DYNAMICS OF FOOD POLICY IN A CENTRALLY-PLANNED ECONOMY:
The Case of Vietnam

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ABSTRACT

This paper attempts to assess the impact of past and presently contemplated policies to maintain food self-sufficiency in a centrally-planned economy. The case of Vietnam is used as an illustration. Experimentation with a system dynamics model of the food production system incorporating relationships concerning soil ecology and agricultural land management policy serves as a basis for this assessment. Short-run policies to increase production are detrimental to maintaining food self-sufficiency in the long-run. A sustainable food production policy must incorporate soil conservation and improvement, control of population and, possibly, finding food sources alternative to grain. Although difficult to implement in a market system, such a policy agenda may be feasible in a centrally-planned economy.

KEY WORDS: Food Policy, Agricultural System, Centrally-Planned Economies, Soil Ecology, Population, Agricultural Land Use.

1. INTRODUCTION

Excessive use of land resources has been known to depreciate soil quality. Soil degradation has occurred in many countries due to erosion, loss of nutrients, loss of texture, water logging and salinity, which have usually been caused by intensive land use (Bowonder 1981).

Centrally-planned as well as market-economy countries encounter these problems. Chandler (1987) observes that the environmental failures of centrally-planned nations rank alongside those of free market economies. The former failed to internalize environmental costs because incentives were provided to managers to boost production. Moreover, the resources allocated to the managers reflected no scarcity value, no opportunity cost, no real price; the cost of using the resource was essentially irrelevant. The absence of prices and competition in the planned economies led to inefficiency as well as widespread environmental abuse.

With only occasional exceptions, assessments and statements made on environmental degradation have little effect on policy analysis and decision making. The first reason for this is a compartmentalized treatment of a complex system, where feedback between the effect of one subsystem on the other is not recognized. The second reason is that planning decisions rarely take into account the cost externalized to the environment, in terms of depleted resources and deteriorated soil conditions, for preparing development agendas (Brown and Wolf 1986). Indeed, the effect of deforestation, soil degradation, and cropland abandonment are generally omitted from agricultural development strategy.

This paper attempts to assess the impact of the past and presently contemplated policies to maintain food self-sufficiency in Vietnam, and also illustrates the case of centrally-planned economies. This assessment is based on experimentation with a system dynamics model of the food production system that incorporates three subsystems: population, food production, and soil ecology. It is demonstrated that short-run policies to increase food production to a state-planned level are detrimental to maintain food adequacy in the long-run. Designing a sustainable food production policy must take into account population control, soil conservation and improvement, and in the case of Vietnam, also finding alternatives to grain.

2. FOOD PRODUCTION SYSTEM IN VIETNAM: An overview

Vietnam is the rugged eastern part of the Indochinese peninsula. Leaning back against the Asian continent, it looks out on the East China Sea and the Pacific. It is situated entirely in the intertropical geographical belt, in the center of Southeast Asia.

Vietnam covers an area of 329,600 km^2, of which three-fourths are composed of mountains and plateaus, and only 17 per cent is arable land under cultivated crops. Food crops are mainly planted in the Red River delta in the North, and the Mekong River delta in the South. Although these plains are not very large, they are relatively fertile and especially suitable for food crops.

The country has a tropical climate with a humid monsoon season. The year is mainly divided into two seasons: winter, which is cool and dry, and summer, which is hot and rainy. In the rainy season, there is enough rainfall for crop planting over the whole year. But without proper water conservation systems, the fields suffer from drought during the dry part of the year. Also, too much rainfall causes water logging and floods during the rainy season. In addition, a prolonged winter harms seed-sowing in the spring, and during heavy rainfall the soil can easily be eroded, and its fertility decreases very rapidly.

The population of Vietnam is at present basically rural and is concentrated in the two main rice-growing deltas mentioned above. As a result, agriculture remains fundamental to the Vietnamese economy and provides a direct living for 70% of the country's labor force, as well as contributing about 45% of the GDP. A population growth rate of appropriately 2.4% per year makes the population double in about 30 years. Population has risen from 16.5 million in 1930 to 32 million in 1960 and to 64 million in 1987. A large population, coupled with limited cultivable land, maintains the arable land per capita at a low value.

Agriculture has been practiced in the country for a very long time. Among the food crops, rice takes first place, leaving all other crops far behind. Nearly all of the area suitable for rice is under rice cultivation. Vietnam's strategy is therefore to promote yield increase rather than to expand rice-growing areas.

Except for the short-term decrease in food output during the adverse years, food production in Vietnam has experienced a long upward trend since 1930. This growth was achieved mainly through increases in both yield per hectare per crop and the intensive use of agricultural land throughout the country. However, the population has risen at a higher rate than the total food production, which has resulted in a downward trend in food per capita. Vietnam is no longer a grain exporting country as it was before the 1970's.

Further, intensive use of soil, made possible through high-yield technology, has contributed to both physical and chemical degradation of soil, especially the loss of soil organic matter. In many places, especially in hilly areas, the soil has become barren. The most serious soil erosion has occurred in deforested highlands, such as in the Northwestern Region.

3. A SYSTEM DYNAMICS MODEL OF FOOD PRODUCTION SYSTEM

The food production system of Vietnam can be characterized by feedback loops shown in Figure 1. The organic relationships underlying the feedbacks loops span population, food production, and ecological subsystems as discussed below.

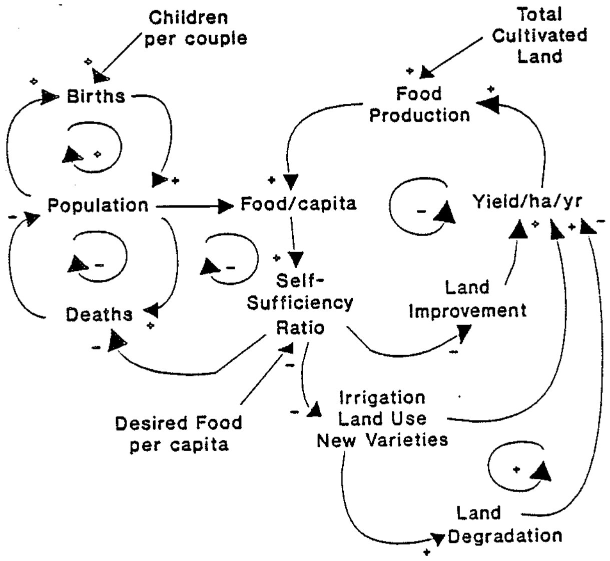

Figure 1: Main feedback loops in the food production system

3.1 *Population Subsystem*

Births and population form a positive feedback loop, which accounts for the observed exponential population growth. When calculating births per year, we can think in terms of birth fraction per year, but, when imposing a policy to decrease it, we do not know how this policy would be implemented. Therefore, number of children per couple is included so that a policy for each couple to reduce number of children becomes more concrete and implementable in reality, especially in a centrally-planned economy.

Population and deaths form a negative feedback loop which governs population growth. Whereas the above positive loop generates exploding growth, this negative loop seeks to regulate growth.

Deaths are assumed to be dependent on the self-sufficiency ratio which is food per capita normalized with respect to a defined value considered adequate. Sustained and increasing food availability leads to higher life expectancy, thus less deaths; and vice versa. Hence population, food, and deaths form a self-correcting negative loop.

3.2 *Food Production Subsystem*

Food supply and yield form several negative loops. As long as food per capita remains below a sustainable level, agricultural planners have no choice but try to increase production by any possible method (normally the quickest and least expensive). However, for countries like Vietnam, where the land suitable for producing food is limited and most arable land has been brought under cultivation, increasing the yield (output per unit of cultivated area and per unit of time) has become a major objective. Well-known methods to increase yield consist of soil improvement, development of irrigation to permit multiple cropping, and adopting of high-yield varieties.

So, a decline in food per capita leads to attempts to boost food production through the above methods, which, in turn, causes food per capita to be increased, ceteris paribus. These self-correcting feedback loops explain why countries with large population but limited land can still experience a growth in food production to feed their population, as in Japan and South Korea.

3.3 *Ecological Subsystem*

Under population pressure and limited arable land, high-yield technology which intensifies land use and uses new high-yield varieties tends to alter soil properties, unless the system is managed properly. Under poor management, this will lead to land degradation that, in turn, eventually will cause crop yield, total food produced, and thus the self-sufficiency ratio to decline in the long-run. The model assumes land degradation is caused primarily by loss of soil nutrients (through erosion or intensive cultivation) and the creation of "adverse land" in problem areas. The model also assumes that the adverse land share is increased with the increase in water-logging and salinization in poorly-managed irrigation of problem soils.

From the above argument it follows that food production and poor land management form a positive feedback loop, aggravating both land degradation and food shortage in the long-run.

More details of the flow diagram developed out of the feedback structure outlined above are provided in Figure 2, while a general description is provided in the appendix. Further technical documentation and a machine-readable program of the model coded in DYNAMO are available from the authors on request.

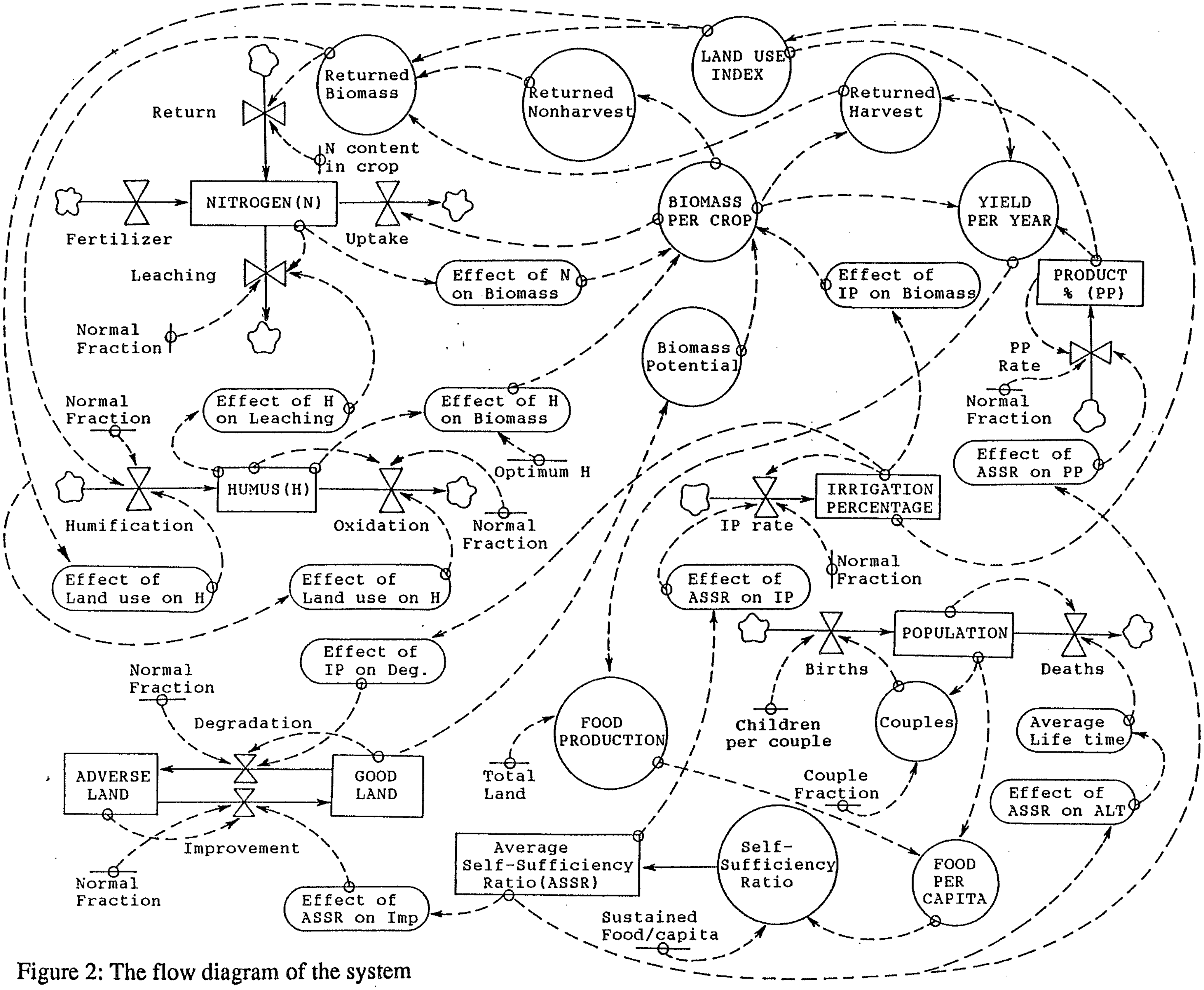

Figure 2: The flow diagram of the system

The important policy assumptions made in the base run are the following:

a) A normal soil fertilization rate is defined such that the system is in equilibrium for the initial conditions, which may be increased somewhat when the need for fertilizer is perceived. However, longer term mechanisms affecting soil dynamics, such as immobilization and mineralization, as suggested by Jones (1984), are ignored.

b) Irrigation, new seed varieties, and soil improvement (conversion of adverse land to good land) are assumed to develop at specified normal rates unless further modified by other processes. They remain unchanged as long as the average self-sufficiency ratio (ASSR) is greater than or equal to 1. When this ratio is less than 1, these activities will be increased.

c) Intensity of land use for cultivation represented by the "Land Use Index", for simplicity, is treated as a linear function of irrigation percentage.

d) The population is aggregated into a single level only. It is assumed that the couple fraction and the number of children per couple do not change over time, except through policy intervention. Average lifetime is a nonlinear asymptotic function of the average self-sufficiency ratio.

e) Total land under food crops (composed of good land and adverse land) is assumed to be constant, although it can be changed in the model for experimental purposes.

Figure 3 shows a simulation of the model giving the behavior of nitrogen, self-sufficiency ratio, and yield per hectare per year. Yield per hectare per year experiences an upward trend, slowly increasing during the early decades of the simulation time, then rapidly increasing due to the use of methods, especially land use intensity, to boost production. Under the assumed poor management practices, this results in a downward trend in soil nitrogen stock, a proxy for land fertility. A high land use index alters the physical and chemical properties of soil, reducing the organic matter returned to soils. New high-yield varieties adopted extract high amounts of soil nutrient during the crop growth stage. Coupled with the continuing growth of population, land degradation gives rise to a decline in self-sufficiency ratio during the course of the simulation, from 1.2 in 1930 to 1 in 1966-1967, then down to nearly 0.8 in 2030. These figures clearly explain why the country, which used to be a grain-exporting, became a grain-deficit country.

Figure 4 displays the explosion of population and the growth in land use index. Notice that good land is increased during only the early decades, and then begins to decline.

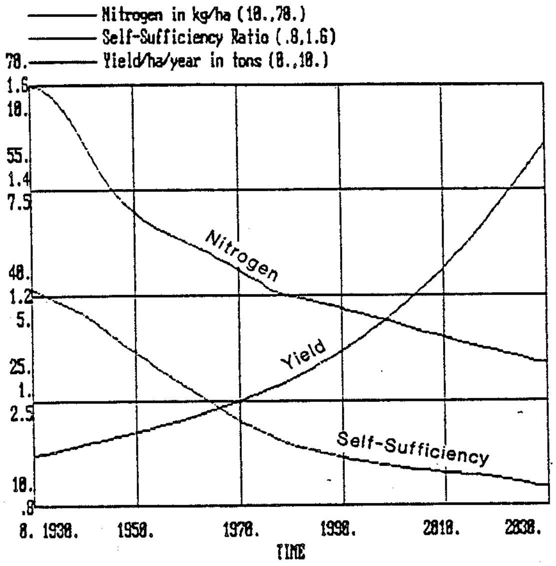

Figure 3: The Base Run

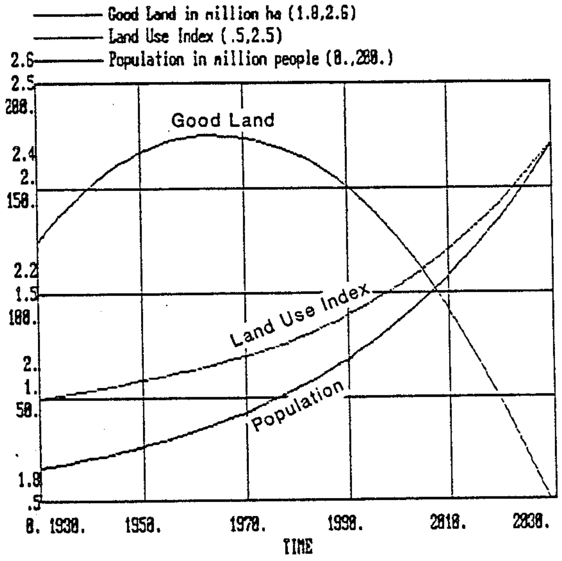

Figure 4: The Base Run

4. SEARCH FOR SUSTAINABLE FOOD POLICY

An advantage of system dynamics computer simulation models over the "real world" is that the models, when carefully developed, can be used fully as experimental laboratories. The modelers, as well as the analysts, can devise controlled experiments and well-designed changes in both the parameters and structure of the systems of interest in order to better understand their endogenous behaviors and their "natural" responses to the changes induced. Such experimenting could help the modelers themselves identify the strengths and weaknesses of the model structures, which, if necessary, makes them modify and improve the system structure until the latter comes to represent the real system rather well.

Furthermore, careful experimentation with a correctly constructed model helps to quickly identify which policies are "good" and which ones are "bad". This second advantage can shed much light into the implications of alternative policies to be adopted so as to improve the system performances in the future.

The experiments described below, for the sake of testing the model, required changes in the system parameters which affected almost all of the system's main parts. The changes are not abstract but meaningful in the sense that they are related to concrete policies which can be implemented in actual practice.

4.1 *Population Control*

As can be seen in Figure 1, the positive feedback loop of births-population causes the population to explode. So, it is reasonable to think that population control measures to reduce the natural birth rate through family planning could increase the food per capita, and hence the food self-sufficiency ratio.

Figure 5 shows that, in order to achieve self-sufficiency at the end of simulation, number of children per couple should be decreased from 3 to 2 (about one-third) between 1988 and 2030.

Figure 6 shows that if after 1988 children per couple are decreased only 22% (from 3 to 2.34) then self-sufficiency can be achieved from the year 2015 onward. Thus, strong population control measures will yield a high outcome. Direct intervention to implement such a measure might appear impractical, although there is evidence of its success in Japan and China. There is a need to develop appropriate policies to implement population control.

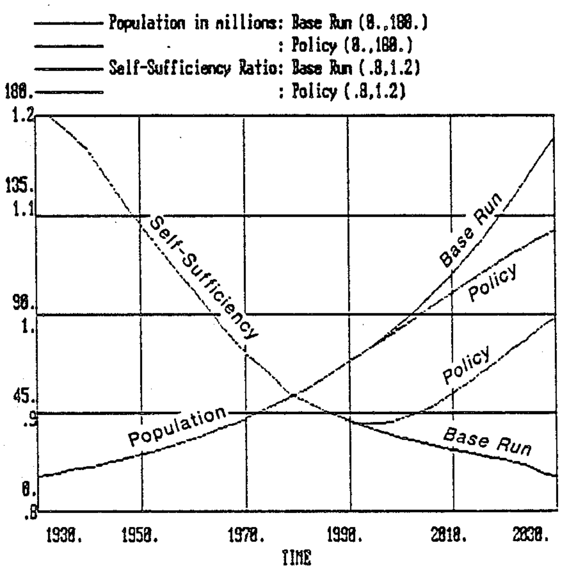

Figure 5: No. of children from 3 to 2

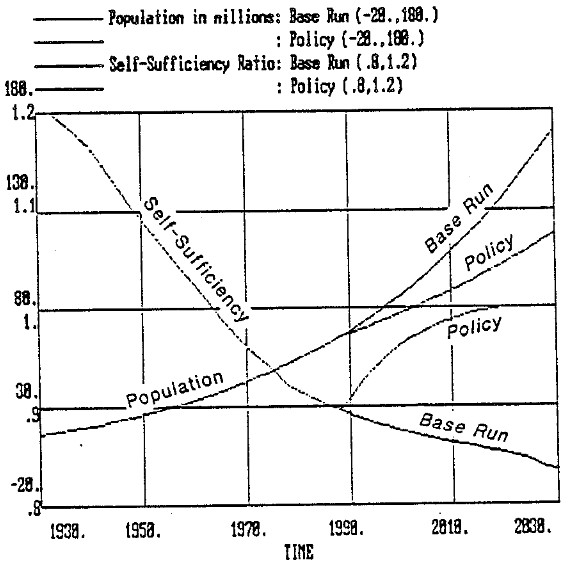

Figure 6: No. of children from 3 to 2.34

4.2 *Land Management Policy*

With a high land use index and high-yield seed varieties adopted, soil nutrients tend to be depleted as shown in the base run. It has been well known that fertilization, when applied properly, and when higher residues are returned to the soil, fertility is sustained. However, the model assumes that the pressure for quick returns and lack of incentives- and money- for proper management will result in soil nutrient losses.

Figure 7 shows the behavior of soil nitrogen if fertilizer application is increased by 35% in 1988. The overshoot shown is due to the fact that nitrogen in the soil is constantly lost through crop uptake and leaching in proportion with its remaining stock. So, a step increase in fertilization only yields increases in soil nitrogen temporally.

An annual increase in fertilizer application at the rate of 2.7% can bring nitrogen to the initial level at the end of simulation as presented in Figure 8. However, self-sufficiency ratio does not return to its initial level.

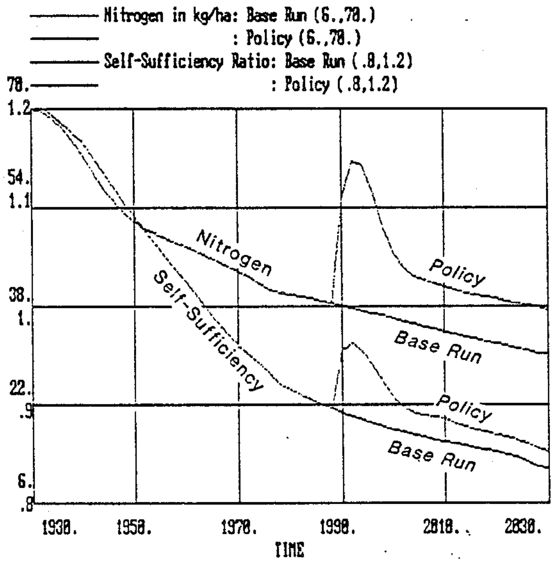

Figure 7: 35% increase in fertilizer

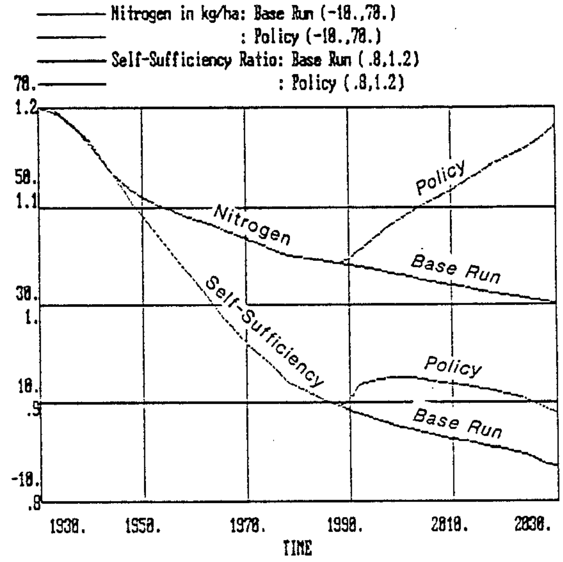

Figure 8: Fertilizer at the rate of 2.7%

Crop residues returned into the soil after harvest, plus animal manure application, does improve the nitrogen stock in the short-term but not in the long-term, as seen in Figure 9. There is a 50% increase in residues returned from 1988 and 2030, but the self-sufficiency ratio is not improved.

Another policy option is to increase investment to improve adverse land conditions. Figure 10 shows a simulation incorporating land improvement effected at the rate of 10%. It results in an upward trend of "good" land share, but a downward trend in the self-sufficiency ratio in the long-run, though the latter exhibits an upward trend in the short-run.

However, all of these policies aimed at improving land management cannot bring the food self-sufficiency ratio above 1 in the long-term, mainly because population is still increasing too rapidly.

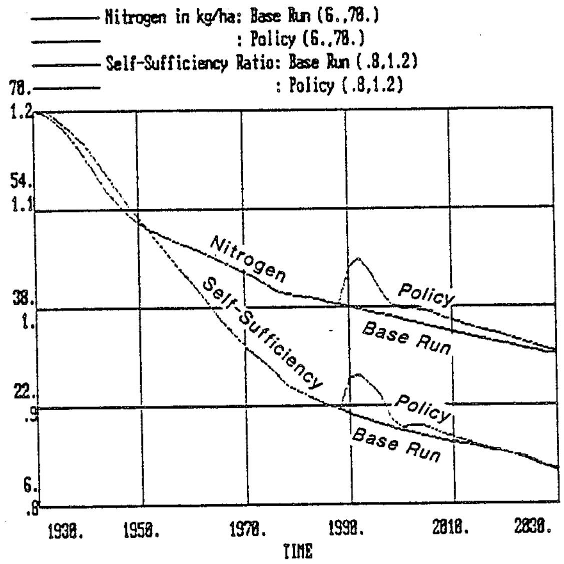

Figure 9: Increase in residues

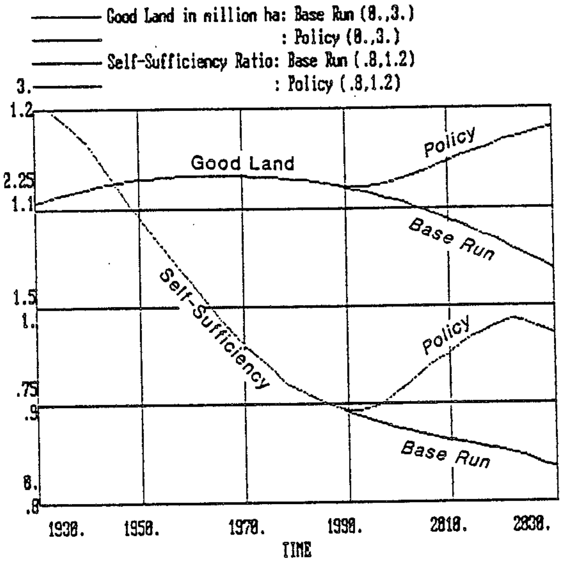

Figure 10: Land improvement

4.3 *Water Management Policy*

A different strategy to boost food output is to increase the land use index through irrigation. As shown in Figure 11, an 80% increase in irrigated land, which is only made at very high investment, steps up food self-sufficiency ratio in the short-run, but may also lead to water-logging and salinization which, coupled with loss of soil nutrients, leads to a decline in productivity. Thus, a more intensive land use policy (with poor management of the irrigation system) is assumed to boost food output at the expense of land degradation in the long-run.

In the all previous experiments, the total land under cultivation was assumed to be constant. Consequently, when population continues to grow (and so the demand for food), the limited land is under great pressure. As an experiment, it was assumed that new land could be opened to raise the total land planted to food crops. Figure 12, where a 20% increase in new land development from 1988 to 2030 is made, shows that adverse land goes up, while self-sufficiency ratio is slightly increased, then decreased again.

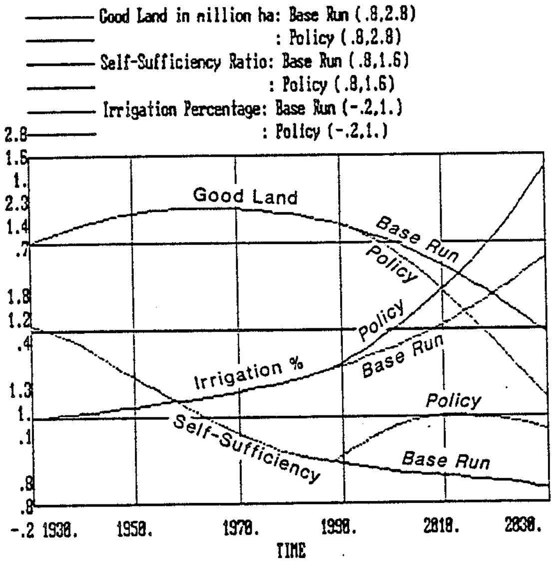

Figure 11: Increase in irrigation

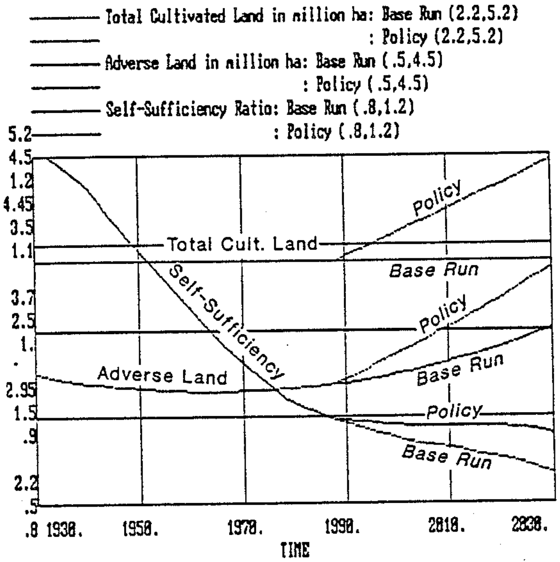

Figure 12: New land development

The reason for this perhaps unexpected result is that since the best land for food production has already been brought into cultivation, only marginal lands remain to be developed, which causes an increase in adverse land, and thus could not bring about the desired outcome (without a large initial investment in land improvement, which the government of Vietnam cannot afford).

5.4 *A Combination of Policy Alternatives*

The previous policies were considered separately, with each related to only one sector of the complex system structure. Now, a combination of the most effective among these policies is examined as an illustration of the promising results that could be obtained.

As can be seen from the above experiments, radical policy changes in each separated area were not successful in achieving food self-sufficiency. In addition, a strong change in each separate policy may be impractical and unfeasible. However, a plausible combination of policies can yield a very encouraging outcome.

Combined policies, currently implemented from the year 1988, consist of:
a) 10% decrease in number of children per couple;
b) an annual 2% increase in fertilizer application to replenish soil nutrients;

c) 10% increase in residues returned into soil after harvest; and
d) an annual 5% increase in land improvement effort in terms of conversion of adverse to good land.

Such moderate changes in each system part may prove to be implementable in practice. The key is to introduce them together.

The long-term result generated by this policy combinations are better than before, as seen from Figure 13. Nitrogen stock could attain the same level as initially. Good land does not decline. Population, of course, still increases, but at a rate lower than in the base run. All these improvements account for the upward trend in the food self-sufficiency ratio, which nearly reaches the initial level.

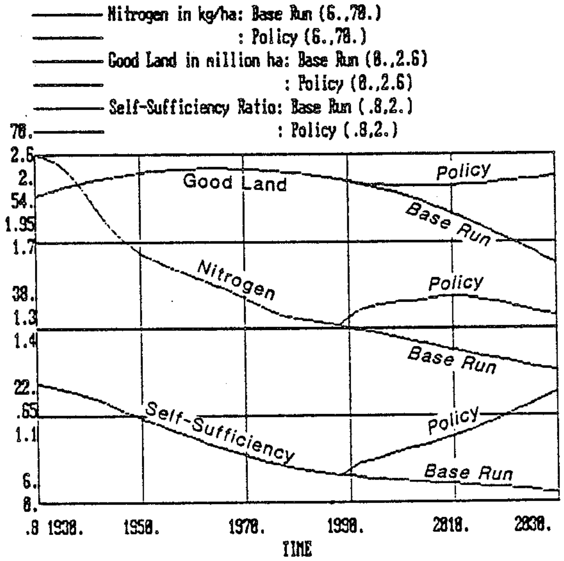

Figure 13: A combination of policy alternatives

5. CONCLUSION

This paper has characterized the food production system in Vietnam at an aggregate level which represents a centrally-planned economy. A model for this system has been developed to incorporate relationships concerning population, food production, soil conditions, and agricultural land management policy.

It turns out that there are policies which, when adopted to keep food production apace with the population explosion, can have very detrimental consequences over the long-term. Intensifying land utilization, expanding cultivation into marginal areas, using "miracle varieties" without adequate fertilization all might bring premature hope and lessen concerns over an exploding population. Such over-optimistic thingking could lead to policies in which the long-term/short-term trade-off are not carefully considered.

The model developed in this study has also demonstrated that food production is basically an extractive activity, which is likely to lead to land degradation. Population growth can be seen as the fundamental driving force behind this process.

It has now become obvious through experimenting with the model that wise land use management and proper population control measures can bring the system into a balance one, which can be sustained for a rather long time. This requires realistic and long-term planning, since degraded land takes a long time to recover and population also takes a long time to control.

The model developed in this paper, however, is a simple and aggregate representation of the real food production system for the centrally-planned economy of Vietnam. In order for a better food policy to be formulated and successfully implemented, the system boundary must be expanded.

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APPENDIX: GENERAL MODEL DESCRIPTION

1. $d(N)/dt = NFAR + f_1(B)*f_2(LUI) - f_3(B) - f_4(H)*f_5(N)$; $f_1' > 0$; $f_2' < 0$; $f_3' > 0$; $f_4' < 0$; $f_5' < 0$;
   N = Soil Nitrogen, NFAR = N Fertilizer Application Rate, B = Biomass,
   LUI = Land Use Index, H = Humus.

2. $d(H)/dt = f_6(LUI)*f_7(B) - f_8(LUI)*f_9(H)$; $f_6' < 0$; $f_7' > 0$; $f_8' > 0$; $f_9' > 0$;

3. $d(IP)/dt = f_{10}(ASSR)$; $f_{10}' < 0$;
   IP = Irrigation Percentage; ASSR = Average Self-Sufficiency Ratio.

4. $d(PF)/dt = f_{11}(ASSR)$; $f_{11}' < 0$;
   PF = Product Percentage.

5. $d(P)/dt = f_{12}(P) - P/f_{13}(ASSR)$; $f_{12}' > 0$; $f_{13}' > 0$;
   P = Population.

6. $d(GL)/dt = f_{14}(ASSR)*AL - f_{15}(IP)*GL$; $f_{14}' < 0$; $f_{15}' > 0$
   GL = Good Land; AL = Adverse Land.