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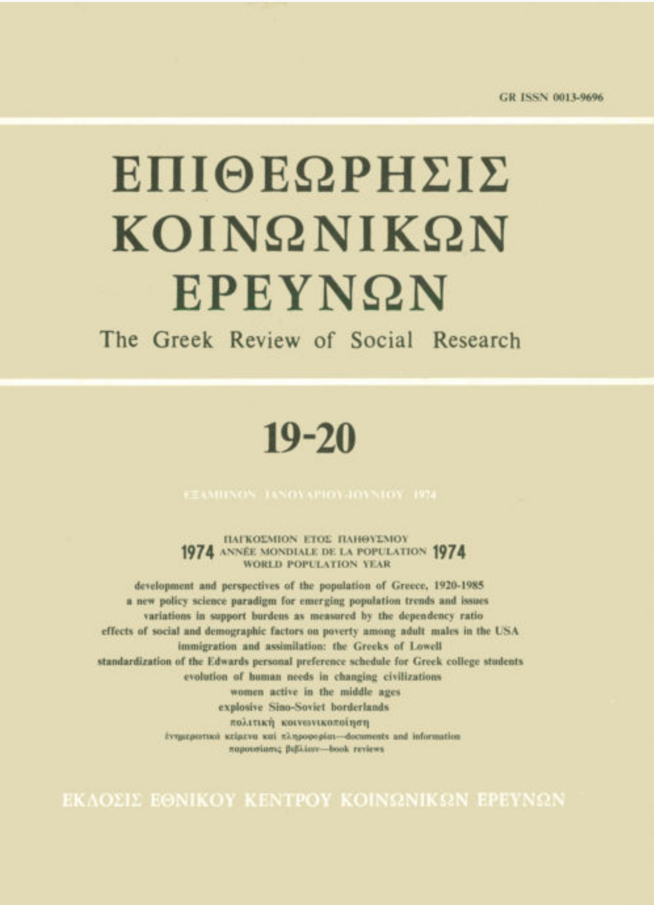

A new policy science paradigm for emerging population trends and issues

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by

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In the last two decades there has been an increasing preoccupation among governmental officials and policy planners with scalar measurements and definitions of economic and social development in such terms as growth rates in Gross National Product. More recently, and in particular since the publication of *The Limits to Growth*[1] last spring, the public's awareness and concern over the issues related to population and economic growth, and their impact on the environment, have been seriously provoked. Numerous studies have already been completed on this subject,[2,3] and a number of debates and conferences, similar to this one, have been organized and sponsored by various institutions.

Most of the debate on «The Limits to Growth» issue, however, appears to be carried out within the context of an industrial macro-economic perception of the meaning of «growth». The policy science paradigm employed appears to be extremely insensitive to the heterogeneous philosophical, religious, and cultural values, and their dynamics, that prevail in the various regions of the world. This «dominant paradigm» presupposes and imputes the validity of universally applicable and time invariant standards of societal goal-achievement, and is fundamentally based on the thinking of policy scientists of the industrialized nations. It essentially implies that «quality life» begins at $1000 per capita income, and that such a national average can be attained through a stategy of high annual increases in the GNP.

The term «dominant paradigm» is used by T.S. Kuhn in his study of *The Structure of Scientific Revolutions* to refer to the basicway of perceiving, thinking and doing associated with a particular vision of reality, transmitted primarily through models. Scientific paradigms emerge and gain their status among the practitioners because they are capable of solving some acute problems. The success of a paradigm—whether Ptolemy's computations of planetary motion, or Einstein's discovery of the general theory of relativity—depends largely on its ability to extend the boundaries of understanding, i.e., to interpret a

* «Originally commissioned by the Environmental Studies Division, Office of Research and Monitoring, Environmental Protection Agency, as a portion of an exploratory research project to be published by EPA in a volume entitled, *Alternative Futures and Environmental Quality,* August 1973.»

1. Meadows, Donella H., Dennis L. Meadows et al. *The Limits to Growth,* New York: Universe Books, 1972. Pp. 205.
2. Commission on Population Growth and the American Future. Report of the Commission: *Population and the American Future*; Also, *Population, Resources and the Environment*, Ronald G. Ridker, Editor. Vol. III of Commission research reports. Washington, D. C.: Government Printing Office, 1972.
3. Kan Chen, Karl Lagler and others, *Growth Policy: Population, Environment and Beyond.* The University of Michigan, 1972. (Mimeographed; for forthcoming book.)

new set of natural phenomena. During the period that the paradigm is «successful», its practitioners manage to solve problems that would previously be unimaginable without the commitment and the contextual base offered by the paradigm. As Kuhn states:

«The existence of the paradigm sets the problem to be solved; often the paradigm theory is implicated directly in the design of apparatus able to solve the problem. Without the *Principia*, for example, measurements made with the Atwood machine would have meant nothing at all.»[1]

The acceptance of a paradigm by a given professional or scientific field affords it the kind of legitimacy and language essential for a more esoteric type of research. It permits the members of the profession to pursue their «normal science» research and to communicate their findings among each other in clear and unambiguous terms. By normal science, Kuhn means the activity in which most scientists inevitably spend almost all their time, and which is predicated on the assumption that the scientific community knows what the world is like.

Historically, there have been instances where normal science exhibited a bias to suppress some novel or strange phenomena which could not be explained by the dominant paradigm. Because scientific education is both rigorous and rigid, scientists have a tendency to defend the validity and *objectivity* of their theories. Many times they fail to recognize that objectivity is paradigm-dependent, and it cannot be attained, even in sciences like physics, in a detached, deliberately impersonal, empirically verifiable, and purposely value-free analysis.[2]

Sometimes, however, normal science laws and experimental procedures fail to explain or to describe these novel phenomena, inspite of the persistent onslaught of the ablest members of the scientific community. When these anomalies pervade, i.e., when the profession cannot eliminate them through the practice of normal science, a revolutionary process sets in that gradually (seldom completed by a single man and never overnight) shifts the perceptions to new practices. Such a «paradigm shift» is what Kuhn in his essay calls scientific revolutions.[3]

It is the main thesis of this paper that a paradigm shift in policy science is desirable in order to better comprehend and to model the contemporary population trends and issues. The recent report of the Population Commission recognizes the seriousness of our contemporary situation:

«Consideration of the population issue raises profound questions of what people want, what they need—indeed, what they are for. What does this nation stand for and where is it going? At some point in the future, the finite earth will not satisfactorily accommodate more human beings—nor will the United States. How is a judgement to be made about when that point will be reached? Our answer is that now is the time to confront the question: «Why more people? The answer must be given, we believe, in qualitative not quantitative terms.»[4]

What I will attempt to argue in this paper is that today's dominant policy science paradigm is not adequate any more for perceiving the policy implications of the population growth and distribution trends, the emerging post-industrial culture, and the requirement for mankind's survival. On account of its extreme bias toward scalar measurements and quantitative macro-economic modeling, the classical paradigm has become «locally» self-perpetuating and self-fulfilling, although it remains «globally» counter-productive and incoherent. If policy scientists want to regain a relevant and meaningful role within a «whole system» context, it is imperative that they develop a *value* - and *culture*- sensitive paradigm. It appears that at least three fundamental categories of values, usually excluded from the classical policy science paradigm, need to be taken into account: (1) those that are widely diffused over space; (2) those associated with future generations; and (3) those not associated with human beings at all.[5]

The need for a growth paradigm with a global perspective and a strong culturally sensitive component is particularly important on account of the heterogeneous nature of the world. Even though almost all the countries of the world are presently undergoing rapid changes, and hence are experiencing problems related to these changes, these problems are by no means identical for all countries. In fact, what is a problem for some countries may be perceived as a desirable goal for some other countries. For example, some countries are suffering from the «success» of their industrialization and resource depletion, while other countries are striving for industrialization, having accepted the fact that industrialization means their countries will be polluted. The material growth of the European and North American countries has become the universal definition of progress and modernization. «Modernization» has been causally linked to the «rationality» of the Greek-European paradigm, which is characterized by such properties as causality, hierarchy, quantification, competitiveness, and homogenization. Classical approaches to modernization are increasingly being questioned, however, primarily because they «assume that 'deve-

1. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, The University of Chicago Press, Second Edition, 1970, p. 27.
2. Lawrence H. Tribe, «Policy Science: Analysis or Ideology», *Philosophy and Public Affairs* I, no. I (Fall 1971).
3. T.S. Kuhn, *Op. cit.*
4. Commission on Population Growth and the American Future, *Op. cit.*, p. 2.
5. Lawrence H. Tribe, *Op. cit.*

lopment' or 'modernization' constitute an 'unilinear' demographic, social, economic or political process, extending, even if haltingly or intermittently, to some plateau whose basic contours will be everywhere the same, despite defferences in detail.»[1]

To summarize, the two major propositions advanced in this paper are:

1. The dominant growth paradigm, primarily on account of its preoccupation with empirical «rationality» and «objectivity,» is singularly inappropriate to deal with the emerging situation, even locally.

2. A «new» ecosystemic policy science paradigm must be developed that will be inherently value-sensitive; it follows that such a paradigm need not be applied indiscriminately to all the cultures of a distinctly heterogeneous world.

population trends and the post-industrial culture

In this section we will briefly review some dominant world and national (US) trends, in order to set the stage for the arguments that follow.

The world's population currently is increasing at about 2 percent annually, doubling every 35 years. It took two million years for the earth's population to become one billion by the year 1830. It took 100 years for the world population to become two billion in 1930, and if the current annual rate of growth continues it will reach 12 billion by the year 2030, and approximately 50 billion by the year 2100.

The Gross World Product was equal to $\$3.5 \times 10^{12}$ in 1970 (i.e., 3.5 billion in 1972 dollars). If current 5 percent annual growth continues, the GWP will be equal to 60 trillion in the year 2030, and become 2,000 trillion by the year 2100.

On the basis of these two dominant trends, one can develop world «context scenarios» to the year 2100, and try to derive their environmental and cultural implications.[2]

There is another dominant world trend that needs to be seriously acknowledged. This is the dynamic evolution of human settlements into continuous urban systems, which will gradually, by the year 2100, merge into a continuous universal city or the Ecumenopolis of C.A. Doxiadis:

> «(Ecumenopolis) is the inevitable future of Human Settelments in the next few generations, and we can foresee that assuming we avoid any major catastrophe, we will have to deal with a universal city whose population will tend to be stable in numbers but increasingly more developed intellectually and socially, which will dispose of much greater quantities of energy and achieve greater social interaction.»[3]

The trend towards the Ecumenopolis is particularly dominant in emerging post-industrial societies such as the US. The metropolitan area growth of the United States has been consistently more rapid than the increase of national population during the 20th century. Measured as a percentage of national population, metropolitan areas in 1960 contained 66 percent of the nation's population. By 1970 this percentage had increased to 71 percent of the national total. This meant that the United States was transformed from a country that was 60 percent rural in 1900 to one that was more than 70 percent urban in 1970. By the year 2000, based on trends of 1940-1970, 85 percent of the Nation's population is projected to reside in major metropolitan areas.[4]

The most startling feature of projected population growth and distribution is that the majority of Americans will most likely live in giant metropolitan regions (or megalopolises) along the seaboards and the Great Lakes. In 1960, the United States contained 23 *great* metropolitan areas of one million or more people, each amounting to a total population of 68.2 million—38 percent of the national total population. The 1970 census reveals that the number of such metropolitan areas has risen to 29 and the population residing in metropolitan regions to 89.3 million or 44 percent of the national total. If these trends are extended to the year 2000, the proportion of the population residing in metropolitan regions of one million or more will amount to 65 percent (under the series B projection of the US Bureau of the Census amounting to 321 million people by the year 2000), residing in 50 such large urban agglomerations.[5]

A *shift* of such dimensions in where people live and work has caused major economic, social, and environmental changes for both the receiving metropolitan areas and the people left behind. As recently as the turn of the century, some 35 percent of America's workers were involved in agriculture. Today only 4.4 percent of the labor force is employed in agriculture and that figure is projected to decline to 2 percent by the year 2000. Employment in goods-producing industries such as manufacturing, construction, and mining has also been continuously declining relative to the total employmet sinnce the 1950's when the post-industrial or service economy

1. S.N. Eisenstadt, «Post-Traditional Societies and the Continuity and Reconstruction of Tradition», *Daedalus* Winter 1973.

2. «The Prospects for Mankind and a Year 2000 Ideology», Hudson Institute Report HI-1648/4-D, August 1972.

3. Constantinos A. Doxiadis, «The Future of Human Settlements», paper presented at the Nobel Symposium on «The Place of Value in a World of Facts», Stockholm, September 1969.

4. Jerome P. Pickard, «U.S. Metropolitan Growth and Expansion, 1970-2000», paper prepared for the Commission on Population Growth and the American Future, July 1971.

5. J.P. Pickard, *Op. cit.*

emerged. Around 1956, the service-producing industries (trade, finance, services, real estate, public utilities, transportation, and government) took the lead over jobs in the goods-producing industries. When this happened, the US became the first nation in the history of the world where the number of manual or blue-collar workers was exceeded by the so-called white-collar occupations. It appears that the policy implications of this *shift* have not yet been completely analyzed and explored by policy scientists.

The continuous eclipse of traditional industrial pursuits, i.e.,agriculture and manufacturing, and the rise of the service-producing industries within a continuously growing metropolitan population, bring on a whole array of significant *shifts* that will profoundly affect the business structure, our daily life styles, and our value systems. Some of the basic *shifts* that are well under way are:[1]

— From primary and secondary industries (agriculture/manufacturing) to tertiary and quaternary industries (service /knowledge activities).
— From goods to services.
— From goods /services produced by muscle power to those produced by machines and cybernetics.
— From materialistic to the sensate.
— From «things» to experiences.
— From physiological to psychological needs.
— From scarcity to abundance and eventually to super abundance.
— From a few stark choices to a bewildering array of choices.
— From durability to disposables and planned obsolescence and back to recyclables, reclaimables.
— From self-interest motivation to broader social and humanitarian outlook.
— From independence and self-sufficiency to interdependence.
— From individual freedom to voluntary restraints to mandatory restraints.
— From Puritan hard-work ethic to leisure as a matter of right.
— From Darwinian self-survival to humanistic security.
— From atomistic to large-scale pluralistic institutions.
— From national to multi-national and «one-world» scale operations.
— From decentralization to centralization and eventual globalization.
— From irrational chaos to futures-creative long range planning.

It is against the backdrop of this *multifold shift* from an industrial (or modern) to a post-industrial (or post-modern) society that we must attempt to understand and to model the phenomena related to population growth and metropolitanization. To perform such an analysis in a meaningful manner it appears that we need a post-scientific (post - economic) policy science paradigm. This «new» paradigm will be useful in addressing very fundamental questions «about the nature and destiny of man, about his ideals regarding his own person, and even about what might be his own successor.»[2]

a classical paradigm calculus

The most simplistic aggregate calculation of the environmental impact of population and economic growth can be carried out by means of a relationship of the form:[3]

$$W = A\ P\ q \qquad (1)$$

where

W = pollutants emitted during a period
P = total population of a geographic entity
q = per capita output

and

A = a proportionality constant.

To transform the quantity W to a spatial concentration C of pollution, or what is normally known as pollution levels, one must introduce the volume V of the medium in which the wastes are placed. One also needs to take into account the natural ability of the environment to cleanse itself through various biochemical processes. Hence, the rate of change in concentration at a point in time t will be the sum of what is added to the environment and what is subtracted because of the cleansing, i.e.

$$\frac{dC}{dt} = \left(\frac{W}{V}\right) - rC \qquad (2)$$

where r is the rate at which the particular medium cleanses itself. By integrating Equation (2) and setting the integration constant equal to C_0 one obtains, after substitution from Eq. (1),

$$C = \frac{APq}{Vr}\ (1-e^{-rt}) + C_0 e^{-rt} \qquad (3)$$

The adverse environmental impacts, or damage D, can be considered as a function of concentration C, i.e.,

$$D = f(C) \qquad (4)$$

1. Graham T.T. Molitor, «A Hierarchy of Needs and Values» in *The «Quality of Life» Concept*, an anthology of selected readings prepared by the Environmental Protection Agency, August 1972.

2. Kenneth E. Boulding, *The Meaning of the 20th Century*, Harper & Row, New York, 1964.

3. This illustrative formulation follows Ronald G. Ridker, «Population and Pollution in the United States», *Science*, June 1972, p. 1085; Also, Paul R. Ehrlich and John, P. Holden, «Impact of Population Growth», Volume III of the Population Commission research reports, Washington, D. C.: GPO 1972.

Our present state of knowledge of the functional form relating environmental damage to population and output (i. e., the feedback effects) is very limited. Also, the positive and negative synergisms that might exist between different pollutants at different levels of concentration are not yet known. Following a simple analytic approach, the per capita damage *d* is set proportional to the concentration *C*, the proportionality constant *B* itself being assumed to be a monotonically increasing function of the concentration of pollutants, i.e.

$$d = BC = f(C)C \quad (5)$$

The total damages, D, can then be represented by

$$D = BCP \quad (6)$$

Substitution of Eq. (3) leads to

$$d = \left(\frac{AB}{Vr}\right)(1-e^{-rt})\, q\, P + BC_o\, e^{-rt}, \quad (7)$$

and

$$D = \left(\frac{AB}{Vr}\right)(1-e^{-rt})\, q\, P^2 + B(C_0 e^{-rt})\, P \quad (8)$$

Defining a «volume» population density $\rho = P/V$, one can rewrite Eqs. (7) and (8) as

$$d = \left(\frac{k}{r}\right)(1-e^{-rt})q\rho + BC_0 e^{-rt} \quad (9)$$

and

$$D = \left[\left(\frac{k}{r}\right)(1-e^{-rt})\, q\,\rho + B\,(C_0 e^{-rt})\right] P \quad (10)$$

where *k* is in general a coefficient whose numerical value depends on the concentration level and the amount of capital invested in pollution abatement facilities.

Equations (9) and (10), although very approximate and simplistic, enable one to make a number of useful observations concerning the environmental impacts of such factors as (1) the size of the population *P*, (2) the geographic distribution or concentration of the population ρ; (3) the amount of production (or consumption) per capita *q*, i. e., the «affluence» variable, and (4) the amount of pollutant generated per capita, of production (or consumption) *k*, which is essentially a variable reflecting technology and abatement policies. One can see, for example, that the damage to the environment *D* increases in proportion to the population *P*, the per capita output *q*, and the population volume density ρ. If per capita output and population density are held constant, Equation (10) tells us that pollution is directly proportional to population. But if population were held constant, pollution could just as well increase, either because of increases in population volume density, or because of increases in per capita output. Hence, in this simple formulation, one is led to the conclusion that «uncontrolled» affluence, and «unplanned» metropolitanization of population can cause environmental damage even at zero population growth.* It is noteworthy that such a simplistic analytic model has confirmed our intuitive knowledge of the gross relationships between population, economic growth, and environmental degradation.

The accuracy and reliability of the simple analytic model leading to Eq. (10) is limited. Realizing this limitation, the Commission on Population Growth and the American Future commissioned Resources for the Future to develop an elaborate and highly disaggregated computer model for the purpose of analyzing the environmental impacts of alternative population and economic growth projections.[1] The RFF approach consists essentially of an industrial input-output model coupled to exogeneous information derived on the basis of four alternative demographic and economic scenarios: high population and economic growth (Census Bureau series B-High GNP), low population and economic growth (Census Bureau series E-Low GNP) and the two intermediate cases (B-Low and E-High). For each one of the four scenarios the model calculates: (1) the main economic indicators, (2) estimates on resource requirements, (3) estimates of pollution levels under different assumptions regarding abatement policy and available technology and (4) the regional and metropolitan area impacts of air pollution.

Employing this model the RFF study arrives at a number of policy-oriented findings. Some of the most important conclusions are paraphrased below:[2]

(1) For the time horizon of the study, i.e., the next 30 to 50 years, the changes in technology, tastes, institutions, policies and international relations will play more important roles than population growth in determining resource adequacy and environmental quality.

(2) For the time horizon of the study, a change in population growth appears to have a smaller impact on resource consumption than a change in economic growth. A one-percent reduction in population would reduce consumption of resources in the year 2000 by 0.2 to 0.7 percent, whereas the equivalent percentage reduction in per capita GNP would reduce consumption in that year by 0.6 to 3.5 percent.

(3) The United States appears to be in good shape relative to other countries, provided we have sufficient lead time to develop domestic alternatives to

* This conclusion also assumes no fundamental changes in production and pollution technology.

1. Ronald G. Ridker, Editor. Vol. III of the Population Commission research reports. Washington, D.C.: GPO 1972.

2. Ronald G. Ridker, «Resource and Environmental Consequences of Population Growth in the United States». GPO 1972.

foreign sources, should the need arise. A slower population growth rate leading to a stable population within the next 50 to 75 years, will buy us time to overcome our ignorance of ecological processes and expand our options in deciding how we want to live in the future; a slowdown in population and economic growth would clearly help in this respect by giving us sufficient lead time.

(4) The relative position of the poorer two-thirds of the world is likely to deteriorate further during the next 30 to 50 years unless some dramatic technological breakthroughs, rapid declines in birthrates, or massive transfers of resources from richer countries take place.

(5) While there is mounting evidence that environmental quality is lower in metropolitan areas that are more densely populated, the underlying causes for the lower quality may not be scale but factors such as: urban forms and transportation systems more appropriate to an earlier era; old, unintegrated service facilities; inappropriate pricing of public facilities and common property resources such as roads and waste disposal; multiple political jurisdictions; and the factors leading to inadequate financing and a predominance of minority groups and poor in the core cities.

A number of observations concerning the policy implications of the RFF model results appear desirable at this juncture:

The first generalized observation that appears significant in studying the RFF conclusions is that they represent an interesting blend of realism and idealism. The «facts» of the RFF report are based on results obtained through the computer modeling of present «reality» and the conditional forecasting of present trends. Such modeling always presupposes some simplifying assumptions in order to reduce the universe of relevant to the situation phenomena to a manageable and quantifiable analytic model. The computer model is capable of generating extrapolations of the present data base with an improved accuracy as compared to the more intuitive model represented by Eq. (10). Nevertheless, the computer model is incapable of generating a significant portion of the *information* that appears to be relevant for policy making purposes. To arrive at conclusions that at least purport to be useful for policy recommendations, it becomes essential to allow some idealism to creep into the deliberations.

The point is, had we remained within the context of our simplistic analytic model of Eq. (10), we would have been more aware of its limitations for decision-making purposes. As we move to the more «sophisticated» computer modeling approach to the problems related to population growth and distribution, it is absolutely essential to raise again to consciousness the age-old realist-idealist debate.[1] It appears that once the idealist perspective of the meaningfulness of the information in terms of «system purposes» is ignored, then we can find ourselves locked in a «computer technology trap» of more and more senseless data. According to West Churchman, idealism and realism interact as a kind of dialectic in the design of large systems:

«If the realist is afraid of looking twenty, fifty, a thousand years ahead, then so much the worse for the realist. If the realist thinks that the past is more clearly recognizable than the future, then this realist thought must be counterbalanced by the opposite thought namely, that the future is far easier to recognize than the past.

«Finally, we also recognize that the realist has the best technology even if he has the weakest philosophy, and that the idealist has the soundest philosophy with the weakest technology. This position characterizes our culture.»[2]

After the brief digression into the realism-idealism dilemma of policy science, it is worth exploring in more detail the conclusions of the RFF model and analysis. Our intent here is not to criticize the substance of this work, which incidentally appears to be analytically thoughtful and imaginative, but to use it as an example of the dominant policy science analysis which appears to become increasingly less relevant to the situation, especially when viewed: (1) from the perspective of the emerging multifold cultural shift, and (2) within a «whole system» design context.

The first conclusion states that within the 30 to 50 years horizon, it is not population growth that should be considered as the critical policy variable, but the changes that might occur in people's attitudes, institutions, and international relations. Since these variables cannot be quantified, they can not be explicitly included in the mathematical model proper. Nevertheless, the analysts recognize *a posteriori* that this set of variables and their time-development can have major resource and environmental policy implications. The point that needs to be stressed in this connection is how can the impact of computer-generated projections on policy-makers and the general public be offset with the more intuitive or conjectured information available for the non-quantifiable variables of the situation. This becomes a delicate task for the value-sensitive and non-quantitative policy scientist, and is what we referred to earlier as the «computer technology trap.»

The second conclusion states that resource consumption is more sensitive to economic growth than it is to population growth. This finding is attributed to

1. C. West Churchman, *Challenge to Reason,* McGraw Hill 1968.
2. C. West Churchman, *Op. cit.,* p. 197.

a feed-back effect connecting population reduction to some offsetting increase in per capita GNP, and hence in the demand for resources. This appears to be a counter-intuitive result, in the sense that the simplistic analytic model represented by Eq. (10) does not bear out. The counter-intuitive aspect of social system modeling has been overly emphasized recently by some authors.[1] Useful as such an insight might be from a social modeling dynamics viewpoint, it is of secondary significance when viewed in the context of policy science, and in particular when one considers it in the light of the ethical dimensions of population control. One can think of this phenomenon as the «counter-intuitive trap.»

The third and fourth conclusions appear to represent a good example of the realism-idealism dilemma. From the national point of view, the US appears to be in «good shape» in the next 30 to 50 years relative to the other countries. The survival of the poorer countries, which represent two-thirds of the world, depends on technological breakthroughs and miraculous transfer of resources. Such a policy posture represents another trap derived from a classical paradigm analysis. If policy scientists continue to reduce the problems of improving their situation into separable nations, mankind is running the severe risk of degrading rather than upgrading the whole system. One can refer to this phenomenon as the «partial system trap.»

Finally, the fifth conclusion recognizes that the environmental problems confronting the cities might not be attributable to scale, but to obsolete and antiquated institutional and physical designs. In some sense, this conclusion is similar to the first one in that it questions the validity and relevancy of the past in making policy for the future of human settlements. Perhaps as a general proposition, the relevancy of the past for policy making is inversely related to the speed of social and technological change. Inherent in the classical policy science paradigm is a rigidity of thought and structure, which sometimes unintentionally leads to policy recommendations that perpetuate and reinforce the observed behavioral patterns. One can think of this phenomenon as the «rigidity trap.»

After discussing and commenting on the conclusions of a specific example of an accurate and innovative analysis of the resource and environmental implications of population and economic growth trends, it is worth attempting to generalize the discussion and to briefly summarize the apparent limitations of the classical paradigm calculus (these limitations are interrelated and overlapping):

— Not responsive (or sensitive) to the emerging multifold cultural shift which represents a very plausible (if not desirable) alternative future.

— Emphasis on empiric level data and analysis, disregarding the role that values and attitudes play in making decisions at the highest levels of policy-making.

— Dominance of quantitative computer macro-economic modeling and data generation, disregarding the lack of «fine structure» and ethical detail requisite for meaningful policy analysis.

— Non-planetary, non-holistic, and simplistic policy analysis, downgrading the potentialities, and diminishing the options, of the world system.

— Increases the gap between the «two cultures» of the science and the humanities, and hence contributes to the presumption of the existence of a «technological fix» to fundamentally non-technological-solution problems.

In the next section an attempt is made to postulate a post-classical paradigm capable of reconciling such troublesome opposites as spirit / body, science / values, or determinism / free will, in a manner similar to the way modern physics reconciles the previously opposing wave and particle theories of light.[2]

towards a post-classical paradigm

There is a very interesting principle of modern physics, called Bohr's correspondence principle, that asserts that the motion of a system as described by quantum mechanics and by classical mechanics must agree in the limit in which a universal constant, Planck's constant $h = 6.62 \times 10^{-27}$ ergs, can be neglected. That is, if the system under consideration is large enough and if our demand for accurate measurement is not too rigid, classical mechanics should furnish a good approximation to the motion of the system. This is also called the *classical limit* of quantum mechanics.

The contemporary world system we are trying to understand and to model is drastically different from our historically inherited perceptions. John McHale has compiled a very illuminating historical data series of world facts and trends.[3] As we mentioned earlier, it took 2 million years for the population to reach the first billion mark at the year 1830. At the present rate of growth, it will take approximately 200 years for the world population to reach 12 billion by the year 2030, i.e., an increase by a factor of 12 within the time-span of 200 years. If one superimpo-

1. Jay W. Forrester *Urban Dynamics,* The M.I.T. Press, 1969.

2. Willis W. Harman, «Key Choices of the next Two Decades», Paper presented at the White House Conference on the Industrial World Ahead, *A Look at Business in 1990,* GPO, Washington, D. C. November 1972.

3. John McHale, «World Facts and Trends», *Futures*, Vol. 3, No. 3, Septemper 1971.

ses on the population growth dimension the increase in travel and communication speeds around the globe, one can easily arrive at a hundred-fold shrinking of the geographic scale of our planet within the span of approximately 100 years, i.e., between 1850 and 1950. That is to say, the time required to travel around the globe in 1850 was a few months, while this same trip was reduced to a few days by 1950, and is now reduced to a few hours.

These magnitudes are included here primarily in an effort to build an analogy between Planck's quantum mechanics constant h, and the phenomena of population explosion and planetary shrinkage that represent substantial evolutionary changes at the global scale. It appears sensible to at least hypothesize that physical changes of such magnitude and complexity must have major ramifications in our perception and modeling of reality. The propagation and interpenetration of these physical and behavioral phenomena exacerbate the need to invent and apply a post-classical policy science paradigm. Pursuing the analogy between physics and policy science a step further, one might even postulate that in the hypothetical limit of a small world population, the classical paradigm will furnish a«successful» representation for the behavior of a system operating in the industrial era.

We therefore start by stipulating that the candidate post-classical paradigm should be complementary to the classical one, in the sense that it recognizes the existence of a multi-echelon structure for the organization of physical, biological, mental, and ethical reality. We will elaborate on this point later on in this paper.

At this juncture it appears desirable to identify and describe the major characteristics of the proposed paradigm. The name of the paradigm is: *Futures-creative ecosystemic planning and learning*. Its main properties are:

(1) *Value-sensitivity*. This property essentially recognizes the role values (and ideology) play in policy science.[1] While some policy scientists themselves are nowadays aware of the limitations of computer modeling when applied to culturally sensitive environments, and are increasingly making explicit the values any particular analysis includes or excludes, policy makers, can be easily misled into accepting the findings of such analyses with maximum enthusiasm and minimum skepticism. The quantitative bias predominant in policy science together with the second bias, reductionism, lead usually to a methodological framework of component hypotheses and actions disregarding the totality of human experience. Values belong to the realm of synthesis, not analysis. Hence one of the guiding principles of the candidate paradigm is the use of graphics as a proper symbolism for a «holistic» policy science. As stated earlier, there are three fundamental categories of values that are usually excluded from the conventional utility calculus, namely: (a) those that are widely diffused over a continuously shrinking global space; (b) those associated with future generations; and (c) those not associated with human beings at all.

(2) *Time-reversed causality*. In the classical paradigm causality is perceived in terms of a forward time flow that links a policy-action A in the present to an impact (or result) A′ in the future. The adopted policy-action is usually perceived within the context of the short-term option-field. We continuously neglect to take into account the fact that the short-term result A′ causes long-term consequences A″ which are in most cases unanticipated and undesirable.[2] In order to avoid the dystopian consequences of results, the candidate paradigm adopts a time-reversed notion of causality, namely that the image of a desirable future feeds backward in time and becomes a valid component of our perception of reality. The time-reversal of causality, therefore, imputes validity to actions taken within the context pf a «future data base» which has no physical existence in the present. Such a definition of causality requires the adoption of an alternative futures approach to policy planning and imposes the requirement for active public participation in the formulation of policy «objectives» and in normative analysis.[3]

(3) *Ecosystemic hierarchy*. This property superimposes a multi-level multi-goal geographic hierarchy on the three principal dimensions (or spaces) of poliéy planning, and names: (a) the axiological dimension (or value space); (b) the phenomenological dimension (or impact space); and (c) the paraxiological dimension (or policy space). The superposition of a geographic hierarchy stipulates that the «world scope» embraces the «national scope» which in turn embraces the «metropolitan scope» and so on.[4]

1. Alexander N. Christakis, «The Role of Values in National Development Policy Planning», paper presented at the Third World Futures Research Conference, Bucharest, Romania, September 1972.

2. Hasan Ozbekhan, «Planning and Human Action», in Paul A. Weiss (ed,). *Hierarchically Organized Systems in Theory and Practice*, Hafner Publishing Company, New York, 1971.

3. The definition of «objective» adopted here is that proposed by R.L. Ackoff in «Toward a System of Systems Concepts», *Management Science*, 1971. His definition is: The objective of a purposeful system in a particular situation is a preferred outcome that cannot be obtained within a specified period but which can be obtained over a longer time period.

4. Alexander N. Christakis, «Regional Economic Development Futures: A Methodological Review and Study Design», *Futures*, Vol. 4, No. 1, March 1972.

FIGURE 1. *Main Attributes of the Classical and Post-Classical Policy Science Paradigms*

TWO POLICY SCIENCE PARADIGMS

(CHARACTERISTICS)

CLASSICAL		POST-CLASSICAL
CULTURE AND VALUE INSENSITIVITY	→	CULTURE SENSITIVITY
REDUCTIONISM (MATHEMATICAL ANALYSIS)	→	HOLISM (GRAPHICS)
PRODUCT (RESULT) ORIENTATION	→	PROCESS (BALANCE) ORIENTATION
FORWARD CAUSALITY (SHORT-TERM)	→	BACKWARD (TIME - REVERSED) CAUSALITY
RIGIDITY (INERTIA)	→	FLUIDITY (EPHIMERALIZATION OF THOUGHT AND STRUCTURE)
TIME AND SPACE INVARIANCE (HOMOGENEOUS WORLD)	→	SITUATIONAL MODELLING (CULTURAL DIVERSITY)
INSTITUTIONAL HIERARCHY (COMPETITION)	→	ECOSYSTEMIC HIERARCHY (COOPERATION)
ELITISM	→	PARTICIPATION
POSITIVIST. (EXTRAPOLATIVE) PLANNING	→	NORMATIVE (DESIGN) PLANNING

(4) *Situational modeling.* This characteristic is responsive to the need to develop a state-specific (including states ofc onsciousness) science.[1] Situational modeling leads to the adoption of X policy-mix for Y entity at Z time. The two corollaries of this property are: (a) *«Expert»* vulnerability, i.e., the willingness of experts to render themselves vulnerable and to learn from errors. This attitude is particularly important in order to overcome the syndrome of «educated uncapacity.» (b) *Fluidity and/or ephimeralization* of thought as well as structure, from the «solid» industrial and technocratic ones towards a fully participative form of society.

(5) *Process and «balance» orientation.* Ecology is customarily defined as the study of the equilibria and the dynamics of «populations» of living entities within given environments. This property of the candidate paradigm extends the notion of ecology to embrace the equilibria and the dynamics of all entities, i.e., of population of facts and concepts, and hence it enlarges our perception of the meaning of «ecological balance.»

(6) *Public participation in alternative futures analysis.* This property is the necessary (but not sufficient) condition for all the other five properties to become operational. Without a viable and on-going public participation process in the exploration of the implications of alternative futures, it is doubtful that the other five properties of the proposed policy science paradigm can become useful to policy-makers.

All the properties of the post-classical paradigm, together with the corresponding classical properties, are schematically shown in Figure 1. As stated earlier, the principle of correspondence is assumed to be valid, so that depending on the particular situation the classical paradigm might still be applicable for certain pre-industrial cultures.

1. Charles T. Tart, «States of Consciousness and State-specific Sciences», *Science*, June 1972, p. 1203.

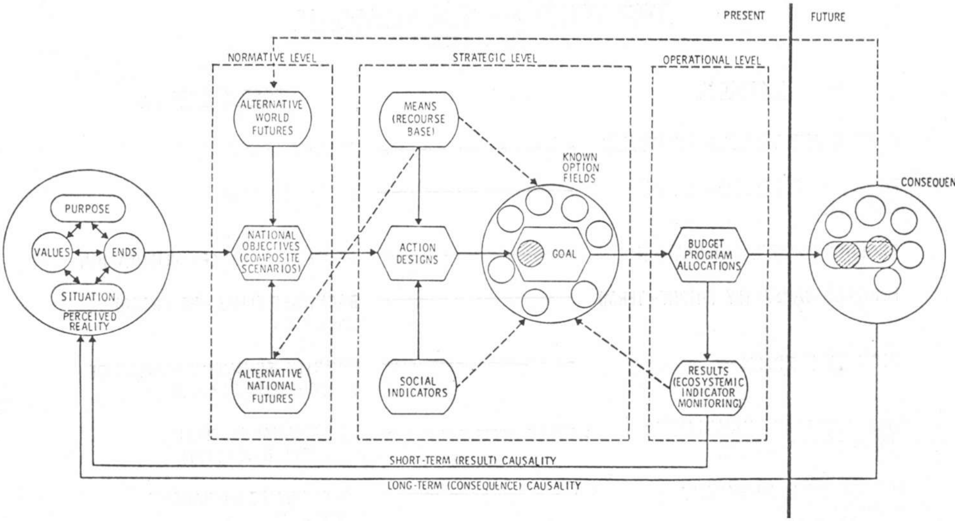


FIGURE 2. *A Participative—Adaptive—Holistic—Purposive—Hierarchical—Time-Reversing Planning/Action Framework*

futures-creative planning and learning

The supreme challenge in transforming from classical (industrial) to post-classical (post-industrial) policy science is the required change from our reactive and result-oriented approach to an anticipatory policy-action mode through long-range planning and consequence analysis. Not only must we derive the consequences of the results through an enquiry with long-range scope, we must also *believe* in them in order to change our modes of behavior. It is on account of this need for public commitment that the property of participation is essential in the post-classical paradigm. The main issue confronting the decision-makers with regards to the phenomenon of population size and distribution is how to choose among alternative policy configurations without being able in advance either to ascertain their consequences or determine which alternative will prove more acceptable by the general public.

A planning and learning process incorporating the basic post-classical paradigm properties is shown in Figure 2. The framework shown in Figure 2 displays a public for choosing among plausible alternative futures and incorporates the following five procedural steps:

(1) Conceptualization of alternative plausible futures;

(2) Presentation of plausible futures and of relevant data to the public;

(3) Public debate of the alternative futures, pathways to achieve them, and of possible long-range consequences;

(4) Public selection of a desirable future and of pathways to achieve it;

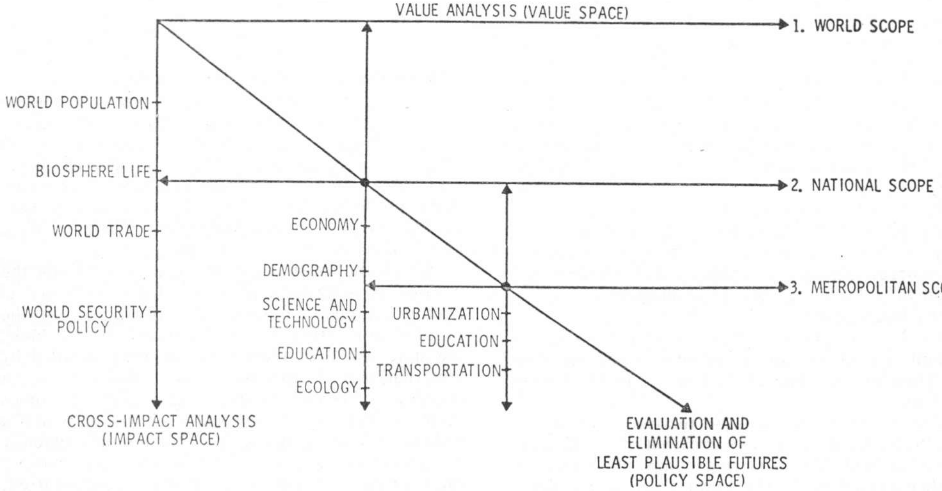
(5) A monitoring process whereby the movement toward or away from the desired future can be ascertained through proper ecosystemic indicator monitoring and corrective steps taken in time to affect the outcome.

In the diagram of Figure 2 the five steps are organized in terms of a three-level system structure that characterizes planning: (a) normative (Steps 1,2, and 3); (b) strategic (Step 4) ; and (c) operational (Step 5).[1]

The main activity of *normative* planning is carried out with reference to ends and their value content, and with the aim to clarify the consequences of al-

1. Hasan Ozbekhan, «Towards a General Theory of Planning» in E. Jantsch (ed.) *Perspectives of Planning,* OECD publication, Paris 1969.

FIGURE 3. *Ecosystemic Geographic Hierarchy of Embracing Contexts for Impact Analysis and Evaluation of Policy/ Action Configurations*



ternative policy-action configurations within a given time horizon as well as for some whole environment or situation. When such consequences have been made clear, the normative plan determines whether they will ultimately be «good» or «bad» for some whole system, and not merely for one person, a city, a region, or a nation-state, etc. That is, a geographic hierarchy of embracing contexts is assumed to be embedded into the normative planning domain.

The *strategic* level of planning defines those decisions which determine what *can* be done given a time interval and a whole situation. The main activity of the strategic plan is the setting of goals for the particular system that will be consonant with the constraints established at the normative level. Hence while the normative plan is objective and consequence oriented, the strategic plan is goal and result oriented.

The third level of planning is called *operational*, and it corresponds to the implementation of decisions that have been reached at the higher levels. Such implementation, however, is never automatic; confronted with an ever fluid situation, day-to-day modifications in applying available means must be made. These operational modifications of the overall planning system are shown in Figure 2 by means of the feedback linking the operational planning level to perceived reality domain. Operational planning is most acceptable anf practiced by different governmental levels of decision-making.

One of the main attributes of the candidate paradigm is that it must provide a framework for the performance of holistic, value-sensitive, ecosystemic analysis of alternative plausible futures. Figure 3 portrays a schema for the analysis, evaluation, and successive elimination of those alternative futures that do not satisfy criteria of consistency and synergy at a given level or within an embracing level in the geographic hierarchy. As stated previously, the «world scope» embraces the «national scope» which in turn embraces the «metropolitan scope» and so on.

The diagram of Figure 3 depicts the three dimensions (or spaces) of policy planning. The diagonal axis corresponds to the policy space. Each policy-action configuration is mapped onto the vertical axis, corresponding to the impact space, and onto the horizontal axis representing the value space. The impact space is subdivided into subspaces corresponding to the various relevant sectors at a given level of the geographic hierarchy. Different sectors appear at different levels of the hierarchy. For example, at the «world scope» the relevant sectors might be: world population, biosphere life, world trade, etc. At the «national scope» the relevant sectors might be: economy, demography, science, technology, education, etc. Those policy-action configurations that satisfy phenomenological (i.e., impact space analysis) criteria at a certain level of the hierarchy are passed onto the lower level for further analysis and evaluation. More specifically, the procedure consists of the following *three iterative steps to be carried out at each level of the hierarchy:*

Step 1 - Paraxiological: Conceptualization of composite plausible scenarios for the relevant entity (world, nation, metropolitan area, etc.) and breakdown into sectoral scenarios for the relevant to the entity sectors.

Step 2 - Phenomenological: Cross-impact analysis among the sectoral scenarios in an attempt to test them against criteria of intersectoral consistency and synergy. This analysis usually leads to the elimination of a large number of configurations from those conceived in Step 1.

Step 3 - Axiological: Synthesis of the surviving sectoral scenarios into composite scenarios and derivation of the value content (value map) of each scenario.[1]

The above three steps can be recycled at each level of the hierarchy until no significant new information is derived. The surviving composite scenarios are then passed on to the lower level as the «embracing context» for the continuation of the analysis and evaluation. Those scenarios that contain inter-level (or inter-regional) inconsistencies should also be eliminated. The whole process can then be repeated.

Figures 2 and 3, together, represent the methodological foundations of the candidate paradigm. Figure 2 is essentially a representation of the notion of time-reversed causality that has been postulated in the candidate paradigm. Figure 3 is a representation of the notion of an ecosystemic hierarchy of embracing contexts. It should be obvious that these two notions are very fundamental for the application of the candidate paradigm.

In the next section a preliminary attempt is made to apply this methodological framework to the emerging population trends and issues. Recognizing that population growth and distribution is an important sector at the world and national levels, the linkages between these two levels will be discussed, while for simplicity almost all the inter-sectoral cross-impacts will be disregarded. Such an approach can only be useful as an illustration of the methodology and cannot, because of its narrowness of scope, lead to policy-action recommendations. The complete application of the proposed candidate paradigm methodology requires the skills and resources of an interdisciplinary group of policy scientists working together as a team.

1. Alexander N. Christakis, «The Role of Values in National Development Policy Planning», *Op.cit.*

population impact and value analysis

While the world population continues to increase, there are policy-action alternatives that might prove effective in controlling population growth. For example, US, India and other countries have liberalized abortion laws and taken steps to reduce the birth rate. Zero population growth has been accepted by many politicians as a desirable national objective. East Germany has already achieved a ZPG, and West Germany is on the verge of doing so.

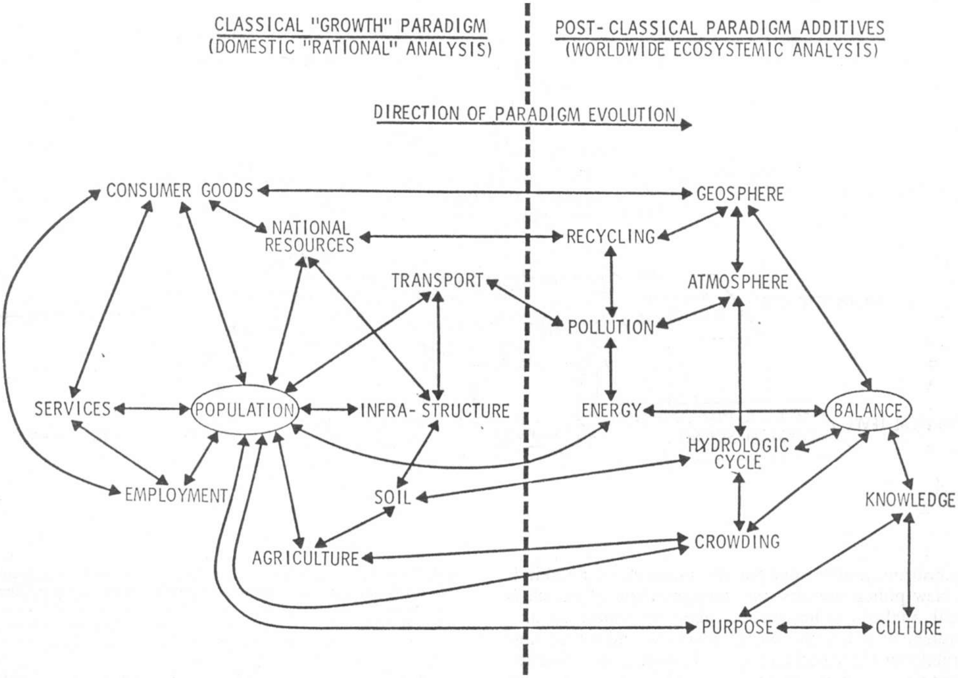
One of the most common events concerning the notions of overpopulation or underpopulation is making simplistic linkages and inferences on the basis of population density. For example, to make the statement that the US is not very crowded by «international standards» because Holland has a population density (people/square mile) 18 times larger, is not very meaningful when viewed within a «whole system» context. The Netherlands actually require large chunks of the earth's resources and vast areas of land outside its borders to maintain itself. It is the second largest per capita importer of protein in the world. It also imports all of its cotton, 77 percent of its wool, and all of its iron ore, antimony, bauxite, chromium, copper, gold, lead, magnesite, manganese, mercury, molybdenum, nickel, silver, tin, tungsten, vanadium, zinc, phosphate rock (fertilizer), potash (fertilizer), asbestos, and diamonds.[2]

The «density fallacy,» and other similar misunderstandings, are related to the classical paradigm's inability to provide a context for: (1) the essential long-range (and time-reversed) horizon and (2) the ecosystemic hierarchical perspective in population policy analysis. Figure 4 shows schematically the type of considerations that enter the classical paradigm population impact analysis, together with some post-classical paradigm additives. It is important to note in connection with this diagram and the implied paradigm shift, that such considerations as «balance,» «purpose of life,» «culture,» «knowledge,» are completely absent from the classical policy science paradigm.

It appears desirable to briefly examine the cross-impacts at the world level between the population and employment sectors within the context of the methodological framework presented in Figures 2 and 3, in order to explicate the implications of the continuation of present policies.

2. Paul R. Ehrlich, et al., *Op. cit.*

FIGURE 4. *Example of a Classical Impact Analysis of the Population Variable with Suggested Post-Classical Paradigm Additives*

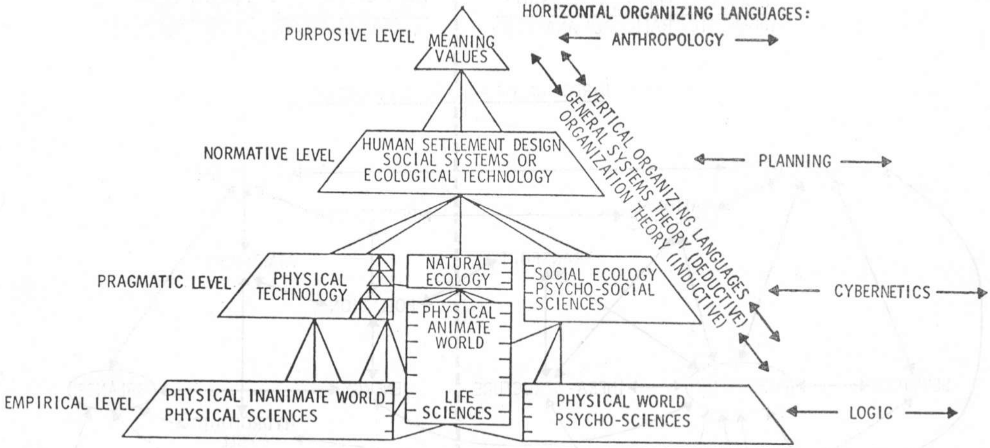


The rapid growth of population at the world level is due to the unprecedented success in recent years to control disease and to provide food. A slowing population growth is a necessary prerequisite to solving many of mankind's most pressing problems, such as widespread illiteracy, rising levels of unemployment in the poor countries, and the deteriorating physical environment. Unemployment is rising in every region of the world. In Latin America unemployment jumped from 2.9 million in 1950 to 8.8 million in 1965, and is still climbing. In countries like Pakistan, Ceylon, Malaysia, and the Philippines, the unemployment rate is 15% or more. Current policies among the rich countries, *perceived within a local context and a short-term option-field,* discriminate against products of poor countries in order to protect their own industries: (examples: textile and shoe industries in US, beet sugar industry in US and Europe, wheat in Common Market countries, rice in Japan).[1] Poor countries thus cannot sell products to rich, and therefore lack jobs. At the same time labor unions raise wages to artificially high levels. Businessmen thus find it uneconomical to employ people in poor countries.

These are only a few obvious examples of the kind of negative synergisms that exist between population growth, unemployment, and trade policies. Continuation of «result-oriented» policies will most likely lead to a worsening of the present situation and will bring about such consequences as an accelerated widening of the gap between rich nations and the poor ones; a widening of the gap between the rich and the poor in poor nations; declining living standards,

1. Lester R. Brown, et al., «An Overview of World Trends», *The Futurist,* Vol. VI, No.. 6, December 1972.

FIGURE 5. *The Organization of Rational Knowledge towards a Purpose in a Multi-Echelon Representation (adapted from E. Jantsch)*



starvation, and misery for the majority of mankind.

New policy options, i.e., an expansion of the classical analysis policy-menu, might be conceived and implemented at the world level by adopting and practicing the candidate post-classical policy science paradigm, and by restructuring the organization of our knowledge towards a purpose, such as the survival of mankind and preservation of the world's natural environment. Before the arrival of the environmental concern, it was «reasonable» within the context of the dominant paradigm for the rich countries to assume that the gap can be narrowed by raising the GNP and the per capita income of the poor countries. The environmental crisis, however, suggests that it may be possible to narrow the gap only by slowing the rise in living standards among the rich countries.

It, therefore, becomes apparent that at least at the world level population growth, employment, and the concommitant environmental crisis, pose major ethical challenges for man which cannot be resolved in the context of the «partial system,» «short-term,» and «value-free» organization of knowledge presupposed by the dominant policy science paradigm. As Lester Brown says in his recent book *World Without Borders:*

«Man must evolve a new social ethic, one which emphasizes economic and demographic stability and the recycling of raw materials. Such an ethic replaces international competition with global cooperation and sees man in harmony with nature rather than having dominion over nature.»[1]

At the national level, too, population control policies pose ethical dilemmas such as: how much procreative freedom, if any, should be given up in order to insure the security-survival of a nation or a community? How much security-survival can be risked in order to promote distributive justice? How much procreative freedom can be tolerated if it jeopardizes distributive justice?[2] Here again, the resolution of these ethical dilemmas requires the interdisciplinary organization of knowledge in the context of a post-classical policy science paradigm.

In his approach to interdisciplinary synthesis, Erich Jantsch adopted a multi-echelon (multi-level, multi-goal, hierarchical) representation presented in Figure 5.[3] In this multi-echelon system, interdisci-

1. Lester R. Brown, *World Without Borders,* Random House, New York, 1972.
2. Daniel Callahan, «Ethics and Population Limitation», *Science,* February 1972, p. 487.
3. Erich Jantsch, «Inter- and Trans- disciplinary University: A Systems Approach to Education and Innovation», *Policy Sciences,* Vol. 1, No. 4 (December 1970).

TABLE 1. *Schematic Impact and Value Analysis of a Population Size Control Policy (Adapted from Kan Chen, et al.)*

Level of Multi - Echelon Structure	Considerations at each level	Population Size Policy (e.g. Abortion Clinics)
Purposive Level (Anthropology)	• Policy Objectives	Growth — Balance
	• Freedoms fostered by Policy	Collective — Self-actualization
	• Implications of Policy in the needs hierarchy context	Basic — Self-actualization
Normative Level (Planning)	• Time horizon	Short — Long
	• Geographic scale	Local — Global
	• Means to obtain Policy objectives	Coercive — Voluntary
	• Knowledge of Policy consequences	Low — High
	• Public participation in Policy formulation	Low — High
	• Communication of Policy	Low — High
	• Cost (relative to alternatives)	High — Low
Pragmatic Level (Cybernetics)	• Social experimentation and learning permitted by Policy	Low — High
	• Impact on natural ecology cycle	High — Low
Empiric Level (Logic)	• Estimate of the degree of physical world (inanimate) interaction and impacts	High — Low
	• Estimate of the degree of psycho-science impacts	Low — High

plinarity constitutes a mode of organization through the coordination of elements at one level from the next higher level, and trans-disciplinarity extends this concept of organization through coordination over the entire hierarchical system. Looking at the «horizontal organizing languages» of the multi-echelon structure of Figure 5, one sees that most of the classical paradigm policy analysis and research is focused at the two lower levels, namely at the «logic» and «cybernetic» levels. In the candidate paradigm the two upper levels, i.e., the levels of «planning» and «anthropology,» need to be addressed and recognized in order to deduce coherent and meaningful policy options.

An exemplary application of the interdisciplinary hierarchical structure to a population control policy at the national level is shown in Table 1. For each level of the multi-echelon structure one can identify relevant considerations and a scale for assessing the impact and «worth» of the policy option; the particular example shown in the Table is that of establishing abortion clinics.[1] Even though this example is very tentative, one can see from Table 1 the type of ethical «fine structure» analysis which is necessary in determining national policies for population control.[2] The advantage of the multi-echelon structure analysis of the candidate paradigm is that it provides an organizing integrative context for policy analysis and recommendations, as compared to the more fragmented, empirically biased, and «logic» dominated classical paradigm analysis. Additional research s required in order to improve the utility and applicability of such interdisciplinary tools for policy analysis within the context of the candidate paradigm as represented by Figures 2,3, and 5.

conclusions

An effort has been made in this paper to explicate the need for a new policy science paradigm for the analysis and evaluation of global and national population trends and issues. The proposed «paradigm shift» is conceived as analogous to the shift from classical mechanics to quantum mechanics in physics. The post-classical paradigm of policy science is postulated as being culturally sensitive and entity dependent, so that given a specific situation it is complementary to the classical paradigm, just as quantum mechanics is complementary to classical mechanics.

The main attributes of the new paradigm are: (1) long-term and time-reversed causality, (2) ecosystemic hierarchy, (3) holistic, value-sensitive and interdisciplinary analysis. These three attributes are represented *methodologically* by Figures 2,3, and 5, respectively.

Figures 2,3, and 5 are the main methodological components of the candidate paradigm. They are, in a sense, the equivalent of the «equations of motion» of Newtonian mechanics. Any policy analysis carried within the context of the candidate paradigm must be based on the nested schema represented by these three figures and their interconnections. Figure 3 is all encompassing in that it displays the dynamics (time dimension) of policy planning, the three level hierarchy of planning, and also embraces two other hierarchies: (a) the ecosystemic geographic hierarchy of Figure 3, and (b) the knowledge or interdisciplinary hierarchy of Figure 5.

Figure 3 represents an ecosystemic hierarchy superimposed on the three spaces of policy science, i.e., the policy space, the impact space, and the value space. It also embraces Figures 2 and 5. That is, at each level of the geographic hierarchy, one must perform (a) a dynamic analysis as shown in Figure 2, and (b) a three-level planning structure corresponding to normative, strategic and operational planning. The interdisciplinarity idea represented in Figure 5 is also embraced by Figure 3, since it is necessary to perform cross-impact analyses among sectoral scenarios and to assess intersectoral consistency and synergy of alternative policy-action configurations when mapped onto the impact and value spaces.

Finally, Figure 5 presupposes the employment of such vertical organizing languages as systems theory (deductive) and organization theory (inductive) in order to integrate all knowledge from the purposive through the planning and pragmatic to the empiric levels. The purposive and planning levels appear to be the ones requiring research in order to make their role more important and useful in the post-classical policy science paradigm. More specifically, it is felt that considerable research effort is needed in order to: (1) expand the notion of ecology to embrace the equilibria and the dynamics of all entities, and (2) translate the proposed policy science paradigm into more operational terms by applying it continuously for decision-making purposes.

1. Kan Chen, *et al.*, *Op cit.*, footnote 3.
2. *Ethics, Population and the American Tradition*, A Study prepared for the Commission of Population Growth and the American Future by the Institute of Society, Ethics and the Life Sciences.