Food and Population: Policies for the United States

Donella H. Meadows

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I. INTRODUCTION

Two United Nations conferences in 1974, one in Rome and one in Bucharest, emphasized the necessity for every nation to confront two interlocking global problems: food shortages and rapid population growth. The World Food and Population Conferences also dramatized the extreme difficulty of formulating effective policies for dealing with these problems on either a national or an international level. The issues are complex, they involve areas of great political sensitivity, and "experts" and ordinary citizens alike express widely divergent viewpoints about the severity, causes, and possible cures of what is often called the "world food crisis." The current debate is not simply bipolar, but multipolar, as the following quotations, all written by Americans, illustrate:

> What, then, accounts for the sharp deterioration in the world balance of supply and demand in the past 3 years? . . . These events can be explained essentially as the result of transitory factors: an unusual, but not unprecedented, series of crop shortfalls in the U.S.S.R., South Asia, and North America; and the failure of the major producing and consuming countries to prepare for such an eventuality . . . What future course of action is suggested by the experience of the past few years? . . . All that would seem to be required is a grain reserve of limited size, though adequate to meet contingencies such as those experienced in the mid-1960's and again in the past 3 years.[1]

1. Fred H. Sanderson, "The Great Food Fumble," *Science*, 188 (1975), 503.

> The current international scarcity of major agricultural commodities reflects important long-term trends as well as the temporary lack of rainfall in the Soviet Union and parts of Asia and Africa. From a global perspective . . . the world is likely to be highly vulnerable on the food front in the years ahead. The poor nations, and the poor people within nations, are in an especially dangerous predicament.[2]

> The United States should remain an island of plenty in a sea of hunger. We are not responsible for the rest of humanity . . . Famine is one of nature's ways of telling profligate peoples that they have been irresponsible in their breeding habits . . . Until those asking for handouts are doing at least as well as we are at reducing existing excessive population growth rates, we should not give away our resources—not so much as one bushel of wheat.[3]

> Some scientists and publicists have seriously advocated a "lifeboat ethic", saying that nations which do not compel human fertility control . . . are endangering the survival of our species —hence they should be starved out of the human race by denying them food aid. This obscene doctrine assumes that men and women will not voluntarily limit their own fertility when they have good reasons and the knowledge and means to do so . . . The World Food Conference dramatically signifies the true interdependence of human beings everywhere, but it emphasizes even more the necessity to change the selfish and shortsighted behavior of many people in both the rich and the poor countries.[4]

If all these writers could agree upon any one thing, it would be that there is a problem, present or potential, that requires some action. No one seems to think that the food situation will get better

2. Lester R. Brown, "Global Food Insecurity," *The Futurist*, 8, No. 2 (April 1974).

3. Johnson C. Montgomery, "The Island of Plenty," *Newsweek* (December 23, 1974), p. 13.

4. Roger Revelle, "The Ghost at the Feast," *Science*, 186 (1974), 589.

if it is simply left alone. There is vast disagreement, however, about what policy would be most effective, and who should carry out that policy. Grain reserves, green revolutions, increased aid, no aid, population control, market control, agribusiness control—all are seriously advocated. In the face of such disagreement, can a national policy be designed, and implemented with sufficient diligence, to produce a perceptible result? Is there any way to resolve the many interpretations of the world food problem, to understand and analyze them, and to forge them somehow into a comprehensive and effective food-population policy?

The present controversy, I believe, arises from three major areas of difference: the *boundaries* of space and time within which the contenders view the problem, the *theories* by which they explain the causes of the problem, and the *values* underlying their respective choices of preferable costs and benefits. Each individual combines these three factors into a consistent mind-set or world-view that influences not only his policy position but also the facts he perceives as relevant and the questions he asks to elicit new information. Unfortunately, in debates about food or population policy the participants seldom state clearly the world views that determine their positions. As a result, arguments rarely address real differences, produce mutual understanding, or lead to a basis for action.

In this paper, after a brief review of some current food and population statistics, I attempt to make explicit the boundaries, theories, and values behind several different policy proposals. Since I feel that no one can view this problem without some pre-established mind-set, I will not pretend to be an objective commentator on the various positions presented. Instead I will define my own position within the same framework applied to the others.

II. THE POPULATION-FOOD SITUATION

Many nations do not take a regular census, very few have reliable vital statistics, and no uniform standards exist for measuring agricultural output, estimating the amount of product that bypasses the cash economy, or ascertaining the actual daily diets of most of the world's people. Nevertheless, any policy discussion must proceed from some perception of the present state of the problem. The

following summary is based on standard statistical sources, primarily the United Nations and the United States government. All numbers are illustrative of the real situation, but not necessarily accurate.

In mid-1975 the world population was estimated at about 4 billion persons. The global population was then growing at an average rate of about 1.9 percent a year (derived from an estimated average birth rate of 3.2 percent a year, minus an average death rate of 1.3 percent a year).[5] The total increase in world population in 1975 was approximately 78 million. The rate of increase is estimated to have been 0.4 percent in 1800, 0.6 percent in 1900, and 1.9–2.0 percent only in the 1960's and 1970's.[6] This recent acceleration is due primarily to a decrease in death rate rather than an increase in birth rate.

Neither population nor population growth is evenly distributed geographically or nationally. About 80 percent of the population increase in 1974 took place in the nonindustrialized countries of the world. Perhaps 12 million persons were added that year to the population of India, 14 million to China, and a little over one million to the United States.[7] Demographic statistics for the fifteen most populous nations of the world (encompassing almost 70 percent of the global population) are summarized on the left side of Table 1. The historic trends that have led to this widely varying set of birth, death, and growth rates will be discussed under the theory of the demographic transition later in this paper.

The average human being requires about 2200 vegetable-equivalent kilocalories of food per day to survive.[8] In 1974 the total world

5. Population Reference Bureau, *1975 World Population Data Sheet*, Washington, D.C., 1975.

6. A. M. Carr-Saunders, *World Population: Past Growth and Present Trends* (Oxford, Clarendon Press, 1936), p. 42; and Department of Economic and Social Affairs, *Statistical Yearbook*, New York, United Nations, 1960–1975.

7. The natural increase (excess of births over deaths) in the United States population from February 1974 to February 1975 was 1.225 million. Added to that was a legal net inmigration of 395,000.

8. Food and Agriculture Organization, *Provisional Indicative World Plan for Agricultural Development, 2* (Rome, United Nations, 1970), 491. To express dietary intake in vegetable-equivalent kilocalories, those consumed directly as vegetable matter are added to the kilocalories derived from animal products, multiplied by the number of vegetable kilocalories required to produce one kilocalorie of animal product. This number varies from 3 to 10. Thus a person eating 1000 kilocalories of meat per day may be consuming as many as 10,000 vegetable-equivalent kilocalories per day from that source alone.

grain production was approximately 1,200 million tons, or about 300 kilograms per person (roughly equivalent to 2900 kilocalories per person per day), if it had been distributed evenly over the global population.[9] When nongrain foodstuffs are added to this total, it is clear that food production in that year was sufficient to support the world population at well above the subsistence level. Total world food output has increased slightly faster than the population over the last decade. About half of this expanded output has come from extending cultivated land and half from better yields on land already cultivated.[10] Both area and yield increases required inputs of numerous other resources. For example, the 34 percent increase in world food production from 1951 to 1966 was accompanied by a 63 percent increase in yearly expenditures on tractors (in constant dollars), a 210 percent increase in use of fertilizers (by weight), and a 300 percent increase in expenditures on pesticides (in constant dollars).[11]

The figures quoted so far have been in terms of world totals and global averages. But food, like population, is by no means evenly distributed. Some food production and consumption statistics for the fifteen most populous countries are shown on the right side of Table 1. As the table indicates, the typical American consumes about five times the grain equivalent consumed by the typical Indian.[12] Over the last decade total food output has grown at about the same rate in both the nonindustrialized and the industrialized regions of the world. In the industrialized regions this growth has amounted to a 15 percent increase in food per capita, while in the nonindustrialized regions, because of rapid population growth, average food output *per capita* has increased very slightly, if at all.[13]

9. Lester R. Brown, *By Bread Alone* (New York, Praeger, 1974), p. 43.

10. Georg Borgstrom, *Focal Points: A Global Food Strategy* (New York, Macmillan, 1974), p. 178.

11. Study of Critical Environmental Problems, *Man's Impact on the Global Environment* (Cambridge, Mass., MIT Press, 1970), p. 118. Fertilizer use from Georg Borgstrom, *Too Many* (New York, Macmillan, 1969), p. 27.

12. Brown, *By Bread Alone*, p. 36.

13. Food and Agriculture Organization, *Preliminary Assessment of the World Food Situation*, Rome, United Nations, 1974.

TABLE 1

Population and Food Statistics for the Fifteen Most Populous Nations

	Population (million people) mid-1975 estimate[a]	Crude birth rate[a] (births/1000 people/year) mid-1975 estimate	Crude death rate[a] (deaths/1000 people/year) mid-1975 estimate	% Population growth/year[a] mid-1975 estimate	Per capita GNP (US$) 1971 or 1972
China	822.8	26.9	10.3	1.7	160
India	613.2	39.9	15.7	2.4	110
USSR	255.0	17.8	7.9	1.0	1400
USA	213.9	16.2	9.4	0.9	5590
Indonesia	136.0	42.9	16.9	2.6	90
Japan	111.1	19.2	6.6	1.3	2320
Brazil	109.7	37.0	8.8	2.8	530
Bangladesh	73.7	49.5	28.1	1.7	70
Pakistan	70.6	47.4	16.5	3.1	80
Nigeria	62.9	49.3	22.7	2.7	130
W. Germany	61.9	12.0	12.1	0.3	3390
Mexico	59.2	42.0	8.6	3.2	740
U.K.	56.4	16.1	11.7	0.3	2600
Italy	55.0	16.0	9.8	0.5	1960
France	52.9	17.0	10.6	0.9	3620

[a] Population Reference Bureau, *1975 World Population Data Sheet*, Washington, D.C., 1975.

[b] Calculated from United Nations, Dept. of Economic and Social Affairs, *Statistical Yearbook, 1971* (New York, 1972), pp. 504-509.

[c] United Nations Food and Agriculture Organization, *Monthly Bulletin of Agricultural Economics and Statistics*, 23, No. 9 (September 1974), pp. 3-4.

[d] Calculated from United Nations Food and Agriculture Organization, *Production Yearbook 1972* (Rome, Italy, 1973), pp. 3-8.

[e] Ibid., calculated by dividing nitrogenous fertilizer consumption by arable land.

[f] Approximated as slightly higher (1900 versus 1820) than the figure given for calories/person/day in UN, FAO, *Monthly Bulletin of Agricultural Economics and Statistics*, 23, No. 9 (September 1974), p. 3.

TABLE 1

(continued)

	Food/person (vegetable equivalent kilocalories/capita/day)[b]	Year of estimation	% Annual growth in food production[b] (exponential trend, 1952-72)[c]	Average grain yield[d] (kg./ha.)	Nitrogenous fertilizer (kg./ha.) cultivated land)
China	3750	64-66	2.3	1788 rice	28.0
India	2640	68-69	2.4	1120 wheat rice	9.3
USSR	7110	64-66	3.9	1407 wheat	8.4
USA	13570	69	2.0	3899 mixed corn	38.7
Indonesia	2070	64-66	2.0	2122 wheat rice	97.8
Japan	4510	69	4.3	5497 rice	180.8
Brazil	4970	66-68	4.4	1369 corn	9.3
Bangladesh	1900f	70	1.6	1487 rice	4.6
Pakistan	4050	68-69	3.0	1268 rice	11.8
Nigeria	2550	64-66	2.0	764 wheat mixed	.5
W. Germany	9660	69-70	2.5	3817 sorghum wheat	149.9
Mexico	4360	64-66	5.3	1376 mixed corn	23.0
U.K.	11812	68-69	2.8	4080 wheat mixed	128.7
Italy	6310	68	2.9	2955 wheat corn	65.7
France	11120	69-70	3.0	4222 wheat wheat mixed	87.55

III. BOUNDARIES IN SPACE AND TIME

If the world food situation is considered in terms of the problems and possible solutions that might appear between now and the next harvest, the conclusions will obviously be different from those drawn by looking from now to the end of the century or beyond. A five-year policy view must center on measures that could have an effect within that time, such as grain buffer stocks, incentives to farmers, or organization of famine relief efforts. A fifty-year view would encompass an entirely different set of factors: population growth, new technologies, new ways of distributing land, labor, or food output.

Long or short time horizons can lead to differing assessments of the situation, and so can wide or narrow space horizons. Those who, by the mandates of their official duties, are concerned primarily with the United States agricultural system may be worried about a revisitation of unmarketable surpluses and falling prices. Those with a global view tend to be concerned about areas of current food shortage or about the effect of higher prices on families already spending 80 percent of their income on food.

Neither of the two extreme viewpoints, the short-term domestic or the long-term global, can be labeled incorrect. Lower prices are indeed a hardship to farmers and a disincentive to increasing production. Higher prices are unquestionably disastrous for the poorest people in all areas of the world. In the short term, population policies might be expected to have no effect and to divert resources from current needs. In the long term, a rapidly growing population may weaken or defeat efforts to improve material living standards. Each conflicting conclusion arising from a different time and space horizon may be valid within its own context.

The debate about whether narrow or wide boundaries or long-term or short-term horizons should predominate in the formulation of public policy must be resolved by the realization that neither view alone is sufficient. Just as a person walking must continually shift attention from the path immediately ahead to the far distance so as to avoid nearby obstacles without losing sight of the ultimate destination, so must a nation find a balance between broad and narrow horizons. Finding this balance may be the most difficult aspect of any political decision, especially since most political rewards and punishments depend on short-term results.

In the case of food and population, I feel that the compromise between the long and short term, and between domestic and international concerns, should be shifted more toward the long-term global view. My reasons for this preference are both pragmatic and moral. The practical necessity for a global perspective is becoming more apparent daily. All the factors that contribute to greater international interdependence—proliferation of nuclear weapons, spreading communication and transportation networks, geographic concentration of energy and mineral resources—render policies made within a national or regional context unrealistic and ineffective. The practical necessity for a long-term view arises from the long delays within food production and population growth processes. A complete global change in either food consumption habits or methods of food production would require shifts in capital stocks and social attitudes that would take decades. Population growth and stabilization are properly viewed not in decades but in human generations. The problems of agricultural shortage and overpopulation are inherently slow to develop, and they are easier to prevent than to solve once they have actually appeared. Transportation of improved seed strains by ship is cheaper than carrying famine relief supplies by helicopter. Overgrazing and erosion can be avoided rather easily, but can be reversed only at great cost. Control of a system with long delays and with high costs for correcting mistakes is impossible to achieve without a long-term perspective.

A moral concern for future generations cannot be justified logically, yet I believe that most people in most cultures feel such concern. In the words of B. F. Skinner: "Why should I be concerned about the survival of a particular kind of economic [or governmental] system?" The only honest answer to that kind of question seems to be this: "There is no good reason why you should be concerned, but if your culture has not convinced you that there is, so much the worse for your culture."[14]

The rest of this paper and its final recommendations reflect my own preference for wider time and space horizons in the consideration of food and population policies. This emphasis does not imply that short-term or domestic concerns should or will be ignored.

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14. B. F. Skinner, *Beyond Freedom and Dignity* (New York, Alfred A. Knopf, 1971), p. 131.

Given the pressures on all social institutions, current urgent problems are not likely to go unnoticed. The short term will certainly continue to influence policy formulation, as it has in the past. In arguing for the broader longer-term view, I am confident that no argument can make that view completely dominant. I simply hope that the scale may be tipped in that direction.

IV. THEORIES OF POPULATION-FOOD INTERACTION

Four distinctly recognizable theories seem to underlie the most commonly recommended policies for dealing with the world food problem. I will refer to them as the Western Economic Model, the Environmental Model, the Socialist Model, and the Demographic Transition Model. Each will be presented here both in words and in causal diagrams, which can sometimes capture the complexity and simultaneity of mental models better than words. My goal is to outline the similarities and differences of the theories, therefore I will emphasize only what I believe to be the most important elements of each, eliminating much detail and nearly all supporting evidence. Finally, the four models will be combined into a composite that represents most closely my own view.

1. The Western Economic Model

> Price and supply fluctuations are inevitable, as long as the forces of nature—weather and pests—prevail. Price changes are the only way necessary production adjustment, to meet supply and demand changes, will come in an incentive economy . . . The whole question of food security finally comes down to the farmer and whether he will produce, whether he and his family benefit by producing, and whether he has the physical and financial tools available.[15]

15. Earl Butz, statement before the House Committee on Agriculture, Subcommittee on Department Operations, July 23, 1974, printed in *World Population and Food Supply and Demand Situation* (Washington, D.C., U.S. Government Printing Office, 1974), pp. 27-29.

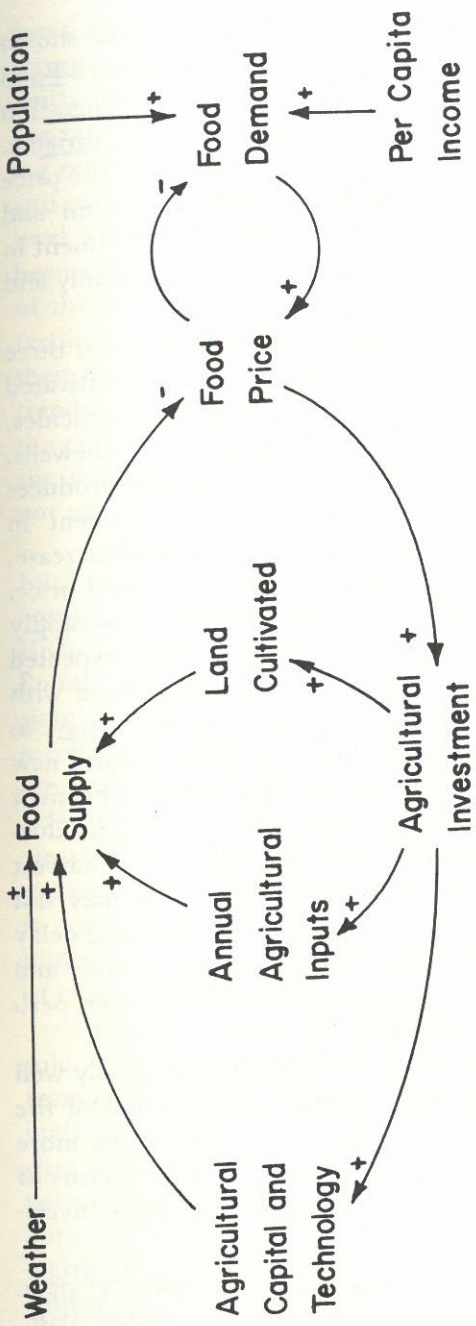

Figure 1. -- Western Economic Model

An *arrow* indicates a causal influence of one element on another. A *plus sign* (+) indicates that the influence is direct—as the element at the tail of the arrow increases, the element at the head of the arrow also increases (if the first element decreases, the second decreases). For example, as food demand goes up, food price also goes up. A *minus sign* (–) indicates an inverse relationship—as the first element increases, the second decreases; and as the first element decreases, the second increases. For example, as food supply goes up, food price goes down. The diagrams do not specify the exact quantitative relationship between elements, nor the rate of response of one element to another (the response may be instantaneous or very much delayed) but represent only rough sketches of underlying models that may be very complicated.

In the Western capitalist nations a model similar to that shown schematically in Figure 1 often forms the basis for policy. Food supply and food demand are brought into balance by the operation of a free competitive market, where food price is the central variable. If supply of any commodity decreases relative to demand, the price will rise. Higher price has two effects—it decreases demand and provides both the funds and the incentive for increased investment in agricultural production. Both these effects tend to bring supply and demand back into equilibrium.

On the supply side, investment can be allocated to any of three factors that increase production—development of new cultivated lands, increase in annual agricultural inputs (fertilizers, pesticides, energy) or increase in longer-lasting agricultural capital (tubewells, tractors, irrigation systems). Investment in research that produces new knowledge may be considered equivalent to investment in long-lasting capital. As land, agricultural inputs, and capital increase, so does food supply, eventually leading to a decrease in food price.

Several factors may interfere with regulation from the supply side of the market system. Weather adds uncertainty to the expected output, even when land, capital, and other inputs are utilized with utmost efficiency. Another complicating factor is the delay in farmers' response mechanisms. Farmers may not believe that a new higher price is meaningful and may not change their investment decisions until it has persisted for some time. Agricultural production can respond to increased investment only after one harvest cycle, at the soonest. Investment in new land or capital may not yield any increased production for several years. This response delay in the supply side of the system can produce alternate over- and under-compensation by suppliers, resulting in the well-known periodic oscillations in many commodity prices.[16]

Those who favor the Western Economic Model are usually well aware of another potential impediment to the responsiveness of the supply side of the system. As investment increases, producing more and more output, diminishing returns to any of the three factors of production may be met—that is, a given amount of additional investment might produce less and less additional output. Diminishing returns are often associated with the approach to some physical limit, such as the amount of potentially arable land in a region, or the rate at which plants can absorb nutrients from the soil. Diminishing returns to fertilizer application, for example, are well understood and often encountered in actual farming situations. On an aggregate level and over the long term, however, diminishing returns have often been offset by new technological approaches. The "miracle grains" of the green revolution continue to produce higher yields at levels of fertilizer application well above those where traditional grains reach their maximum yield. Such examples, and analysis of actual historic trends, have led many Western Economists to assume that limits to the effectiveness of agricultural investment are surmountable through the development of new technologies. Thus diminishing returns are not usually included in the Western Economic Model.

Food demand is determined by total population and per-capita food consumption. In the Western Economic Model per-capita consumption is a function of food price and per-capita income. Higher food price relative to per-capita income decreases demand. Population increase stimulates demand, unless per-capita income simultaneously falls. The demand side contains another regulatory mechanism: people demand more food when it is abundant (prices are low) and less food when it is scarce (prices are high). The demand side of the system is not perturbed by unpredictable factors such as weather, but demand may shift to reflect variation in population, per-capita income, or consumer tastes. Response on the demand side is relatively rapid, since it depends on consumer decisions, not on biological or physical processes such as crop growth or construction of capital equipment.

Since it is more rapid, demand adjustment usually plays a major role in maintaining the supply/demand equilibrium. Regulation from the demand side, however, becomes both undesirable and ineffective under one important set of conditions. When food price rises so high that a mere subsistence diet absorbs a large fraction of per-capita income, consumers have no more freedom to reduce consumption in response to higher prices—in economic terms the elasticity of demand approaches zero. Under these conditions supply shortages can be alleviated only by alterations on the supply side, or by malnutrition.

16. For an extended discussion of this phenomenon, see Dennis L. Meadows, *The Dynamics of Commodity Production Cycles* (Cambridge, Mass., Wright-Allen Press, 1970).

According to the Western Economic Model the interplay of supply and demand, if allowed to proceed without interference, will produce efficient allocation of resources to food production and efficient distribution of food to consumers. Policies based on this model tend to work toward freeing the market mechanism, by restricting monopolization on the supply side and by opposing government interference in the market. From this point of view, interference is only permissible if it is directed toward correcting known imperfections in market operations. Buffer stocks can help smooth out weather fluctuations. Public support of agricultural research, low-cost capital improvement loans, or better information systems can shorten response delays on the supply side. Direct donation of food would be counterproductive, however, because food aid would lower price, thereby destroying local incentive to invest in increased production capacity.

The Western Economic Model, focusing on the continuous and mutual adjustment of supply, demand, and price, represents the agricultural system as self-regulating and self-maintaining. Since, according to the model, short-term adjustments keep the system at or near a desirable equilibrium at all times, a long-term view is unnecessary. Population affects the agriculture system from the outside, but as long as population grows slowly enough, the system can accommodate it. More recently, however, many people who favor the Western Economic view have recognized that the system operates unsatisfactorily when supply is near subsistence and regulation from the demand side breaks down. Thus some free-market supporters advocate measures to slow population growth or to provide sufficient employment to the destitute to keep them in the market. In general, however, the Western Economic Model is associated with optimism and not with strong or urgent recommendations to change the food-population system. The food problem, as seen through this model, is solvable. Governmental policy need only be concerned with protection of market mechanisms, support of basic research, administration of food buffer stocks, dissemination of new technologies, and in the poorest regions widespread employment opportunities combined with family planning.[17]

17. For examples of this argument, see Sanderson, "The Great Food Fumble"; Thomas T. Poleman, "World Food: A Perspective," *Science*, 188 (1975), 510, and Don Paarlberg, statement before the House Committee on Agriculture, printed in *World Population and Food Supply and Demand Situation*, p. 16.

2. The Environmental Model

> The land of every nation has a limited carrying capacity. The exact limit is a matter for argument, but the energy crunch is convincing more people every day that we have already exceeded the carrying capacity of the land. We have been living on "capital"—stored petroleum and coal—and soon we must live on income alone.
>
> The harsh characteristics of lifeboat ethics are heightened by reproduction, particularly by reproductive differences. The people inside the lifeboats of the wealthy nations are doubling in numbers every 87 years; those outside are doubling every 35 years, on the average. And the relative difference in prosperity is becoming greater.[18]

From an Environmental viewpoint the economic system and the price of food are very nearly irrelevant. The emphasis falls on real physical quantities, rather than on social artifacts such as money or prices. What matters is the amount of food actually available per person, which is most simply determined by the food supply and the number of people among whom the food must be shared.

As in the Western Economic Model, the food supply is increased by capital, annual agricultural inputs, and land development (see Figure 2). However, the Environmental Model includes important limits to all these factors and therefore to the total amount of food that can be produced. Land expansion is limited by the total area of cultivable land on the earth. Capital and inputs are limited by their ultimate resource base, the terrestrial deposits of metals, phosphate rock, fossil fuels, and other nonrenewable resources. Increasing agricultural investment as a policy may increase food supplies in the short term, but only by pushing the entire system nearer to the limits and thereby making further increases in the long term more difficult. The economic concept of diminishing returns to investment in any of

18. Garrett Hardin, "Lifeboat Ethics—The Case against Helping the Poor," *Psychology Today* (September 1974), p. 88.

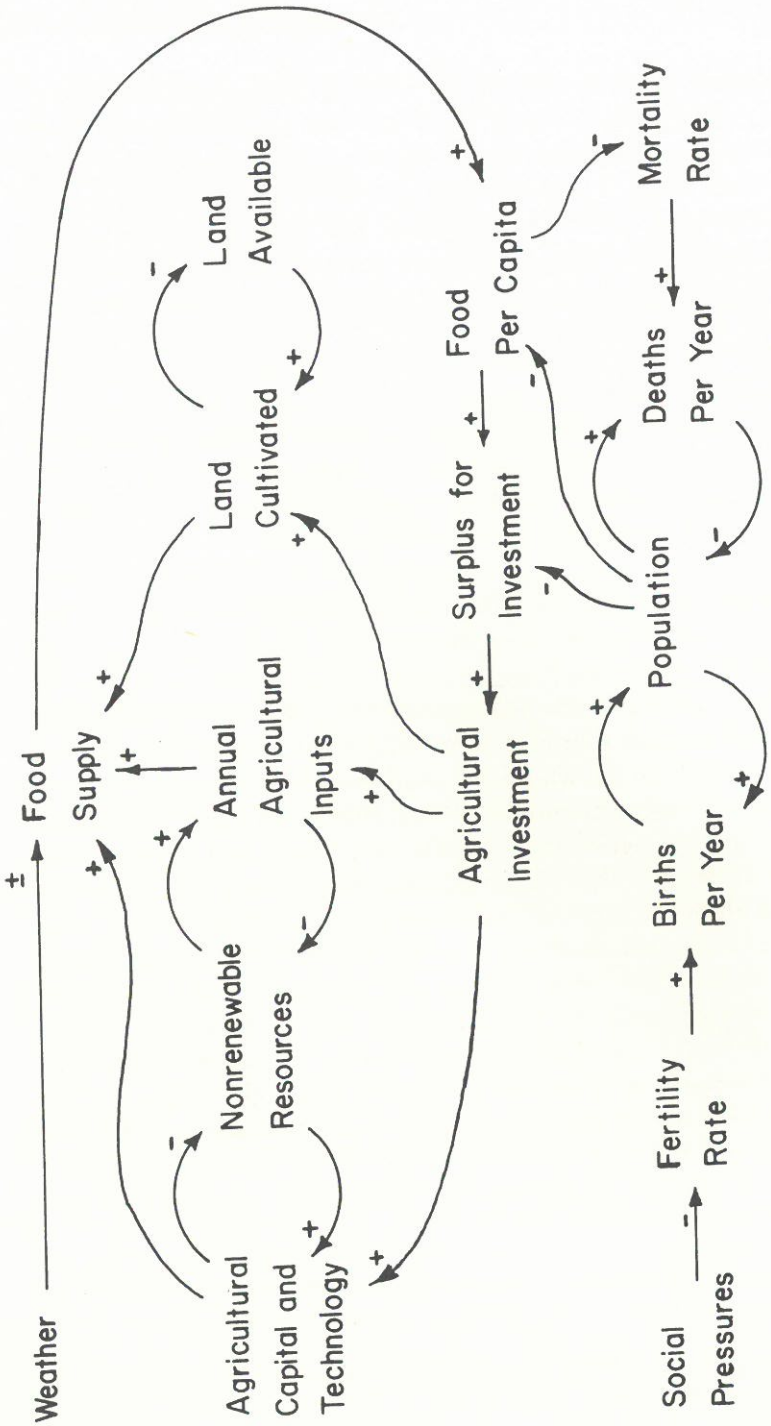

Figure 2. -- Environmental Model

the three factors of agricultural production plays a very important role in this model. Though the absolute limits may be far away, and technology may permit a closer approach to them, the cost of approaching the limits is seen to become higher and higher. In this model technology is primarily a tool for shifting the factors of production from one resource to another; it does not expand the actual size of the resource base.

Since policies to increase food output are ultimately limited in the Environmental Model, more concern is devoted to controlling the other factor in the determination of food per capita: the population. Environmentalists are aware of the tendency of human populations, like all biological populations, to grow exponentially. The number of births per year is determined by the number of people in the population and by the fertility rate. At a given fertility rate the more people there are, the more births will be produced per year. If these births are not balanced by deaths, the population will grow. Eventually the new people will produce still more births. The population will increase ever more rapidly until something happens to make the fertility and mortality rates equal, either by reducing fertility or by increasing mortality.

Environmentalists, like the Western Economists, see a natural self-controlling mechanism in the population-food system, but unlike Western Economists they do not like the mechanism they see. An increasing population tends to decrease food per capita, all else equal. A decrease in food per capita for any reason provides a social impetus to increase agricultural investment. In the long term, however, increased investment pushes the supply side of the system toward the ultimate earthly limits to food production. As those limits are approached, food production can no longer keep pace with population growth, and food per capita declines. Finally malnutrition causes death rates to rise. When mortality has risen so high that deaths balance births, the population stops growing. The natural equilibrium and the final consequence of increasing agricultural investment, in the Environmental view, is a population living near the limits of the earth, held in check by a near-subsistence standard of living.

Since no one desires this outcome, Environmentalists see the need for fairly urgent and major changes in the food-population system. Efforts to increase food supply are considered counterproductive,

since more food merely increases population growth and hastens the onset of the undesirable equilibrium. A better outcome can be reached only through a decrease, or at least a stabilization, of the population. Since no one favors population stabilization by increasing deaths, the only acceptable policy must be to decrease births. The more quickly the birth rate falls, the more favorable will be the ultimate balance between population and global resources.

Therefore, the Environmental Model calls for social pressures of one sort or another to decrease human fertility. The fertility reduction policies that are advocated range from further extension of family planning[19] through various incentive or disincentive programs,[20] to "mutual coercion, mutually agreed upon."[21] Sometimes the Environmental argument is also accompanied by opposition to short-term measures for decreasing mortality (the arguments labeled "triage" or "lifeboat ethics").[22]

Environmental policies are focused on the long term and are aimed at increasing the resource/population ratio, so as to improve the standards of living and the quality of life. Thus in addition to supporting population-control policies, Environmentalists tend to favor less wasteful resource consumption habits. They promote technologies such as solar energy conversion or organic farming, which rely upon renewable, rather than nonrenewable, resources. They would encourage deliberate conservation long before the market signals the need for it through scarcity and rising prices. They seek to live within the limits of the earth rather than to try to push those limits outward.

This basically conservative world view leads to a fairly radical policy position. Since the system does not naturally seek a desirable state, large changes must be made. Sociocultural patterns should be altered to favor small families. Resource allocation decisions should not be made by short-term market forces alone. The world food

19. Bernard Berelson, "Beyond Family Plannning," *Science*, 163 (1969), 533.

20. Lenni W. Kangas, "Integrated Incentives for Fertility Control," *Science*, 169 (1970), 1278.

21. Garrett Hardin, "The Tragedy of the Commons," *Science*, 162 (1968), 1243.

22. Garrett Hardin, "Lifeboat Ethics," and William and Paul Paddock, *Famine-1975!* (Boston, Little Brown, 1967).

situation is a symptom of a larger problem: the material desires of the human population are approaching the sustainable physical capacity of the earth. The only solution is to stop the growth in those desires by stabilizing the human population and its material consumption.

3. The Socialist Model

> One of the greatest outrages of the present food situation is the excuse it has provided for muddle-headed apologists for capitalism to blame it all on the "population problem" . . . The very existence of the phenomenon described as "agricultural Malthusianism" represents the greatest *potential* leap forward in the whole of human history—it holds the promise of food productivity on a scale such that *food would become so plentiful it would not be possible even to give it all away*. But under capitalism, such a development would be intolerable . . . The solution to the crisis of world food production can only be realized through its reorganization as social production for human need.[23]

If the price system is irrelevant to the Environmentalist point of view, it is anathema to the Socialists. They believe the most important human goal is the provision of enough food and other goods to meet basic human needs, regardless of price or freedom of the market. The Socialist Model contains some elements in common with the two models described previously, but with some important additions and deletions (see Figure 3).

The central focus of the Socialist Model is on distribution, primarily of the means of production (capital and land) and secondarily of the output from production (food, services, and manufactured goods). The capitalist free-market system and economic exploitation by the rich perpetuate inequities in distribution. These inequities are the cause of the present food problem. The millions of deaths due to hunger each year could all be prevented by a different economic world order.

23. Cliff Conner, "Hunger," *International Socialist Review* (September 1974), p. 20.

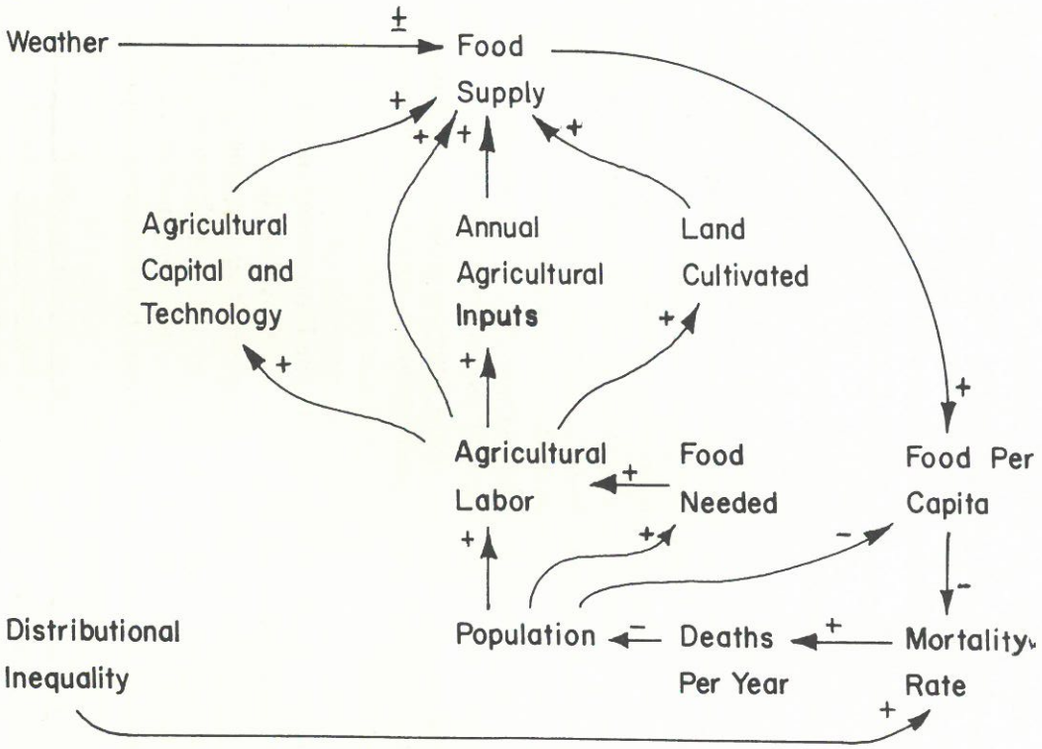

Figure 3. -- Socialist Model

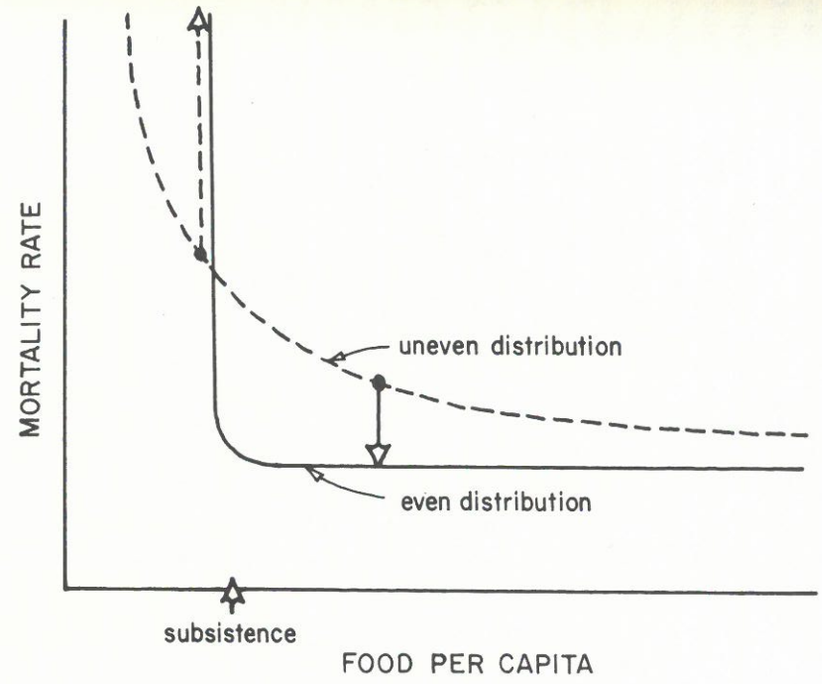

Figure 4. -- Effect of Food Distribution on Mortality

Figure 4 shows possible forms of the relationship between food per capita and mortality, each dependent on a different pattern of distribution. If distribution of food (and all other goods and services) were perfectly even, mortality would be uniformly low. If equal sharing persisted at a food per-capita level below subsistence, however, mortality would soar upward, since no one's share would be adequate for survival (represented by the solid curve in Figure 4). On the other hand, if distribution were uneven (as shown by the dashed curve) some people would die of starvation even if average food per capita were more than adequate, and some people would have sufficient diets even if the average level were below subsistence. Since the amount of food per capita available in the world today is well above subsistence, the food crisis should be solvable through redistribution. As the solid downward-pointing arrow in Figure 4 indicates, the mortality rate could be reduced, not by growing more food but by distributing it differently. "The first maxim of nautical ethics is that you don't go to the lifeboats, which will save only a few, until you've made every effort to salvage the ship for the sake of all."[24]

Environmentalists would answer this Socialist argument by pointing out that in the long term decreasing mortality rates by redistribution would increase population, which would decrease food per capita, moving the system to the left in Figure 4, toward a Malthusian equilibrium. Socialists would agree that a capitalist regime could produce this outcome, but under a socialist system of production, they maintain, the additional population would provide more labor and increase output. Food supply would grow faster than the population, and food per capita would rise. In a society truly devoted to socialist principles, population would become stabilized at a point long before diminishing returns to labor would set in. In fact, many of the socialist nations of the world are now experiencing population growth rates very near zero.

No concept of global limits appears in the Socialist model, nor does any concern for overpopulation. Of crucial importance is the addition of human labor to the factors of production. In fact the Socialist Model elevates labor to the primary factor, upon which all

24. Frances Moore Lappé, "Fantasies of Famine," *Harper's* (January 1975).

others depend. Since each new mouth comes equipped with two new hands, overpopulation is unthinkable. Recently some Socialist thinkers have also embraced the idea of "intermediate" or small-scale, labor-intensive technology,[25] which places even more emphasis on labor as the key to increasing agricultural output.

Policies favored by those who see the world through the Socialist Model center on economic reorganization and redistribution. Population policies are viewed with suspicion as distractions from the real issue, and perhaps as disguised genocide. Attempts to increase production under a capitalistic free market are considered exploitive. Socialists are generally enthusiastic, however, about new technologies that increase output, especially technologies that are dependent on the productive factor accessible to everyone—labor—rather than on heavy concentrations of privately owned capital. Socialists vary in the degree to which they would favor complete restructuring of the capitalist system, but most of them would agree that measures such as land reform, food aid, progressive taxation, village-level agricultural education, and alteration of international terms of trade are steps in the right direction.

4. The Demographic Transition Model

> In order to bring the birth rate down, in order to create the conditions in which people see their own interest in having smaller families, we need a continuation of economic development, particularly in the developing countries. In my opinion, it is essentially impossible . . . to expect people in these countries to behave in a way that will stabilize population . . . unless they have sufficient economic development so that they see some reason for doing so.[26]

The theory of the Demographic Transition is based upon the demographic history of nations that have undergone the industrial revolution. The historic pattern of birth and death rates for three

25. See E. F. Schumacher, *Small is Beautiful* (New York, Harper and Row, 1973.

26. Roger Revelle, interview with William L. Oltmans in *On Growth* (New York, G. P. Putnam's Sons, 1974), p. 185.

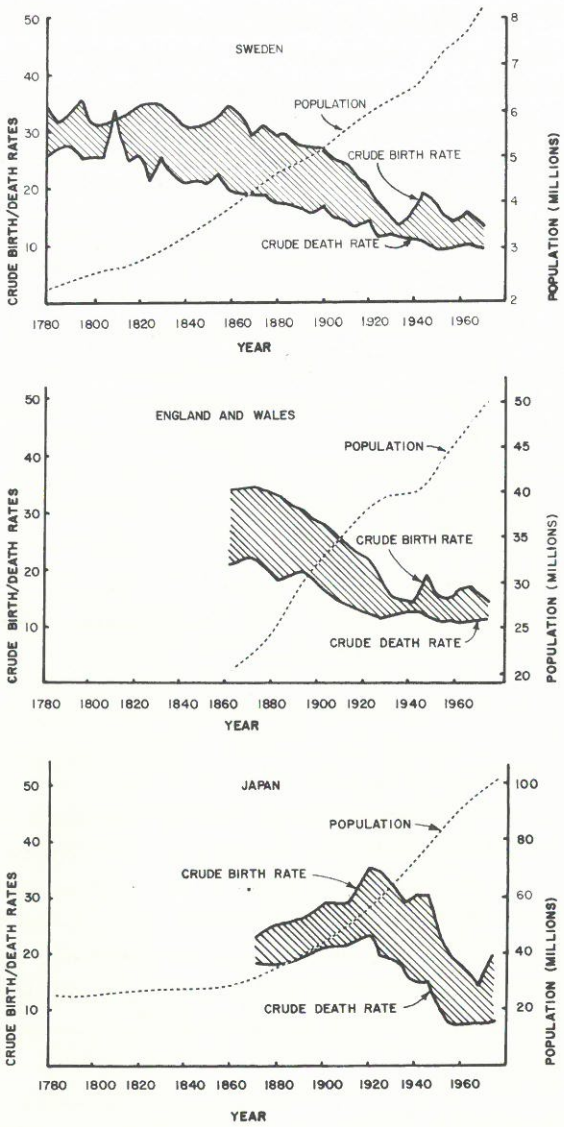

Figure 5. -- Demographic Transition in Industrialized Countries

industrialized nations—Sweden, Japan, and Great Britain—is shown in Figure 5. In all three countries the birth and death rates were once relatively high and the population growth rate was slow. As economic development slowly permitted better living conditions, more reliable food supplies, and medical knowledge, death rates decreased. In the case of Sweden, the crude death rate dropped gradually from 25 deaths per 1000 persons per year to 10 deaths per 1000 per year over a period of 120 years.

As the death rate decreased, the birth rate followed, but even more slowly, typically with a lag of thirty to fifty years behind the death rate. The widening gap between birth and death rates meant rapid population increases for many decades, as shown in Figure 5. Only in the twentieth century have the birth rates of the industrialized countries fallen to about the same level as the death rates, so that the rate of population growth is again relatively slow.

The demographic history of Japan follows a pattern similar to that of European nations, but more compressed in time. After the Tokugawa period of moderate birth and death rates and slow population growth, the Meiji restoration of 1868 effectively eliminated abortion and infanticide, which had been prevalent.[27] Both birth and death rates increased. Around 1900 these trends began to reverse. Within fifty years Japan's birth and death rates were as low as those of Europe.

The historic pattern of change from high birth and death rates to low birth and death rates, illustrated by the three graphs in Figure 5, is called the *demographic transition*. It has been observed in some form in all countries that have industrialized, although its onset, rate of development, and conclusion vary greatly.[28] Despite these variations, however, the demographic transition is the most prominent and consistent demographic phenomenon observed in the history of industrialized areas. It has therefore led to a general theory of population dynamics that is often extended to nonindustrialized nations as well. The basic

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27. Ryoichi Ishii, *Population Pressure and Economic Life in Japan* (Chicago, University of Chicago Press, 1937).

28. Ansley J. Coale, in *Proceedings of the IUSSP International Population Conference* (International Union for the Scientific Study of Population, Liege, Belgium, 1973), pp. 53-77.

assumptions of the Demographic Transition Model are represented in Figure 6.

The Demographic Transition Model is primarily concerned with two social forces that are assumed to reduce birth rates. First, a decrease in mortality, especially infant mortality, will cause parents to perceive that they are less likely to lose a child. Since they need not have so many children to achieve their desired family size, the number of births will fall. (In historical demographic transitions, death-rate decrease nearly always preceded birth-rate decrease.) Second, an increase in all aspects of industrialization and modernization (represented in Figure 6 by an increase in income per capita) changes the perceived costs and benefits of having children. The Demographic Transition Model assumes, and many current spokesmen for the Third World affirm,[29] that large families in preindustrial societies are needed and wanted. Children are seen as inexpensive labor and as insurance for old-age protection, as well as sources of all the noneconomic, psychic, and cultural benefits associated with children everywhere. Furthermore, in nonindustrial societies children are not regarded as a burden; they do not require much space, food, education, or other material expenditures, and their care is often shared by a large extended family or clan. As a society industrializes, however, the benefits associated with children decrease and their costs increase. The family must become mobile and urbanized to find industrial jobs, so the extended family breaks up. The children, instead of working on a family farm, must become educated so that they too can qualify for the new jobs. Alternate forms of social security emerge. On balance, children are still regarded as highly desirable, but the concept of having only as many as one can afford becomes dominant.

The Demographic Transition Model holds out hope for treating both the food supply and the food demand side of the problem with the same set of policies. Increasing industrial output leads to smaller family size, and also to greater food output, through all the

29. See Maaza Bekele, "False Prophets of Doom," *UNESCO Courier* (July-August 1974), p. 42; interview with Mercedes Concepcion in *Ceres* (U.N. Food and Agriculture Organization, November-December 1973), p. 58; Varendra T. Vittachi, "No Future Without a Present," *Newsweek* (September 2, 1974), p. 12.

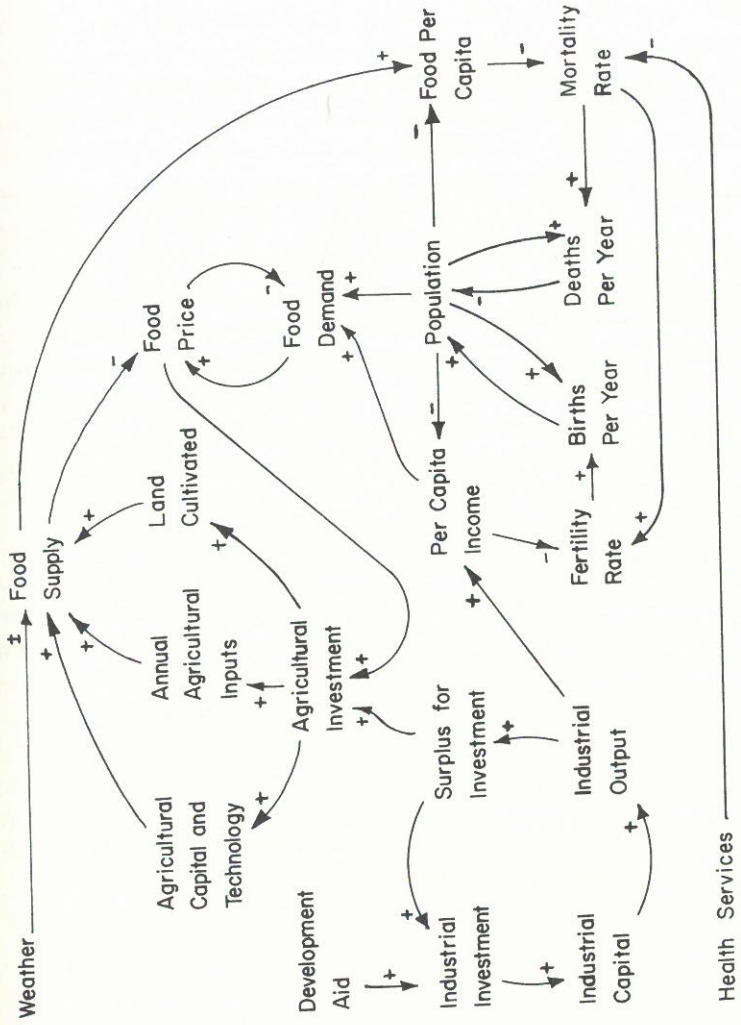

Figure 6. -- Demographic Transition Model

technologies dependent upon industrial capital. Tractors, fertilizers, irrigation systems, and pesticides depend on the same steel mills, oil refineries, assembly plants, and petrochemical factories that create the jobs that raise per-capita incomes that lower birth rates.

What policies follow from the Demographic Transition Model? First, child mortality should be decreased through public health services to start the first part of the demographic transition. Second, industrial investment should be emphasized to stimulate the second part of the demographic transition, the decrease in fertility. Family planning may play a part in this second stage, but only after the desire for smaller families has been awakened by economic development. Before then, large families are desirable, and the population does not regard family planning as acceptable or necessary.

Many people who believe in the Demographic Transition Model would agree with the Socialists that more equal distribution is desirable, because birth and death rates will decrease much more rapidly if the benefits of economic development are experienced by a large fraction of the population rather than by just a few.[30] On the other hand, equal distribution may not be advantageous for economic growth, since a rich person usually can invest a larger fraction of his income and take greater entrepreneurial risks than a poor person.[31] The Demographic Transition Model is usually thought to be more consistent with centralized, large-scale technology than with labor-intensive intermediate technology, for two reasons. First, modern capital-intensive technologies may permit more rapid increase in industrial output. And second, labor-intensive technology, with its emphasis on family-scale techniques, might maintain the desire for children as contributors to the family economic base, thereby delaying the birth-rate decrease expected in the Demographic Transition theory.

30. See, for example, William Rich, "Smaller Families through Social and Economic Progress," Washington, D.C., Overseas Development Council, January 1973.

31. For a refutation of this argument, see Rich, "Smaller Families," p. 34.

5. A Composite Model

The four models presented here are often viewed as mutually exclusive and basically inconsistent. For example, at the World Population Conference in Bucharest no agreement was reached between Western Economists and Environmentalists on one side, calling for population control, and Socialists and Demographic Transitionists on the other side, calling for redistribution and economic development. On other issues, such as resource conservation, the Western Economic and Environmental models would lead to very different and seemingly irreconcilable conclusions. On still others, such as the best path toward economic development, those who favor the Socialist and Demographic Transition models would probably part company. Although few people see the food problem simply through one of the models as I have described it, probably even fewer can see all these points of view simultaneously.

When informed and reasonable people consistently maintain very different models of the same underlying reality, it seems probable that no one of those models can be totally wrong, nor can any one be totally complete. Each model is probably a correct description of *part* of the real system. Much can be learned by trying to combine the important insights of all the models into a composite or holistic view. I shall present such a composite model here, starting with the Western Economic Model and adding to it important concepts from other models. A causal diagram of the Composite Model is shown in Figure 7.

The central structure of the Composite Model is the price mechanism of the Western Economic Model. The price mechanism can produce fine-scale adjustments of food supply and demand in the short term and eliminate the necessity for extremely detailed centralized planning. Relatively high food price is a signal that stimulates investment in agricultural factors of production and attracts labor to agricultural jobs, allowing increased food production, as long as reasonable marginal returns to land, labor, capital, and annual inputs can be realized.

When the assumptions of the Demographic Transition Model are added to the Western Economic Model, a reassuring picture of the total food-population situation emerges. With the market to correct supply/demand imbalances in the short term and industrial

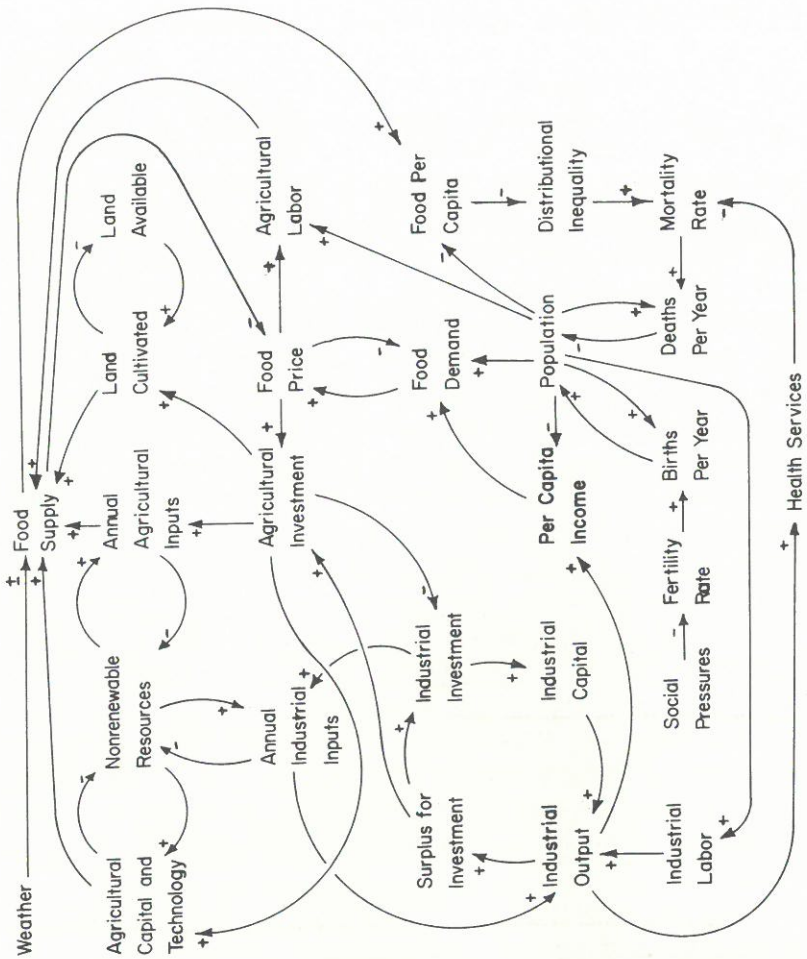

Figure 7. -- Composite Model

growth to increase supply while stabilizing population in the long term, the food problem might be viewed as a temporary problem that is about to solve itself.

For some parts of the world, over some historical periods, the combined Western Economic-Demographic Transition Model provides a sufficient explanation of what has actually occurred. Industrialization has proceeded relatively smoothly, birth and death rates have decreased, and food scarcities have been temporary or nonexistent. The diminishing returns of the Environmental Model and the distributional problems of the Socialist Model do not seem important in representing the history of these now industrialized nations. However, all nations have not followed this pattern, and future patterns need not necessarily resemble historical ones. In order to decide whether the Socialist or Environmental Models can increase the applicability of the Composite Model to the future and to the poorest areas of the world, we must examine more carefully the assumptions behind the Western Economic and Demographic Transition models and the nature of the environmental limits and distributional inequalities that might alter those assumptions.

To begin with the demographic transition, Figure 8 illustrates the historic demographic behavior of three nonindustrialized countries. Comparison with the industrialized-country transitions in Figure 5 will reveal both similarities and differences. A point-by-point comparison of the demographic situations in the nonindustrialized countries during their historical transitions and in the currently industrializing countries indicates that the Demographic Transition Model is not entirely applicable as a guide to future development patterns:[32]

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32. Similar criticisms of the general applicability of the Demographic Transition Model can be found in Ansley J. Coale and Edgar M. Hoover, *Population Growth and Economic Development in Low Income Countries* (Princeton, N.J., Princeton University Press, 1958), pp. 13-17, and in Michael S. Teitelbaum, "Relevance of Demographic Transition Theory for Developing Countries," *Science*, 188 (1975), 420.

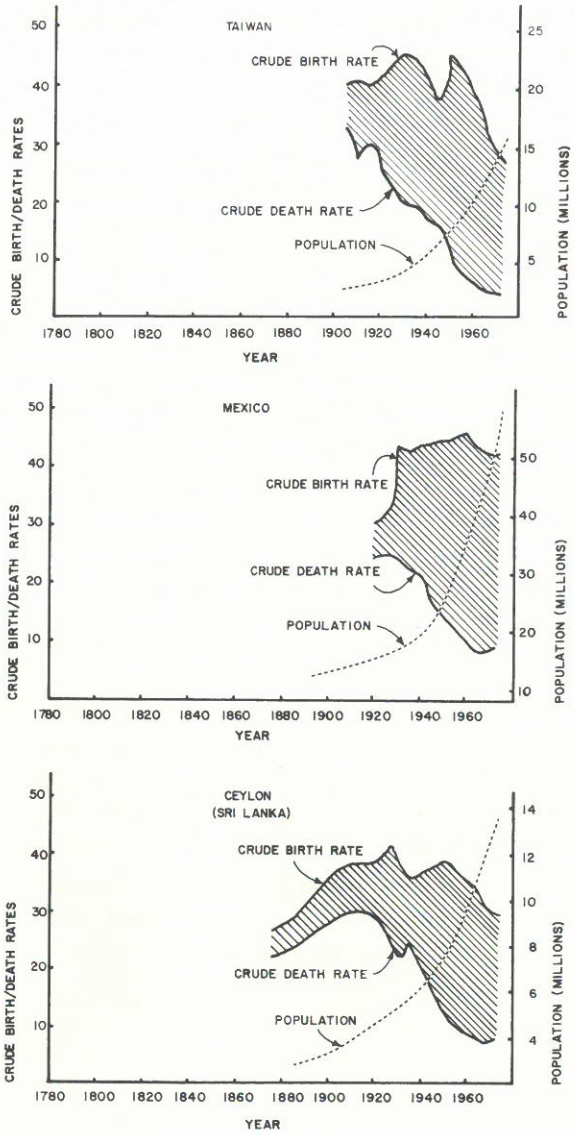

Figure 8. -- Demographic Transition in Non-industrialized Countries

Industrialized Countries

Decreases in death and birth rates accompanied profound social change. The process of industrialization altered nearly every aspect of the family; its organization, its economic base, its importance relative to other social institutions, and the costs and benefits of having children. All major social changes take time; this one typically extended over 100 to 200 years.

During the transition the widened gap between birth and death rates resulted in a multiplication of the preindustrial population by a factor of 4 or 5.

In many European countries the population increase was counteracted by significant outmigration to the New World.

The maximum rate of population growth in the demographic

Industrializing Countries

The decrease in death rate has preceded, not accompanied, the deep economic and social changes that result from industrialization. Birth rates are still high and can be expected to remain high, because the traditional family structure is still basically unchanged. The completion of the economic and social development that may bring birth rates down in these countries can be optimistically expected to require at least 50 more years.

The populations of the non-industrialized countries have already increased by factors of 4 or 5 in this century, with much of the transition still ahead of them. Assuming rapid birth-rate decreases in the near future, these countries will experience a total population multiplication by at least 10 before their transition is complete.

Many of the industrializing areas are already densely settled, and there are essentially no New Worlds left to absorb their population growth.

Typical population growth rates now are 2 to 3 percent a year in

transitions of the European countries was typically 1 to 1.5 percent a year. Sweden's fastest actual population doubling took 95 years; Great Britain's, 70 years; Japan's, 60 years.

In most European countries the transition began from a birth rate that was already moderate—30 to 35 births per thousand persons.

Because of the moderate birth rates, the fraction of the population under age 15 and economically dependent was rarely more than 35 percent at any time during the transition.

At the end of the transition, the populations of the industrialized countries are still growing. Because of their larger population bases, their annual population increments are not now greatly different from those experienced during the transition. Sweden's 1860 population of 3.5 million increasing at 1.4 percent a year produced an annual increment of 49,000 persons. Sweden's 1970 population of 8 million growing at 0.4 percent a year increased in one year by 32,000. The increase of the U.S. population in 1860 (30 million at 2.2 percent) was 660,000; in 1970 (200 million at 0.8 percent) it was 1,600,000.

the nonindustrialized countries, or about twice the rates ever experienced in Europe. Mexico's last population doubling took 20 years; Ceylon's, 25 years; Taiwan's, 20 years.

The crude birth rates at the beginning of the transition are considerably higher than those that obtained in Europe—40 to 50 per thousand instead of 30 to 35 per thousand.

The population of dependent children in these countries is typically 45 to 50 percent of the total population.

In short, the current demographic situation in the nonindustrialized nations is not analogous to that experienced by the West before and during its period of industrialization. Health services generated by industrial development in the richer countries have lowered mortality in the nonindustrialized countries and altered the traditional relationship between the rate of population growth and the state of industrial development. Rapid population growth slows the rate of growth of per-capita income, literacy, and industrial employment, retarding the social changes that seem to bring down birth rates. The larger population demands more food. In response to hunger and high food price, either the market mechanism or social planning diverts output from industrial investment to agricultural investment, further slowing industrial growth. The intrusion of externally generated health services in the race between growing population and growing capital can disrupt the entire development process. The disruption could be balanced by the addition of externally generated capital as well, but only if the returns to that capital are reinvested in the economy of the developing country, and if the entire population benefits from the additional output generated.

When these considerations are added to the Composite Model, the resulting theory provides both a broader description of reality and a more uncertain forecast of the future. The model now accounts for imperfections in the market mechanism and interruptions in the demographic transition. It predicts that industrial growth and demographic transition could proceed much more slowly in the future than they have in the past. This result is certainly not inevitable, but it is particularly likely if governments assume that an automatic and effortless demographic transition will solve the population-food problem, or if the capital-intensive approach to development is emphasized over the labor-intensive, or if death rates are lowered with no coordinated attempt to lower birth rates. In other words, the Demographic Transition Model, like the Western Economic Model, is valid only under special circumstances. Those circumstances include a tight linkage between industrialization and mortality, an industrial labor demand that absorbs displaced farm

workers, an internal reinvestment of the returns from capital, and a fairly even distribution of the increasing goods and services of the growing economy. Few of these conditions now prevail in the non-industrialized areas of the world. Therefore, distributional constraints, exponential population growth, and perhaps environmental constraints as well should be added to our model.

If the entire world population completes the demographic transition, so that the average global birth rate reaches replacement level by 1980-85 (a development rate that most people would consider impossible), the stationary global population would total 6.4 billion. If the completion of the transition takes until the year 2040 (perhaps more likely), the final population will total more than 15 billion.[33] That number has meaning only in relationship to the earth's carrying capacity—the number of people that could be sustained indefinitely by the ecosystem. If the carrying capacity is well above 15 billion, the Environmental Model's concepts of diminishing returns and earthly limits can be left out of the Composite Model. Policies can then concentrate on establishing the proper conditions for promotion of industrialization and the demographic transition. If an industrialized population of 15 billion would strain the earth's carrying capacity, however, physical limits should be included in the model and should influence policies derived from it.

Taking into account three basic resources—land, water, and solar radiation—a recent study has estimated an absolute maximum global food yield of 49,830 million metric tons per year.[34] This amount of food would support 217 billion persons at subsistence, or 50 billion at the consumption level of a typical European country today (10,000 vegetable-equivalent kilocalories per person per day). The study assumes widespread improvements in technology, optimum weather, perfect management, perfect distribution, no damage from insects or diseases, no limit to material or energy resources,

33. Thomas Frejka, *The Future of Population Growth* (New York, John Wiley and Sons, 1973).

34. P. Buringh, H. D. J. vanHeemst, and G. J. Staring, "Computation of the Absolute Maximum Food Production of the World" (Wageningen, The Netherlands, Agricultural University, 1975), p. 47.

multiple cropping, no pollution problems, and no loss of cultivable land to erosion or to uses other than agriculture. The authors of this study do not themselves believe that this output is actually achievable, nor desirable from an ecological viewpoint. Let us assume, however, that it is substantially correct, and simply reduce the limit by 20 percent to allow for weather fluctuations. That gives us an estimated upper limit, on the basis of food needs alone, of 40 billion persons living at industrialized standards of living. As shown by curve A in Figure 9, this limit would be reached, if current population growth rates continued, about the year 2075 (note that the vertical scale in Figure 9 is logarithmic). Two other population projections are shown in Figure 9; curve B illustrates a demographic transition by 2040 to 15 billion people; curve C, a transition by 1985 to 6.4 billion.

The horizontal dashed lines in Figure 9 indicate the possible positions of several other kinds of limits to the global population. The upper limit of 40 billion takes into account only land and water resources and only the food needs of the population. It assumes that energy, capital, fertilizers, and all other resources are available to the agricultural sector in whatever quantities are necessary for maximum yield, and also that arable land and fresh water are used only for food production, not for other human needs. If some other resource is more limiting than land or water, or if agricultural resources must be shared with other sectors, the real physical limit will lie below 40 billion.

Whatever economic system prevails, at some point the added cost of producing more food will be considered not worth the added gain. Resources must be used to produce other things besides food. Under any economic system and technology now conceivable, the point where the marginal cost of producing more food exceeds the marginal benefit will lie far short of the actual physical limit. Especially in an industrial society, the economic limit to food production is lower than the physical limit, simply because the list of human needs contains other items than food alone. In Figure 9 the economic limit has been set at 10 billion, a guess based on the supposition that the present global mixture of capitalist and socialist economies will support the cost of expanding cultivated land by 50 percent and global average yields

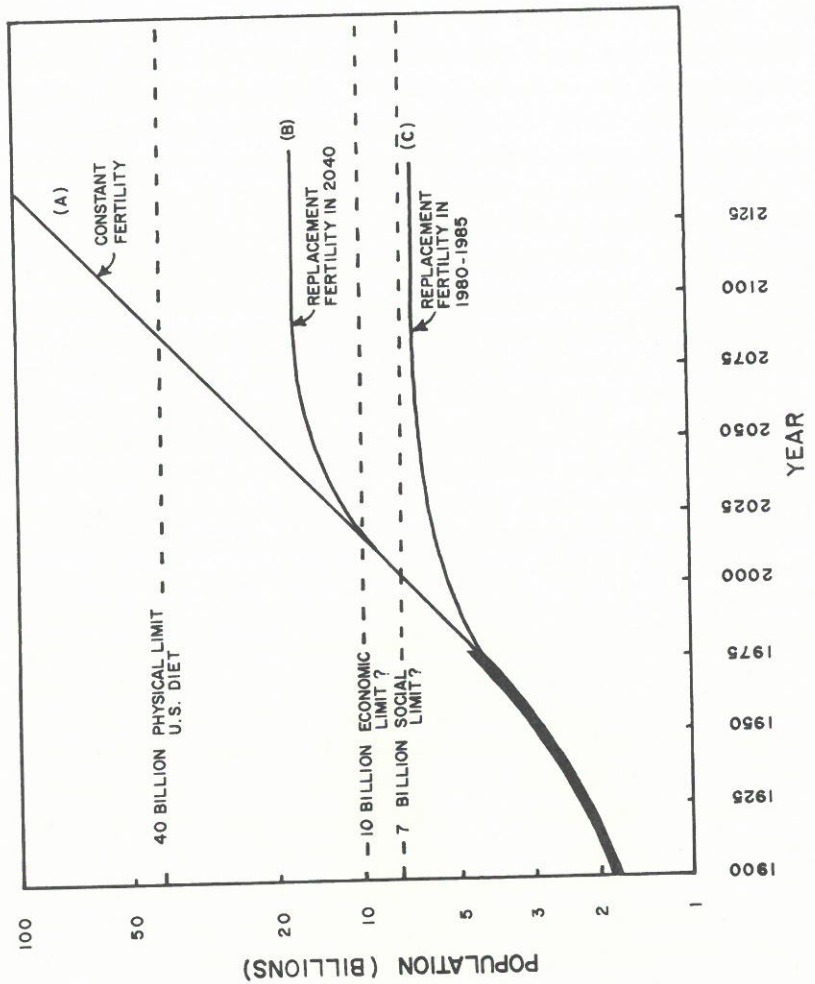

Figure 9. -- Limits to Food Production

by 400 percent over current values. A more careful study, based on considerations of availability of other resources, has actually set this limit at 7 billion.[35]

The third limit shown in Figure 9 arises from the realization that economic decisions are seldom ideal and that many human actions are based on factors other than the most rational allocation of resources to recognized social goals. This social limit accounts for misallocation of resources due to war, greed, corruption, economic monopoly, mismanagement, and resistance to change. Because all men are not of good will, and even men of good will make mistakes, resources are rarely optimally distributed to production processes, nor are final products distributed so as to maximize human welfare. Furthermore, the pressures for maldistribution and the opportunities for and costs of mismanagement probably increase as physical limits are approached. Therefore the social limit must lie somewhere below the economic limit. In Figure 9 it has been rather arbitrarily set at 7 billion. The exact positions of all the limits in Figure 9 are uncertain, and the social limit is certainly the least certain of the three. It has been estimated quantitatively here simply to indicate its position relative to the other limits.

The lower two limits in Figure 9 could be raised by social and technological improvements; the upper one could not, unless the human food supply is drawn from some resource base other than land, water, and sunlight. If the population actually reaches one of the two lower limits, the average material standard of living will begin to fall and the resource base will erode. Eventually the aggregate death rate will rise to equal the birth rate and population growth will stop, until social or technological innovations push the limit upward.

This excursion into the unknown realm of earthly limits has been deliberately oversimplified. I have ignored the vagaries of weather, markets, and international politics that complicate the calculations by imposing short-term fluctuations on the lines in Figure 9. I have not distinguished the disparate and important subregions of the earth, some of which are much closer to their

35. D. L. Meadows, W. W. Behrens, D. H. Meadows, R. F. Naill, J. Randers, and E. K. O. Zahn, *The Dynamics of Growth in a Finite World* (Cambridge, Mass., Wright-Allen Press, 1974).

limits than others, some of which have been able to push the social and economic limits much nearer to the physical limits than others, and some of which are approaching the limits at a much faster rate than others. Since we can never know physical or social limits exactly, the only reason for considering them at all is to ask whether any limits are conceivably near enough to be included in a policy oriented model. The estimates and arguments already presented here lead me to believe that some limits may indeed be encountered before a worldwide demographic transition can be completed. Therefore I feel that the constraints of the Environmental Model should be added to the Composite Model.

To summarize, the important concepts from the four partial models that have been included in the Composite Model are:

Western Economic Model
- price as a useful signal of supply/demand imbalances
- use of the market for short-term, incremental adjustments and detailed decision-making
- correction of deficiencies in free market operation.

Environmental Model
- importance of diminishing returns to capital, labor, land, and other inputs
- tendency of populations to grow exponentially unless constrained by physical or social pressures.

Socialist Model
- importance of labor as a factor of production
- moral and pragmatic necessity for equitable distribution
- reorganization of production through intermediate, labor-intensive, operator-owned technologies.

Demographic Transition Model
- coordination of industrial and agricultural development
- role of individual motivations in determining birth rates
- association of industrial development with declining birth and death rates.

The Composite Model leads to the following general conclusions about the future world food situation and the policies that may affect it:

- A free market mechanism is efficient in adjusting short-term supply and demand differentials. Therefore policy should strive to keep the market mechanism operating and should not duplicate its role by imposing detailed, day-by-day interferences with supply, demand, or prices.
- Important long-term forces such as population growth, systematic inequities, and resource limitations tend to push the market system into regions of inelasticity of supply or demand, so that normal adjustment mechanisms are ineffective or unacceptable. Thus policies to maintain the free market must include protection against these long-term trends.
- In all cultures children are desirable, and parents are likely to desire more than a replacement number of them. Populations will grow until some constraint brings birth and death rates into balance. The constraint may be physical, tending to raise death rates, or social, tending to reduce birth rates. Industrialization has historically caused social and economic pressures that reduce birth rates, but not necessarily to replacement levels.
- Considerable expansion of agricultural output is possible, but at a cost in terms of resources needed for other human desires. The cost increases as the level of output increases. Technological advancements may shift the cost from more limiting factors of production (historically, labor and land) to less limiting factors (historically, capital and energy).
- More people could be supported by even distribution of the earth's resources than by current patterns of uneven distribution. Distributional equality may be easier to achieve when resources are abundant than when they are scarce.
- The global resource base may not be sufficient to permit a worldwide transition to industrialization, especially given the rate the transition is currently proceeding, present consumption levels in the most highly industrialized countries, and rates of population growth in nonindustrialized countries.
- National economies today are so tightly intercoupled that even those societies farthest from their resource limits must be concerned about societies that are close to their limits.

V. VALUES AND PRIORITIES

One of the first publications of the newly formed United

Nations was the Universal Declaration of Human Rights. This document reads, in part: "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing, and medical care and necessary social services."[36] Similar statements of rights have been issued periodically by various organizations of the United Nations and by many national governments. One of the most recent was released at the U.N. World Population Conference at Bucharest, Romania, in August 1974: "All couples and individuals have the basic right to decide freely and responsibly the number and spacing of their children and to have the information, education, and means to do so."[37]

Declarations of rights are statements of fundamental policy goals, primary objectives that governmental policy should seek above all else. The right to a minimum standard of sustenance and the right to establish a family and determine its size are reiterated constantly in discussions of food and population policy. Yet the Composite Model of the food situation suggests that under some circumstances these two rights may come into conflict with each other, with other human goals, and with the physical laws that govern the earth. Unless by chance families choose to have on the average exactly the number of children required to balance the aggregate death rate, the right to reproduction could lead on an exponential path to the limits of the earth's resources, eventually restricting the right to sustenance. Recognition of this dilemma is by no means recent:

> When goods are increased, they are increased that eat them.
> —Ecclesiastes 5:11

> To feed a family of five
> A farmer must work like an animal

36. *The Universal Declaration of Human Rights* (New York, United Nations, 15th Anniversary Edition, 1963).

37. The World Population Plan of Action, *Studies in Family Planning*, 5, No. 12 (December 1974), 383.

> To feed a family of six
> Even a flogged animal will not work
> Chinese adage[38]

> Our numbers are burdensome to the world, which can hardly supply us from its natural elements; our wants grow more and more keen, and our complaints more bitter in all mouths. . . . Pestilence, and famine, and wars, and earthquakes have to be regarded as a remedy for nations, as a means of pruning the luxuriance of the human race.
> Tertullian, 3rd century A.D.[39]

> The pressure arising from the difficulty of procuring subsistence is not to be considered as a remote one which will be felt only when the earth refuses to produce any more, but one which actually exists at present over the greatest part of the globe.
> Malthus, 1830[40]

If two important goals, such as freedom of reproduction and guarantee of sustenance, are in direct conflict, pursuing them both may waste effort, at best, and fail to achieve either objective, at worst. The essence of policy-making is the choice among conflicting goals. Choices cannot be made without reference to a theory that suggests what the future costs and benefits of a course of action might be, and to a set of values that indicates what is good, what is bad, and how various goods and bads should be balanced against each other. Even if the model or theory of the causes and consequences of the problem is agreed upon, different sets of values may lead to very different policies.

The world food problem raises some classic value questions,

38. Quoted in J. L. Buck, *Land Utilization in China* (Chicago, University of Chicago Press, 1937).

39. Quoted in Harrison Brown, *The Challenge of Man's Future* (New York, Viking Press, 1954), p. 30.

40. Thomas Robert Malthus, *A Summary View of the Principle of Population*, 1830 edition.

debated by many societies for centuries. Is individual freedom more important than social stability and order? Are the needs of future generations as important as the needs of people alive now? If efficiency and equity are inconsistent, which should be sacrificed? How much of a risk to survival justifies how much of an incursion on freedom, justice, or material welfare?

Models and values are certainly not independently learned or chosen. Much of the appeal of a model may stem from its congruence with a particular value set, and the model may then lead to conclusions and observations that reinforce that value set. For instance, the Western Economic Model focuses more on freedom and efficiency than on equity. The Socialist Model sets equity as the highest value, while the Demographic Transition Model emphasizes material welfare and freedom. Of all the models discussed here, only the Environmental and Composite Models suggest a risk to long-term survival and raise the problem of weighing that risk against other values that a society might cherish.

I am not aware of any way of determining a single set of values and priorities that is applicable to all persons at all times. Yet each of us readily forms an operational set of priorities that guides our choices and decisions. These individual value sets may be very different, and the differences may be undebatable. Nevertheless, discussions of policy alternatives might be enhanced if we could make our value sets explicit, not to argue their relative merits, but to increase our understanding of the various viewpoints within our society. My own primary values, in order of priority, are:

1. survival (of the total social and ecological system)
2. material welfare (up to a level of simple comfort, after which this entry goes down to the bottom of the list)
3. equity (equal access to other items on this list)
4. freedom (individual self-determination, diversity)
5. efficiency (maximum output per man-hour)

Of course I consider all five of these goals important and worth pursuing. However, my mental model suggests that striving for efficiency could undermine all four of the other values, a sacrifice I would not be willing to make. To me individual freedom would be meaningless without the first three items on the list; I would give up my personal freedom, if necessary, to obtain survival, material sufficiency, and equity. Equity in poverty does not appeal to me, so I would seek basic material welfare before distributional justice. Survival seems to be necessary before any of the other values can be enjoyed. I would not tolerate a very high risk to total social or ecological survival for any reason, even for one of the other values on the list.

My value set is included here not because it is the best or only defensible one, but because I would like to show what a value set looks like, and because my own policy recommendations depend on my ordering of value priorities. Some of the policy-relevant conclusions that seem consistent with my value set are:

- The long-term survival of human society and the stability of the natural system upon which human society depends should be the highest goal of any policy. Therefore risks to the total system should be minimized, including implicit dependence on as yet unproven technologies.

- According to my value set, the costs of social change are more tolerable than the costs of physical destruction of resources or of environmental integrity.

- Short-term sacrifices, especially material sacrifices, to preserve long-term stability are justified. In accordance with the goal of equity, sacrifices for the future should be borne disproportionately by the privileged of today.

- The quality of human life is more important than the quantity, and material sufficiency is more important to quality of life than is the freedom to have more than two children. Therefore, the right to sustenance has a higher priority than the right to reproductive freedom.

- Several important aspects of quality of life cannot be measured in strictly economic terms. Therefore decisions should be made on a broader basis than simple economic cost-benefit analysis.

- Industrialization is a means to one end that can improve the quality of life, namely material welfare. It may not be the only means to that end, and it is not an end in itself.

- In the interests of preserving individual freedom and diversity, intervention by centralized government should be minimal. Intervention is justified only to preserve the three values prior to freedom: survival, basic material welfare, and equity.

VI. PRIMARY POLICY CONSIDERATIONS

In the remainder of this paper I will attempt to translate these idealistic value statements into general guidelines for United States food and population policy. I shall assume throughout this discussion that the primary purpose of food-population policy is to solve the problem of world hunger, not to gain national or personal political power or to achieve any other short-term, narrowly bounded goal.

All possible solutions to the world food problem can be grouped into three major categories:

- *Produce more food*. Both technological and social changes can bring more land into production and increase yields on land already cultivated. These policies aim to move the economic limit closer to the physical limit to food production. Future extension to non-land-based food production (such as single-cell protein and hydroponics) raises the physical limit itself by substituting other resources, particularly energy, for land. Most current policy efforts fall into this category. They have the advantage of relatively short-term payoffs and of emphasizing technological sophistication, the major asset industrialized countries have to offer. The costs of these policies tend to be economic and environmental, rather than social. They require little change in the way industrial societies are used to doing things, but they demand major revisions in the life styles of non-industrialized populations.

- *Allocate food more efficiently*. In this category fall efforts to control agricultural prices and trade flows, to change nutritional habits, to establish buffer stocks, to provide famine relief, to reduce luxury consumption, and to restructure economic systems. All these policies attempt to move the social limit and, by changing priorities, the economic limit closer to the physical limit. They would allow more people to be nourished, even if food output did not increase at all. These policies could reduce hunger very rapidly, once actually implemented. Their costs are almost entirely social; they require attitude changes and new institutions. Their effect on the environment would be minimal. They would require economic readjustment, but probably very little additional economic cost in terms of total investment or resources.

- *Slow population growth*. Current efforts here are dominated by family-planning programs. A few governments have experimented

with rewards or punishments for conforming or nonconforming family sizes.[41] Population-control policies are necessarily long term; they may not produce visible results for decades. Their costs are largely social; they would probably result in net economic and environmental benefits. The aim of population stabilization is to avoid all limits to food production, and therefore it offers the only permanent solution to the food problem.

Discussions about food and population policy sometimes degenerate into arguments about which of these three options to pursue exclusively. I believe it would be more fruitful to decide which mixture of all three would be best; how much time, research, thought, and investment to devote to each. When that decision has been made, the detailed administration of each option will require further implementation decisions. For example, under the category of producing more food, secondary policies turn upon questions such as the best way to market new grains or fertilizers, the most effective form of agricultural education, and the appropriate budget to be allocated to nitrogen-fixation research. Most decision-makers necessarily spend a majority of their time on such secondary, implementation questions, often with no opportunity to review the primary decision about the relative emphasis on major options. I will begin here with this primary question and move from there to questions of implementation.

Current policies in most countries seem to concentrate on producing more food, with some emphasis on food distribution, and only a few serious efforts at population control. The time horizon, model, and value set I have presented here would suggest that, although all three options must be pursued vigorously, the order of priorities should be reversed. Population control is the only ultimately effective solution and the one with lowest total costs; therefore it should receive the most effort. Since population control measures cannot be accomplished quickly, however, redistribution and more efficient food production will be needed to minimize

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41. See, for example, Willard A. Hanna, *The Republic of Singapore: Population Review 1970*, American Universities Field Staff Reports, Vol. 19, No. 5 (1971) and *China's Experience in Population Control*, Committee on Foreign Affairs, U.S. House of Representatives, Washington, D.C., U.S. Government Printing Office, September 1974.

medium-term food shortages. Redistribution can produce almost immediate results with low ecological and economic costs, and it is also morally desirable, according to my values. Therefore it should receive emphasis second only to population stabilization. Food production, the third priority, should be labor-intensive in order to use the major resource of the most needy countries, and should be concerned with conservation of energy and natural ecosystems, as well as with increased output.

Setting the policy priorities in this order raises many secondary questions about how such measures could be implemented. Is redistribution consistent with market economies? How can governments influence birth rates? What ecologically sound food-production technologies are possible? What would a world based on the model and values presented here be like?

VII. IMPLEMENTATION CONSIDERATIONS

One reason that current policies emphasize technological adjustments rather than socioeconomic adjustments may be that governments have already at hand the mechanisms, institutions, and personnel necessary to implement technological changes. Western governments, in particular, are accustomed to guiding technical activities. When it comes to directing a deliberate change in values, life styles, or social arrangements, however, current governments have almost no experience and very little imagination. For example, many people can picture government involvement in population stabilization only in terms of direct dictation of individual family sizes, with punitive action for offenders who produce too many children. Visions arise of policemen in bedrooms and of forced sterilization. If Orwellian measures are the only imaginable way to implement population policy, it is not surprising that such policy is carefully avoided. Unfortunately, the very belief that no acceptable social-change policy exists cuts off all discussion of government involvement in social change, and therefore the innovative thinking that might produce acceptable policies is not encouraged.

I would like to discuss implementation considerations here in just enough detail to indicate what directions might be followed. My aim is to outline some possible programs, more to stimulate

imagination and generate new ideas than to ascribe any completeness or uniqueness to the examples I have chosen. I assume that once a general direction is agreed upon, experimentation, observation, evaluation, and revision can be used to work out operating details.

These implementation recommendations have been derived from the Composite Model and the value set already presented. I believe they are consistent with that model and those values. The recommendations have been conceived as a whole and should be evaluated in that light. I would not advocate some of the individual recommendations unless they were combined with the others.

One last word of warning before the list of recommendations begins: food-population issues, perhaps above all others, are impossible to separate cleanly into foreign and domestic spheres of influence. Domestic food prices may be changed by new export arrangements or massive donations for famine relief. New agricultural technologies can alter the lives of American farmers as well as African ones. The annual increase in the United States population, because of its higher rate of per-capita consumption, increases the effective demand on the world food supply by nearly as much as the much higher annual increase in the population of India. Even if the United States were primarily interested in improving the food supply-demand balance in the Third World, our influence might be greatly enhanced by consistent population and food policies at home. As George F. Kennan stated in a speech on foreign policy in 1954:

> Now this problem of the adjustment of man to his natural resources, and the problem of how such things as industrialization and urbanization can be accepted without destroying the traditional values of a civilization and corrupting the inner vitality of its life—these things are not only the problems of America; they are the problems of men everywhere. To the extent that we Americans become able to show that we are aware of these problems, and that we are approaching them with coherent and effective ideas of our own which we have the courage to put into effect in our own lives, to that extent a new dimension will come into our relations with the peoples beyond our borders.[42]

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42. George F. Kennan, *Realities of American Foreign Policy* (Princeton,

1. Population Policy

In the spirit of the above quotation, I believe that the single most effective policy the United States could implement to promote population stabilization in the world is to announce and seek the goal of population stabilization at home. Population stabilization has already been recommended by the Commission on Population Growth and America's Future,[43] who took into consideration domestic needs alone. Stabilization of the United States population would also enhance population policy efforts abroad, by weakening suspicions of genocide and imperialism, and by providing us with practical experience in programs we are urging others to adopt. Although fertility in the United States is relatively low, our population is still growing. No deliberate governmental policies have been responsible for the recent decline in the birth rate, and none has yet appeared to prevent it from rising again. What sorts of policies could possibly do that?

The birth rate is the result of millions of individual decisions made by families and affected by the complex of rewards and constraints, economic and social, perceived at the family level. Better birth control methods help families achieve the number of children they desire more efficiently and at lower cost. But birth control cannot stabilize population unless families happen to desire, on the average, the number of children just required to balance the death rate of the population. Birth control programs are necessary, but not sufficient to ensure eventual population stabilization.

Governments continually influence the economic and social conditions felt by families, and thus governments are already involved in determining birth rates, implicitly and almost accidentally. Such accepted governmental powers as taxation, housing policy, public health administration, highway construction, education, and monetary policy all affect family incomes, expectations, costs, and location. Any of these factors could alter childbearing decisions. For example, birth rates are known to increase in times of economic

N.J., Princeton University Press, 1954), quoted in *The New Yorker* (April 21, 1975), p. 29.

43. Commission on Population Growth and the American Future, *Population and the American Future* (New York, Signet, 1972).

growth and to decrease in depressions;[44] and apartment size may have an influence on family size in several industrialized countries.[45]

Since there is no question that governmental policy will influence birth rates, we need ask only whether the influence will be accidental and unpredictable or deliberate and consistent with other social policies. Stabilization measures in the United States could begin with reexamination of current policies that are inadvertently pronatalist, including unequal income-tax rates for single persons and childless families, subsidization of middle-income housing facilities, and the remaining forms of discrimination against women. Positive steps could include demographic education both in schools and in the media, and free clinics for contraception, abortion, and sterilization. Probably most effective of all would be the public acceptance of a small family norm through as many channels of public information as possible, from presidential speeches to advertising campaigns.

With respect to population growth in other countries, I feel that the United States should support all locally originated policies to reduce birth rates. We should not attempt to impose any particular strategies or techniques, or to oppose measures acceptable to other cultures but not to ours. An American advisory service could provide aid in family planning, demographic record-keeping, and other population-related services, but only as requested by the recipient nation.

Although I very much favor national autonomy in dealing with population questions, I believe United States policy should be insistent upon one simple condition: measures to lower death rates should be linked directly with measures to lower birth rates. All forms of death control, from public health consultations to food donations, should be available on request of any nation, but only as a package that includes serious population stabilization programs, chosen by the recipient, as well. No nation need be pressured to accept this package, but under no condition should one part of it be available without the other. The choice of high birth and death

44. Richard A. Easterlin, "On the Relation of Economic Factors to Recent and Projected Fertility Changes," *Demography*, 3 (1966), 131.

45. Bernard Berelson, ed., *Population Policy in Developed Countries* (New York, McGraw Hill, 1974).

rates may be more acceptable to other cultures than it is to ours. The choice of low birth and death rates may take a long time to achieve, as it did in our own country, but we should help implement it upon request. The one unacceptable choice, from a global viewpoint, is high birth rate and low death rate. No ecosystem can support that choice for long, and our own policy should be to refuse any attempt to implement it. Clearly this policy should be followed only in combination with our own domestic population-stabilization efforts; we should not impose conditions on others that we are unwilling to impose on ourselves.

From a short-term viewpoint, this policy may appear coercive and antihumanitarian. It is coercive in that it dictates one major constraint to all nations—birth rates shall not be maintained higher than death rates. That constraint is derived from the physical laws of the planet, however, not from the selfish desires of any one group of people. The condition of population stabilization interferes with some freedoms, but it lets each government accomplish that interference as it sees fit. At the same time it creates other freedoms by reducing the threats to survival, welfare, and equity that overpopulation would bring.

As for humanitarianism, decreasing death rates in an otherwise unchanged society may appear beneficial for a few decades, but the resultant population growth rates will ultimately hinder efforts at further development. In the long run a short-term humanitarian impulse could produce a population driven to its physical limits with little hope of betterment. According to my value system, a nonindustrialized society might better postpone decreases in the death rate until social and economic conditions have evolved to permit concurrent decreases in the birth rate. Then both vital rates can move downward in phase, as they did in the demographic transitions of the West, and a *permanent* reduction in mortality and fertility can be achieved.

2. *Distribution Policy*

I believe that distribution policy, like population policy, should begin at home. The Bucharest and Rome Conferences demonstrated that a nation with 6 percent of the world's people consuming 30-40 percent of the world's resources can be viewed only with deep suspicion by the Third World. If the United States hopes to persuade other countries to follow long-term, globally oriented population and food policies, we must actively try to reduce our own consumption of food-related commodities, including fertilizer and energy. Measures to be considered include luxury taxes on grain-fed meat, tobacco, and highly processed foods; limitation of fertilizer use to agricultural purposes; control of pet populations; nutrition education; and numerous energy-conservation measures, from minimum fuel-efficiency standards for automobiles to deregulation of natural gas and petroleum prices. These measures would do more than increase the international credibility of the United States. They would also improve our domestic economic health by reducing our dependence on imports of vital resources, and by hastening the coming technological transition from nonrenewable to renewable resources.

Domestic conservation policies may increase the already large amount of food the United States has available for sale on the world market. Some of this surplus should be allocated to grain buffer stocks for countering weather-induced emergencies. I believe the remainder should be sold on the international market, not given away. Donated food provides short-term aid to poor countries, but at the same time it destroys local incentives, encourages corruption, and tends to lower death rates without providing an incentive for lowering birth rates.

Reduction in food aid does not imply reduction in other kinds of aid or disinterest in the plight of the poor. Quite the contrary, if food-importing countries are to benefit from United States surplus on the international market, they must have purchasing power derived from their own economic systems. At least in the medium term, the development of those economic systems could be hastened by foreign aid, but aid of a different kind than direct transfers of Western food, capital, or technology. This paper is not meant to be a disquisition on economic development. I would simply like to mention two directions of change in aid policy that might lead to a fair and permanent global redistribution of economic power.

First, a new attitude about the ability of the United States to develop other countries might be useful. Current examination of several past decades of foreign aid is resulting in a healthy skepticism about the general applicability of Western methods, resources,

and organizational forms to non-Western societies. Out of this reassessment should come not discouragement and abandonment of effort, but a constructive humility and openness to other ways of doing things. If we could approach the problem of each country's development as a co-explorer with that country, willing to listen and learn as well as to teach, we might not only be more welcome, we might also make more progress. Further suggestions along this line are included in the following section on food production.

Second, a more systematic understanding of the distributional consequences of international trade is needed. The Third World countries have often complained that the international terms of trade discriminate against them. Recent studies confirm that the operations of multinational corporations[46] and of the world food market[47] both result in an effective subsidy to the rich nations from the poor. If the international economic system regularly undoes what aid programs are attempting to do, then a restructuring of trade as well as aid would certainly be in order.

One last factor to be considered under the topic of redistribution is the relationship between the free market and equity. I have already described some of the short-term regulatory advantages of the free market in my description of the Western Economic Model. A long-term problem of the market system, however, is that it creates and exacerbates inequality by rewarding the most competitive producers and consumers with the means to produce or consume even more competitively in the future.[48] Ultimately the system leads to its own destruction by producing oligopoly. If the advantages of the market system are to be preserved, this long-term tendency must

46. Richard Barnet and Ronald Muller, *Global Reach: The Power of Multinational Corporations* (New York, Simon and Schuster, 1974).

47. H. Linnemann, "Fourth Report to the Club of Rome" (Amsterdam, The Netherlands: in press).

48. For further discussion of this aspect of the market system, see Bertram G. Murray, Jr., "What the Ecologists Can Teach the Economists," *New York Times Magazine* (December 10, 1972), p. 38; Garrett Hardin, "The Cybernetics of Competition," *Perspectives in Biology and Medicine*, 7 (1963), 58, reprinted in Shepard and McKinley, *The Subversive Science* (Boston, Houghton Mifflin, 1967); and D. H. Meadows, "Equity, The Free Market, and the Sustainable State," paper, Proceedings of the First Biennial Assessment of Alternatives to Growth, The Woodlands, Texas, October 19-21, 1975.

be constantly opposed. Domestic policies to redress the distributional imbalances of the market could include, on the demand side, a truly progressive income tax and a minimum income allowance, and on the supply side, meaningful enforcement of antitrust legislation and a land reform that limits farm size, similar to land reforms we often suggest to other countries. For reasons given in the next section, I do not believe that a reduction in the size of producing units would reduce total efficiency. Even if it did, I would value the gains in freedom, equity, and stability of smaller units of production more highly than the slightly greater output from larger units.

3. Food Production Policy

Agricultural research and development is already well funded in this country, and it has contributed greatly to increased production all over the world. I would add to the ongoing efforts only two suggestions. First, we need a national policy to preserve our own agricultural land and keep it in production. Second, food production research should focus on the particular needs of nonindustrialized areas, including tropical agriculture, and on intermediate-scale technology.

Intermediate agricultural technology is an approach that emphasizes tools and inputs that are appropriate for villages and small farms and that can be manufactured and repaired locally from renewable materials. It also involves more human and less fossil fuel energy. Examples of intermediate agricultural technologies include digesters to produce fertilizers from household and urban organic wastes, biological pest control, windmills for pumping water, solar grain driers, small sturdy hand tractors, methane generators, and many sorts of handtools. Some of these suggestions may sound like a return to old-fashioned practices. But new designs, materials, and knowledge are now being combined with traditional methods in some ingenious attempts to capture the best of the new and the old.[49]

Intermediate technologies are ideally suited for nonindustrialized countries with excess labor and a shortage of capital. They are

49. For examples see such publications as *Appropriate Technology* (quarterly from Intermediate Technology Publications, Ltd., 9 King Street, London WC2E8HN) and *Coevolution Quarterly*, Box 428, Sausalito, Calif., 94965.

naturally conservative of commodities whose prices are now rising, such as petroleum and natural gas. Ecologically, intermediate technologies are much more acceptable than current Western farming methods. They can combat erosion and gradually improve soil fertility and they tend to introduce fewer foreign substances into ecosystems, since they are based on naturally occurring renewable materials.

The intermediate scale is fully compatible with redistribution goals that call for smaller farms. Neither intermediate-technology farming nor smaller units of production are likely to reduce output. In many countries smaller farms consistently outproduce large farms on a per-acre basis, although they do produce less output per man-hour.[50] In other words, they maximize returns to an increasingly scarce factor of production, land, rather than to an increasingly abundant one, labor. These production methods are therefore capable of producing both increased total output and increased rural employment.

The most promising aspect of small-scale, intermediate-technology may be its potential for promoting self-sufficient production and maintenance on the village level. This approach may be the key to the redistribution necessary to keep poor consumers in the market, and ultimately to the social changes that can bring about real, internally generated development and the demographic transition. As E. F. Schumacher says:

> Give a man a fish . . . and you are helping him a little bit for a very short while; teach him the art of fishing, and he can help himself all his life. On a higher level: supply him with fishing tackle; this will cost you a good deal of money, and the result remains doubtful; but even if fruitful the man's continuing livelihood will still be dependent upon you for replacements. But teach him to make his own fishing tackle and you have helped him to become not only self-supporting, but also self-reliant and independent.[51]

50. For examples from developing countries see Keith Griffin, *The Political Economy of Agrarian Change* (Cambridge, Mass., Harvard University Press, 1974), pp. 38, 42, 59. For data from the United States, Japan, and India, see Kusum Nair, *The Lonely Furrow* (Ann Arbor, University of Michigan Press, 1969).

VIII. CONCLUSION

There may be no more important social problem in this century than the increasing imbalance between the human population and the resource base that sustains it. This problem is creeping, diffuse, and undramatic compared with others that command attention—nuclear proliferation, international monetary disturbances, oil prices, or the politics of the Middle East. Yet the food-population problem is related to all these problems, and to others now barely visible on the horizon. Although solving the food-population problem is unlikely to mitigate all world problems, many world problems and conflicts will certainly get worse if the food-population balance is not restored.

> As physical resources are everywhere limited, people satisfying their needs by means of a modest use of resources are obviously less likely to be at each other's throats than people depending upon a high rate of use. Equally, people who live in highly self-sufficient communities are less likely to get involved in large-scale violence than people whose existence depends on worldwide systems of trade. . . . As the world's resources of nonrenewable fuels—coal, oil, and natural gas—are exceedingly unevenly distributed over the globe, and undoubtedly limited in quantity, it is clear that their exploitation at an ever-increasing rate is an act of violence against nature which must almost inevitably lead to violence between men.[52]

The food-population situation will not be improved without a major global change in policies, priorities, and social institutions. No problem can be solved while preserving every aspect of the system that generated it. The system must change, but this is a statement that should be viewed not with despair but with hope. We surely

51. E. F. Schumacher, *Small is Beautiful*, p. 186.
52. Ibid., p. 57.

can imagine many worlds better than one in which a large fraction of the population is poor and hungry. Some of the necessary changes, such as lower birth rates, are already happening spontaneously, but slowly, and need only be accelerated. Other changes, such as redistribution, are desirable in their own right. New technologies based on conservation of resources and preservation of small-scale control will surely be welcomed in the petroleum-depleted long run by rich and poor countries alike.

Although many of the policies I have recommended may seem extreme from the well-fed and only slightly worried perspective of the American middle class, all are intrinsically possible, and most are clearly beneficial to current as well as future generations. My suggestions require a shift in viewpoint more than any real sacrifice. Millions of Americans are voluntarily moving toward satisfying, productive life styles based on small families, less consumption, and more concern for the unfortunate of the world.[53] My own family has moved in that direction, and the result is not a loss but a clear and substantial gain in the quality of our lives.

In this paper I have followed an idealistic process and come to idealistic conclusions. I do not believe that idealism is out of order in policy discussions. Social change can occur only when there is a perceived gap between the ideal and the real. Thus any society that is evolving, not stagnant, should welcome both criticism of the current state of the system and descriptions of possibilities that are yet unrealized. Politics, "the art of the possible," can make no progress without occasional reminders that more is possible than is currently being done.

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53. For examples of "how-to" publications with circulations in the millions, see *Organic Gardening and Farming*, Organic Park, Emmaus, Penna. 18049, *Mother Earth News*, P.O. Box 70, Hendersonville, N.C. 28739, and Frances Moore Lappé, *Diet for a Small Planet* (New York, Ballantine, 1971).