

Working Paper

Population Beyond the Boundaries of Demography

N. Keyfitz, G. Heilig, W. Lutz, S.Scherbov

WP-89-106
December 1989



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Foreword

We in the Population Program of IIASA are frequently asked what systems analysis signifies in relation to demography. How does a systems approach differ from specialized analysis in the field of population? This working paper attempts to answer that question. It says, in brief, that systems analysis brings in a wider range of variables, tries to find mechanisms by which population influences the economy, the polity, the environment, and how these in turn influence population. It seeks to reveal those negative feedback mechanisms by which stability is maintained, and positive feedbacks that build up uncontrolled consequences.

Different writers have necessarily different ways of representing systems analysis. The examples that follow, provided by myself and my colleagues, will show something of the range of legitimate interpretations.

Nathan Keyfitz
Leader
Population Program

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POPULATION BEYOND THE BOUNDARIES OF DEMOGRAPHY

Nathan Keyfitz

After half a century of exhortation to be interdisciplinary we still find little interdisciplinary analysis in the literature. That applies to demography as to other fields.

There are reasons for this. A discipline builds up exacting standards of quality by which individuals are judged. The competent interdisciplinarian—unless he has the rare ability to meet the standards of two disciplines—is looked on as an amateur, an outsider, not to be taken seriously. He is a foreigner in each disciplinary group, who cannot be placed; no one knows just how to talk to him.

All this is to the good insofar as specialization is the condition for depth. No one can know everything; better to dig deep, to have a good knowledge even of a narrow field; to extend one's interests over a wide territory is usually to be shallow. Yet the trouble is that the world outside does not respect disciplinary boundaries. There are no purely biological phenomena independent of the laws of physics, nor economic phenomena independent of the operation of politics. Some of the most conspicuous examples of policy advice not working have been due to disregard of the essentially interdisciplinary character of the outside world.

The point will be applied to six fields of demographic analysis.

Fertility

In the usual family planning model poverty generates many children; let people become better off and they will have fewer children; with fewer children they can raise their standard of living further, a positive feedback, a beneficial circle that indeed justifies population control programs, but does not make them seem very urgent. Yet under current conditions development has an environmental cost, one that depends on the number of persons in the developing territory; the very number of these may make development that would have the effect of controlling fertility impossible. Introducing the environment changes the logical circuits, introduces a new urgency, even shows that there is a narrow window in time in which development is possible.

Migration

Rural-urban migration—especially to capital cities—is accounted for by the justly approved Harris-Todaro model—there are indeed poor people in the city, but there are also very rich people; migration will occur as long as the expected value of future income in the city is greater than the expected value in the countryside. But in a competitive market such migration would lower incomes and end in equilibrium; it does not account for the continued indefinite increase of urban populations. That is explained by a positive feedback loop: city populations pressure governments for lower food prices, that bring more people into the city, that increase the political pressure, and exact further benefits, and so on indefinitely.

Aging

The difficulties of social security are attributed by experts to the aging of populations: with low fertility there are fewer workers in prospect, and with low mortality people will draw longer. Correct of course; but if this were the whole story people would simply work to an older age and thus offset the aging of the population. Unexplained is the younger age of retirement in advanced countries despite the fact that old people would have more years of leisure even if retirement age was constant. The problem is not aging but the drive to younger retirement, and that installs a direct conflict of interest between the working generation and their elders.

Perverse effects

An element that is mostly out of the view of the experts is the effect of social security itself on the aging of populations. Not needing children for support in one's old age takes away one of the main reasons for large families. People saving for their own old age contribute capital to the community in their youth whose real production they can draw on when old; as they have become richer and so more able to provide for their own old age the State has removed the incentive for them to do so.

Mortality

The assumption of a large part of health costs by the State has had the effect of raising those costs above what they were in the free market that preceded. Charges have always been what the patient could afford to pay; they still are that notwithstanding the State's contribution. More important, they convert old age from an honored condition to a burden: the working population pays for health (including medical research) only in ord-

er to extend life and so impose on itself the further cost of longer pensions.

The family

A part of the cause of the lower fertility of the rich countries is the weakening of bonds within families; couples divorce for minor reasons, many couples do not even marry in the first place. Family experts have tried to explain why husbands leave their wives and wives their husbands. But it is also the case that priests leave their church, workers leave their jobs, students leave their studies, all more casually than ever before. The specialized analysis of the family in its very nature is incapable of finding the more general cause of institutional fragmentation.

Ecology

The disciplines of economics and ecology pursuing their separate studies come up with projections for the future that are wholly incompatible with one another. Contemporary economics curves (unlike those of up to 50 years ago) are exponential upwards; the only dispute is whether the exponential is to be at 2 per cent or 5 per cent per year. Ecological models tend to be level; the web of life that is in balance generates so much fish, so much wood; any exponential increase is strictly temporary. An economic-ecological model that will be generally accepted is yet to be presented; it will be very different from either of the two separate models.

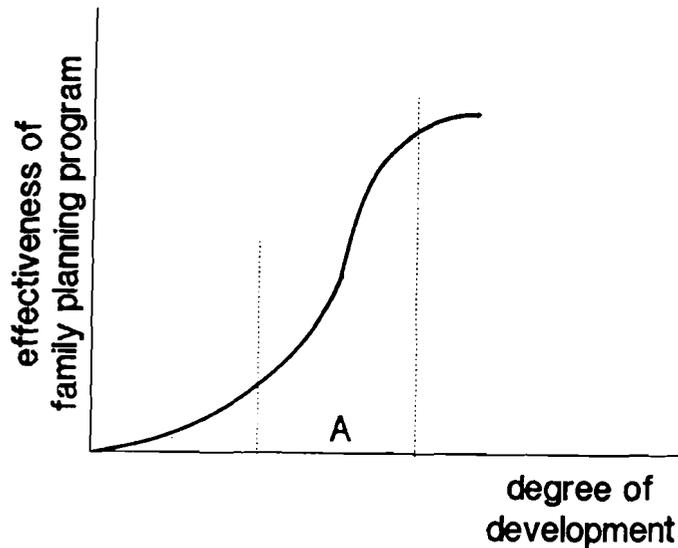
In these six illustrations the interdisciplinary approach can be contrasted with the disciplinary or expert approach: fertility, migration, aging, mortality, family, environment. All of these show the contrast, though in different ways. I have to simplify in order to make the point; some of the qualifications are spelled out below.

FERTILITY

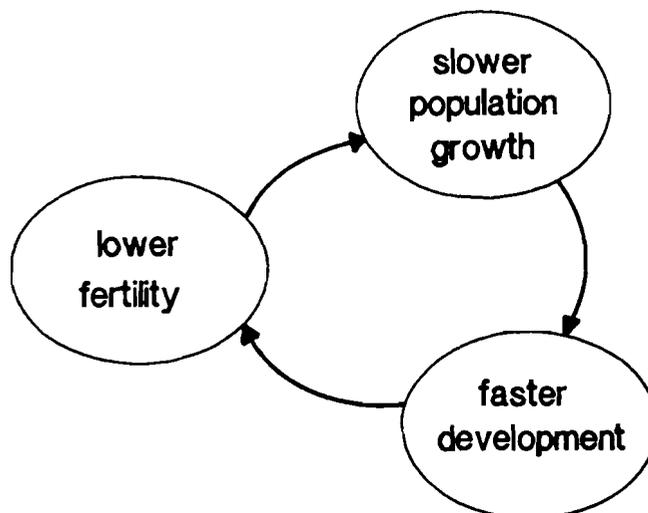
Fertility policies in developed countries aim to raise birth rates; in LDCs to lower them. And within each of these there are differences: family allowances encourage births in poor communities like Newfoundland; in rich ones like France or Italy they have much less effect. Where housing is scarce its allocation on the basis of the number of children is a strong incentive; where housing is plentiful it is no incentive.

Again in those very poor LDCs where couples want many children the provision of contraceptive equipment will serve little purpose; where there is already some interest it can help a good deal; where sophistication on birth control has been attained, again it

adds less. Thus there is a certain intermediate phase of development in which population programs are most useful. That is to say these programs are at their most useful on the shoulder of the development curve (Interval A below).



In the most common model applying to the intermediate phase of development marked A, lower fertility slows population growth, and that permits faster development, which in turn further lowers fertility. This beneficial circle continues until the community is beyond the need for birth control programs, say until births have come down about to the level to replace deaths. It tells us that birth control is needed, but any time for starting it will serve, and any speed of application is as good as any other. Birth control is indeed desirable on this model but not very urgent.



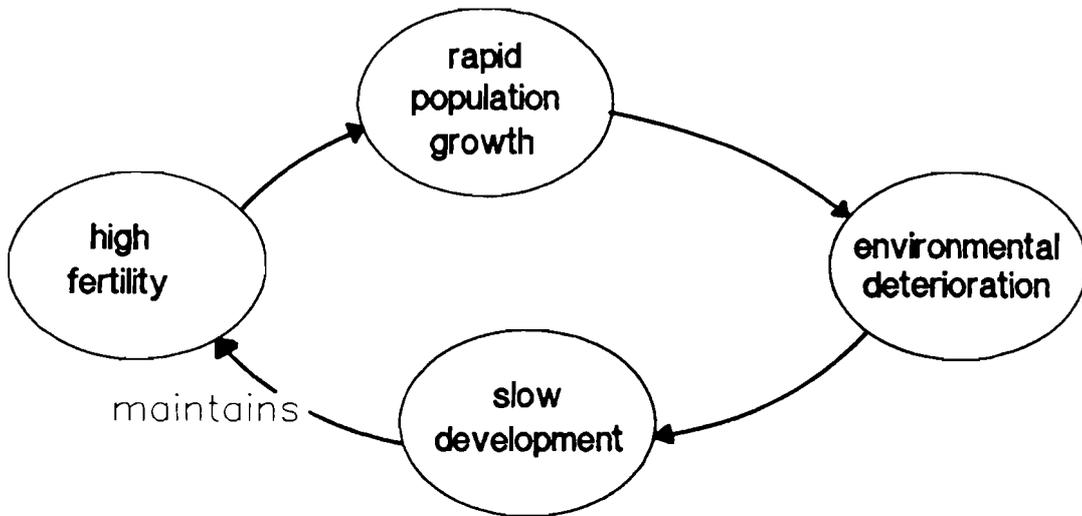
Such assertions are narrow, in that among other matters they neglect the ecological setting. What is going to happen to the forests of Thailand if population continues to increase and cutting goes on at the present per capita rate? Certainly flooding, and perhaps in the end desertification. And insofar as the forest products are exported, and so pay for the capital for industry, their disappearance has multiple consequences for employment. It is in such ways that population, environment and employment are interlinked.

We aim at a demographic-economic model, but one in which population and the economy are seated within the ecology, a configuration that has been neglected in unidisciplinary models. Like other disciplines, economics as well as demography are driven by the impulse to autonomy: no specialty wants to be dependent for its ideas on another. The autonomy and specialization bring great power in some respects, but weakness in others. For instance, without environmental limits the population could expand to infinity.

Our antecedents in this should be the great political economists of the 19th and 20th centuries, working before the several disciplines became so specialized. Contemporary economics fashion theory suited to deal with short term questions (what will the bank rate of interest be next month?) but the investigator of the long term questions of population cannot afford to neglect the natural setting of the economy, the ecological base in which it sits.

Thus seen from the narrow viewpoint of the national accounts, getting oil out of the ground so that it may be burned on the highways is production; from a wider viewpoint it is destruction, or expressed more moderately, it comes at an unrecorded ecological cost. that is not recorded in social or private accounting systems. The using up of our patrimony of crude oil deposits is not counted as a cost in any financial account. National accounts recognize the cost of cleaning up the oceans after an oil spill, and add disbursements for this into the national income, but they do not make any deduction for the damage that is being repaired, nor for the fish killed and other harm done by oil spills that cannot be cleaned up.

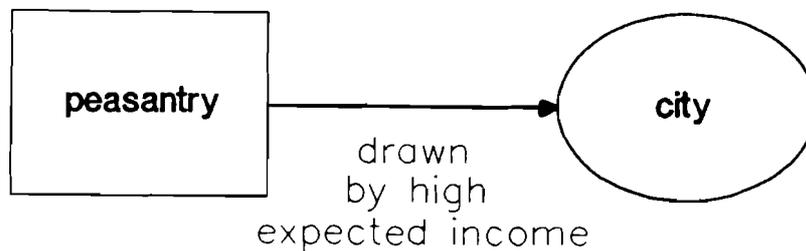
The ecological costs of population growth are what put the urgency into policy. Population control is a condition of development, on the one hand, and on the other will be automatically attained once development takes place. The question is whether the natural base of the LDCs will be so eroded by the weight of population and economic activity that it will prevent the development that would control population.



This is represented by a figure in which the circuit on the left, relating population and development, interacts with the figure on the right representing the finite environment. When population grows fast and development is slow a population control program acting on the left side of the above diagram is interfered with by the circuit on the right recognizing environmental deterioration.

MIGRATION

The standard theory of migration to the city is in terms of the expected income over a period of years if the peasant stays in the countryside, and his expected income if he comes to the city. Certainly there is much unemployment and underemployment in the city, but there is also the chance of a fortune, and the latter weighs heavily in the peasant's anticipation of the economic return to migration.



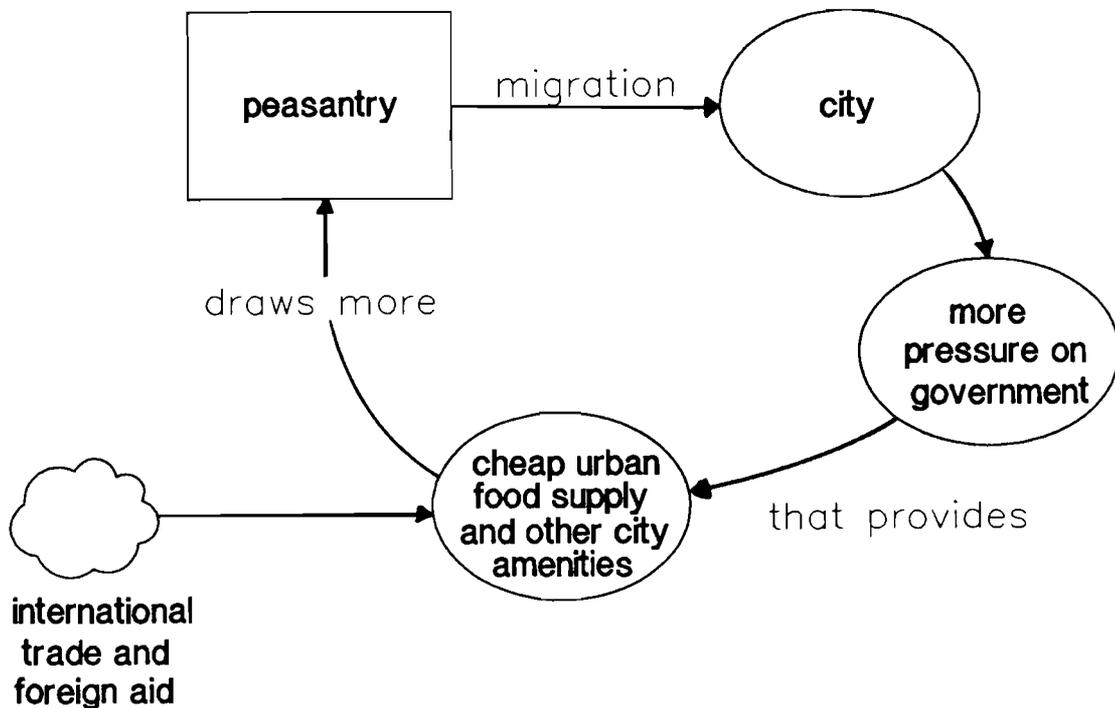
This economic theory of internal migration is certainly valid, but one may doubt that it is the whole explanation of a phenomenon as vast and as persistent as the rural exodus of the less developed countries. That movement is the largest of any time in history. Cities of the third world are overflowing. Mexico City, now approaching 20 million, is followed by Cairo, Calcutta, Jakarta, and many others. Governments strain to provide low-priced food, adequate schools and streets for the newcomers, not to mention houses and clean water; they know the political pressure to provide these (along with suitable employment) that can be exerted by concentrated millions, and they fear above all the sanctions in the form of riots and strikes that such masses can exercise. As the United Nations (1989, p.) says of Jakarta

Of far greater importance than explicit spatial policies have been such factors as highly subsidized public services, which have created a bias in favor of the larger urban centres; the importance of physical proximity to central government officials for obtaining licenses and permits.

The availability of cheap foodstuffs alone would support movement to the city. As the result of the pressures exerted by city masses, governments pass legislation ensuring that grain is priced low. The peasants are forced to submit to below-market prices for their output, and even where there is no price fixing by government but instead subsidies for city markets, the subsidies may well be paid for by peasants through taxes or other indirect device.

Yet price is not the only consideration; supply is even more important. In hard times in the past depressed conditions pushed people out of the cities onto the land; now it is the opposite: the city is where food is to be found. The international trade in cereals means that the city no longer has to be supplied from its neighboring countryside. Foreign aid plus the sale of raw materials provides the needed foreign exchange. Governments persuade their farmers to produce peanuts or other export crops, whose sale price it can collect and then only partly funnel back to the peasant. Food policies alone would initiate a circuit with positive feedback and expand the cities without limit.

Note that it is population pressure, especially that in the cities, which inspires bad economic policies.

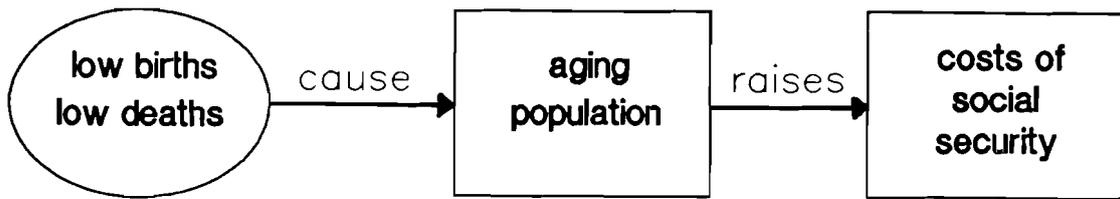


The diagram suggests the more extended model needed if we are to recognize in the theory the political influence that operates on the economy.

What makes this a systems issue is the reciprocal action: on the one hand the presence of masses of people close to the seat of government exercises pressure for various benefits; as these benefits are dispensed they make the city more attractive to other immigrants. There is no feasible way of making life better for those already in the city without attracting more people from the countryside. Thus the political factor completes the positive feedback loop within which the economics operates, and is creating third world cities of unprecedented size.

AGING

Much of the study of aging is concerned with the rising social security costs that will be faced when the baby boom of the industrial countries starts to retire early in the 21st century. These are contrasted with the relatively low costs of the present, when the baby boom is of working age and contributing, and the people drawing are the relatively few who have survived from earlier higher mortality.

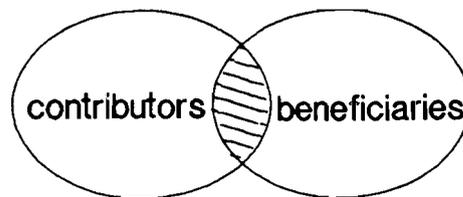


Yet if the problem was merely one of aging it could readily be met by people working a few years longer. Calculation for the United States shows that a gradual rise of the pensionable age from 65 to 70 over the years 1990 to 2025 would keep the ratio of pensioners to working virtually constant.

Instead of such a rise we observe a steadily falling age of retirement, along with constant political pressure to increase the benefits, especially when a temporary surplus in the trust fund comes into sight. One fears that social cohesion may not be sufficient to hold the system together when the bills come in for the present generous legislation presently in force. Many young people now doubt whether the generation subsequent to them will agree to pay the high costs of their old age pensions.

What changes in the payments and benefits will make it more stable, more immune to the destructive pulling and hauling that is now anticipated? The answer is to be sought in the greater participation of the old on the contribution side. Starting the state pension at an older age, contributions at higher rates for those who are closer to retirement, subjecting the pension to income tax, encouraging private funded pensions, allowing young people to secure some benefits from the fund, are all in the direction of lessening the potential opposition of contributions vs. beneficiaries. They diminish the amount of social cohesion needed for the system to operate.

Yet nearly everyone, after contributing, goes on to draw, so are not the two groups really the same people? No, in effect they are not, for if there is any discounting of the future the ones starting to contribute and those starting to draw will have very different perspectives. This is true even discounting at 3 per cent per year, and the difference in their stakes becomes gross at present commercial rates of interest.



overlapping helps identification and overcomes aging problem

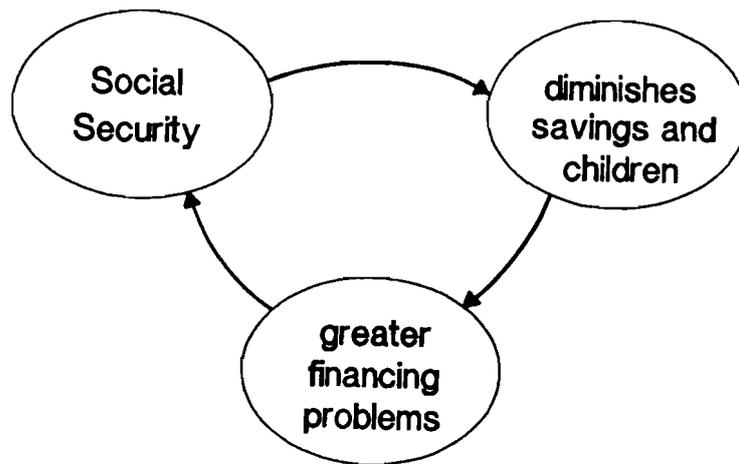
shaded area:

- pension benefits start at older age
- higher contribution rates for those close to retirement
- sabbaticals during working life

Any measure that increases the overlap between contributors and beneficiaries is helpful, for as long as these are two distinct groups tension is inevitable between them. Especially favorable would be permitting younger people to draw benefit for a sabbatical year or two (perhaps devoted to training for a new occupation) for which they would pay by having their final pension start correspondingly later, or in some other way.

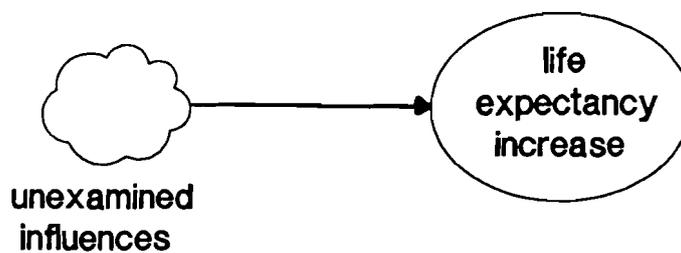
A systems analysis also raises the question whether social security tends to undermine itself. In logic at least its effect could be to render both children and saving unnecessary for the individual family, and so to lower the amount of both. Is it possible that the lack of savings weakens the economy, and the lack of children makes for an older population, and the result of both of these is the uncertainty of social security now feared?

The basic point is that a purely economic, let alone a purely actuarial, formulation does not get at the real problem of social security, which is that when one group pays and another group benefits (whatever the entitlement) then standard economics by itself provides no answer—for instance to the question of what the nature and amount of social security ought to be.



MORTALITY

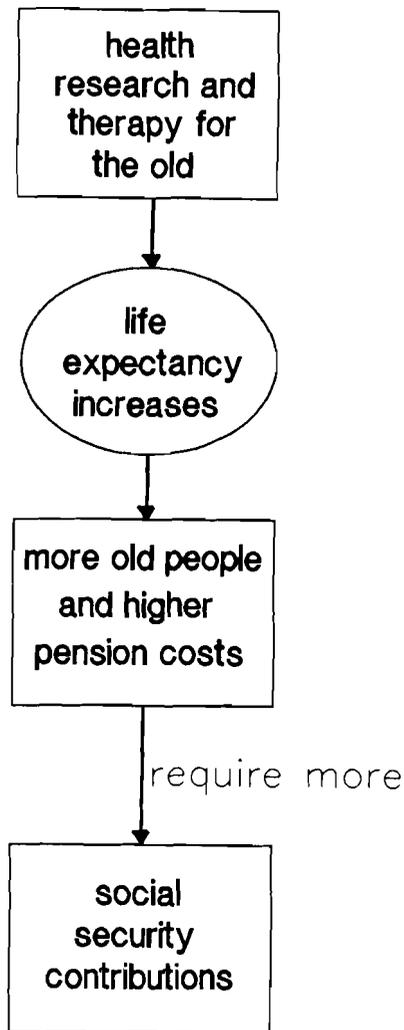
Demographers spend much effort in the analysis of mortality and in forecasting what future mortality will be. Many models exist, all within the discipline of demography, which is to say that they use past demographic data to predict the demographic future. Economic, medical, behavioral, political, considerations are referred to only in passing, or omitted altogether. The construction of life tables from observations; making of model life tables that would show the course of mortality improvement followed up to now by advanced countries and so constituting a means of forecasting for countries that are behind, parameterizing mortality curves, breakdowns by cause of death, finding correlates of mortality and incorporating them in hazard models, are what the literature consists of.



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Yet ultimately the questions asked by demography cannot be answered within that discipline. Part of the answers lie in medical and social science. The current rapid rate of improvement of mortality in advanced countries is due to medical discoveries plus change of behavior—better eating (less red meat and eggs), more exercise, less smoking, etc. These improved practices seem to start with the better educated parts of the population; how fast they will move to others is a question of cultural diffusion. Neither demographers nor physicians can get at this diffusion process within their respective disciplines.

A wider question applies to medical research and therapy, of which a large and increasing fraction is paid for by the state, i.e., by those of working age in their capacity as taxpayers, largely for the benefit of the old. Thus the young pay to extend the lives of the old, and as a result have to pay for more years of social security for them. Hence the London Economist ("A Time for Dying", August, 1989) says enough is enough—it is pointless to prolong life further. The Economist speaks of the pain that disease brings to the old, and this justifies its conclusion that they ought simply to withdraw from the world. Evidently the writer has in mind a causal scheme such as that below. If the effect of putting state funds into health H is to require more of social security expenditure S then there is a bottomless pit. The grim choice presented by the Economist would never occur to anyone if people paid for their own medical service and saved for their own pensions.

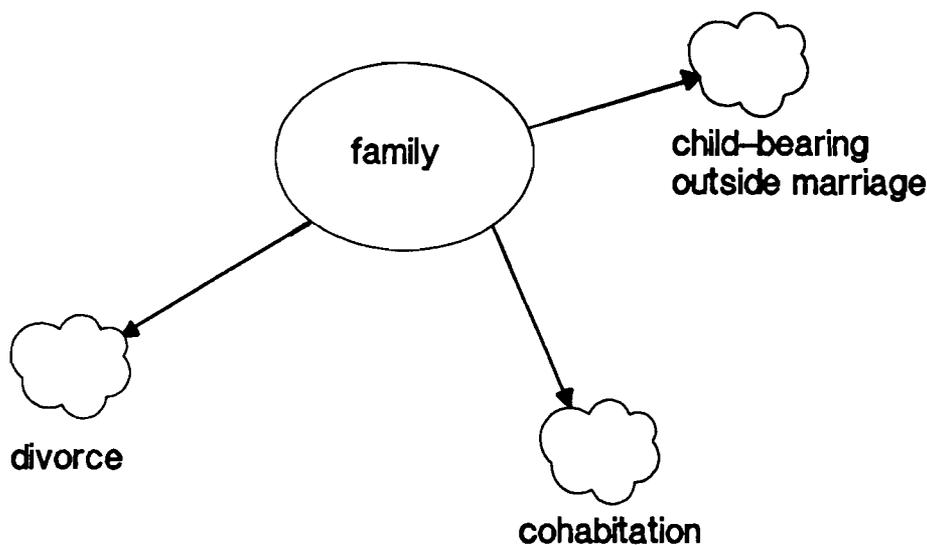


We have evidently gone through a historic cycle that started with boundless goodwill in state provision for the comfort of the old through medical research and therapy as well as social security, at least partly at the expense of the State, and then when costs rise and the bills come due, the goodwill gives way to the thought of how inconvenient it would be if the old were to live much longer than they now do. We have so far only heard a whisper of this, but with further medical advances it could well come to be said much louder. The evolution of popular thought from goodwill to just letting those old folks die is a phenomenon that will take a number of disciplines— and some courage—to analyze.

FAMILY

Specialists have written at length on the high contemporary divorce rates, that reflect centrifugal forces within the modern family, and its resultant fragility. People voluntarily living alone, separate from children, parents, ex-spouses, or other kin, are a new phenomenon. The ability of women to earn a living as men do makes them independent. One surprising result of a test of the negative income tax, providing poor women as well as men with a base income, was to increase divorce; this feature was what caused abandonment of the negative income tax in the United States.

Much trust is placed in marriage counseling to help keep families together, and indeed family policy has not gone much beyond this. Housing subsidies may have some effect, but no one knows how much. Not many ideas for strengthening the family come out of pure family study, whether by sociologists or economists.



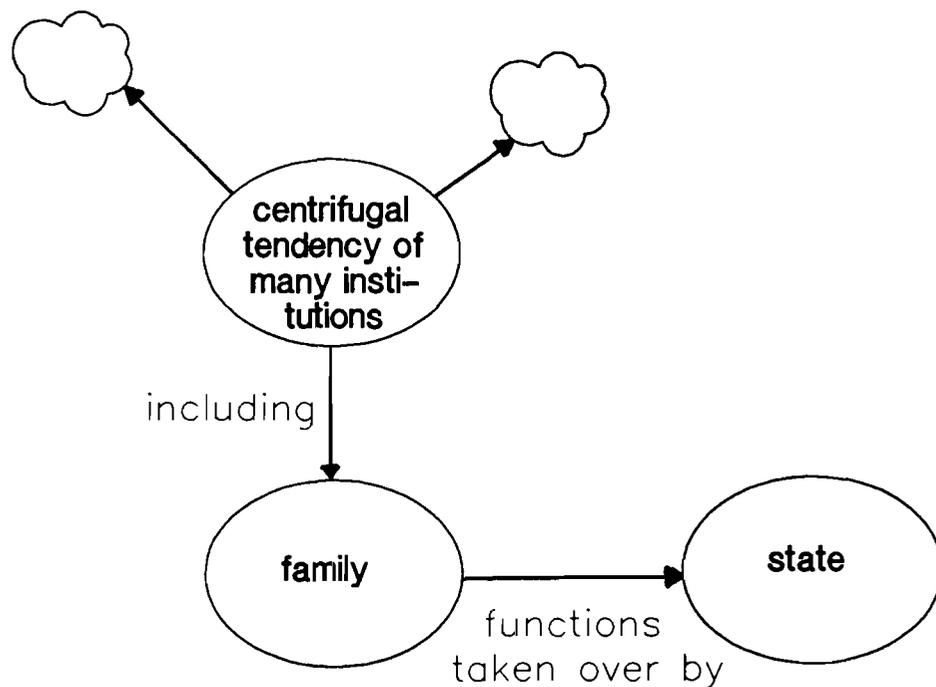
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What specialists fail to notice is that the weakening of the family is paralleled by a weakening in many other institutions. Not only do husbands leave their wives and wives their husbands, but priests leave their church, soldiers leave their units, workers leave their jobs, students leave their schools. It is all very well to seek special explanations of the splitting of families, but elaborate explanations specific to the family are under suspicion if other institutions are also splitting. A systems approach tries to find what it is in modern culture that lessens social coherence, and stimulates the cult of the lone individual.

A specific problem for the family is the taking over of many of its functions by the State, so that the family becomes a unit of affection without being a unit of activity—in production, defense, education, etc. Losing the material functions that have traditionally been interwoven with familial affection, the affection tends to fall away. People like other people with whom they are engaged in important activities, the affection being in part an epiphenomenon of the activity.

If this is true a revival of the family will depend on nothing less than its finding important activities for the members to carry on in common. Laws, subsidies, and marital counselling cannot solve the central problem.

The diagram below represents the problem. What the solution may be has not yet emerged.

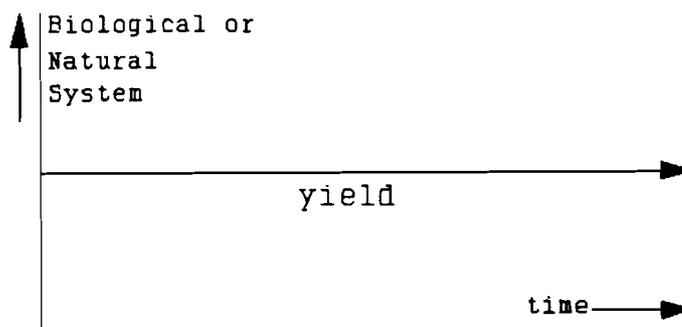
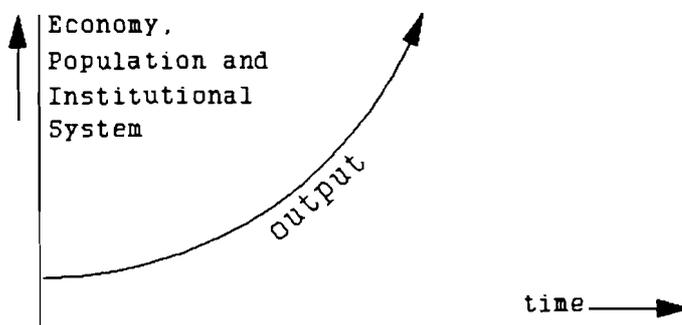


POPULATION AND ENVIRONMENT

The relation between population size, style of life, and institutions on the one side, and stress on the environment, using up of materials, waste disposal, etc. on the other, could well be given more attention than that provided by individual disciplines. These latter treat population and environment separately, and come out with very different conclusions.



Economists foresee steadily rising inputs and outputs, but without taking full account of the increasing exchanges with the environment implied by this (first panel below). Biologists have tended to see the natural world as independent of man (second panel), though they are quicker to sense the implications of current developments than the rest of us. In any case different disciplines foresee future developments that are wholly inconsistent with one another, symbolized by the very different curves below.



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We need to reconcile such one-discipline models.

Let us admit that with given technology and style of life the inputs and outputs demanded from the environment will be exactly proportional to population. In contrast with this linear relation, the stress on the environment as it provides those inputs and accepts those outputs is far from linear. At low population levels there is no stress; the

man agency is part of the natural system in equilibrium; at higher levels of population density a point comes where the natural system is seriously interfered with. Equilibria that have existed for thousands of years can be upset in a decade or two, and a major resource (say a forest or fishery) diminished or destroyed.

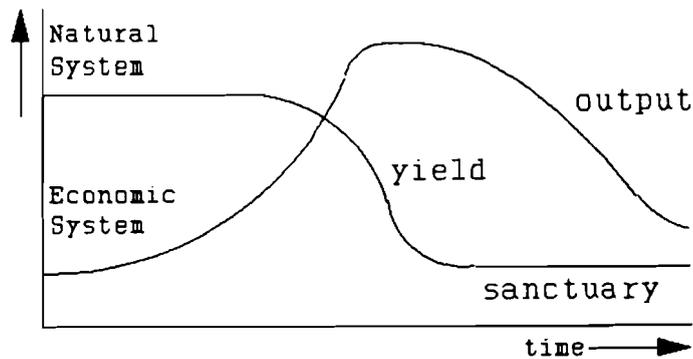
Because of the nonlinear relation between population and stress the visible destruction comes on suddenly. Population has been growing for a long time; why does the growth of just this last decade or two have such dramatic effects? The matter is especially puzzling in that the rate of increase is actually going down; if the planet could stand a growth rate of 2.0 per cent per year why can it not stand a growth rate of 1.8 per cent per year? We submit that the answer cannot be found in economics or sociology or earth science alone, but only in the interaction between the growth of population and human institutions on the one side and the natural system on the other.

The ocean fisheries are an example of this interaction between institutions and nature. In them the world fish market gears into the biology of fish reproduction. There is harmony between the two as long as the population and its demand for fish are satisfied with no more harvest than the sustainable production of the ecological system. Let that be exceeded, and productivity starts to be reduced by overfishing; then even without any further increase of population or demand, in relation to the smaller fishery the overfishing will by itself intensify. Further capitalization in the competition to catch what fish are left is a rational economic response. *If the price elasticity is greater than unity*, rising prices can bring new entrants into the fishery just in the phase of declining capacity of the biological system.* And existing firms with their capital already invested would continue in the field after there were no further new entrants. The interaction between rising prices and declining supplies can be guaranteed to produce cumulative stress on the fish ecology, among other effects leading to the capture of immature fish. If the fishing is selective for commercially usable species these will be replaced in the waters by unusable species.

After a certain phase in the decline in productivity it will no longer pay to put out to sea, and the vessels will rust in harbor. If we have been fortunate there will have been places for the commercial species to hide, so that recovery can slowly take place. Under competitive conditions a small amount of recovery would make it profitable for the ships to put to sea again, and so with some oscillations the fishery would continue at a low level of productivity. If there was no sanctuary the fishery would be permanently destroyed. It

*More exactly we have to compare the elasticity of profit as a function of production with the elasticity of production as a function of effort.

would also be destroyed even if there was a sanctuary if the noncommercial species got such a start that they prevented the recovery of the commercial ones. Extinction of a species is obviously irreversible, but some changes short of extinction can also be irreversible. When the economist's projection and that of the ecologist are reconciled they come out like the following diagram.



The fisheries exemplify issues common to forestry, soils, underground water supplies, fur bearing animals, etc; in all such cases realistic study requires analysis of the interaction between a social system and a biological system.

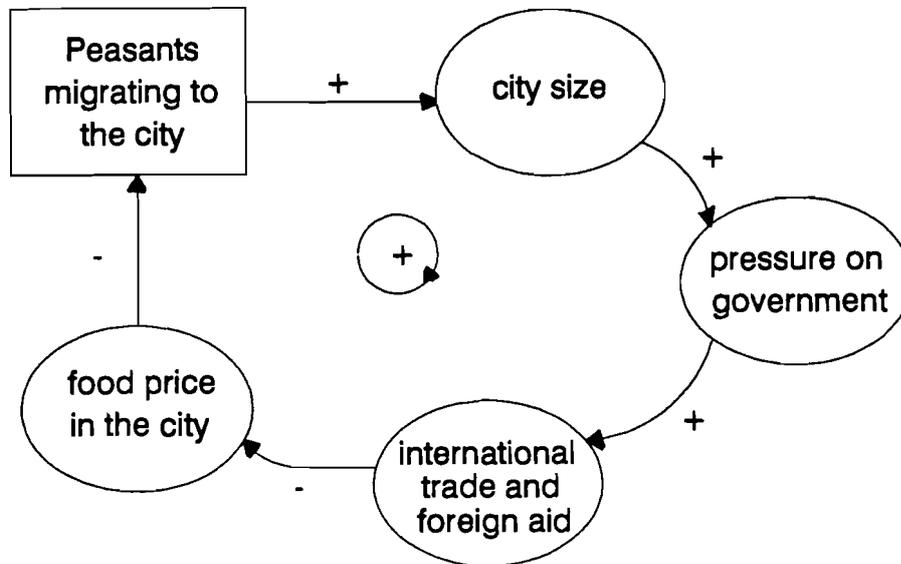
No one wants to be against empirical study, and yet given this configuration experience of the past can be dangerously misleading. Britain and America made their greatest economic progress when their populations were growing fastest. For the world as a whole if 2 per cent growth did no harm in the 1960s, how can 1.8 per cent growth hurt today? To interpret empirical data requires an appropriate model.

Because of the distinctly non-linear interaction between human and natural systems simple extrapolation of data from the past can give very wrong results. And such extrapolation is included in the common procedures of the individual social sciences. If we are really in a novel and difficult situation now, and past empirical data, however voluminous, will show the way out only when suitably interpreted in a multi-disciplinary perspective.

SYSTEMS DIAGRAMS

Sergei Scherbov

The phenomena described by N. Keyfitz can be illustrated with the help of causal-loop diagrams used in the system dynamics approach.



Causal-loop diagram of city growth, a positive loop.

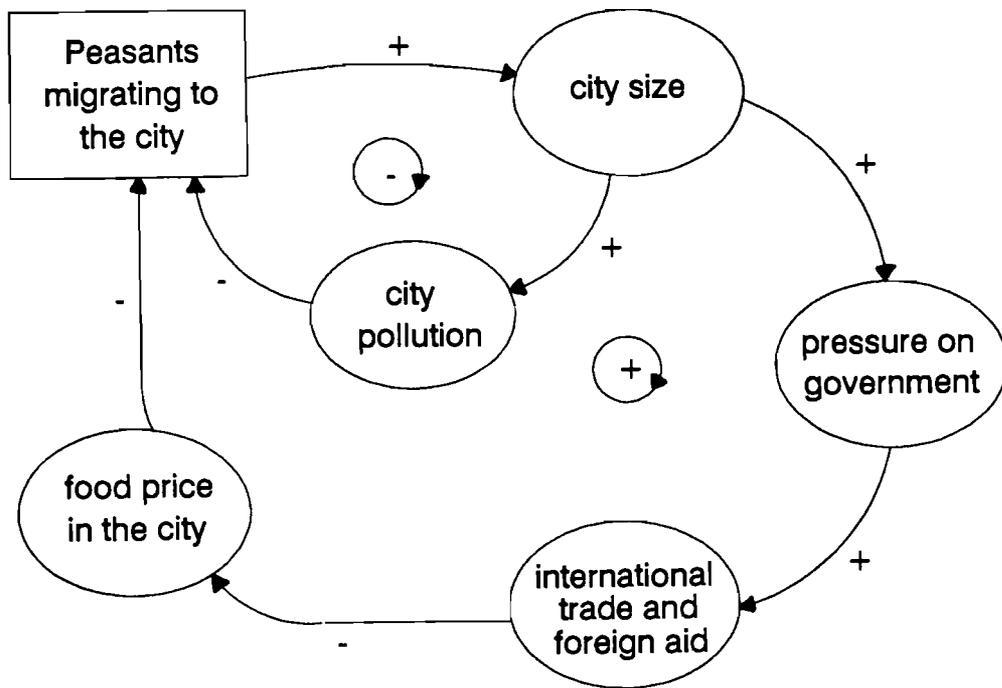
Such a diagram can be read in the following way: the item at the tail of the arrow causes a change in the item at the head of the arrow. The plus (+) sign near the arrowhead indicates that the item at the tail and the item at the head of the arrow change in the same direction. If the tail increases the head increases, if the tail decreases the head decreases.

The minus (-) sign near the arrowhead indicates that the item at the tail and the item at the head of the arrow change in opposite directions. If the tail increases the head decreases, if the tail decreases the head increases.

The plus (+) sign is placed in the center of the loop to underline that it is a positive causal loop, one in which behavioral changes are reinforced. One of the ways to identify the sign of the feedback loop is to see how many minus (-) signs there are around the loop.

An odd number of (-) signs suggests that the loop is negative. An even (or zero) number of (-) signs around the loop suggests that the loop is positive. Negative loops tend to keep the system under control by counteracting change. But generalization about the behavior of negative and positive loops must be viewed with caution. Given only the causal-loop representation of a system structure, the analyst can judge only approximately how that system will behave over time.

In our case according to the figure above we have a positive feedback loop and such a system may not have an equilibrium point. But cities cannot grow indefinitely. Other forces not shown in a simple loop would ultimately stop uncontrolled growth. This means that other feedbacks exist restricting the number of migrants to the city.



Extended causal loop diagram of city growth including a negative feedback loop.

With the growth of the city, environmental conditions worsen to the point where they reduce the attractiveness of the city and thus the number of migrants. To describe this we could add another feedback loop to the existing one. Thus, by adding a negative feedback loop our system can attain stability.

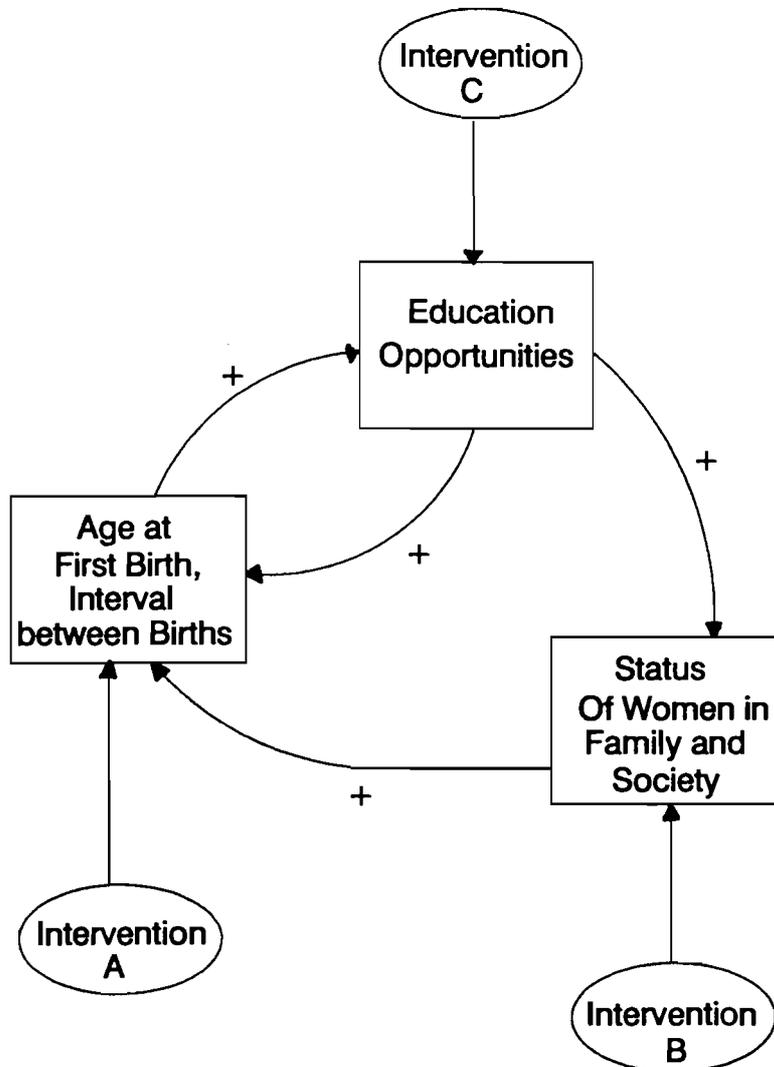
Another outcome of unconstrained growth of the city may be a deteriorating communications network or an overburdened transportation system. Finally, some laws restricting the number of migrants to large cities could be adopted by the government.

In real life there are many different feedback loops that tend to move the system in different directions. The systems approach rather than a single-discipline approach aims to catch the most important relations and feedbacks that determine behavior using knowledge from different disciplines.

THREE MODES OF INTERVENTION IN THE SYSTEM THAT KEEPS FERTILITY HIGH AND STATUS OF WOMEN LOW

Wolfgang Lutz

Studies on the factors associated with continued high fertility in many less developed countries of the world have shown the existence of a positive feedback loop that seems to work both on an individual and aggregate level: women who have their first birth at a very young age and usually also have a large number of children in rather short intervals have almost no chance to improve their educational status even if adequate educational services were available, because they are stuck with the children. Without more education, however, young women have little chance to improve their status in their own family and in society. Consequently they are not likely to resist the social pressure from their husbands, kin, and the traditional community to have more children with only short intervals.



If this vicious cycle were somehow broken, however, the system would work to the benefit of women's status and also bring down fertility. In this case better education is likely to both change the value system of the woman by moving the emphasis from "quantity" of children to "quality" of children and at the same time strengthen her status in society (e.g. to have a job) and within the family, where she is better prepared to resist pressure from her kin for early marriage and from her husband for continued childbearing. And, in turn, a delay of first birth and a smaller total number of children is a prerequisite for further improvements in education and consequently in her social status.

What are the chances to intervene into this process and make the vicious circle a beneficial one?

Intervention A: Traditionally, family planning programs tried to influence the fertility rates directly. The expectation was that the availability of contraceptive measures would directly bring down the number of children by delaying first birth, lengthening birth intervals, and stopping fertility after a certain number of children. Many of these programs, however, turned out to be a complete failure because they did not consider the dynamics described above. Women did not use contraceptives because in their value system they either did not want to delay first birth and limit the number of children or could not afford to do so because of the social pressure from their family.

Intervention B: Another possible intervention lies in direct measures intended to increase the status of women. These could be legal measures to secure certain rights or programs that, for instance, make it easier for women to find a job outside the home. But with low education of the woman and with a large number of children to look after, there is little chance that the woman can actually benefit from such measures.

Intervention C: Female education, finally, turns out to be the key variable for the reversal of the mechanism because it can reach women before they start to have children. If women have the chance to learn reading and writing at young ages and even receive some secondary education, then this will significantly increase their probability of having some employment before marrying, and this will consequently delay their first birth. It is also likely to increase the woman's status in society and her power to deliberately choose her desired family size.

In summary, in the above described positive feedback loop education of women might be the key factor to turn the vicious cycle into a beneficial one, but the other two factors, namely availability of contraceptive methods and some policies to enhance the woman's status in a legal and economic way, are also necessary to make the beneficial circle work. In this case the systems approach indicates that a single action, especially when it is trying to influence fertility directly, does not work. Only if several strategies are fol-

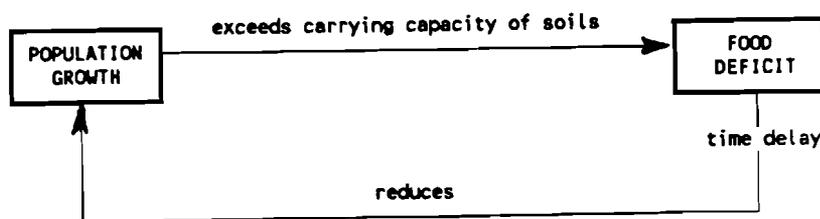
lowed simultaneously with a right dose of emphasis on the various necessary interventions, may the desired outcome be achieved.

POPULATION AND FOOD

G.K. Heilig

1. *The traditional concept*

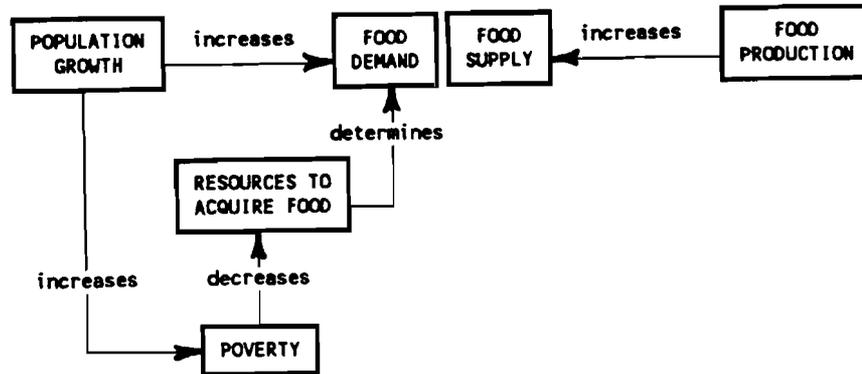
Throughout the 1950s and most of the 1960s it was generally believed that the number of people in Asia, Africa and Latin America would simply outgrow the carrying capacity of their soils to supply enough food. It was argued that excessive population growth slows down agricultural development, while at the same time it increases food demand. Gloomy projections were made that the growing food deficit in the Third World would result in widespread starvation, which - through the feedback effect of increased mortality - would slow down population growth in the end. This argument is visualized below. It rests on the classical, mono-causal explanation of hunger first introduced by the (early) Malthus.



2. *The extended model*

By the end of the 1970s, however, this point of view was under challenge. It could be shown that in many parts of the Third World the level of food production had kept up with population growth. Actually average food production per capita in the 1970s was well above the level of the 1940s and 1950s - despite the fact that the population has nearly doubled since then. Nevertheless, millions were still hungry. This was the time when it was realized that widespread malnutrition is not necessarily the result of a shortage of food supply. If people do not have the resources to acquire food they will starve even in the face of well stocked markets. Hence the conventional model of a mono-causal relation between population growth and hunger had to be extended by a third factor. Now it was

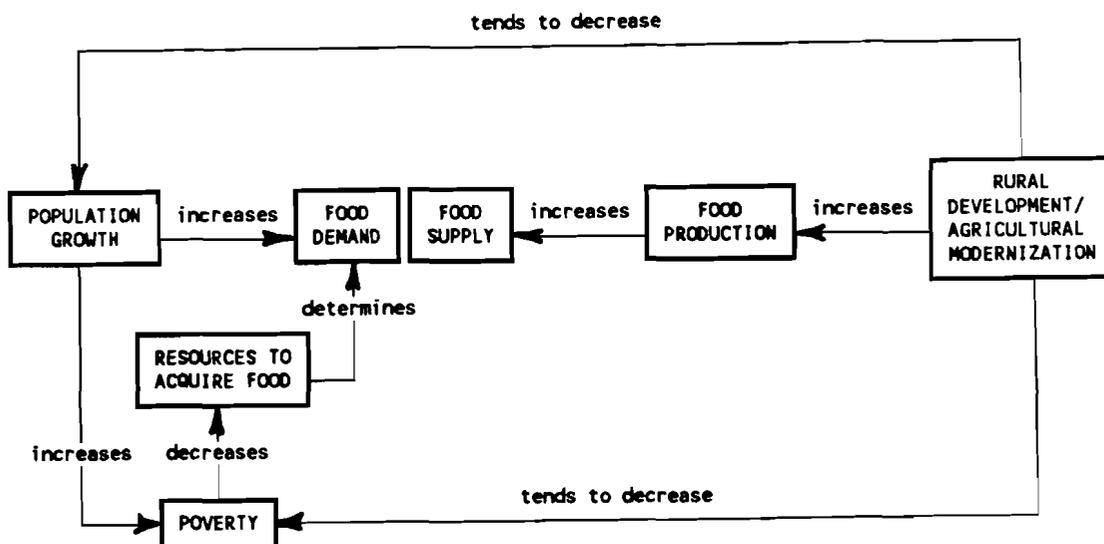
necessary to distinguish explicitly between the supply of food and the ability of individuals to acquire food. It was discussed why certain groups of the population failed to gain access to food, but most scientists accepted poverty as the key factor of the food problem and economic development as part of its solution. The basic logic behind this argument is shown graphically below.



3. *The concept of agricultural modernization*

During the late 1970s and early 1980s development in many developing countries (especially in Asia) accelerated. They improved their rural infrastructure (streets, irrigation systems), increased the supply of modern agricultural inputs (such as fertilizers and seeds of high yield varieties), intensified agricultural research, introduced free market-prices for agricultural products and thus encouraged farmers to increase production. Several record harvests in India, Thailand and China during the 1980s seemed to prove that economic development and agricultural modernization could break the vicious circle of population growth, poverty and hunger. After centuries of recurring famines India, for instance, could declare self sufficiency of food.

The basic idea behind the concentration on rural areas was that poverty and population growth are the result of a stagnation in the development of the rural economy and society. Agricultural modernization was intended to trigger rural development and attack the problem of hunger from three sides: first, to provide better economic chances for the rural population to fight poverty, second to encourage family planning in order to lower population growth, and third to increase food production.



4. *Beyond the concept of rural development and agricultural modernization - a systems approach*

Despite the great success of the "Green Revolution" and high rates of economic growth in certain parts of Asia there is no way to overlook the fact that millions still suffer from malnutrition and poverty. In fact Africa south of the Sahara even experienced a rapid decline of per capita food production during the 1980s. It has become obvious that very often African subsistence farmers and cattle breeders are unable to feed their own families - to say nothing of their urban relatives. This shows that agricultural modernization as a means to eradicate hunger is only possible under certain conditions.

The "Green Revolution" was only successful in those (Asian) areas, where it was implemented by competent planners and executed by experienced farmers with a long tradition in agriculture. It also required sufficient rainfall or highly sophisticated irrigation systems, such as can be found in the Pundjab-area in Northern India, in Bali or in Thailand. In order to use expensive high-yield seeds, artificial fertilizers and more efficient tools it was necessary that some investment capital was provided for the farmers. These conditions, however, are not given in most parts of Africa south of the Sahara. Droughts regularly strike large areas, not seldom for several years in succession. Many soils are not suited for irrigation because minerals (such as salt) are washed out. The high-yield seeds of rice, wheat and corn which doubled the harvests of some Asian countries are not adapted to the dry African climate. On top of this a large number of civil wars and conflicts with neighboring states devastated many agricultural areas, absorbed labor and

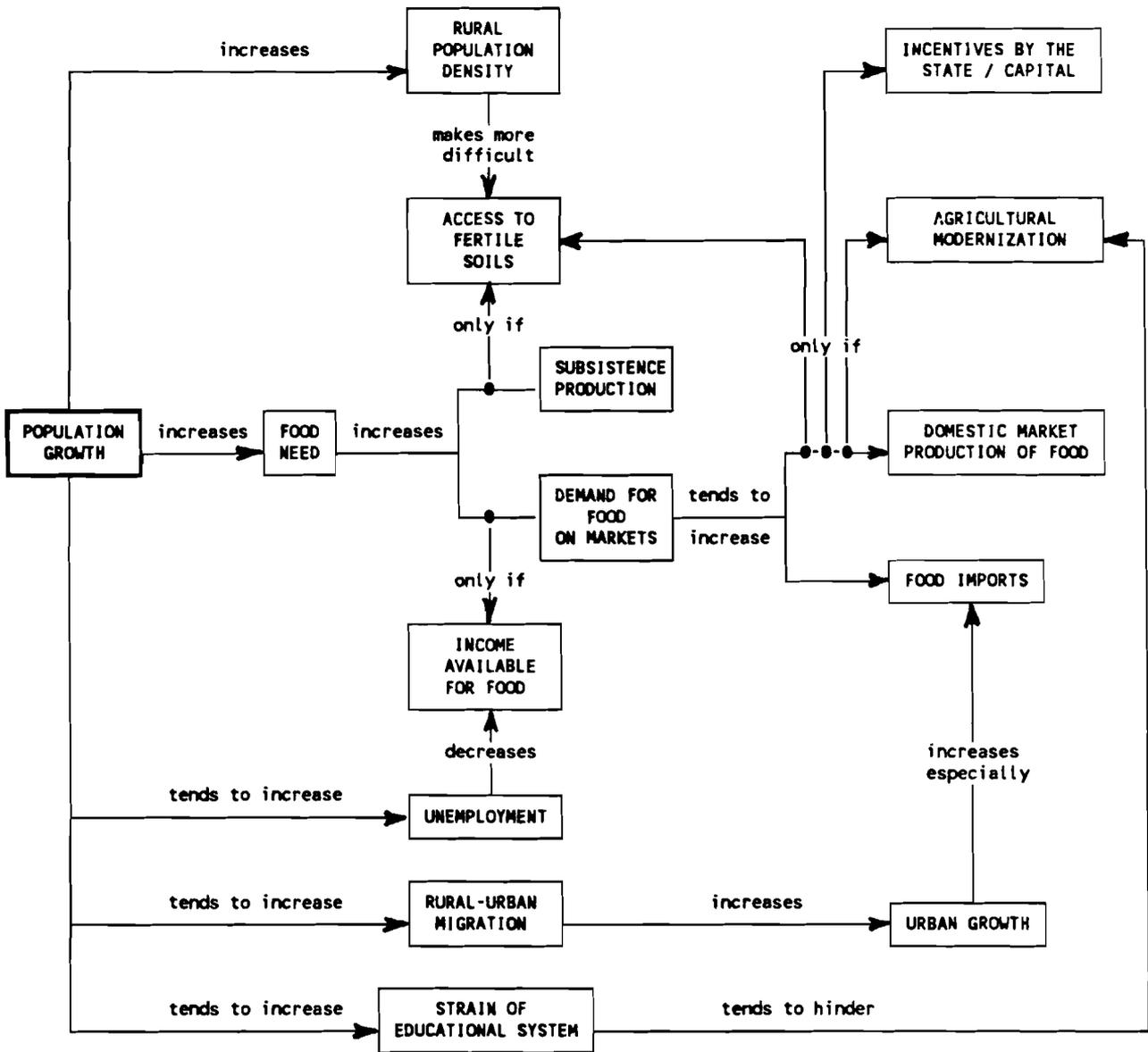
drove the rural population from their traditional lands - as in Mozambique, Angola, Ethiopia or Somalia. "Hunger" has become a political weapon in Africa: sometimes governments have stopped foreign food-aid to certain areas controlled by rebels. The agricultural disaster in most parts of Africa south of the Sahara during the 1980s and its historical record of famines and food shortages during this decade finally destroyed the confidence in simple, straight-forward theories of how to solve the world food problem. Given the complexity of demographic, economic, socio-cultural and political factors of hunger in Africa, it would be rather naive to analyze demographic aspects of food-deficits in isolation. Only a systems approach is capable of improving our understanding of the world food problem and to guide political action.

Today we know that neither population growth nor drought nor poverty or any other single factor as such is the cause of hunger. It is the network of interactive effects between human, social and environmental components which determines the emergence of hunger. To study the causes of malnutrition from a systems analysis point of view it would be necessary to take into account at least the following aspects:

- Population density: if population density is very low, even a high rate of population growth might initially be harmless.
- Urbanization: if a large proportion of the population lives in cities the demand for imported food is especially high.
- Food imports and food aid: the food supply of a country comes from two sources: domestic food production and imports. High food imports might result in a shortage of foreign exchange. Today many experts are convinced that permanent food aid is one of the causes of hunger in developing countries: it ruins the food prices on local markets and discourages domestic farmers.
- Economic policy: the level of agricultural modernization depends heavily on the overall economic framework of the country (free market/centrally planned economy).
- Resources: food security is also a function of the availability of certain natural and economic resources (soils, water, fertilizers; investment capital, banking system).
- Human capital: probably the most important factor for rural development is human creativity and initiative. To increase the level of education and technical skills in a rural population might be more important in the long run for the eradication of hunger than the organization of international food-aid or the implementation of a radical family planning program.

- **Technology:** a scientific analysis of food shortages has to take into account that modern (agricultural) technology has opened a productivity gate which offers a chance to adapt agriculture to much higher levels of population growth than was the case in the past. Agricultural modernization alone, however, does not solve the food problems in the less developed countries. It might even have negative feedback effects on population and food in the short run. Modernization programs tend to favor larger-size farms which have easier access to investment capital and know-how than small-holdings. As a result of increasing productivity agricultural modernization also produces rural unemployment which fuels the migration to the urban areas.
- **Distribution of land and income:** it does not make sense, for instance, to study population growth in Latin America as a factor of food shortages, being blind to the problem that the great majority of the rural population has no access to the fertile soils.
- **Environmental side-effects:** environmental destruction might result from increased agricultural production, which is the inevitable consequence of population growth in the less developed countries. While it is certainly necessary to avoid negative environmental feedbacks of agricultural intensification, it would be hypocritical to blame only the less developed countries for this problem. When poor settlers in the Amazon are clearing large areas of rain forest to grow food they are just doing the same thing as our grand-grandfathers did in Europe and Northern America. Environmental degradation as a result of increased food production is a global problem.

A demographic systems approach to the problem of malnutrition has to take into account the links between population, society and natural environment. Below is a provisional model to analyze some of these links.



The model assumes that population growth directly increases the amount of food required ("food need") due to the growing number of food consumers. To meet this additional need for food a rural family can either increase its own production or buy food on the local market. Increasing production, however, is only possible if the family has access to additional soils or modern inputs to increase productivity. The ability to buy food depends on the family's income available for food, and a free market which reacts to increasing demand. Hence, the pattern of adapting food supply to population growth is linked to the environmental, social and economic situation of a country. The level of (rur-

al) unemployment, for instance, determines the amount of income available to rural families to buy food. On the other hand: a possible increase of subsistence production depends on the availability of additional soils for the rural population. The potential agricultural area, however, might be restricted by ecological conditions or legal regulations.

In countries with a market economy the supply-side of the food system is fueled from two sources: domestic market production and (net)imports of food. The increase of domestic market production is essentially a matter of agricultural modernization, governmental support for infrastructure and investment, and the availability of fertile soils. Agricultural modernization, in turn, heavily depends on the level of education and technical skills among the rural population. High rates of population growth, however, tend to increase the strain on the educational system and thus tend to hinder progress in education and training. The amount of food imports in a country often correlates with its level of urbanization. Since rural population growth tends to increase rural-urban migration it indirectly increases the demand for food imports.

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