A Search for an Operational Environmental Policy Based on the "Limits to Growth" Study

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Abstract

Experimenting further with the World3 model, this paper attempts to formulate the operational means to implement the critical recommendations of the "Limits to Growth" study. Using feedback as the organizing principle and the work of Daly (1991), Page (1977) and Saeed (1985) as guidelines, additional policy space was built into the model for self-regulating its critical policy parameters. The policies so created not only appeared to lie within the scope of the existing and the potentially feasible regulatory institutions, they were insensitive to their respective behavioral parameters and also the timing of intervention. The operational policy design procedure adopted in the paper is also seen to create an important heuristic for policy design in general, which should strive to create operational rather than power-based intervention.

Key Words: Resources, environment, limits, system dynamics, intervention, policy design

Introduction

The environmental issues cut across natural resources, society, economy and technology domains creating some of the most complex abstract systems of the present day world. After the Rio Conference, the environmental issues have become as significant as development issues and have received high priority at national, regional and global levels. However, many of the policy interventions aimed at abating the environmental problems are seen to be futile and even counter productive. A large part of these policies appear to call for powerful exogenous intervention, although many doubts have been raised about the efficacy of such an approach. Complex systems into which such interventions are made may self-regulate themselves to neutralize any interventions that do not recognize the internal tendencies arising from system structure. Also, the power institutions created to affect an intervention might move away from their original remits and work instead for maintaining their own power.

System dynamics modeling is usually expected to identify policies that might change system behavior by influencing the day-by-day decisions of the actors, but in many cases this might still call for a powerful exogenous intervention, especially when the policy design is left at directly influencing sensitive parameters and the logistics of the intervention are not designed. A case in point is the "Limits to Growth" study, which commissioned a system dynamics model to identify critical elements of an environmental policy in limiting population growth and drastically reducing resource use but did not spell out the operational means for implementing such a policy.

We have attempted in this paper to reassess the policy premises adopted in the Limits study from the point of view of their implementation and to develop guidelines for operationalizing them. The original Limits model is slightly revised to accommodate the logic of the policy space needed for the extended experimentation. The operational policies developed mobilize fiscal and service instruments within the existing and potentially feasible institutional scope to affect day-by-day decisions of the actors for achieving the sustainable patterns postulated in the original study.

The Premises of an Operational Policy

On the basis of the underlying decision theories, the approaches to policy design can be placed in two broad categories, normative and descriptive. The normative decision theory is concerned with how people should act in order to achieve better results. It provides rules that will improve the consequences of actions. The policies formulated with an orientation of normative decision theory involve an imposition of prescriptions decided exogenously, and often without taking into account the compatibility of such prescription with the existing circumstances. Due to the very nature of the premises behind the policies of this class, intervening through a power institution is the most common strategy adopted for the implementation of normative policies. The descriptive decision theory, on the other hand, is concerned with how people actually go about handling a problem irrespective of whether the outcomes are admirable or not. This theory describes the patterns of behavior that characterize action. So it provides a simple picture of how an organization works, which is the basis for improving organizational performance (Bauer 1968, Bower 1968).

In either approach, the process of policy formulation involves several distinct steps, such as setting goals, formulating general policy directives and guidelines, identifying appropriate policy leverages and, finally, selecting policy instruments. Although the nature of the formulated policy might depend on its underlying decision theory orientations, if it fails to define operational instruments for affecting the day-by-decisions of the pertinent actors in the system, the implementation of the policy would necessarily require power intervention. Indeed, policy design has traditionally incorporated an interventionist perspective requiring centralization of the power to make decisions by an outside autonomous hand. Unfortunately, such designs invariably fail. Firstly, it is not an easy task to achieve the required level of centralization. Secondly, even when decision making can be centralized, the actors entrusted with making the decisions may not sympathize with the objectives of the design. Finally centralization may conflict with a prevalent management ideology, may be unacceptable to the members of organization in which the design is to be implemented and may invoke much conflict that is destructive (Saeed 1990, 1994).

Saeed (1994) also suggests that it is possible to design operational policies by employing the heuristical protocol of system dynamics, although this is rarely achieved. The policy design based on system dynamics must aim in theory at mobilizing the internal forces of the system into creating functional patterns and avoiding dysfunction.

Such a design can bring about evolutionary changes in the system by influencing motivations of the actors that guide their day-by-day decision. However, if this design is conceived in terms of changing a few sensitive parameters, its implementation may still require a powerful intervention by the leadership who may often neither have the motivation nor the means to commit to such an intervention, especially when the context is public interest rather than profit motive. Policy design, therefore, must be conceived in terms of either new feedback loops that are created to modify the anatomy of a critical decision or the way the influence structure of the existing feedback loops is changed so that the dominance of insidious mechanism is minimized and the role of benign mechanisms enhanced.

The policy prescriptions of the World3 model commissioned by the Limits study have not gone beyond identifying and changing the sensitive parameters of the model. This process has indeed located the important policy entry points into the system, however, any changes in the policy-related parameters can not be affected unless a very powerful and centralized global institution is set in place. Further experimentation is needed with the model after modifying its structure to incorporate operational policy space. The policies so created would control the magnitude of the identified parameters through changing operational parameters that affect day-by-day behavior of the actors. Since system dynamics lends itself easily to the formulation of such operational policy agenda, the premises of the Limits can be built upon to explore this possibility.

We have attempted in this paper the design of operational environmental policies based on the entry points identified in the Limits study by first setting criteria for the policy goal (which is same as those of the Limits study) and then creating a feedback structure that may realistically achieve those goals. Thus, the sensitive parameters identified in the original study provide entry points for further policy exploration. Policy space is then created around the sensitive parameters through feedback structure which, in practice, defines the role of actors within the existing institutional framework of the system. Several additional policy options are also explored that became feasible when the policy space of the model was extended.

Revision of the World3 Model

The original World3 model has been minimally revised for our experimentation by creating additional information structure to accommodate operational policy without losing the identity of original model. The most significant changes were made in the natural resources and population sectors as these were the key points of entry for policy in the original model. The revised model also includes variables for the proposed policies with switches which can be activated at any point in time. This was done to experiment with the timing of the proposed policies to determine their sensitivity to their time of implementation, since the policies of the Limits study are time-sensitive. The revision of the World3 model, thus, consisted of two stages - the revision of the base model and the structural additions representing policy agenda.

The policy exploration strove for three possibilities: reinforcing existing functional feedbacks, stimulating latent functional feedbacks and creating new functional feedbacks. In real world, this approach corresponds to making use of existing institutions, revitalizing inactive institutions and creating new institutions. We also took care in our experimentation to move progressively to the subsequent policy possibilities, so that when the capability or the scope of an existing institution is fully exhausted, then only the option of creating new institutions is chosen. This prevents the creation of unnecessary institutions which are a sink of resources as well as a source of defusing welfare agenda due to their own need to sustain and increase institutional scope and power. The model revision (both the creation of policy space and policy agenda) was guided by the abstract concepts intuitively created through repetitive experimentation with the model and supplemented further by the literature on physics of resources and economics of environment.

Above considerations translated into making the following structural changes in the natural resources, population and other sectors of the model.

Revision of natural resources sector:

Natural resources sector is one of the five principal sectors of World3. A nonrenewable natural resources stock is the only level variable in this sector. The nonrenewable resources have been defined as mineral or fossil-fuel commodities essential to industrial production. They are regenerated on a time scale that is long compared with the 200-year time horizon of the model (Meadows and et al 1974). The initial value of the resources stock is fixed in the original model and the only rate connected to it is the outflowing usage rate, meaning that no part of the resources can be renewed. In terms of the physics of the resources, this really implies that the composition of the resource basket is fixed with the aggregate regeneration time being much longer than the time frame of the model. In reality, however, some of the resources with very short regeneration time (often classified as renewable resources) can be substituted for those with long regeneration time (often classified as nonrenewable resources), hence the aggregate regeneration time in fact can be varied through technology policy (Abelson 1976, Brooks 1974).

The resource ecosystem of the earth is a relatively small subsystem within the universe which derives its energic inputs from the environment maintained by the larger subsystem - the sun. The resource ecosystem in turn, maintains an environment form which human society - an even smaller subsystem- obtains its energic inputs. With the help of energic inputs it receives from the sun, the ecosystem is quite capable of regenerating resources from an unusable form to a usable form. Therefore, given enough time, almost all resources of earth spent over a certain period of time could be regenerated. Thus, the pace of circulation of resources through the resource ecosystem cycle - which determines the availability of resources in usable form - basically depends on the regeneration time. The aggregate regeneration time of consumption basket can be increased or decreased by adjusting the consumption basket with an addition of rich (long regeneration time) or poor (short regeneration time) resources respectively (Saeed 1985).

With above considerations, a resource regeneration structure is incorporated into the model in which the regeneration time represents the resource basket in use, that in turn is determined by the technological choices made. These technological choices can be influenced through indirect policy levers.

The policy levers affecting the resource basket built into the model are based on the principle of neoclassical economic theory and the physics of the resource ecosystem. The neoclassical economic theory advocates using natural resources to maximize the present utility determined by market situation, interest rates and technology in use. However, the neo-classical economic theory focuses largely on micro issues and lacks the macro dimension (Daly 1991). In an effort to extend the economic logic driving resource use from micro to macro dimension, Page (1977) suggests that we can think of resource policy at three levels: reactive – responding to immediate pressures, corrective –

attempting to improve the working of the markets, and reflective – informed indirect interventions attempting to preserve resources.

Most resource policies currently in use fall in the reactive category. These policies respond to particular pressures and a collection of them may often lack internal consistency. Implementation of reactive policies often requires powerful exogenous intervention. These are not considered in our experimentation.

The corrective policies aimed at improving the market mechanisms attempt to ensure efficient use of resources. As the market becomes a better allocator of resources to various uses, a sustainable balance is expected to be reached. This is also the approach advocated by the resource economics stream of the neoclassical economics, although there exist valid skepticism about the ability of the market to arrest the increasing trend of erosion of natural resources. Since the original limits premises lend themselves easily to explore operational corrective policies, instruments subsuming this level of intervention are experimented with in our study

The market mechanisms are, however, good only for assuring intra-temporal efficiency of resource use and they cannot address the issue of inter-temporal equity (Pearce, 1989; Page, 1977). Because, according to the theory of market economy, reserving resources for future use makes sense only when the expected future price of the resources is increasing, at least, at a rate equal to the market rate of interest. However, the market rate of interest generally exceeds the rate at which the society wishes to discount future. Hence, the market mechanisms always favor the present use of resources over the future use, which does not serve the societal interest of inter-temporal equity (Solow, 1974). Also, this approach cannot ensure the maintenance of an adequate level of slack in the resource stocks thereby making the society more vulnerable to shocks.

To address the problem of inter-temporal (or inter-generation) distribution of natural resources, Page (1977) suggests moving to the reflective level of policy interventions which basically favors informed government interventions to keep resource base intact. Realizing the fact that even well functioning competitive markets may fail to allocate resources properly over time, Solow (1974, p 12) also favors public intervention to slow down and stretch out the exploitation of the resource pool. This level of intervention is further explored in our study.

Figure 1 shows the feedback loops created in the revision of the resource sector. At the outset, a provision for resource regeneration is introduced in the model. Implicit sources of regeneration are the geological processes, recycling, and substitution from the pool of backstop resources. The revised structure incorporates active as well as latent feedbacks. First, it has been assumed that market imperfections are removed to enable the market signals to create appropriate feedbacks. The market clearing mechanism has, however, not been modeled as the level of aggregation of World3 did not allow this. However, the price adjustment is assumed to be responsive to resource availability. The price level thus transmits appropriate signals to the technological progress related to substitution, recycling and use of natural resources. The market mechanism assumed here forms part of the revised model. The graphical relationships concerning this revision are shown in Figure 2.

The price system discussed above can at best only ensure intra-temporal efficiency of resource allocation. So, to ensure inter-temporal equity, indirect intervention through the provision of a severance taxation system is proposed. To address the problem of inter-generation equity, the severance tax structure must assure that consumption and regeneration rates are matched through an appropriate selection of the resource basket.

This requires continuous monitoring of resource use rates and resource stocks to determine coverage time for each stock, which is translated into its availability. The severance tax is, then continuously adjusted in response to resource availability, assuring in the long run there are no inter-generation transfers of cost.

The severance tax simultaneously influences the recycling rate, the substitution rate (from the stocks of the backstop resources), the efficiency of use, the indicated level of industrial production and the regeneration time constant (determined by the composition of the resource basket in use). The technological dimension is implicitly included in each of these influences. Hence, one of the premises of the revised structure is that technology can be influenced endogenously through severance tax. As all newly created feedback loops are of balancing nature, the advancement in technology is automatically guided towards sensible choices cognizant of environmental considerations.

The severance tax mechanism can also be a useful instrument for the capital sector. In original World3 model's policy package, the desired per capita industrial output was exogenously restricted to 320 units in 1990. With the introduction of the tax provision, we can see that the desired industrial output must respond to the level of tax through the pricing mechanism.

Revision of population sector:
Population sector determines fertility and life expectancy. The Limits study identifies the desired completed family size as the sensitive policy parameter in this sector. In World3 model this variable is influenced only by industrialization, which is consistent with the classical theory of demographic transition. However, recent work on the political economy of fertility reveals that industrialization is not the sole reason for demographic transition experienced in western countries. There is substantial historical evidence, even in the industrialized countries, implicating government policy interventions as the primary cause for the fall in fertility rates. Thus "soft" government policy is able to govern the private micro level decisions made by reproductively active adults (Ryan 1991). Demeny (1988) links such soft and indirect policy to the creation of a gravitational field of incentives, rewards and punishment, that with a minimum of specific intervention would shape individual demographic behavior so as to best harmonize conflicting individual interests.

All policies in the population sector are intended to indirectly influence individual decisions on desired family size. for this purpose costs and rewards are adopted as policy instruments. Likewise the level of service delivery and income distribution are seen as additional instruments for bringing the maximum number of people into the mainstream group which is responsive towards the incentive system created by the policies.

Figure 3 shows the feedback structure underlying the revisions made in the population sector. This structure involves income multiplier, service multiplier, population growth rate multiplier and food multiplier. Two of the model variables, the multiplier for service allocation and the service-income distribution multiplier offer policy options for ultimately influencing the family size. The allocation multiplier pushes the fraction of allocation for service, which increases the service output per capita. The distribution multiplier modifies the desired family size due to income redistribution. Both policy variables influence fractional population increase (percentage of 1970's population). The graphical relationship between different variables related to the revision are shown in Figure 4.

Revision of other sectors
The only changes made in the other sectors of the model are in terms of constructing new information links from the respective stocks to the policies based on the information residing in them and connecting those polices to the flows affecting the related stocks. The main policy objective in the capital sector is to stabilize industrial growth, which can be accomplished by influencing the decision to invest and which eventually determines the level of industrial outputs. The condition of natural resources availability and persistent pollution are the key stocks responding to the investment policy. This policy objective can be achieved through indirect government intervention, for example the fiscal instruments influencing the investment decision. The volume of adjustment to be made in the industrial output determines the extent of indirect intervention needed.

The policy objective in the agricultural sector is to promote environmentally sustainable agricultural practice that calls for additional investment for technology development and land maintenance. The variables to be monitored and influenced by policy intervention are soil erosion, land fertility, pollution generation by the agriculture sector and food production. Likewise, those for the pollution sector are industrial and agricultural pollution. The graph functions related to the policies space created in the capital, agriculture and persistent pollution sectors are shown in Figure 5.

Policy Experimentation Operationalizing Entry Points of Limits Study

We began our experimentation by simulating the revised model without activating any of the policy structure created in the revision. The policy structure is then activated progressively. Before experimenting with any of the policy options, the factors causing the problem behavior in the revised model are first carefully traced out. Following this, a policy or a group of policies likely to correct the problem are activated and the model further experimented with. This process is repeated with different policy options until an improvement occurs in the problem behavior. If an activated policy alleviates the original problem but creates other problems, additional policies are activated. In this way, a wide range of policy alternatives are experimented with. Finally, effective policies are combined into a set that appears to best correct the problem behavior

Base run with the revised model
Figure 6 shows behavior of the revised model incorporating changes in the population and natural resources sectors, which are activated in the year 1900. The system still exhibits the characteristic behavior mode of overshoot and collapse, but the collapse of population is slightly less severe than the base run of the original model, while the collapse is also deferred for some time. This occurs because regeneration replenishes some of the usable resource stocks. Ultimately, the population goes down with all indices of standard of living declining. The resources are just enough to maintain a minimum level of industrialization and food production by the end of the twenty-first century. After that, there appears an even more severe collapse. These results show that even if a perfect market is established for the natural resources, it is not possible to alleviate resource scarcity in the long run as widely believed in traditional economics.

Simulation run with severance tax and its influence on technological progress
Figure 7 shows the behavior when the model is simulated with the additional policies of clamping severance tax on the scarce resources and making technological progress responsive to resource scarcity. The model structure corresponding to the severance tax

and technological policy are activated in the year 1975. The severance tax policy pushes the resources price higher than that determined by the market which simultaneously stimulates substitution, recycling and efficiency of use technology. These policies do not, however, alleviate the problem of collapse. We can see from the diagram that when the resource constraint is removed, the industrial growth is accelerated resulting in excessive pollution. Thus, the excessively high level of pollution created by the accelerated industrial growth (supported by the resources stock) is now responsible for the collapse.

Simulation run with pollution and agricultural policies
In order to avoid excessive pollution, additional policies of pollution reduction and sustainable agriculture are activated in the year 1975. This is accomplished by activating the link between Investment in Agriculture and Combined Erosion-Pollution Index. Similarly the information link between Persistent Pollution Index and Required Level of Pollution Abatement Technology is also invoked. The behavior resulting from this is shown in Figure 8. The problem of excessive pollution is taken care of but the industrial production is severely restrained due to the lowering of the productivity of capital caused by the environmentally benign production processes adopted and from the additional investment channeled into the agriculture sector for sustaining it. The decline of industrial output eventually brings down all indices of standard of living

Simulation run with industrial output stabilization policy
The industrial output stabilization policy is activated in the year 1975 in addition to the above policies. This policy attempts to maintain an indicated level of industrial output by influencing the society's consumption practices. The desired level of industrial output is continuously adjusted in response to the level of persistent pollution and the stock of natural resources through indirect interventions, such as taxation. This eventually influence investment trends in the industrial sector. The results of the simulation are shown in Figure 9. The desired level of industrial output is maintained and the system is stabilized into an equilibrium state.

Simulation run with policies of raising investment in services sector and distributing services and income more equitably.
In this run an experiment is performed to see the impact of raising investment in the services sector above the normal level and redistributing the services and income. This is accomplished by activating links created in the revised model from Fractional Population Increase to Service and Income Distribution multipliers. These policies are also activated in the year 1975. Figure 10 shows the model behavior. There is no significant change except a slight reduction in population. Apparently, these policies are not decisive in terms of bringing the system into equilibrium as long as the normal level of service investment and service-income distribution, as assumed in the base model are maintained. These policies could, however, be important in a situation where the service level is lower than the normal and the distribution of is highly unequal.

Simulation run with all policies activated in the year 2000
In the previous run the policy package consisting of severance tax, technological progress responsive to resource availability, pollution reduction, sustainable agriculture, industrial output stabilization, and investment in and distribution of services could bring the world system into equilibrium when implemented in the year 1975. The same policy

framework is now activated in the year 2000 in order to observe the time-dependence of the policy framework. Figure 11 shows the model behavior, which is quite similar to the last case where policy implementation occurred in the year 1975. This implies that the feedback-based policy framework proposed is not only effective in correcting unsustainable world behavior but is also time-independent.

Policy Experimentation Operationalizing Additional Entry Possibilities

Additional feedback structure was built into the model for allowing implementation of the reflective instruments, whose effect is translated into regulating the resource basket so the aggregate regeneration time of the resources in use is influenced as proposed in Saeed (1985), the provision of family planning services as proposed by Demeny (1988) and Ryan (1991), and controlling information flow in the regulatory process. The impact of these policies is discussed below:

Regulating resource basket
Figure 12 shows the impact of the policy directing technological progress towards decreasing regeneration time of aggregate resource basket, when consumption rates rise as proposed in Saeed(1985). The technological progress so created tends towards using natural resources with shorter regeneration time as the resources availability goes down. This increases the rate of circulation of the resources through the eco-system thus relaxing a significant constraint on growth created by the resource scarcity. We can see that the proposed policy, not only conserves resource stocks, it also reduces the pressure on technological progress needed to increase resource use efficiency, since availability does not go down as much due to increased circulation through the resource ecosystem. Lastly, this policy also seems to solve the problem of inter-temporal allocation of resources by attempting to match the consumption and regeneration rates of the resources in use for which the market mechanism alone was not effective. It should be added, however, that the implementation of this policy would require creation of a monitoring institution, like a natural resource board, that can keep track of the consumption rates and the stocks of the resources in use. With the availability of modern monitoring and information processing technology, such institutions would be feasible to create at the regional and national levels.

Provision of family planning services
Figure 13 shows simulation plots comparing the impact of family planning services and that of general social services on total fertility. The first run is simulated with the normal level of family planning services and an improved general services level. In the second run the family planning services are increased by 50 percent while the policy of improving the level of general service is deactivated (keeping active all other sectoral policies). It is evident that under the normal conditions (that is the fraction of services allocated to fertility control as assumed in the original model) the policy of increasing family planning services is not effective in bringing down the fertility level. This is because the total fertility is determined jointly by maximum fertility, level of family planning services and desired fertility. Under normal conditions, the family planning services are enough to meet the demand and bring total fertility close to the desired fertility. In such a case, the desired fertility should be lowered to reduce total fertility. By increasing family planning services one can not be motivated to have fewer children though it might help those already motivated (due to other factors). The raising of family

planning services above normal level therefore does not help the level of total fertility.

Controlling information flow in the regulatory process
Figure 14 shows the effect of increasing resources stock averaging time, used to determine availability, on the resources stock and on indicated level of substitution technology. The first run is with an averaging time of one year and the second with ten years. We can see that as the averaging time increases, the natural resources fraction goes down and more pressure is created for upgrading substitution technology. From these results it can be inferred that the information flow in the monitoring of resource stocks should be carefully controlled. The delay in monitoring gives wrong signals causing flow of distorted information for resources related decision.

Each of the above policies entails a negative feedback loop representing an institutional mechanism, existing or to be created. These feedback loops make the model behavior insensitive to a wide range of variation in the magnitudes of the behavioral parameters entailed in the policy. The most sensitive parameter is the substitution fraction in the resource sector, although this too does not create a change in the basic pattern of the behavior. Thus the operational policies proposed can not only be implemented through institutional mechanisms, they are also robust in terms of the of their response to the behavioral parameters.

Conclusion

The Limits study, despite its valuable conclusion about the unsustainable behavior of the world system, has prescribed interventionist policies which are difficult to implement. These policies were based only on changing sensitive parameters in the world model and not on the principle of feedback. Experimenting further with the Limits model, this paper has attempted to design operational policies that can create sustainable population and environmental patterns.

The operational policies identified, which are based on the principle of feedback rather than parameter change, appear to be superior to the ones prescribed in the Limits study in terms of the need for power intervention for their implementation. These policies, in fact, influence motivations of the actors and thereby guide their day-by-day decisions towards the desired end instead of requiring them to make drastic changes in their life-styles. It was also found that these feedback-based policies are insensitive to the changes in their respective behavioral parameters as well as to the timing of their implementation.

Further refinements of this study must examine regional aspects of the system and the trade relations within and between the regions since they inter-regional resource transfers that affect sustainability. Also important are the political relations within and between the regions whose dysfunction can result in excessive allocation of scarce resources to the unproductive control activities thus diminishing productivity.

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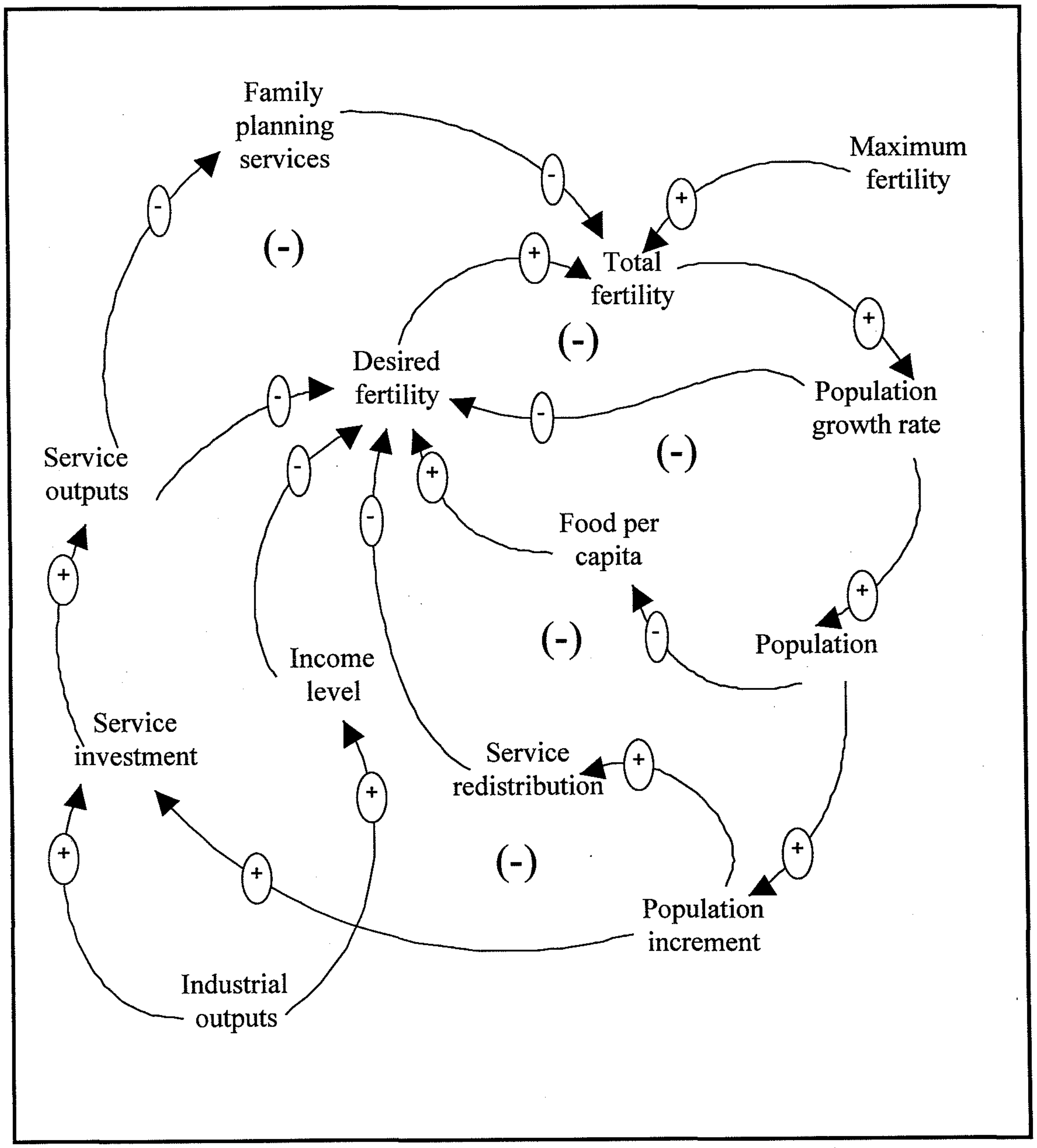

Figure 3: Feedback loops for revised section of the population sector.

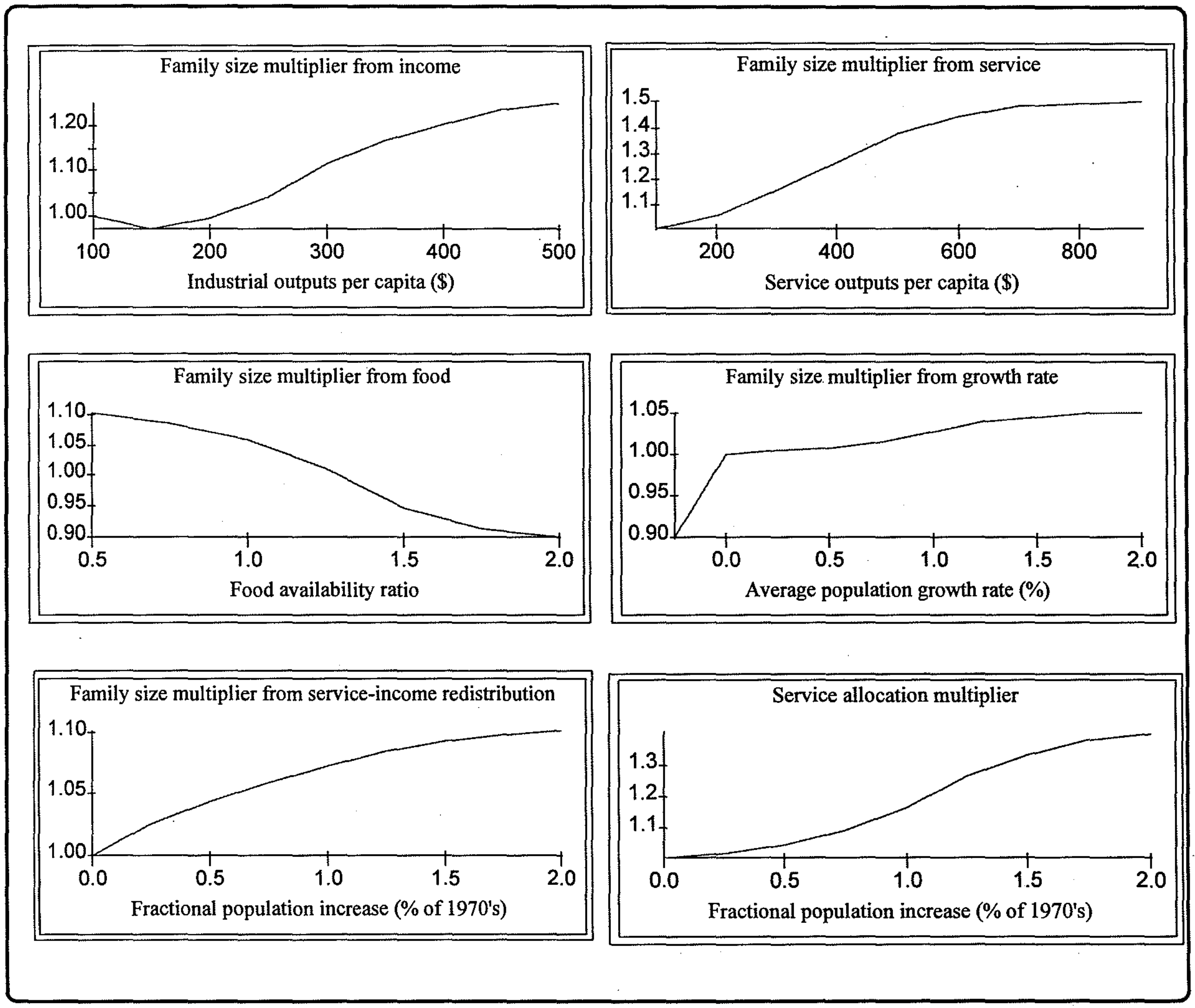

Figure 4: Graph functions related to the revised section of and policies for population sector.

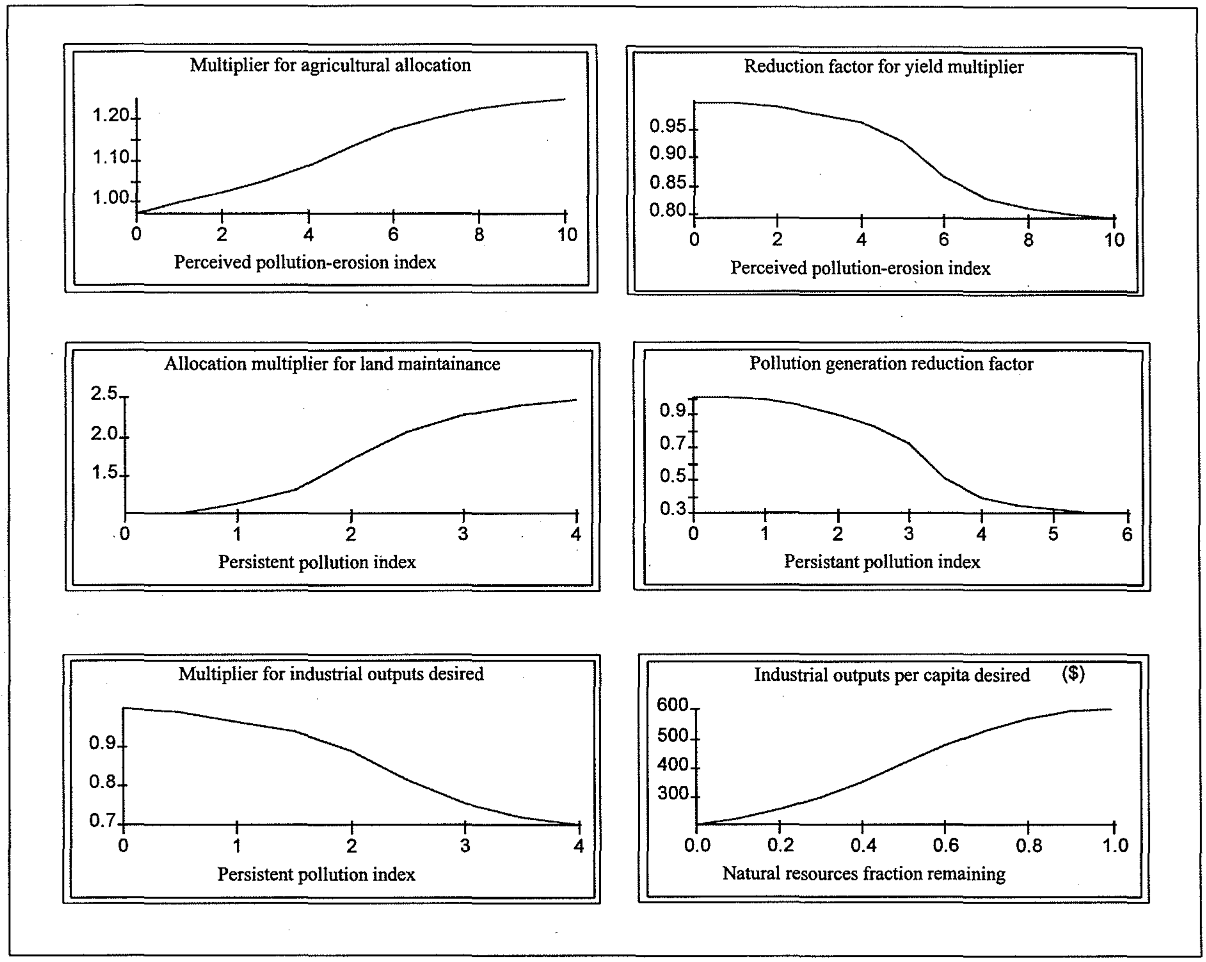

Figure 5: Graph functions related to policy frameworks for Capital, Agriculture and Pollution sectors.

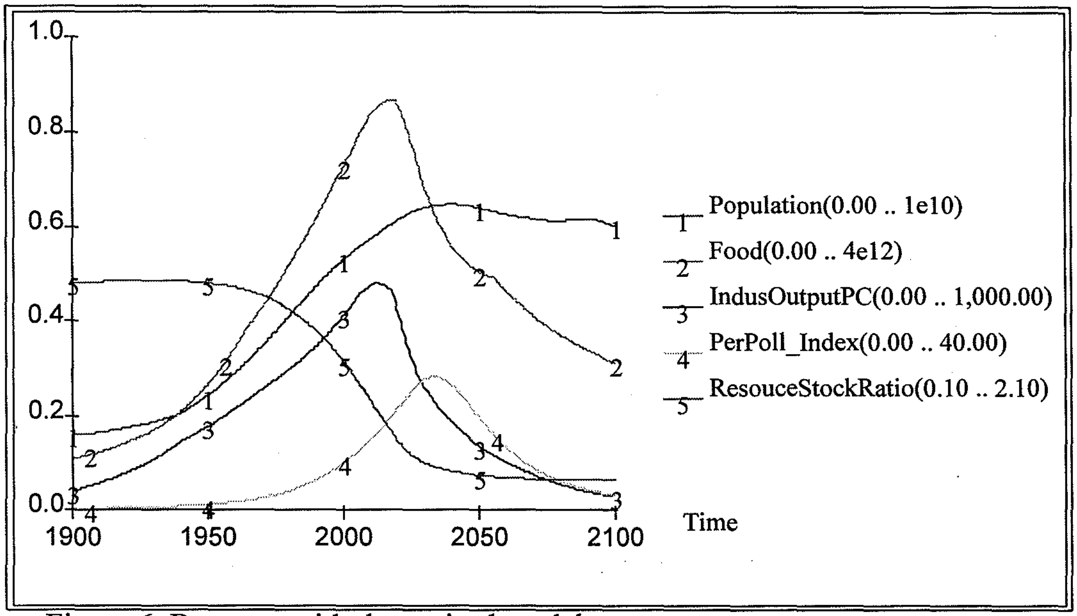

Figure 6: Base run with the revised model

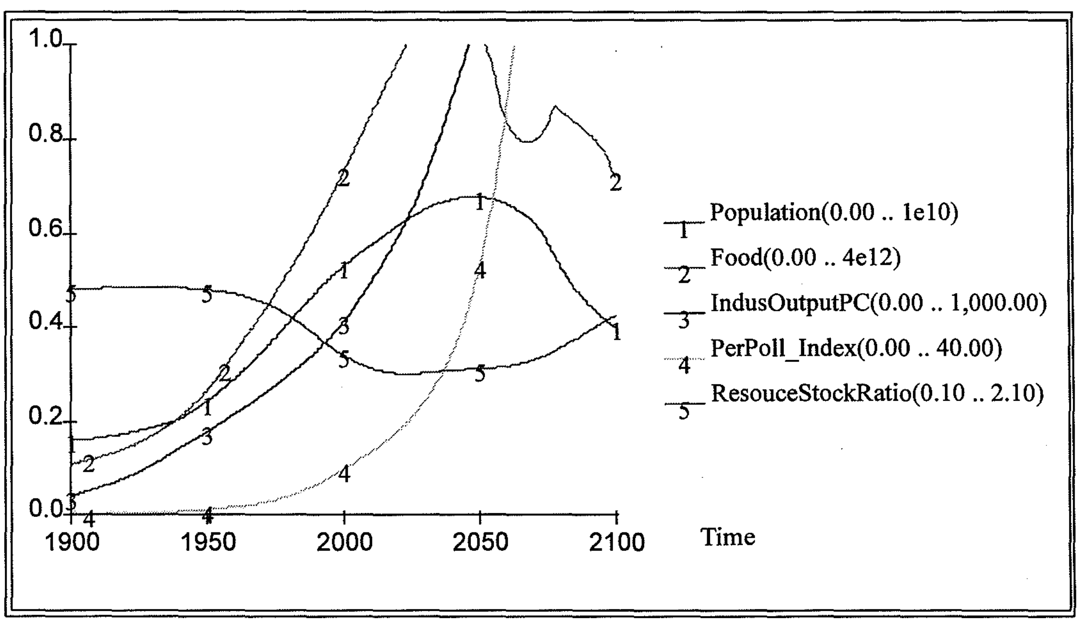

Figure 7: Simulation behaviour with severance tax and technology (resource) policy.

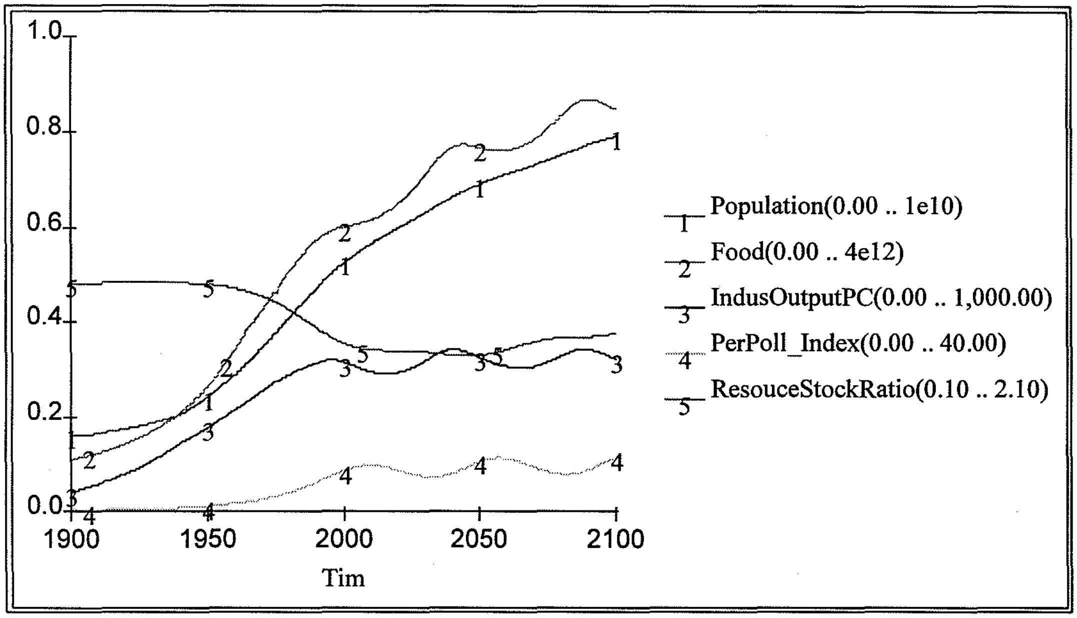

Figure 8: Simulation run with (additional) pollution and agricultural policies.

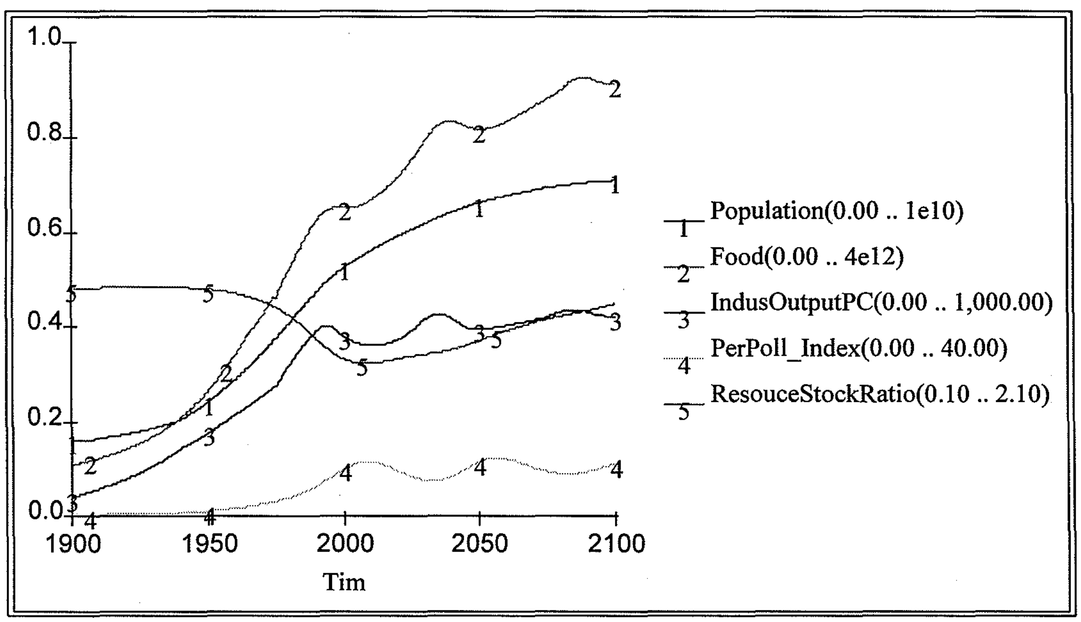

Figure 9: Simulation run with (additional) industrial output stabilization policy.

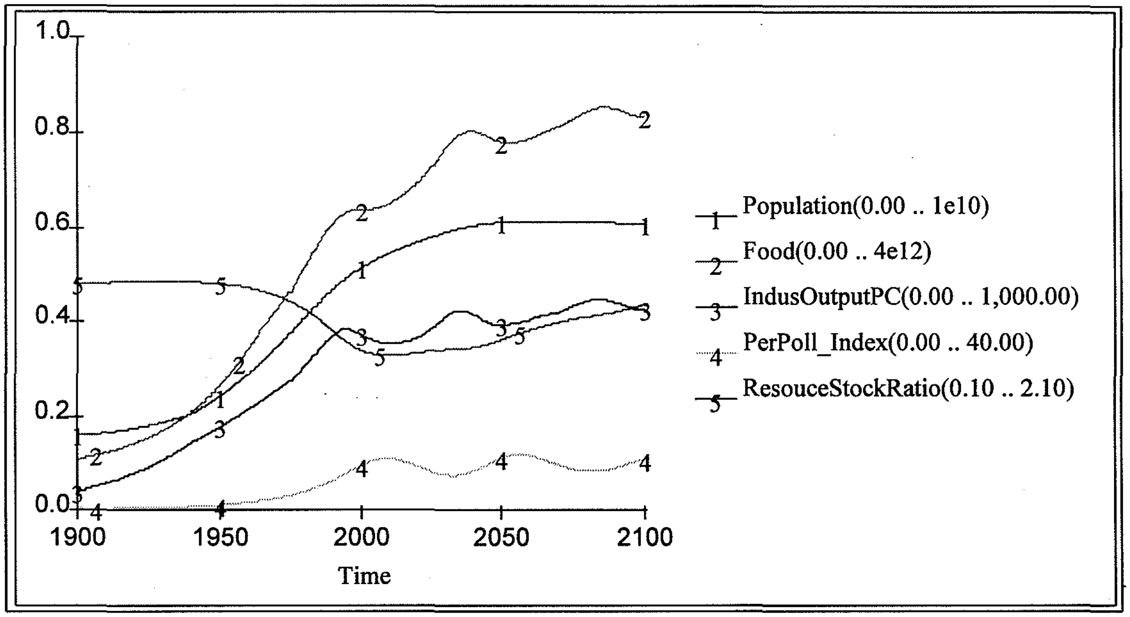

Figure 10: Simulation run with service and income distribution policies.

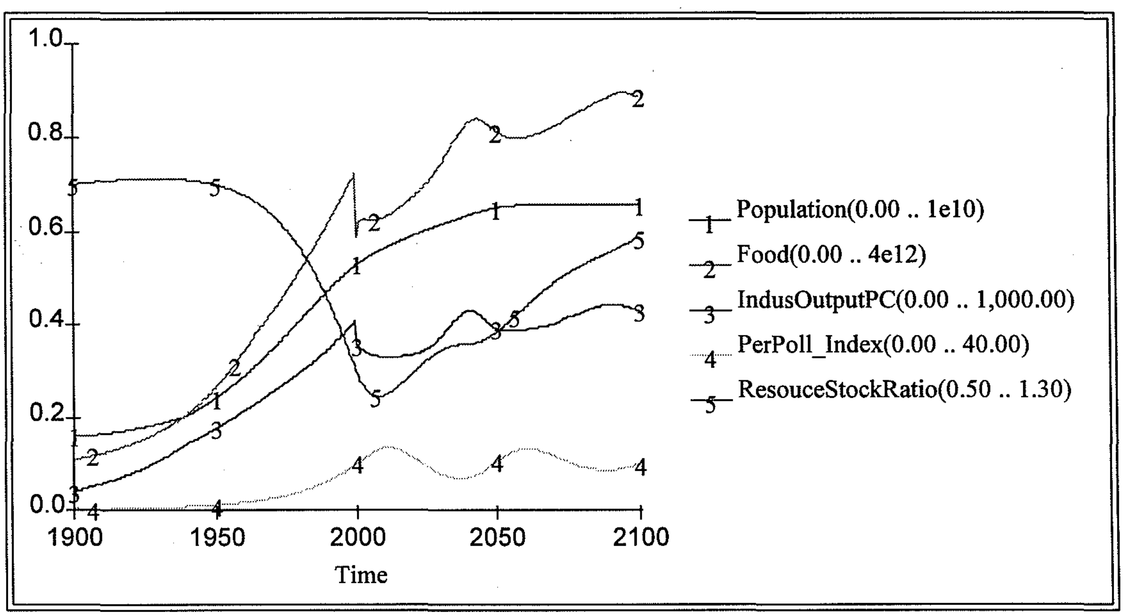

Figure 11: Simulation run with all policies activated in the year 2000.

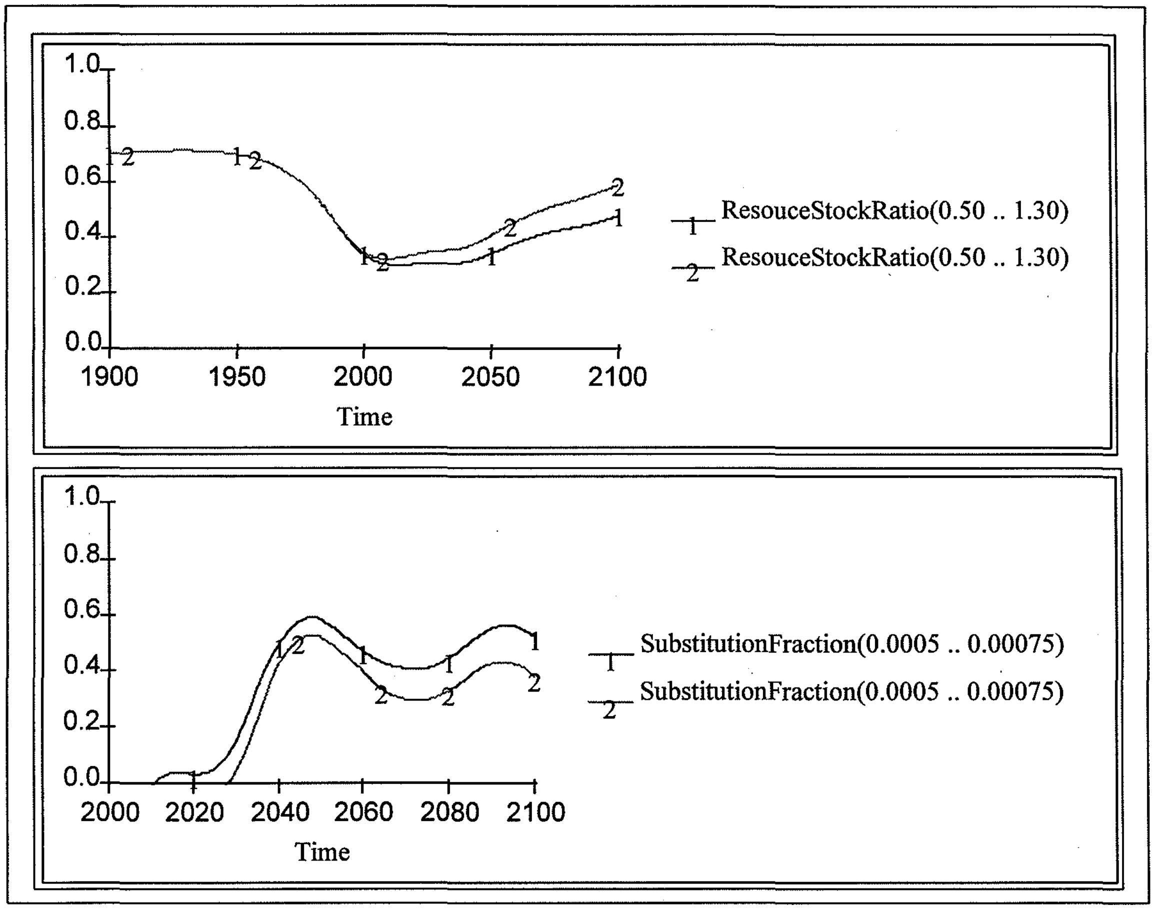

Figure 12: Simulations showing impact of policy directed towards decreasing regeneration time of aggregate resource basket. Plot (1) is run with historical policy and (2) is with proposed policy (i.e. shorter regeneration time).

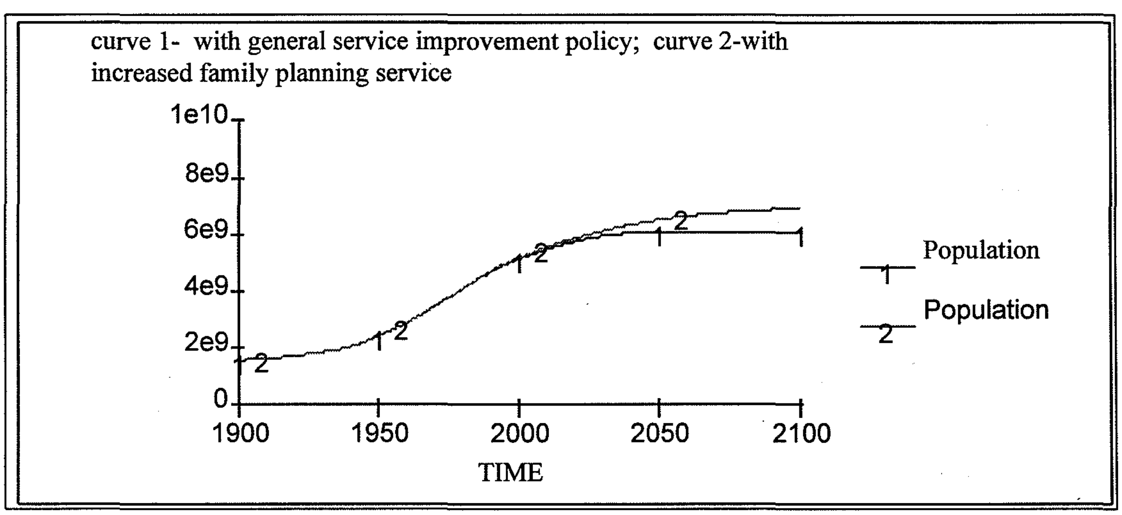

Figure 13: Simulations showing impacts of improved general social services and increased family planning service.

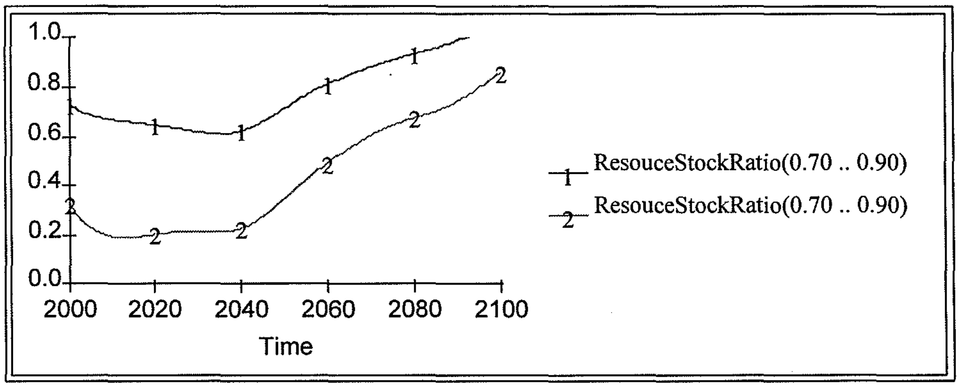

Figure 14: Simulations showing impacts of avaraging time for resource availability on resources stock ratio. Plot (1) is obtained with averaging time of 1 year and plot (2) is obtained with that of 10 years.

The Threshold 21
Sustainable Development Model
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