and Fig 15(b) show the effect on land ownership of the land ceiling imposed in POLICY VI. The higher degree of asset distribution leads, as expected, to more equal income distribution which is clearly indicated in the comparative graphs for the GINI coefficient in Fig 19. However, the benefit obtained in 1981-83 are not sustained fully at the later period (as shown by the increasing value of GINI over the course of time). This behaviour is explained by the fact that the economic advantages enjoyed by the big farmers enable them to consolidate their position and

Table 4: Results of Policy Experiments (Policy I and VI to IX)

Category	Policy No.	Criterion	Inequality in Income Distribution (Average GINI coefficient)	Average per Capita Expenditure (RS/Year)			Average Growth Rate (% per year)	
				Big Farmers	Small Farmers	Wage Earners	Food Production	Net Domestic Product
1	I	Continuation of past behaviour	.47023	1540.4	246.6	45.2	2.57	5.45
4	VI	Imposition of land ceiling at 1981	.38113	1382.7	229.4	53.5	2.70	5.46
	VII	50% subsidy on fertilizer for small farmers	.42682	1537.5	322.3	45.4	3.20	5.53
	VIII	Imposition of minimum wage rate	.31520	1343.6	237.8	118.6	2.45	5.43
	IX	Drastic policy for equality (combinations of policies VI to VIII)	.23344	1085.1	301.9	126.6	3.12	5.50

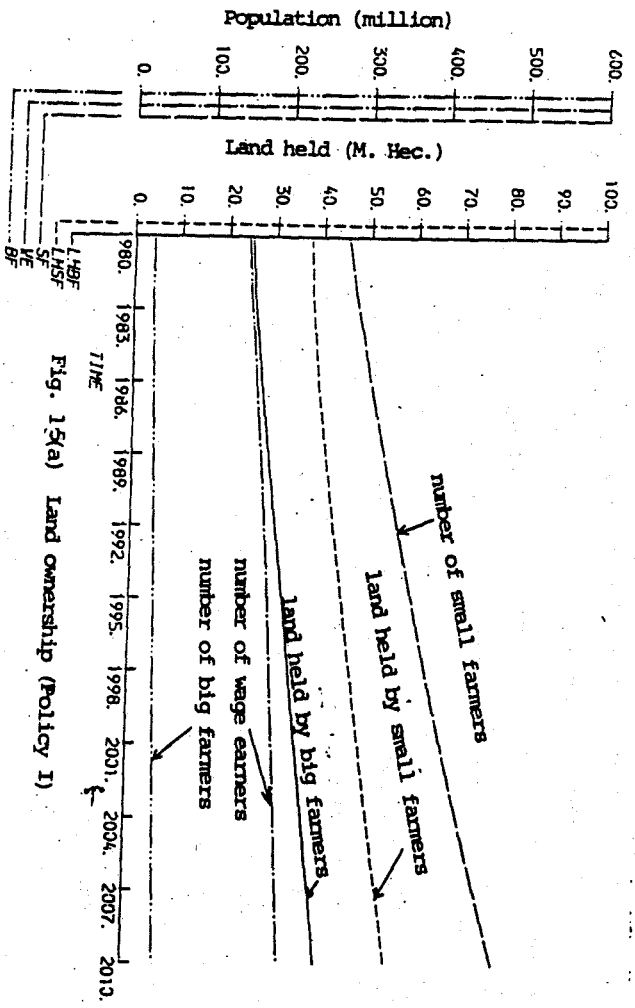


Fig. 15(a) Land Ownership (Policy I)

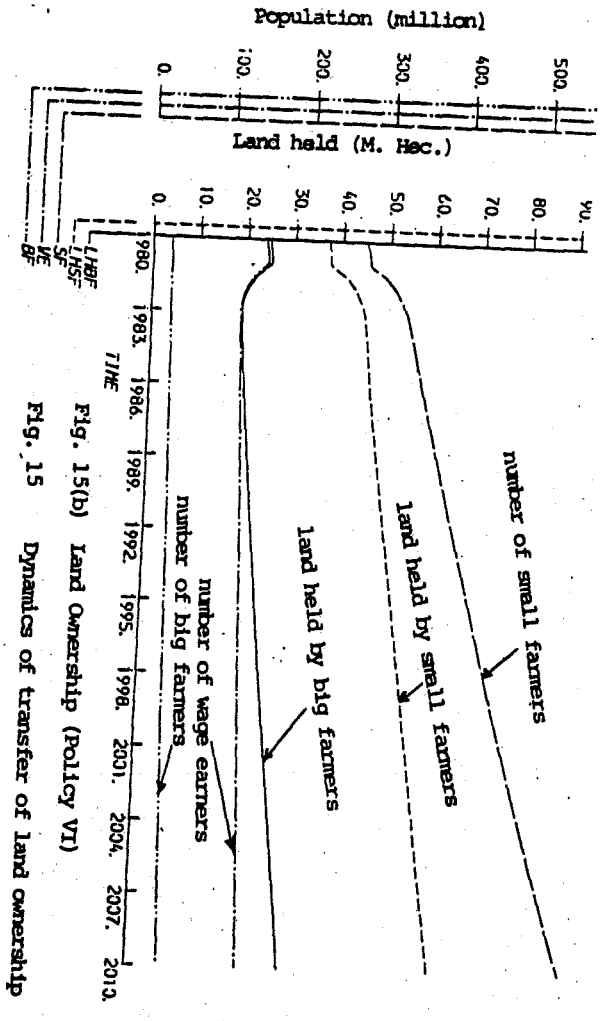


Fig. 15(b) Land Ownership (Policy VI)

Fig. 15 Dynamics of transfer of land ownership

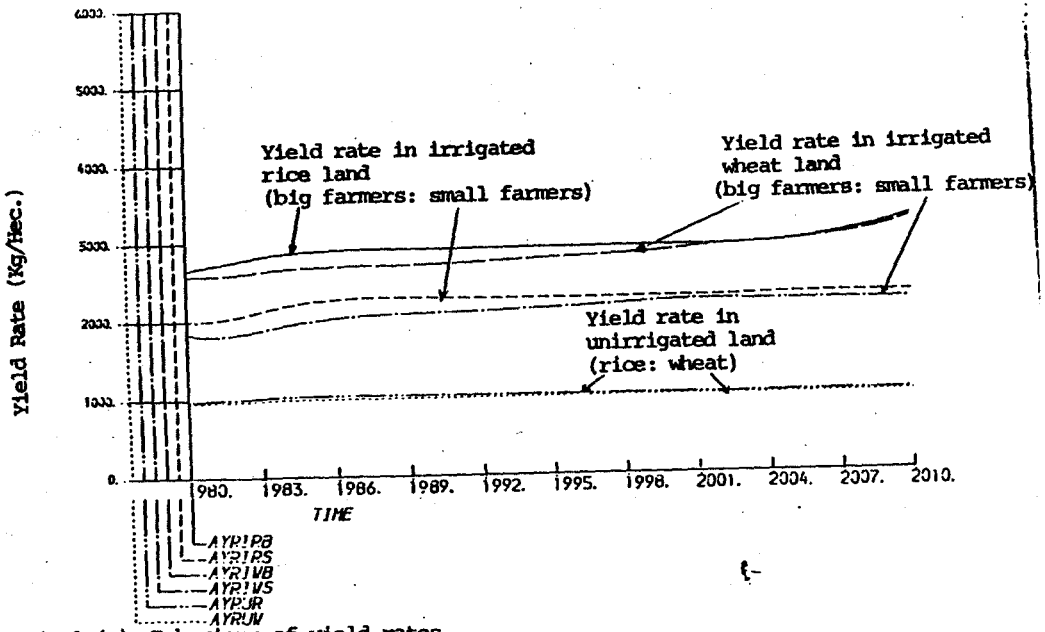


Fig.16(a) Behaviour of yield rates

PRESENT POLICY (POLICY I)

NDMB- NATIONAL DEVELOPMENT MODEL

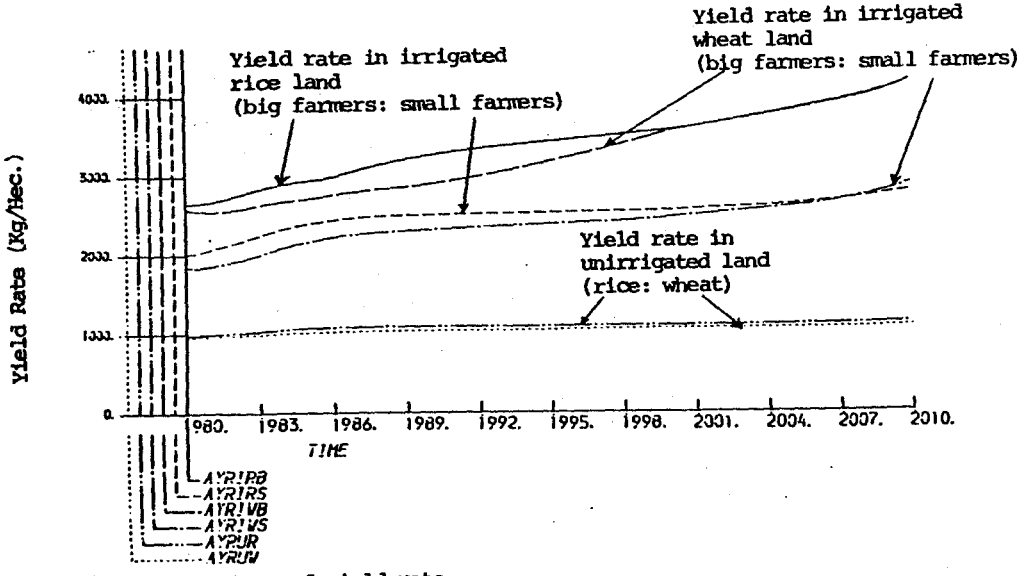


Fig.16(b) Behaviour of yield rate.

50% SUBSIDY ON FERTILIZER FOR SMALL FARMERS (POLICY VII)

NDMB- NATIONAL DEVELOPMENT MODEL

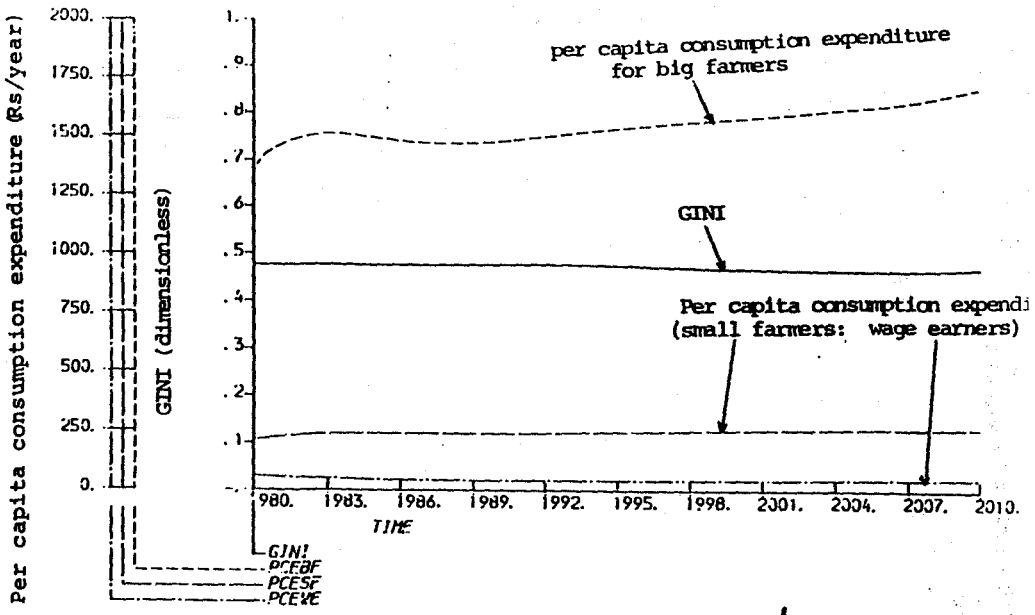


Fig. 17(a) Per capita consumption expenditure

PRESENT POLICY (POLICY I)

NDMB- NATIONAL DEVELOPMENT MODEL

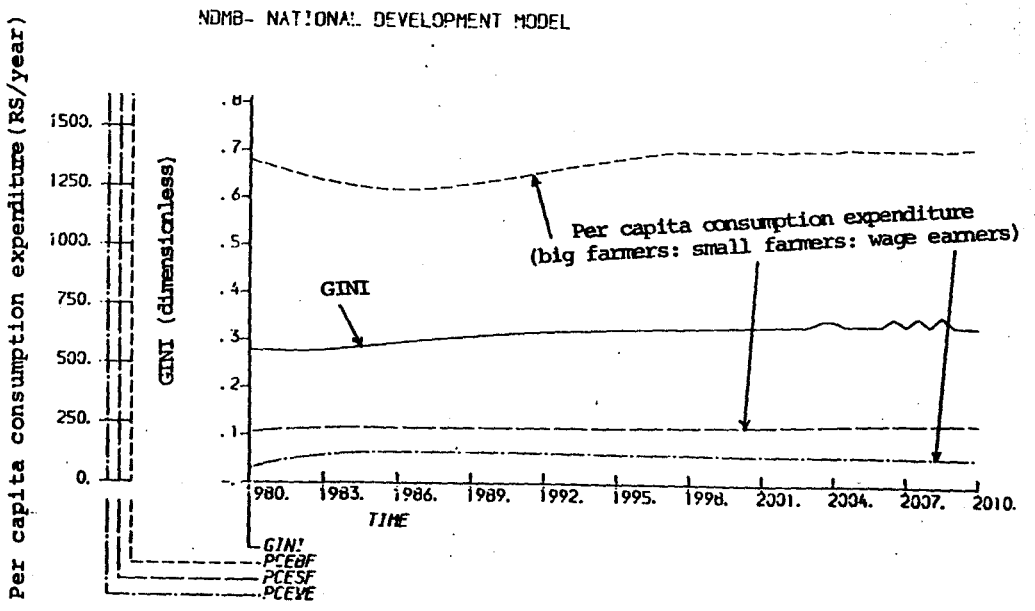


Fig. 17(b) Per capita consumption expenditure

IMPOSITION OF MINIMUM WAGE RATE (POLICY VIII)

NDMB- NATIONAL DEVELOPMENT MODEL

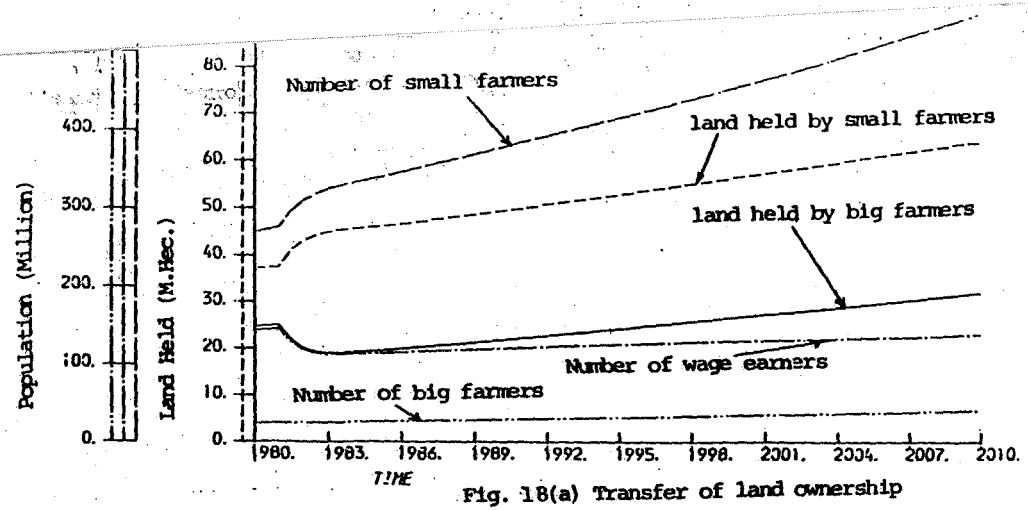
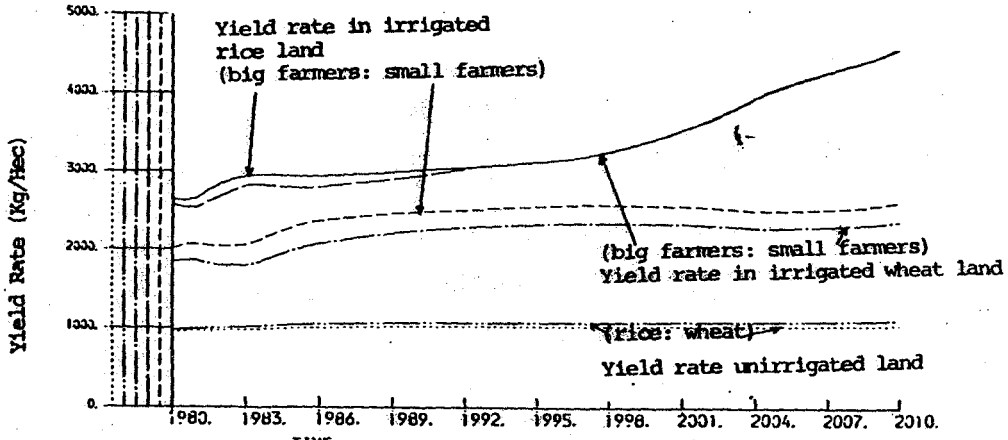


Fig. 18(a) Transfer of land ownership



(Fig. 18(b) Yield Rate Behaviour

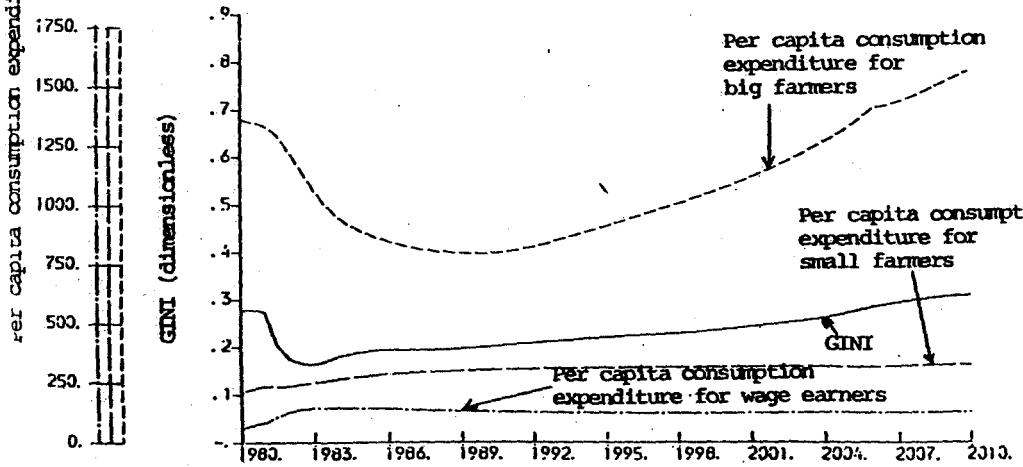


Fig. 18(c) Per Capita Consumption Expenditure

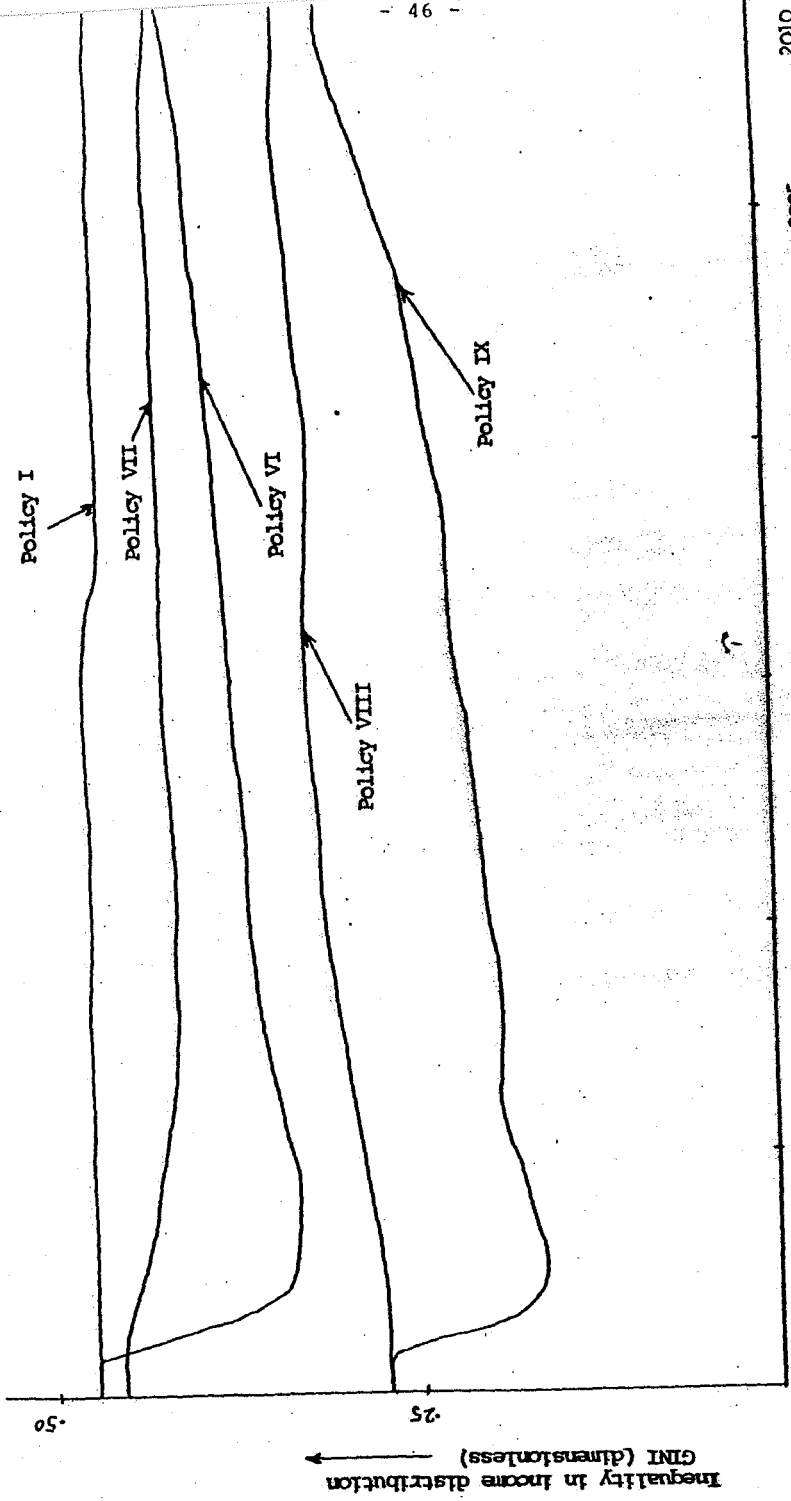


Fig. 19 Dynamics of income inequality (Policy I and VI to IX)

eventually to overcome external shocks such as the imposed land ceiling. Earlier work of Saeed[13] also confirms this idea.

Improvement in income distribution is also achieved by subsidising fertilizer for small farmers (see graph of GINI for POLICY VII in Fig 19). Fig 16 compares the yield rate graphs for POLICY VII with the yield rates obtained from base POLICY I. This indicates substantial and sustained improvements as would be expected since fertilizer is the most important determinant of crop yield. The subsidy both facilitates an increase in the quantity of fertilizer used and an increase in the revenue generation from crop sales, the latter enabling more subsidised fertilizer to be bought and used by small farmers.

In POLICY VIII imposition of a minimum wage rate helps the transfer of revenue from the big farmers to wage earners and thereby to improve the income distribution situation as again seen in the GINI graph in Fig 19. Fig 17 compares POLICY VIII with the base POLICY I for per capita expenditures in each of the population categories, which reflects an improvement in per capita expenditure for wage earners and a deterioration for big farmers. However, this policy has a detrimental effect on the overall growth rate by restricting the economic freedom of the big farmers.

Fig. 18 explains the effect of the combination of the above three policies (Policy IX) on transfer of land ownership,

349 yield rate and per capita consumption expenditures. The performance of this combined policy is dramatic and is reflected by the relative positions of the dynamics of GINI in comparison with other policies.

CONCLUSIONS

The policy experiments conducted in the above Section and their results indicate the immense opportunity offered by the model for evaluating various development scenarios. The model is capable of quantifying the effects of alternative policies and identifying the impacts on each sub-sector.

The preliminary findings from the alternative investment allocation policies indicate that a higher total growth of agriculture and also of the overall economy might be achievable by allocating investments among all the major activities rather than concentrating on a few activities. This is evident from the values of variables in Table 3 for the policies I to IV. This finding is consistent with the government philosophy on all round development for sustainable economic growth.[12]

The effects on growth and equity of the various policies tested here lead to a number of important interpretations. Firstly, that the overall growth rate in agriculture can be significantly changed by policies associated with the redistribution of factors and means of productions among various sections of the rural population. Evidence of this inference is seen from the table values of the policies VI and VII in

Table 4. Two, that policies concerned with only income equalisation may be restrictive to the rate of development, as has been in the case of Policy VIII. This example clearly highlights the general suggestion that the objectives of income equalisation conflict with those of maximising growth rate and emphasises the need to balance these factors. This leads to the third conclusion that policies must, if possible, be sought which enable improvements to be simultaneously made in both growth and equity.

It is stressed that all the conclusions made here are based on the preliminary work with the model and are not intended as definitive statements.

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