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Science and Sustainability: Discussions and Comments on Selected Papers on IIASA's 20th Anniversary

Keyfitz, N.

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April 1994

Science and Sustainability

Discussions and Comments on Selected Papers on IIASA's 20th Anniversary

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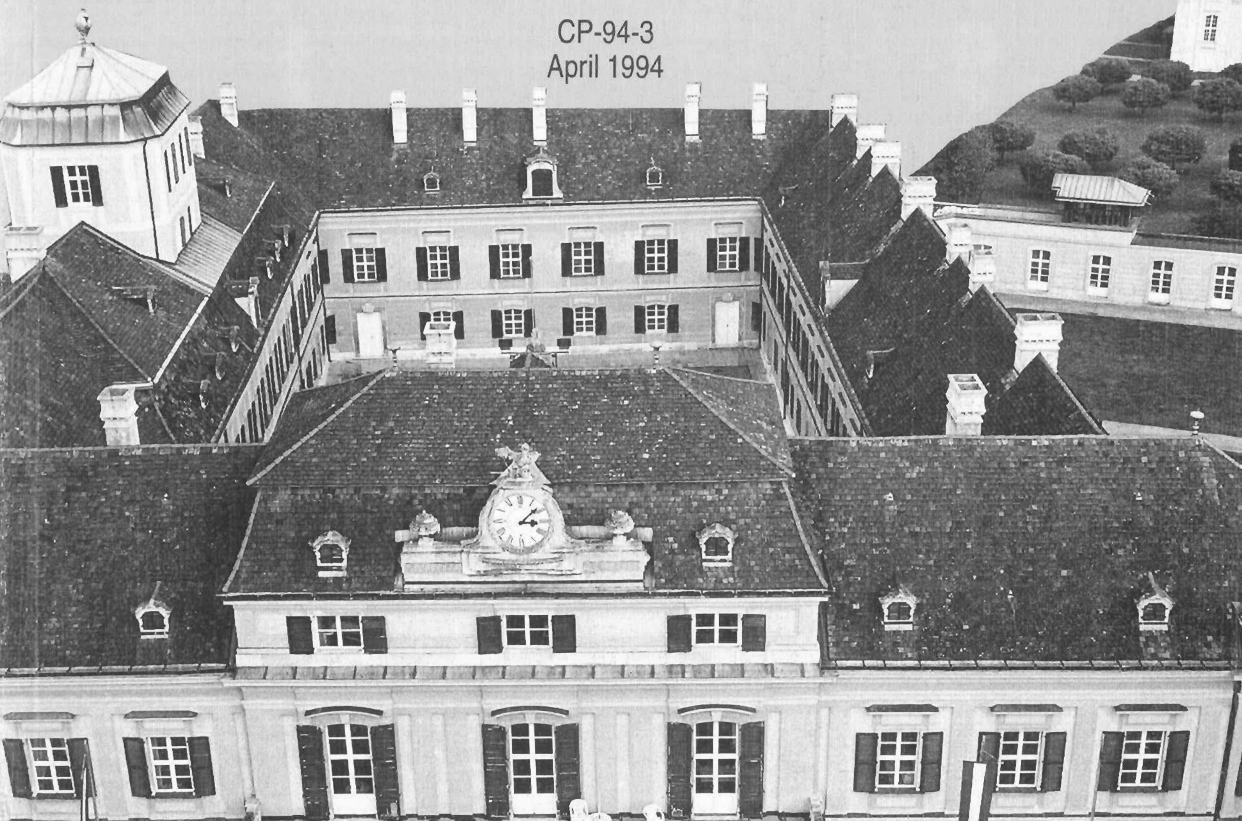
April 1994



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Selected Papers on IIASA's 20th Anniversary

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Discussions and Comments on Selected Papers
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Science and Sustainability

Discussions and Comments on Selected Papers on IIASA's 20th Anniversary

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*The full text of the papers under discussion are included in *Science and Sustainability. Selected Papers on IIASA's 20th Anniversary* available from IIASA.

Introduction

IIASA celebrated its twentieth anniversary on May 12–13 with its fourth general conference, *IIASA '92: An International Conference on the Challenges to Systems Analysis in the Nineties and Beyond.* The conference focused on the relations between environment and development and on studies that integrate the methods and findings of several disciplines. The role of systems analysis, a method especially suited to taking account of the linkages between phenomena and of the hierarchical organization of the natural and social world, was also assessed, taking account of the implications this has for IIASA's research approach and activities.

No phrase that has come out of a conference has had more resonance than "sustainability." It was well chosen, with a suitable measure of ambiguity yet specific enough to ring a bell in most people's minds. In the one word it could claim to summarize the vast literature that took off from Rachel Carson and the Club of Rome. It is positive, where "limits" is for many unacceptably negative. It goes well in combination with other desirable entities, as in "sustainable growth." This latter enables it to appeal to the poor who look to growth, as well as to those better off who focus on the damage that growth causes to the natural environment. To hear "sustainable growth" is reassuring, for it seems to tell us that, in Harvey Brooks' expression, "economic development and protection of the environment are not necessarily in conflict with each other."

Environmental study requires the contributions of a number of disciplines, and its models bring together variables not ordinarily associated with one another. In these regards it exemplifies the ideas of systems analysis. But there are other fields that also bring out those ideas. The pension problem that will soon face every country as it develops, just as it now faces the industrial countries; uncertainty is universal whenever models aer used to illuminate the longterm future; every model faces questions of identification, in its attempt to infer the underlying structure that generates the observed data; that the several world models now extant reach such different conclusions throws light on the difficulty of identification and on the uncertainties of world modeling.

We believe that the papers contained in the first volume, *Science and Sustainability. Selected Papers on IIASA's 20th Anniversary* (IIASA, 1992) dealing with these themes, along with the comments on the papers and the reports of the discussion groups contained in this volume, will at least help clarify difficulties that will always be with us in science as they are in policy making.

Committee for IIASA '92
Nathan Keyfitz (Chair)*

*Members of the Committee for IIASA '92 were: Nathan Keyfitz (Chair), Peter E. de Jánosi, Alexander Kurzhanski, Arkadii Maltsev, Nebojša Nakićenović, Roderick Shaw, Claudia Heilig-Staindl, Evelyn Farkas

PART I

What is Sustainability?

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Harvey Brooks

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Technical University, Vienna, Austria

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Foreword

Amomg public debates of recent decades that between the advocates of economic growth on the one side and of care for the environment on the other stands out for resistence to compromise. In none have the sides taken seemed so irreconsilable, the advocates so unwilling to listen to one another. The word sustainable, as used for instance in "sustainable growth," seems to bridge the gap, but the issue is moe than verbal – no word, however brilliantly chosen, can resolve it.

Harvey Brooks discusses real solutions. He is not in a position to offer one that is definitive – no one is – but at least he tells us how and where to pursue the search for an answer that would go beyond words. He wants to translate sustainability into action, to operationalize it, to say what has to be done, and done now, in order that what is a very general long-term goal can be attained. He is more than ware that once a precise mening is assigned the unanimity falls away and interests and values come into play. The point of his analysis is to show what directions of knowledge suitably applied can lead to the result desired by all, but without using means that would harm or offend any. For the moment these means are not yet to hand, but it is still a step ahead to show their natre. For example if technology shifts far enough in the direction of producing equal satisfaction with less use of materials, the direction spoken of as dematerialization, one can visualize a condition of ecological stability even far into the future.

Until such ideal technology is invented protection of the environment will lower some incomes in comparison with what they would be without protection. Large differences of opinion on what should be done in the way of protection in this period – which could be long – are inevitable. One dares to hope that the sense of community, and the common solicitude for the fragile natural base of our economy, will be strong enough to permit the needed compromises during the transition to an adequately dematerialized way of life. That at least is how we interpret Professor Brooks' message.

Committee for IIASA '92

Discussion

Fritz Paschke

Peter de Jánosi made a mistake when he asked me to be a discussant for the subject. Firstly because my knowledge is concentrated on technology and my experience is limited to engineering; secondly, wherever I do have experience, there is more agreement with Brooks than controversy or severe doubts. On the other hand, when reading or listening to Brooks' stimulating account, associations arise which may be worth communicating. I shall limit my comments to

- a remark on the definition of sustainability;
- a deliberation on technology assessment and
- reflections on values applied by an engineer in practice.

1 Sustainability

The satisfaction of human demands of the present generation without decreasing opportunities for future generations is considered a wise and practical combination. Take, as an example, the automobile. Every economic assessment shows that the automobile is an indispensable product and cannot be replaced at present by anything without serious problems. At the same time, there is no doubt that the operation of large numbers of automobiles leads to severe contamination of the atmosphere. In an optimistic view, which I personally share, the key technologies of the closing century may cut a path toward sustainability:

- Microelectronics lead to better engine control.
- Material synthesis, analysis, and treatment enable safe and low-weight designs with almost total recycling.

- Energy technologies are improved by computer simulation and similar methods allowing the operation of a 100 horsepower diesel engine with a consumption of about 4 liters per 100 km and very low contaminants in the exhaust gas.
- Even biotechnology may contribute something through alternative fuel production.

These. accomplishments are possible without considering radical changes, such as the introduction of electrically powered engines.

The example of the automobile – among many others – leads me to argue against a distinction between "old" and "new" technologies. There is no old branch of products closed to pervasion by new technologies. To stay in the field of traffic: just think of the progress of railway systems caused by new technologies!

2 Technology Assessment

Technology assessment plays a key role in achieving sustainability. To assess a new technology in order to secure controllability, the dynamics of the innovative process have to be considered.

In a grossly simplified view, four phases of development may be distinguished (*Figure 1*). Basic research is knowledge-oriented and may lead to a scientific discovery, which stimulates a mode of research which is typical for our century, a function-oriented scientific task which I call forefield research. It aims to derive economic advantage from a scientific discovery: the target is an invention, a product idea which is subsequently followed by product development with clear specifications for product performance and cost. Finally product transfer to a pilot production has to be accomplished. It is well known that expenditures rise sharply with approximation to the market, while the times available to perform shrink. What has this to do with technology assessment? The ability to control, in a gross approach, is a product of the ability to assess the development and the ability to reverse the process of development. Controllability is proportional to assessability times reversibility. As indicated in *Figure 2*, assessability rises from zero in the phase of basic research to 100% in production, while due to economic and social constraints, reversibility shrinks from 100%

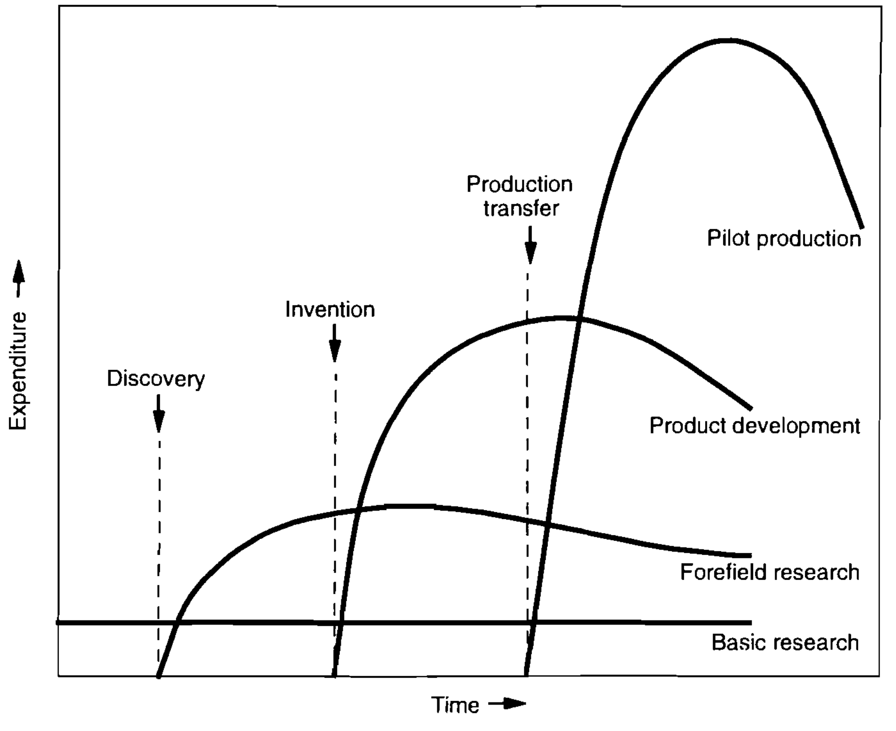


Figure 1. Creation and development of a modern product.

in basic research to zero in production: controllability apparently shows a maximum in the phase of forefield research. Now, here again I present an oversimplified view, chosen, of course, for the sake of argument and to emphasize my conviction that technology assessment has to be integrated in the innovative process and is a prerequisite of sustainability.

3 Values

Values are as important to engineering work as they are difficult to implement in practice. It depends on the degrees of freedom enjoyed by the engineer; in industry, economic survival plays such a dominant role that proper political decisions have to be imposed to secure progress toward sustainability. Take again the example of

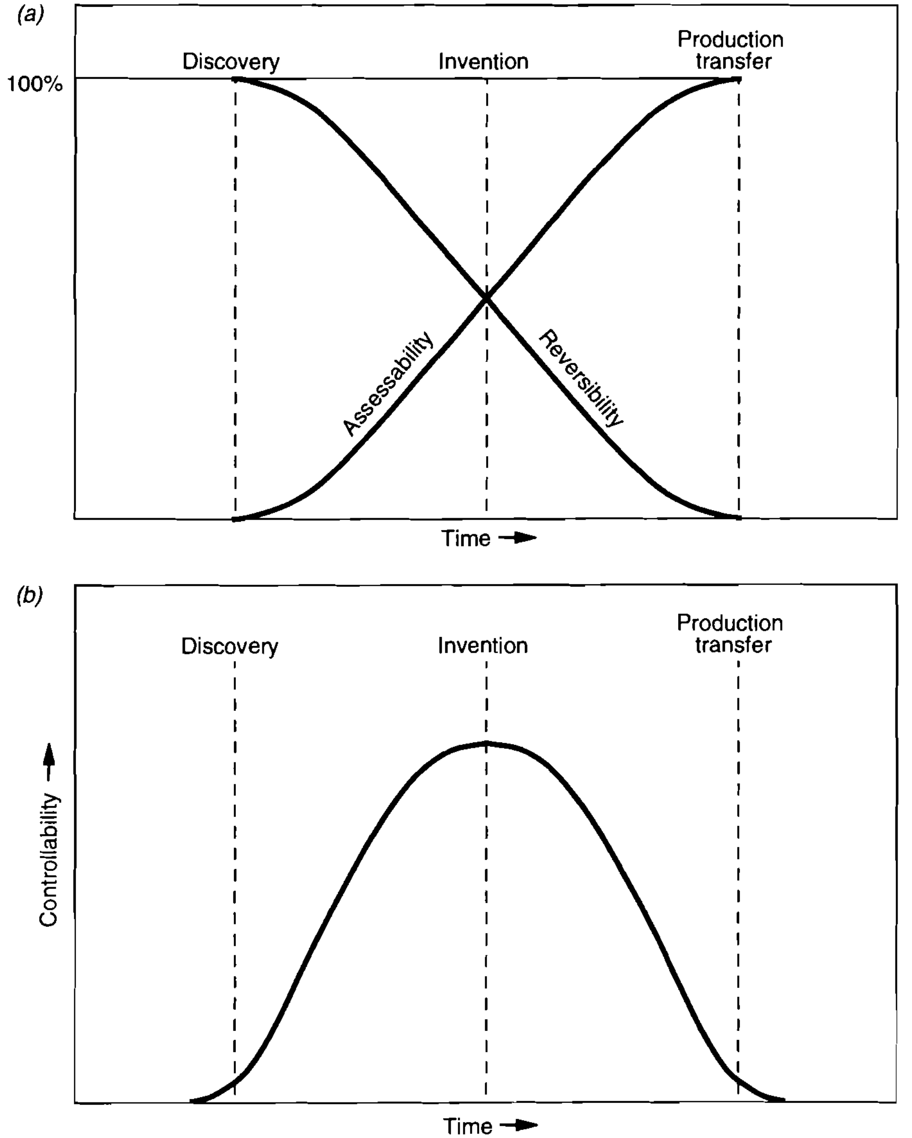


Figure 2. Assessability and reversibility of development (upper part). Controllability is proportional to assessability times reversibility (lower part).

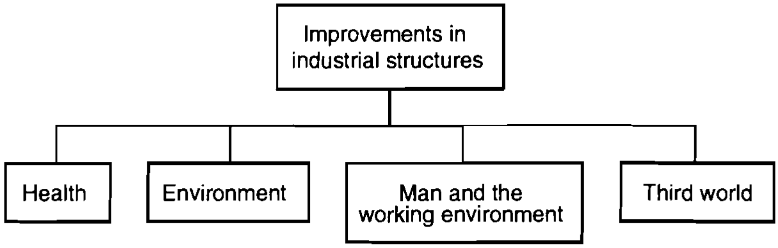


Figure 3. Priorities.

the automobile: the catalytic converter was considered an excellent product for the limitation of air pollution long before laws had to be introduced to enforce its use. Or take the silent but less powerful trucks which are imposed on industry by the Austrian Government through the Transfer Treaty with the EC – it is not a technological problem at all, but rather a socio-economic task which calls for political action.

At the university, academic freedom allows a more direct approach toward sustainability. In the case of the institute which I head, we distinguish between two levels of priorities (*Figure 3*). Top priority is allocated to projects which promise an improvement in European economic structures, particularly in Austria, and which do not collide with priorities on the lower level. These priorities are: health, environment, adaptation of the working environment to man and balance between developed and underdeveloped regions. I hasten to say that success in the various priorities depends on the quality of ideas, which are unforeseeable (the "positive surprises" of Brooks) and can only be stimulated but not planned. Consequently, our record of success does not follow priorities, but engineers willingly believe in Dante's advice:

'Wisdom follows action.'

Sustainable Development: A Guiding Principle in Search of Operationalization

Bert de Vries

Abstract

The present scientific ambiguity in the concept of sustainable development should not be eliminated. It ensures that the paradigmatic embedding of the concept is not lost. Scientific operationalization should focus on the formulation of sustainability indicators which are linked by meta-models in an appropriate network of activity-stress-impact chains. Simulation-gaming offers the prospect of providing a socio-political context for learning, communicating and exploring sustainable futures on the basis of existing scientific insights.

4 Sustainable Development and its Necessary Embedding in Paradigms

Since the 1970s the concept of sustainability has emerged as a way to organize a variety of thoughts and actions which represent the widespread feeling that humankind is over-exploiting the earth to the detriment of itself and other living beings. Originating from nature conservation movements and ecologists, the concept became politicized by the World Commission on Environment and Development which postulated an explicit link between [un]sustainability and poverty (WCED, 1987). Sustainable development has now become the catchword for the future. At present sustainable development mainly functions as a *guiding principle*, not unlike the Declaration of Human Rights, as is clearly demonstrated, for instance, in the formulation of the Earth Charter.

Many people rightly insist that the concept should be operationalized in such a way that indicators can be constructed to design and implement strategies for sustainable development, with the support of scientific facts and models. Yet, we should beware of killing the fertile richness and ambiguity of the concept by the prevailing scientific reductionism. Such attempts, if successful, would eliminate or obscure the fact that a concept like sustainable development necessarily incorporates an underlying world view (paradigm, perspective) and value spectrum. Without suggesting that it can or should fill the emptiness after Nietzsche's "Gott ist tot" or Fukuyama's "end of ideology", I like to emphasize its exploratory and heuristic value in trying to deal in new ways with old as well as new problems.[1]

The paradigmatic background of the concept of sustainable development has been evident from its inception (see, e.g., Coomer, 1981). Naess (1973) introduced "deep ecology" to contrast it with the reductionist science of ecology – "shallow ecology". O'Riordan (O'Riordan and Turner, 1979) distinguished between technocentric and ecocentric attitude toward nature. Bookchin (1982) introduced "social ecology" to link anarchism and ecology, challenging the established interpretation of environmental problems within the framework of neo-classical economics. Various authors have explored Buddhist and other spiritual views of nature as an ingredient of sustainability (see, e.g., Chaitanya, 1983). A thoughtful and integrative discussion is given in the IIASA book, *Sustainable Development of the Biosphere* (Clark and Munn, 1986).

Several *classifications of paradigms* have been proposed in the context of sustainable development – more or less explicitly rooted in earlier works of philosophy and the social sciences. *Figure 1* gives a brief characterization of four perspectives which can be distinguished with respect to sustainable development (de Vries, 1989).

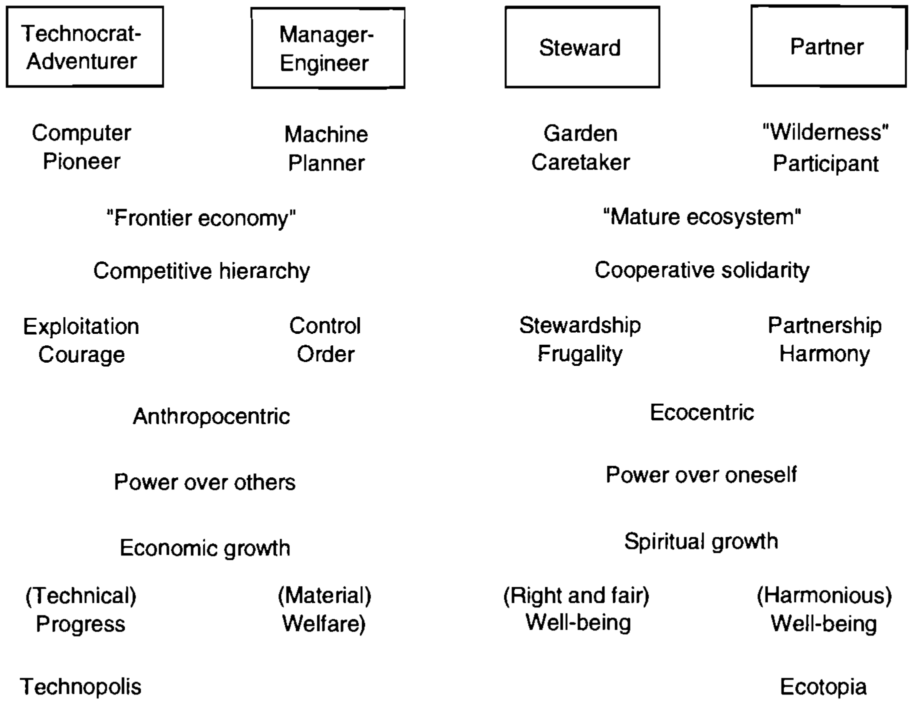


Figure 1. Brief characterization of four perspectives on sustainable development.

On the one hand is the view that the quest for sustainable development is to be understood as constraints on man's longing for material well-being and outer adventure. If an issue at all, the focus is on exploring new frontiers and on new technologies. On the other hand, the emphasis is on man as an integral part of his natural environment, and in innumerable and partly unknown ways interacting with Nature. The quest for sustainable development, then, is one of frugality, inner adventure, and appropriate technology. Colby (1990) has proposed a similar classification. He distinguishes four paradigms: frontier economics, environmental protection, resource management, eco-development, and deep ecology, and suggests that a gradual shift is taking place away from frontier economics toward more ecologically inspired world views.

Since its inception by environmentalists and ecologists, the concept has been increasingly researched by economic and social scientists. An interesting contribution has been made by Thompson *et al.* (1990) with what they call the "cultural theory". It combines the anthropological insights from, among others, Douglas (1982) with the ecological knowledge as expressed by, among others, Holling (1986). Societies, it is argued, can be characterized along two axes: group and grid. The group axis is a measure of the degree to which individuals are behaving and feeling themselves part of a larger group of individuals with whom they share values and beliefs. The grid axis indicates the extent to which individuals are subjected to role prescriptions within a larger structural entity. The group-grid characterization offers four different contexts from which people perceive the world and behave in it: the hierarchist, the individualist, the egalitarian and the fatalist (and the hermit who, however, isn't in the game). *Figure 2* is an attempt to visualize the view of Nature within each perspective. Whereas the hierarchist focuses on control and expertise to manage a world of stability-within-limits, the individualist imagines himself in a world of inherent stability and abundance. The egalitarian emphasizes the fragility of Nature; fatalists experience the world as governed by chance.[2]

There are signs that economic science is again broadening its view beyond the free-market ideology. The Central Planning Bureau (CPB) in the Netherlands introduced long-term scenarios which distinguish between the equilibrium, the coordination, and the free-market perspectives – in remarkable isomorphism with some of the previous classifications (CPB, 1992).

It is necessary to keep the paradigmatic background an integral part of the search for a more sustainable world. It serves to give appreciation to the role of various [sub]cultures in the debate, e.g., between the countries of the North and the South and between ecologists and economists.[3] It can also provide a socio-cultural context for decision-making and negotiation processes. Of course, one should bear in mind that people seldomly express these paradigms in their extreme form – nor should one give in to the temptation to caricature other people accordingly.[4]

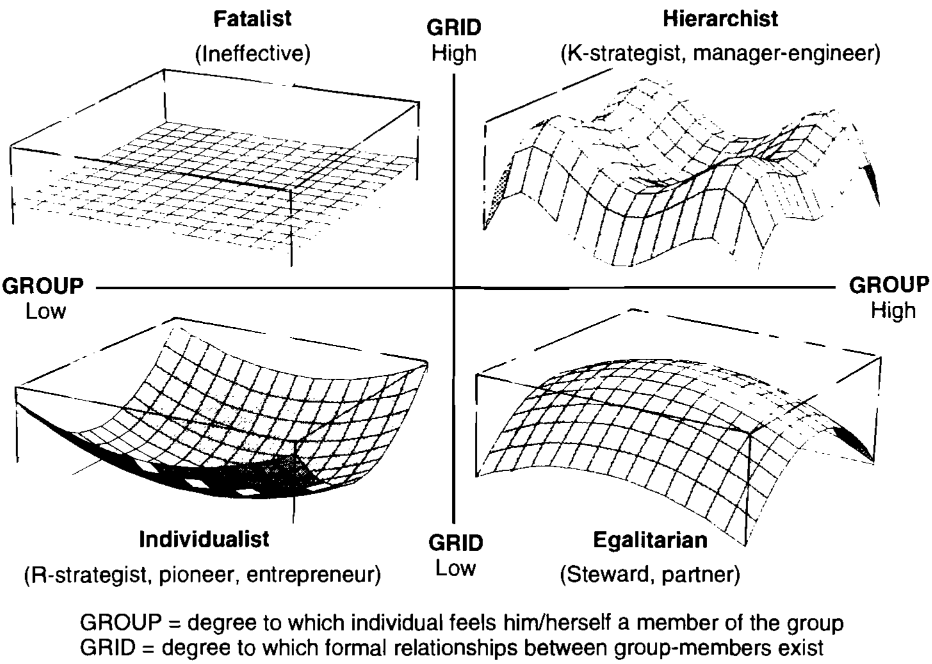
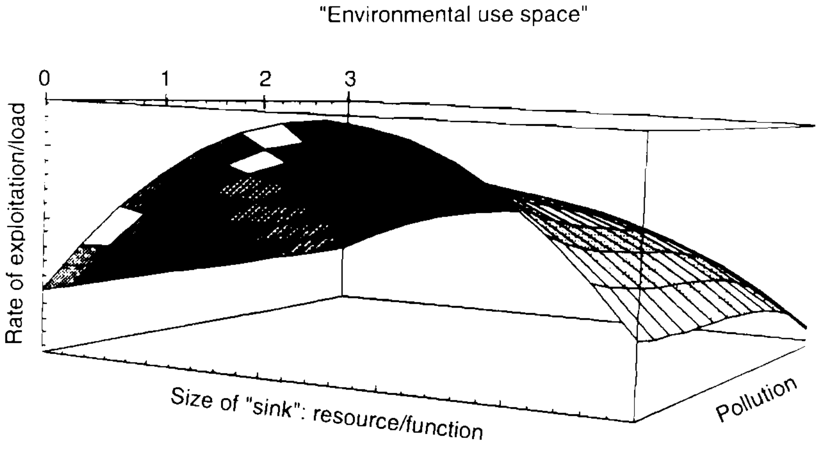


Figure 2. Four ways to perceive Nature (after Thompson *et al.*, 1990).

5 Operationalizing Sustainable Development: Indicators

With this statement, it is evident that the scientific community should strive for scientifically sound and politically relevant operationalization of the concept of sustainable development. Quite a few attempts have been made over the past years (see, e.g., de Vries and de Greef, 1991). Most of them are more appropriate in communicating basic principles than in providing a scientific framework. For example, Daly's three principles of sustainability can be graphically represented as shown in *Figure 3*.[5] Using the standard model for renewable resource exploitation and hypothesizing some relationship between natural growth rate and the level of pollutants, the "environmental use space" suggests a downward sloping cave in



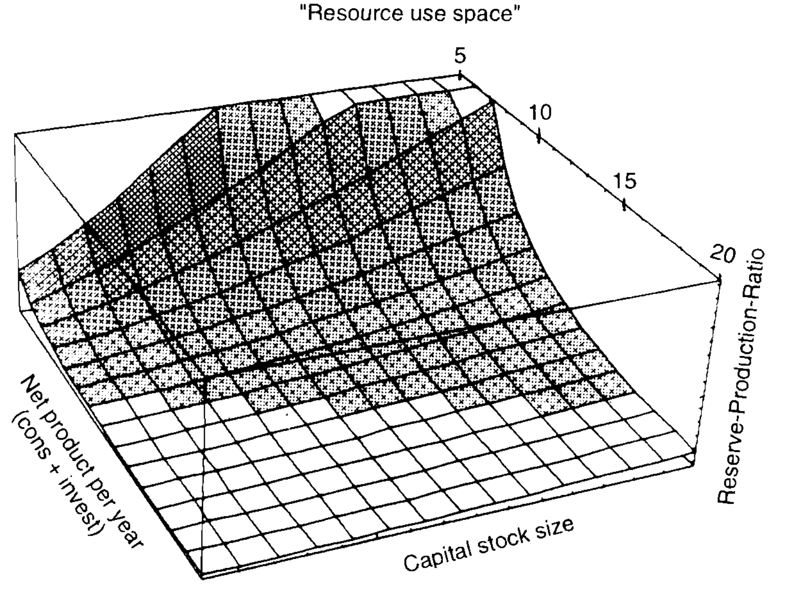


Figure 3. The upper figure shows how the exploitation domain of a renewable resource is diminished by pollution, according to a simple renewable resource model. The lower graph shows how the useful lifetime of a stock of non-renewable resources varies with different levels of consumption and capital, according to a simple economic growth model.

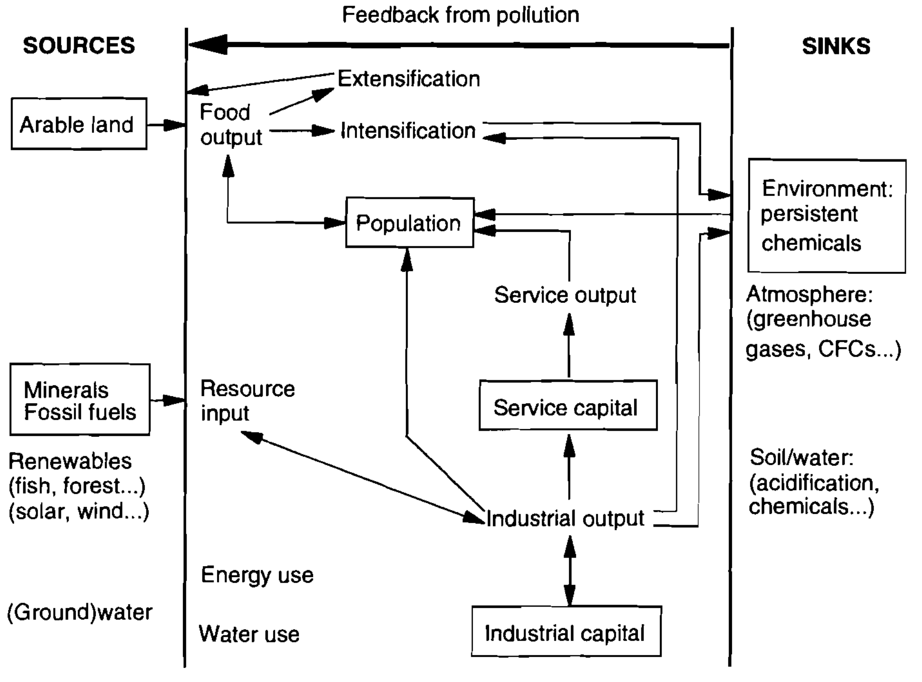


Figure 4. Overview of the World3-model as used in *Beyond the Limits* (Meadows *et al.*, 1992). Italics indicate the areas to be include in the model extension presently under way.

which a ceiling, not the sky, is the limit (Opschoor, 1989). Using the standard model for economic growth, one can picture in a similar fashion a "resource use space". The reserve-production ratio (RPR) of a fixed amount of non-renewable resource is a function of welfare (equated to the flow of consumption and investment) and capital stock. If resource conservation takes place by substituting resource use for capital, the RPR increases at a given welfare level.

A more comprehensive framework is the World3-model which has been presented in the book *Limits to Growth* (Meadows *et al.*, 1972) and its recent update *Beyond the Limits* (Meadows *et al.*, 1992). Despite its simplifications and global aggregation level, the World3-model still provides an integrated representation of the global population-economy-environment system within the source-sink constraints set by the planet's physical limits (*Figure 4*).

Sustainability should be approached both from the sink and the source side. A promising approach is to construct *networks of indicators* along the chain of activities (or causes) to stress to impacts (or effects). The various indicators should be linked by meta-models which in a transparent and scientifically valid way represent their interrelationships. Starting at the sinks – "downstream" – with impact indicators, targets have to be formulated which reflect a desirable future in terms of sustainability. The recently published *National Environmental Outlook for The Netherlands* (RIVM, 1992) has made some attempts along these lines.[6] So one of the issues to confront is the nature of the "sustainable state": should it be like the "unperturbed" state of sixty years ago (as proposed for species abundance) or like what it was before pollutants entered the environment (as with the pre-discovery level of chloride in the stratosphere)? Can it be based on the engineering concept of steady-state mass fluxes? Should we use some categorical imperative based on ethical considerations (as proposed for Antarctica and biodiversity) or introduce more anthropocentric notions such as restoration costs and degree of irreversibility (as is discussed with regard to landfills for solid waste)? Clearly, we are back here in the realm of values – for which scientific facts and models are no substitute.

Once some sustainable state in terms of a desirable and feasible future has been formulated, one can anticipate the environmental consequences of "stress" scenarios over the relevant time-span, e.g., of greenhouse gas emissions over the next century. Undoubtedly, the resulting "impact" scenarios will be clouded by uncertainties – yet, it appears to be simply a necessity to do the best we can. Within the Steward perspective it is a moral duty, within the hierarchist paradigm it is a liability to do so. Based on the sustainable state formulation and the inclusion of uncertainty and risk aspects, scientists should derive target time-paths for more measurable and tangible indicators, e.g., greenhouse gas concentrations and emissions. These, in turn, can be translated into policies with regard to technological development, resource pricing and the like.

"Upstream", at the source side, sustainability is concerned with [over]exploitation of renewable resources like soil, fish, groundwater, forest, and with depletion of non-renewable resources such as fossil fuels and mineral ores. Here, too, yardsticks for sustainability have been proposed. Some argue in favor of a fixed RPR, others use sophisticated mathematical optimization techniques. The "sink" and the "source" approaches have to be integrated for a final set of aggregate sustainability indicators. The relative importance of sink versus source considerations will probably change over time and differ from region to region.

There are many examples of this approach. Recently, the various stocks and flows of cadmium in the Netherlands have been represented in a dynamic simulation model (Gilbert and Feenstra, 1992). Various policies have been assessed and the future system states have been aggregated into two sustainability indicators. One is the net in–c.q. outflow of the metal, reflecting the materials-balance approach in which sustainability is associated with a steady-state. The other is the degree to which accumulation of the metal in the soil exceeds the official standard, linking sustainability to health- and risk-related considerations.[7]

Another example is *global warming*. Ecologists have tentatively suggested trying to achieve a rate limit of 0.1°C per decade and an absolute limit of 2°C increase for the global average surface temperature to avoid major risks resulting from climate change. The temperature increase to be expected on the basis of the IMAGE-model for the four emission-scenarios outlined by the IPCC Working Group 3 are shown in *Figure 5*. The Business-as-Usual scenario leads the world around the year 2035 into the high-risk area; the scenario with the most stringent emission reductions (Accelerated Policies) will enter the low-risk area around the same year. To reduce the risk as soon as possible would require even more drastic cuts in greenhouse gas emissions, as is indicated by the Low-Risk scenario. If the world community is able to agree on an acceptable risk, the technical and economic instruments to realize such a path have to be designed. Science should provide the public and the policy-makers with yardsticks such as the ones in *Figure 5* with which to measure progress toward a more sustainable development path.

The case of global warming is an interesting one. Much progress has been made in research as well as in formulating issues. Now that

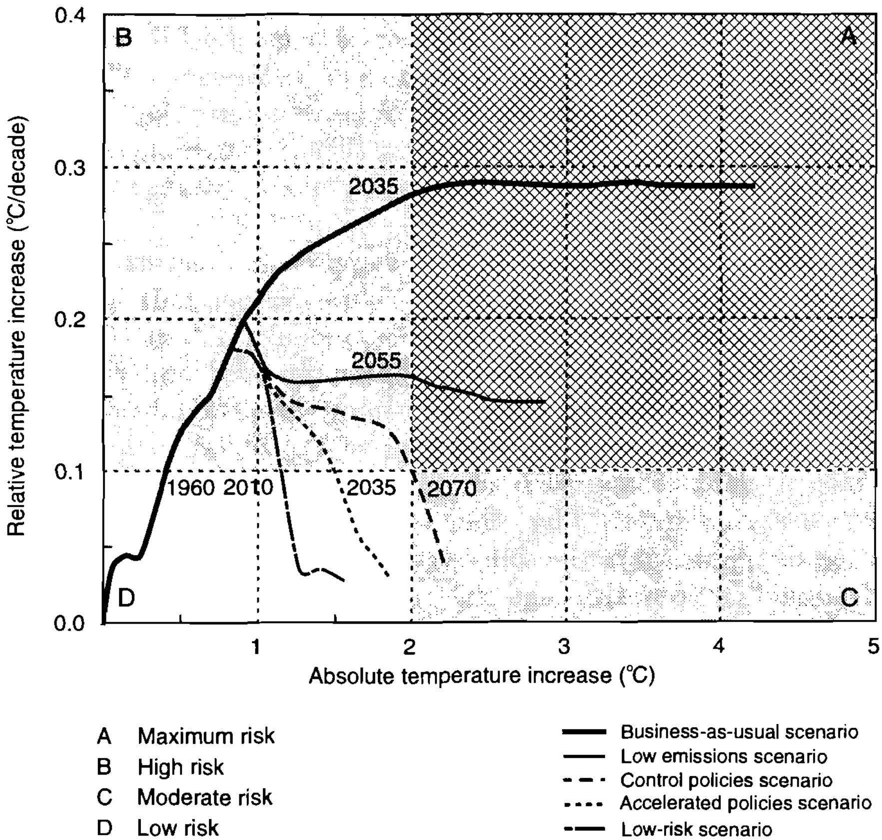


Figure 5. Pathways of the IPCC scenarios in the space of anticipated relative and absolute change in average global surface temperature.

many governments are in favor of taking action, it is becoming clear that proper understanding of social and economic dynamics is lacking. Major efforts are needed now to extend and integrate insights from the social sciences. Which kinds of "laws" could be used to represent the dynamics of technological and infrastructural change (cf., Chapman and Roberts, 1983; Grübler and Nakićenović, 1991)? What are the micro- and macro-economic impacts of drastic energy price increases? In which ways can the developments in "life-style" be brought to agree with the exigencies of a finite earth? And in what ways can the various political and institutional arrangements be made more appropriate for the task of facing these new global challenges?

Some caveats are necessary if we are to design and use sustainability indicators such as the ones in *Figure 5*. First, they have to be re-assessed and renegotiated as new scientific evidence appears and performance with regard to other developments and environmental targets can be appraised. The key point here is, it seems, the degree to which a fair and widely accepted emission management regime can be agreed upon and implemented by the members of the world community. The second UNCED/Conference in Brazil was indicative of the difficulties to be overcome.

Secondly, the process of re-assessment and renegotiation needs some firm commitments for, e.g., the next five or ten years. Only then will the parties involved resist the temptation to come up with ever new arguments in favor of more or less stringent targets – which might do further damage to the reputation of politicians not doing anything about the problem at all.

Thirdly, one should keep in mind that one or two indicators for organizing the policy-making process may be dangerous in themselves. For instance, global average surface temperature change conceals regional impacts, extreme-events frequency distributions, and links with other environmental stressors, to name a few. This brings me to the last consideration: a plea for an exploratory and adaptive approach to management for a sustainable future.

6 Learning About Sustainability: Exercises in Planning for an Uncertain Future

From the previous paragraphs it will be clear that I favor an open-minded, exploratory and heuristic approach to what is referred to as sustainable development or sustainability. One argument for this is that mankind is facing a world which is at once speeding up and becoming more complex, largely due to its own dynamics. Anticipating the future in such a world is increasingly difficult and tedious, and to some – and possibly increasing – extent impossible. Here, too, exists a limit which is receding from one perspective (data

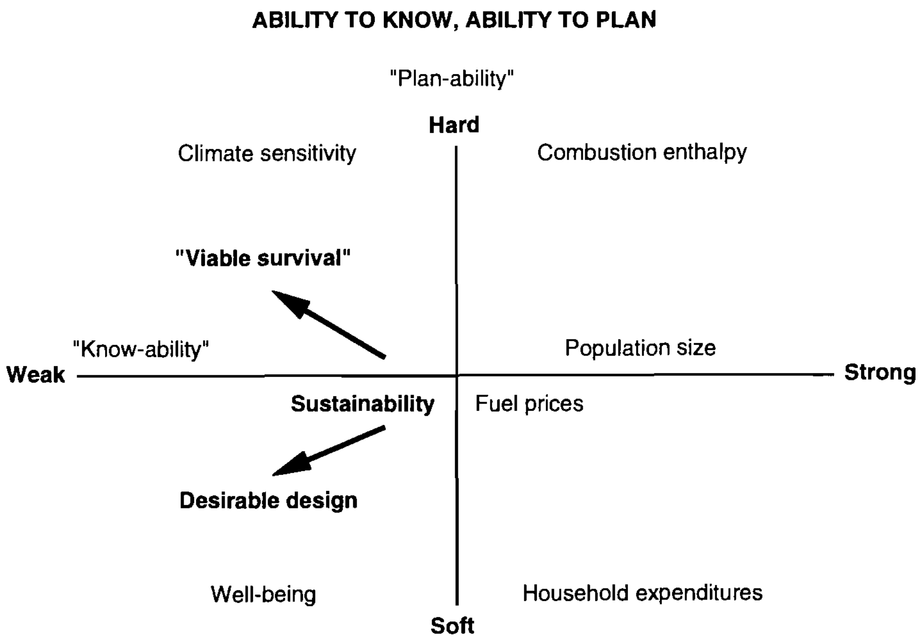


Figure 6. Schematic way to characterize model variables. The axis strong–weak indicates the degree to which a [sub]system can be known. The axis hard–soft measure the degree to which a [sub]system is amenable to manipulation and control.

availability and processing, for example) but is coming nearer from another perspective (timely understanding of the consequences of our own actions, for example).

One may visualize this limit along two axes which I call *know-ability* and *plan-ability* (*Figure 6*). The axis strong–weak represents the degree to which the object of study can be known in the sense of logical empiricism, the prevailing paradigm within the natural and engineering sciences. On the one hand, there is much strong knowledge of physical-chemical systems which can be analyzed in the isolated environment of laboratory experiments. On the other hand, many systems which are of interest from an environmental point of view or many living entities like ecosystems, economic and social systems cannot, or not satisfactorily, be subjected to repeated experimentation. The concept of sustainable development covers many phenomena of which our knowledge will inherently be weak. Both scientists and the public have to learn to deal with this fact.[8] The other axis, hard–soft, represents the degree to which [parts of] the object of study can be manipulated and controlled for planning purposes. It is often related to the strong–weak axis and any judgment on soft versus hard depends on personal experience – which is often difficult to express in formal models.

In such a generalization, the extremes are most easy to distinguish. Statements about the combustion enthalpy of coal can be strong and hard for a given system boundary. Estimates of climate-sensitivity with regard to increasing greenhouse gas concentrations will be weak and hard. Propositions about a person's well-being are relatively weak and soft. Information about fuel prices is in between: some actors may rightly think they have strong insights and great influence on fuel prices within their realms of control.

There are some interesting corollaries with the previously discussed paradigms. The hierarchist tends to appreciate and rely on strong knowledge about hard variables, reflecting "official realism" with emphasis on expertise and control. The fatalist will perceive a large part of his environment as hard and weak – if interested in knowledge at all. Egalitarians, inspired by their ideals, often tend to overestimate the degree to which society can be managed – the softness of culture: they emphasize the weakness of our knowledge of Nature. The individualistic pioneer/entrepreneur may well see himself, with some disdain for scientific knowledge, as a hero who can soften the hardest rock.

Within this framework, the quest for an operational definition of sustainable development can take several directions. One is to interpret it as the search for viable survival routes for humanity – the hard edges of a world which can be only partially known. Another is to look for desirable designs for the future – a mix of culture and nature which preserves the best of both worlds (cf. *Figure 6*).

In this situation the combination of game-theoretic insights and experiences and the availability of ever faster computers provides a new tool to explore strategies for a [more] sustainable world: simulation-gaming. Depending on whether the emphasis is on the computer model or on the game-elements, one also speaks of interactive simulation, policy exercises, strategic planning exercises, etc. In essence, a context for social learning and decision-making is constructed around a core of relatively strong models simulating relatively hard parts of reality. This provides the participants with ways to explore the relatively weak and soft manageable parts of strategies to guide a country along a sustainable development path, to confront fishermen with the tragedy of the commons (Meadows, 1990) or to formulate an acceptable electricity policy in terms of costs, reliability and environmental damage (de Vries *et al.*, 1991).

Sustainability is not something to be ordered from above. It is a slow and difficult restructuring process, in which present ways of thinking and behaving have to evolve into new and as yet largely unknown directions. It is essential to communicate the scientific findings about environmental developments, at the global, the regional and the local levels, to as large an audience as possible. Simulation-games have proven to be extremely helpful in teaching few but basic lessons; new multi-media techniques will further enhance these possibilities. Based on personal experience, I expect and hope that simulation-gaming will develop into a most useful tool to explore and communicate these new directions. Among its great merits are:

- It allows non-experts to come to a broader, dynamic understanding of what science can tell – and not tell – about the problems at hand.
- It provides a learning environment in which mistakes can be made, ignorance can be tolerated, risks can be taken – that is, a laboratory.
- It calls for personal involvement both in the sense of learning and communicating insights and for expressing and sharing values.

One may hope that these new tools will be helpful in transcending the deadlocks due to the strict separations between the expert and the decision-maker/layman or between the natural and the social scientist. It also invites participants to go beyond mere intellectual efforts, making it more of a whole as well as a healing experience.

Notes

[1] This in apparent contrast to Brooks' feeling that "...the term has a ring of scientific objectivity which can serve to legitimize various personal or group political agendas, overt or hidden, and thus has a rhetorical value in public discussions which is not matched by its operational usefulness" (Brooks, 1992, p. 2). To me, it seems, such a tension is unavoidable – as is evident for instance from the discussions about the concept of the free market.

[2] Thompson *et al.* argue that these four paradigms are dynamically interacting on the basis of surprise experiences and that none of them can exist without the other three.

[3] As illustrated by Keyfitz, for example, in the observation that "The notion of carrying capacity is congenial to natural scientists and an irritation to social scientists" (Keyfitz, 1991, p. 5). For paradigms and the role of science, see Jasanoff (1992).

[4] Brooks (Brooks and Johnson, 1991) rightly asks some critical questions about a classification like the one proposed by Thompson *et al.* Yet, he acknowledges that this "[provocative characterization] ... initially based on other areas of risk management such as nuclear power ... has a great deal of explanatory value [for the genetic engineering debate]" (p. 269).

[5] These principles are (Daly and Cobb, 1989):

- We should not exploit renewable resources beyond their natural rate of regeneration;
- We should not exploit non-renewable resources beyond the rate at which renewable substitutes are made available;
- We should not burden environmental resources with pollutants at a higher rate than they are capable to assimilate them.

[6] It will be evident that such an approach to the future is quite a nuisance to people who adhere to the Pioneer/Entrepreneur paradigm "pur sang".

[7] *Cf.* the critical loads approach to deposition of acidifying compounds (Hettelingh *et al.*, 1991).

[8] This may seem untrue for the ever larger part of our world which is artificial in the sense of man-designed and man-made. However, here, too, complexity has its price and these artefacts are still submerged into the much larger planetary flows of energy and materials.

References

Bookchin, M., 1982, *The Ecology of Freedom*, Cheshire Books, Palo Alto, California, USA.

Brooks, H., 1992, Sustainability and Technology, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Brooks, H., and Johnson, R.B., 1991, Comments: Public Policy Issues, in B.D. Davis, ed., *The Genetic Revolution*, John Hopkins University Press, Baltimore, MD, USA.

Chaitanya, K., 1983, A Profounder Ecology – The Hindu View of Man and Nature, *The Ecologist* **13**:127–135.

Chapman, P., and Roberts, F., 1983, *Metal Resources and Energy*, Butterworths Monographs in Materials, London, UK.

Clark, W.C., and Munn, R.E., eds., 1986, *Sustainable Development of the Biosphere*, Cambridge University Press, Cambridge, UK.

Colby, M., 1990, *Ecology, Economics and Social Systems*, Ph.D. Thesis, University of Pennsylvania, Philadelphia, USA.

Coomer, J.C., ed., 1981, *Quest for a Sustainable Society*, Pergamon Press, Oxford, UK.

CPB (Centraal Plan Bureau), 1992, *Scanning the Future*, The Hague, The Netherlands.

Daly, H., and Cobb, J., 1989, *For the Common Good*, Beacon Press, Boston, USA.

Douglas, M., ed., 1982, *Essays in the Sociology of Perception*, Routledge and Kegan Paul, London, UK.

den Elzen, M.G.J., Jansen, M.A., Rotmans, J., Swart, R.J., and de Vries, H.J.M., 1992, *Allocating Constrained Global Carbon Budgets*, RIVM Report 222901011, Bilthoven, The Netherlands.

Gilbert, A., and Feenstra, J., 1992, *An Indicator of Sustainable Development – Dispersion of Cadmium*, IvM Free University Report R-92/06, February, Amsterdam, The Netherlands.

Grübler, A., and Nakićenović, N., 1991, *Evolution of Transport Systems: Past and Future*, RR-91-8, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Hettelingh, J-P., Downing, R., and de Smet, P., eds., 1991, *Mapping Critical Loads for Europe*, RIVM Report 259101001, Bilthoven, The Netherlands.

Holling, C.S., 1986, *The Resilience of Terrestrial Ecosystems: Local Surprise and Global Change*, in W.C. Clark and R.E. Munn, eds., *Sustainable Development of the Biosphere*, Cambridge University Press, Cambridge, UK.

Jasanoff, S., 1992, Pluralism and Convergence in International Science Policy, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Keyfitz, N., 1991, *From Malthus to Sustainable Growth*, WP-91-23, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Meadows, D.H., Meadows, D.L., Randers, J., and Behrens, W.W. III, 1972, *The Limits to Growth*, Universe Books, New York, USA.

Meadows, D.L., 1990, *User's Manuals for Strategem-I and Fish Banks Ltd.*, Institute for Policy and Social Science Research, University of New Hampshire, USA.

Meadows, D.H., Meadows D.L., and Randers, J., 1992, *Beyond the Limits*, Earthscan Publications Ltd., London, UK.

Naess, A., 1973, *The Shallow and the Deep, Long Range Ecology Movement*, Inquiry 16(1973)95–100.

Opschoor, H., 1989, *Na ons geen zondvloed – voorwaarden voor duurzaam milieugebruik* (in Dutch), Kok Agora, Kampen, The Netherlands.

O'Riordan, T., and Turner, R.K., eds., 1979, *An Annotated Reader in Environmental Planning and Management*, Pergamon Press, Oxford, UK.

RIVM (National Institute of Public Health and Environmental Protection), 1992, *National Environmental Outlook 1990–2010*, Bilthoven, The Netherlands.

Thompson, M., Ellis, R., and Wildavsky, A., 1990, *Cultural Theory*, Westview Press, Boulder, Colorado, USA.

de Vries, H.J.M., 1989, *Sustainable Resource Use – An Enquiry into Modelling and Planning*, Ph.D. Thesis, University of Groningen, The Netherlands.

de Vries, H.J.M., Dijk, D., and Benders, R., 1991, *PoerPlan – An Interactive Simulation Model about Electric Power Planning*, IVEM Groningen, The Netherlands.

de Vries, H.J.M., and de Greef, J., 1991, *Sustainable Development as a Framework for Environmental Policy* (in Dutch), RIVM Report 481501001, Bilthoven, The Netherlands.

WCED (World Commission on Environment and Development) 1987, *Our Common Future*, Oxford University Press, Oxford, UK.

Sustainable Underdevelopment: Commentary on Unresolved Issues

Sven B. Lundstedt

It should come as little surprise that benefit–cost structures and procedures to implement them are to be found everywhere. An especially unique and complicated form of benefit–cost structure exists in the critical trade-offs between economic development and global ecological balance in the environment. We usually cannot have it both, or all, ways for very long in any program of economic development and reform without redressing this imbalance. This apparent fact of life suggests that "sustainable development", as defined by Harvey Brooks in his excellent analysis (Brooks, 1992, pp. 29–59), will remain difficult to define and difficult to achieve in practice.

We may reasonably assume that useful economic productivity in one economic system will always have some negative systemic spill-over effects leading to associated costs appearing in others. Given the complicated interrelationships and interdependencies known to exist between the different parts of any economy, fully industrialized or developing, these forms of complexity present serious management problems. However, not all second, or third-order effects from an industrializing economy are necessarily negative. There are also unanticipated good side effects that occur from time to time. I want to draw attention to the need for better understanding of the dynamics of both positive and negative spill-over effects in any given case. The traditional idea of costs has to be significantly enlarged to be included in even seemingly difficult to measure costs such as human suffering.

The beloved automobile is an especially interesting example of a technology with an increasing negative to positive ratio of primary to secondary, and tertiary, systems spill-over effects. Automobiles and other gas driven vehicles such as trucks and buses increasingly seem to create, in the short and long term, greater and greater physical, biochemical, social, financial and even psychological costs. At least for the next decade no practical alternative to the internal combustion engine has proven itself widely cost-effective, although other fuels and engines are being widely studied. Because of the adverse physical and economic power of this unique transportation invention many essential world systems are now at risk, including the atmosphere itself. Their sustainability, by any definition, is certainly in question.

Worldwide energy production systems for heating and industrial production are also other examples of complex systems of critical benefit–cost trade-offs. The way things are going it may be impossible, in the near future, to achieve lower cost sustainability by keeping critical environmental and ecological systems stable in order to achieve some form of overall systemic balance, without incurring serious political, monetary, technological, biological and social costs.

It would be utopian, indeed, to expect to achieve truly balanced "sustainable development" in any case, given the present choice of fuels. *Ideal* levels of sustainable development are impossible to achieve, as well as impractical. I suggest that we may eventually need to develop another kind of "impossibility theorem" similar to Arrow's critical logical decision analysis in name only (it would at least have to agree with Arrow's "impossibility theorem" to the extent that social agreements jointly decided cannot be determined by logic alone and require value choices) (Arrow, 1951). That is, it has to be a realistic alternative to the idea of an endless development in the form of a cornucopia, which is often based on dangerously naive expectations of what can be, or even should be, delivered in comparison to development models based on economies in the West. We need to begin, also, to understand the ubiquity of economic suffering often created by unrealistic expectations and foolhardy utopianism.

Economic development, therefore, has to develop an idea of *least painful sustainable underdevelopment*, as well as its currently popular utopian counterpart. Yet it also must allow for a positive image and a vision of sustainable development to grow, in order to provide human beings with an infusion of new hope that many improvements are possible in the future. This also has to include coming to a more realistic understanding of the down side of what we are already doing in development in the world. It is not a form of development heresy to attempt to face reality, rather it should be seen as an unequaled opportunity to build positively upon it.

Policy planners and decision-makers in industrial development, for example, need to know more or less precisely just *how far* they should go in achieving sustainability and development in specific cases before they begin hurting people and damaging or wasting too many natural resources. Governance is critical. Effective local control and participation through proper forms of subsidiarity are also required. If the developing countries succeed in making a quantum leap to industrialization in the next 50 years, how much polluted air and water are all the people to be potentially affected willing, or even able, to tolerate before environmental and human costs skyrocket? Can one imagine, for example, a time when every tenth citizen of China or Russia might conceivably own an automobile? Unless new technologies that do not pollute appear on the scene, given demographic trends, the result would surely be a world disaster with regard to pollution. Kenneth Boulding once said of the arms race that we are skirting the edge of a chasm. By not understanding better the human tolerances toward the down side of sustainable limits of development, as well as the persistence of unrealistically high hopes, we may be skirting the edge of a chasm. This creates a dilemma for politicians, to be sure. Given the adverse effects from a degrading and increasingly unstable global ecology, what are the limits of human tolerance for *sustainable underdevelopment*? In many cases, in the developing countries any improvement in quality of life would be considered reasonable progress in economic development.

Many will argue quite correctly that we are already trying to find many of these parameters. And to calculate, wherever we can, new forms of cost analyses for ecological systems to provide the critical feedback signals about human and environmental limits of sustainability at both ends of the development continuum. Even given enormous progress, most of the scientific findings to date, however, have not been functionally integrated into positive environmental control programs in development to permit policy implementation. Still, most governments have not yet implemented proper environmental control programs. With the practical need to maintain incentives and inducements for direct foreign investment, more often than not, the environment is compromised. Many businesses still cling to the traditional form of accounting in which the environment is seen as an unnecessary externality, rather than to see environmental costs as a legitimate part of the overall cost structure.

Much to the chagrin of some economists, there is no endless cornucopia of economic development possible, sustainable or otherwise, over the entire world as we have been told over and over again. At best, and for many resources, prices only control market access to dwindling supplies, as in the case of oil, as geologists have demonstrated for over two decades. As suggested by the pioneering work on the "limits to growth" there are real system boundaries for everything, including the limited resources in the ground.

After all the promises that have made by some development administrators and political and industrial leaders, what a sad day it may become for the people of a developing country when they must painfully learn to adapt to the fact that they cannot have everything their Westernized economic development programs may have led them to think of as possible to achieve. What an impossible political and distribution problem this will pose in the future without an accurate sense of the realistic lower and upper limits of human tolerance for *sustainable underdevelopment*.

If this alternative vision of *sustainable underdevelopment* is indeed found to be the true picture imposed by the constraints of the environment, how do we learn to live with the hard fact that not everyone, or perhaps even at times the most needy, will necessarily share equitably in the world's wealth, even to sustain their basic needs? Should development planners encourage an approach to development that attempts to meet basic human needs to assure that only basic survival is possible? Hardly. How will those who may believe in a purely market oriented approach to development resolve this ethical dilemma of distribution? If this is indeed true, then from what philosophy of life and human betterment will we have to find renewed hopes for the future? And what about the economic, moral and political justifications for living with less than one hoped to get from all the promises made in the name of progress and human betterment in the past? A danger is that people may become too deeply stoical and cynical if this deeper human aspect of the human personality is not considered. In cooperation with the rest of the world, both West and East may have to share with each other more of their various philosophies, justifications, wisdom and creative forms of culturally based problem solving about how to achieve economic fullness in life, as well as whatever else may be required.

Materialism, or technology alone, surely cannot provide the entire answer. Economies based on purely materialistic assumptions to the neglect of moral and spiritual considerations have been shown to be not particularly successful in providing appropriate solutions to meeting human needs. Human satisfaction within the economies of the world may also have to be based on people acquiring much more knowledge and education, as well as the appropriate spiritual satisfactions that reach beyond material technologies, important though the technologies, are. These are areas in which *sustainable overdevelopment* should, and can, flourish.

References

Arrow, K., 1951, *Social Choice and Individual Values*, John Wiley, New York, USA.

Brooks, H., 1992, Sustainability and Technology, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Rapporteur's Report

Joanne Linnerooth-Bayer

The challenge raised by Harvey Brooks in his paper, *Sustainability and Technology*, is to translate the concept of "sustainable development" into operational criteria. Brooks' main point is that the term *should* be operational, by which he means that a consensus should be sought on the meaning of sustainable development which makes clear the underlying goals and values of those using it. The danger is that the term continues to be used in a "catchall" manner or primarily for its rhetorical value. It is important, according to Brooks, that those using the term be explicit about their underlying goals and values for the future of global society.

One generally shared goal for a sustainable society is the long-term survival of humankind, for which there may exist many paths, each dependent on a particular social and cultural context. If survival is the goal, then sustainability is a necessary, but not entirely sufficient, condition for a desirable society. For instance, it may be possible for the earth to support a much larger population than generally considered feasible. Taking into account radically different technologies for producing food, even a population of 100 billion might be imagined. Yet, this path may not be desirable. Considering the diversity of values, especially between the developed and developing countries, separating the concepts of "sustainable paths" from "desirable paths" might establish the basis for a consensus on the concept of sustainable development.

Bert de Vries, in his discussion of Harvey Brooks' paper, questions whether such a consensus with respect to its definition of sustainability is either desirable or even possible. Much like the concept of human rights, which enjoys little consensus on its precise meaning but which has proven powerful in changing the behavior of many governments, the practical usefulness of the sustainable development concept may lie more in its intuitive and symbolic value than its precise meaning. A fruitful concept of sustainable development, de Vries argues, should take into account the different images or metaphors of the future of those using it. The rather short history of the concept of sustainable development suggests five possible clusters of these images or perspectives, including the technological, the resource-economic, the environmental, the ecological, and the cultural.

For the technologist, human resources in terms of skills, adaptiveness and ingenuity are the means for overcoming physical resource and pollution constraints. Technology is the major driving force, in fact, the greatest threat may be an image of a future which is laden with a fear of the constraints. The resource economist does not have this same sense of technological inspiration, but does consider it necessary to use technology in carefully managing the future. The environmentalist sees the human's role on earth as a steward, and the essence of the environmental perspective is anthropocentric care of the "Garden Earth". To the ecologist, nature is characterized by a vision of interdependence, harmony and partnership, not by exploitation and utility. Finally, the cultural orientation differs from the previous perspectives in the sense that human psyche and culture are the starting points, and the debate on sustainability should, in this view, be related more to "quality of life". If life is to be sustained, it should also be worth living.

These different perspectives, de Vries points out, are closely related to the concept of plural rationalities found in cultural theory as developed by Mary Douglas, among others. (See, for example, Douglas and Wildavsky, 1982, or Schwarz and Thompson, 1990.)

They do not, however, necessarily contradict Brooks' plea to separate or be explicit about value judgements. However, we know from debates on the social acceptability of technology that these different rationalities ultimately obstruct meaningful communication since the very essence of the problem is framed and defined differently depending on the rationality of the participants in the discussion. The same appears to hold true for the concept of sustainable development, and without this communication it is hard to conceive of a consensus on its definition. The complexity of reaching a consensus will be manifest then, not only in the "North–South" dialogue, but even within the borders of a country.

Brooks conceptualizes a sustainable development policy for the selection and deployment of technologies as one that forecloses as few options for future generations as possible. In assuring that these options are not closed off, we should take account of the resources we use up as well as the resources we leave behind. This includes not only physical infrastructure, but in addition knowledge and social capital in the form of social organization, norms, networks, trust and a sense of community – all of which enhance the future's capacity for coordinated action. In many ways, this concept of sustainable development reflects, but also goes beyond, de Vries' perspective of the technologist for whom resources in terms of skills, adaptiveness and ingenuity are the means for overcoming constraints in terms of population, resources and industrial waste.

This rather optimistic concept of sustainable development raises at least two major concerns. The first involves the distribution of resources over the planet. It is important to ask *which* societies sacrifice their current natural resources and *which* societies inherit the knowledge and social capital. The second issue concerns how far this technological and social/institutional inheritance will take future generations in addressing the problems we endow them with, and what might be the unanticipated or inevitable surprises. Again revealing his optimism, Brooks suggests that we hope for positive surprises. Indeed, surprise is a form of information since if we expect something, the information content is nil.

Perhaps one of the more controversial points in Brooks' paper, and one that caused a great deal of discussion at the workshop, is his argument that the rate of change of the level of development and population is more important than the absolute numbers, at least at the present time. One important reason, of course, is that our social institutions and infrastructures have a more difficult time adapting to rapid or discontinuous changes. But some participants queried whether the absolute levels of population and pollution in some areas were not, even today, reasons for considerable concern. While the social capability to adapt appears to be increasing, what societies must adapt to, even today, may be outstripping this capability.

Brooks argues further that economic development and sustainable development can be synergistic; in fact, any strategy that destroys the economy is certainly not sustainable. When considering economic development, it is important to recognize that economic growth can take many different forms, including growth in the area of health and education in developing countries. The issue appears to be how to channel economic growth to promote a sustainable world. In this regard, the discussants noted several difficulties. One major problem appears to be the social propensity to couple innovations that conserve resources and reduce pollution with behavior that increases resource use. Two examples were given at the workshop: The European Community is considering proposals to make trucking more energy efficient and less polluting, but the proposals will hardly keep up with the rapidly increasing numbers of trucks on the roads. Nor, for that matter, did the revolution in information technology reduce the amount of paper we use.

Another unsettling difficulty is the number of technological innovations that do not come onto the market. Fritz Paschke pointed to the automobile as an example. The environmental contaminants from automobile use can be reduced significantly. The use of microelectronics results in better engine control; advances in material resources can lead to lighter frames and almost total recycling; and computer simulation can make it possible for engines to operate with far less fuel. Advances in biotechnology can lead to alternative fuels, and electric engines are already in operation. Hence the problem appears not to lie in technological innovation, but rather in marketing the innovations. The troubling fact is that many of the above advancements were already available many years ago. (The basis for the innovation of the direct injection diesel engine was already available in the 1930s!) If technology does significantly change the way we operate, it will likely be through the slow, incremental processes that we have experienced in the past rather than by radical changes.

The issue of technological innovation and dispersion naturally leads to a discussion of the role of the market in directing technological development towards more sustainable paths. While it is now taken more or less for granted that the market has serious deficiencies when left unregulated, several discussants suggested that market distortions on the part of government may be a more serious source of environmental degradation than the intrinsic failure of markets to internalize environmental externalities. A recent study on deforestation by the World Bank reveals that major culprits are government subsidies and other types of market interference. The same holds true in many other areas, i.e., road subsidies, energy pricing, and farm supports. The message is not that the government should not interfere with the market, but that it should interfere in such a way that the prices "tell the truth" or reflect the true environmental and social costs.

Another problem with government interference, or even noninterference, is that the measures often have the opposite effect from their intent. For example, in many developing countries it is considered immoral to charge for water even when water resources are extremely scarce. But since the rich often have sole access to the plumbing necessary for receiving the water, water vendors charge the poor!

The North's responsibility towards the developing world is central to any discussion on technology development and global sustainability. The industrialized North uses far more energy and other resources per person, and therefore produces more CO_2 and other greenhouse gases than the South. Hence, it is sometimes argued that the First World, rather than the Third World, ought to limit population. This view was not wholeheartedly accepted by the participants, however. Since the Third World is intent upon attaining the economic levels of the First World, and as rapidly as possible, it is inconsistent to treat the less developed countries as though they will always be poor. One of the big problems of the debate about sustainability, it was bemoaned, is that population is often off limits as a controllable variable.

Technology and knowledge transfer is certainly not off limits, and it is often and rightly argued that economic development in the Third World, with the aid of the North, is the most promising way to reduce population. There is little scientific disagreement that the most critical variables for family size are education and income. The World Bank asserts that if women were educated worldwide, the average number of children per woman would decline from seven to three. The argument for transferring significant sums to the South for technological development and environmental improvements gains even more momentum considering that, in many instances, the industrialized North can reduce global pollutants more cost effectively by introducing new technologies in the South. Unfortunately, the enthusiasm for this route to a sustainable world is dampened somewhat by the numbers. One participant referred to a study in Finland which showed that the investments in energy technology alone, in order to ensure that the developing world achieves the same level as the developed, would be far more costly than what is presently even discussed for technological aid. But it may be these kinds of costs that are necessary, since there was little disagreement that closing the rich–poor gap is necessary for any long-term *social* sustainability.

If technology and income transfers from North to South are crucial ingredients for a sustainable world, we have to face the trade-offs that such transfers imply. One trade-off may be the options that we leave to future generations in the form of endowments in knowledge and social capital. As one participant asked, what is more likely to promote global sustainable development – investments in scientific research or technology transfers to the developing countries? Difficult trade-offs of this sort must be faced if we are to meet Brooks' challenge of translating the concept of "sustainable development" into operational criteria.

References

Douglas, M., and Wildavsky, A., 1982, *Risk and Culture*, University of California Press, Berkeley, CA, USA.

Schwarz, M., and Thompson, M., 1990, *Divided We Stand: Redefining Politics, Technology and Social Choice*, University of Pennsylvania Press, Philadelphia, PA, USA.

PART II

Present Trends Need Cause Only Minor Concern

2. Toward Dematerialization and Decarbonization Tokio Kanoh

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Dr. Leo Schrattenholzer
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Foreword

In his paper Tokio Kanoh writes of the unprecedented prosperity that technological innovation has provided. Aside from giving us such rich consumption of varied goods, technology has also shortened working hours, extended longevity, and enriched our supply of information. One after another mankind's dreams have come true.

Potentially grave difficulties reside in the fact that 80 percent of this affluence is powered ultimately, directly or indirectly, by hydrocarbons, mostly fossil fuels. These have already begun to reveal numerous problems: we hear complaints on the disposal of waste; throw-away consumption including frequent replacement of durable household equipment; urban pollution; acid rain; land erosion; and global warming. Nor does that complete the list of problems that have become associated with industrial society. On another level are drugs, crime, AIDS, homelessness, and a variety of other social ills. A range of miscellaneous concerns goes all the way from traffic accidents and congestion of roads to growing inequities between North and South that disturb the world community. These all remind us that civilizations do not last forever, and some of those we read about in history have lasted but briefly. Is that likely to be the fate of ours?

Not if we recognize the problems and deal with them, for the solutions are as obvious as the difficulties themselves. Once we become attentive to the problems, which means becoming more humane and ecologically minded, we will make durable goods genuinely durable and then be willing to use them longer and build adequate roads and other infrastructure before rather than after supplying the market with the convenience of private cars.

Deposits on bottles and other containers will be high enough to constitute adequate incentives for recycling. Industrial waste heat can be salvaged for heating homes, spent nuclear fuel can be reprocessed. When environmental costs are included in product prices by means of appropriate taxes energy conservation will be spontaneously looked after by citizens.

The list of what can be done is a long one. Better design of houses, including better insulation, would lower use of fuel for heating and cooling, and be worth while even after district heating that utilizes waste heat from industry becomes general. Prototypes have already shown that automobiles can run at a much higher efficiency than any now on the road. Cars would be run less if mass transit systems were improved and their use encouraged. Hydro and geothermal sources of energy issue no emissions, and they ought to be promoted to the extent that sites can be found.

In the past, energy use has grown pari passu with income, almost as though every dollar or yen of income required a constant amount of energy. In fact there is no such constant ratio of energy to income, and Kanoh would go further toward decoupling the two: let income rise by all means, but hold down energy use.

The above eminently practical measures could be undertaken without appreciable sacrifice; our standard of living would continue to rise, even if not quite as rapidly as without such measures. Not as rapidly in the short run, that is; in the long run such measures would permit faster rise than would be possible without them. Yet the obviousness of these suggestions, depending very little on new technology but only on better use of the existing technology, does not ensure their use. We see more verbal agreement on them than we see actual implementation. In only a few countries are these changes being made at all, and for the most part not very wholeheartedly.

Cooperative programs are needed to stimulate conservation in countries with carbon dioxide emissions above the average. For the developing countries transfer of the technology for energy conservation measures is strongly recommended.

Tokio Kanoh has provided an exhaustive account of the difficulties the industrial world faces, and insofar as these are due to excessive energy use he shows the means for dealing with them.

Committee for IIASA '92

Discussion

Alessandro Vercelli

Mr. Tokio Kanoh's paper is a broad survey of the issues related to dematerialization and decarbonization well documented by comprehensive worldwide empirical evidence and accompanied by a long list of policy proposals.

The paper is very stimulating and informative, but I would like to comment that the conceptual framework underlying the analysis is not fully made clear. Why should we pursue dematerialization and decarbonization? What, if any, is the nexus between the two goals? How should we pursue them?

The empirical evidence and the policy proposals put forward by Mr. Kanoh may have different theoretical and practical implications for different answers to the preceding questions.

What I can try to do in my comments is just to give a few suggestions for the possible directions of analysis. Being an economist, I will base my suggestions on an ecological economics framework.

My first observation is that economic development would not be sustainable in the long run without a sufficiently rapid process of dematerialization and decarbonization. The reasons are not so obvious as they may appear at first glance, and they are partly different for the two processes. In addition, this thesis may be analyzed from two different points of view, depletion of exhaustible resources and pollution.

Let us begin from the point of view of depletion and analyze dematerialization and de-energification first. Economic development has been traditionally defined by the economists as implying a growth in output per capita and consequently in material and energy inputs. Since part of the material input comes from exhaustible resources and part of the energy input comes from non-renewable sources, economic development seems condemned to be unsustainable. Optimistic economists claim that the problem may be easily solved by substituting non-exhaustible resources for exhaustible resources and renewable energy inputs for non-renewable energy inputs. In addition, they believe that the market mechanism would be perfectly efficient in performing this substitution process rapidly and correctly. From this viewpoint, as a resource approaches exhaustion its price would rise because of its enhanced scarcity, and this would reduce its utilization and increase the utilization of less scarce resources.

Unfortunately, it can be shown that there are limits to this process of substitution so that the market is unlikely to succeed in exploiting the potential benefits of substitution efficiently enough and rapidly enough. There are many reasons for market failures that are related to different kinds of external effects which the market is unable to evaluate. I will just mention one. Substitution may occur only when how to do it is known, but existing technological knowledge is insufficient to allow substitution whenever this is necessary for sustainability. In addition, we cannot just rely on technological progress, as its results are always deeply uncertain: technological change cannot be fully planned and perfectly forecasted. Research on substitution must start long before it becomes urgent: however, the market mechanism is short-sighted and unable to give the right signals in time. Even those who believe in the virtues of a perfectly competitive market as far as the static allocation of resources is concerned recognize that it does not work well for inter-temporal allocation, particularly under conditions of strong uncertainty [see, e.g., Hahn (1989) and Vercelli (1991, ch. 5)].

Since we cannot fully rely on the substitution of non-exhaustible resources for exhaustible resources and renewable energy sources for non-renewable energy sources, development can become sustainable in the long run only by relying on a continuing process of dematerialization and de-energification. In other words we must find a way to increase the output without increasing either the material or the energy inputs.

Fortunately, this process has already begun. Kanoh gives interesting examples, particularly for the de-energification process. In particular he shows (in Figure 7) that in the Japanese private industrial sector the consumption of energy did not increase after 1973, notwithstanding a great increase in output; more generally, after the oil shocks of the 1970s, the consumption of energy began to increase less than the output ("decoupling of energy from GNP" in Kanoh's words).

Kanoh also maintains that the process of dematerialization began long ago and is currently going on. He stresses in particular the process of structural change (see pp. 69–72 and Figure 2) which has shifted production from the more resource-intensive sectors (steelmaking, chemical, aluminium refinery, cement) to less resource-intensive sectors (informatics, bio-technology, services). He also mentions recycling as a potentially powerful means of dematerialization. In fact, recycling reduces the percentage of new material inputs contained in a unit of product. Unfortunately, recycling is currently developing too slowly, as the author himself recognizes.

We can recall two other important processes which may induce dematerialization:

1. Miniaturization, i.e., the reduction in size and weight of a certain good. The case of electronics is particularly clear. Computers, for example, have progressively become smaller and smaller while becoming more and more powerful. This means that the material input of goods measured in use value is steadily decreasing.
2. Increasing the content of R&D in the value of goods which again implies a reduction in the material and energetic content of goods per unit of value.

It has been observed that the new technologies are ambiguous from the point of view of dematerialization (see, in particular, Herman *et al.*, 1990). Miniaturization in electronics has increased greatly, for example, the number of computers per capita, while the diffusion of computers – somewhat surprisingly – has greatly increased the consumption of paper, and so on. However, if the effects of technological change are ambiguous at the micro-economic level, they are much clearer at the macro-economic level. The percentage of national income produced by primary (agricultural) and secondary (industrial) sectors is declining, while that produced by the tertiary sector (services) is increasing. Since the percentage of material inputs in the tertiary sector is, generally speaking, lower than in the primary and secondary sectors, the process of tertiarization contributes to the dematerialization at the aggregate level.

Coming back to the conceptual framework of the paper we may say that, from the point of view of the depletion of exhaustible resources, the nexus between the first part of the paper which deals with dematerialization and the second part which analyzes the so-called decoupling of energy from GNP, is quite clear. Less clear is the nexus with the third part which deals with decarbonization of energy sources.

The most urgent reason for dealing with decarbonization is not scarcity: in the paper presented in this conference Dr. Umberto Colombo (1992) clearly shows that, paradoxically, proven reserves of oil and natural gas have kept increasing faster than their depletion and that "proven reserves [of coal] could guarantee more than 230 years of energy supply at present levels of consumption". The most urgent reason for promoting decarbonification is, of course, pollution leading to the greenhouse effect, acid rain, damage to health, etc. Pollution may also justify, in part, dematerialization and de-energification. Any material process of production and consumption of goods and energy is potentially polluting, but here again the main problem is the substitution of less-polluting, productive processes, goods and sources of energy for the existing ones.

The relationship between depletion and pollution in the framework of a model of sustainable development may be seen in a different time-scale: depletion of exhaustible resources is mainly a long-term problem, while pollution is also a medium- and short-term problem.

However, there is also a deeper relationship between pollution and depletion. What makes the environmental problems particularly urgent and intractable is the interaction between depletion and pollution. Pollution induces the rapid depletion of vital resources, which are not classified as exhaustible per se but are heavily affected by pollution in their quality: in particular water and air. In other words, what is rapidly becoming very scarce is clean air and clean water. I could add in the same category other commons such as bio-diversity and cultural diversity, which continue to shrink as a consequence of economic growth (see Dasgupta *et al.*, 1993).

What is really dangerous, as Professor Harvey Brooks (1992) reminds us in his paper, is a scarcity not signalled by prices. Pollution induces negative externalities, which the market is unable to express through prices. The depletion of clean air and clean water and other resources is so worrying exactly because its causes and consequences are not signalled by market prices. Moreover, in this case, it is very difficult, if not impossible, to find viable and acceptable substitutes for the depleted resources. In addition we cannot remedy the problems induced by externalities through Pigouvian taxes and subsidies, because for these kinds of resources property rights are neither defined nor easily definable.

Mr. Kanoh does not limit himself to a description of current trends in dematerialization, de-energification and decarbonization; he also suggests a long list of policy proposals meant to accelerate the pace of these processes. Most of these proposals may be considered sensible, although not particularly original. Unfortunately the priorities and compatibilities among them are not discussed in the paper. For example, investment in "attractive infrastructures" (p. 67), or in "district heating and cooling systems" (p. 67 and 78), or in better insulation in housing (p. 78), may imply, at least in the short run, an increase in economic activity which could augment public expenditure and growth and put higher pressure on resources.

Another possible incongruence in the policy part of the paper may be seen in an alleged confidence in the power of the price mechanism (pp. 72, 78), while the policy proposals neglect the measures based on the correction of the price system in order to internalize the externalities and decentralize the economic incentives and dis-incentives (ecological taxation, marketable permits, etc.).

Finally a safe and peaceful utilization of nuclear power is advocated without discussing the technological and economic objections which have been raised against this policy.

We must conclude that, the lack of a clear conceptual framework partly undermines also the policy part of the paper. Notwithstanding this weakness, we must thank Mr. Tokio Kanoh for his lucid, informative, and insightful description of the current processes of energy decoupling and decarbonization.

References

Brooks, H., 1992, Sustainability and Technology, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Colombo, U., 1992, Sustainable Energy Development, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Dasgupta, P., Maler, K., and Vercelli, A., eds., 1993, *The Economics of Transnational Commons*, Clarendon Press, Oxford, UK.

Hahn, F., ed., 1989, *The Economics of Missing Markets, Information and Games*, Clarendon Press, Oxford, UK.

Herman, R., Ardekani, S.A., and Ausubel, J.H., 1990, Dematerialization, in *Technological Forecasting and Social Change*, **38**:333–347.

Vercelli, A., 1991, *Methodological Foundations of Macroeconomics*, Cambridge, Cambridge University Press, UK.

Discussion

Ernst von Weizsäcker

Mr. Tokio Kanoh's paper "Toward dematerialization and decarbonization" addresses three important issues relative to the need of eco-structuring the world economy: (1) the de-materialization of affluence, (2) the de-coupling of energy from GNP, and (3) the decarbonization of energy.

Kanoh makes a number of proposals for actions on international levels. With few exceptions they are part of the international discussion today. Nevertheless, all warrant further consideration, in particular from the point of view of the LDC's. Perhaps the most controversial of Kanoh's proposal is his suggestion to increase nuclear power supplies for countries "without natural energy resources" as soon as possible.

The following questions should be considered in connection with Kanoh's paper:

- Which substances should receive priority attention in the dematerialization process, using toxicity, depletability, climatic "toxicity" as criteria?
- How far can resource and energy productivity (welfare output per resource unit-input) be increased?
- Which steering mechanisms will lead to significant increases in energy and resource productivity?
- How can forest mining, petrol mining, the mining of fossil water, etc., be stopped or slowed down?

A consistent strategy for initiating toward more sustainable development may be composed of the following elements:

- Systems analysis of energy "demand" including price elasticity of energy consumption.
- Systematic increase of energy productivity.
- Conversion of the "demand" for energy and goods into a demand for services.
- An ecological tax reform de-penalizing human labor and putting an increasing fiscal burden on energy and resource consumption.

Further reading: Ernst U. von Weizsäcker, Forthcoming, *Earth Politics – Ecological Realpolitik at the Threshold of the Century of the Environment*, Zed Books, London, UK.

Rapporteur's Report

Leo Schrattenholzer

Scheduled Discussants

Professor Ernst von Weizsäcker's point of departure was the hypothetical goal of halving global primary energy demand by the year 2030 in deference to the need to stabilize global climate. As a means of achieving this, he proposed a tax reform, by which real prices of energy, water, and bulk materials would be increased by 5% per year, and other taxes such as VAT and income taxes decreased in a revenue-neutral way. As a result, he expects an increase of energy productivity by a factor of three at least. In many instances, the high prices of these primary materials would serve the environment more efficiently than regulations or permits. As an illustration that higher energy prices do not necessarily go along with lower economic performance, he presented a graph showing a positive correlation between energy prices and "economic performance" (as defined by a compound of economic output, number of patents, and others) in the time period 1975–1990 in the USSR, the USA, the EEC, and Japan.

Alessandro Vercelli formulated two questions that he felt had been only implicitly asked in T. Kanoh's paper, i.e., *Why should we decarbonize*? and *How should we do it*? As a possible answer to the first question he suggested that development cannot be sustainable without decarbonization or dematerialization. By definition, the general strategy for achieving sustainability is the substitution of depletable by renewable inputs. In reality, however, there are limits to this substitution, and market forces alone are insufficient to bring it about. He argued that technological knowledge is the key to overcoming these difficulties in practice. Moreover, this knowledge must exist much earlier than the urgent need for it arises. As a relevant achievement of the past he mentioned miniaturization, and as a concrete strategy for the future he suggested increasing the "thought content" of goods. As one particular example of market imperfection he mentioned the lack of price signals reflecting the depletion of common goods such as clean air and drinking water.

General Discussion

In response to the favorable role played by nuclear energy in the session's paper, discussion about the well-known positive and negative aspects of nuclear energy followed but, as was to be expected, no conclusion was reached.

Kanoh argued that electrification could lower birth rates – as the examples of Japan (100% electrification and 11 annual births per 1000 inhabitants) and the Solomon Islands (10% electrification and 45 births) suggest.

Discussing von Weizsäcker's proposal of a tax reform, it was argued that the responses to such a price signal could easily be much weaker than assumed by its proponents. As another possible drawback, concern was expressed that the acceptability and other socioeconomic consequences (such as its regressive feature) of an energy tax might be in the way of its implementation.

As an example of the enormous problems faced by the developing countries, it was mentioned that, although China has a huge potential for hydropower (370GW), there is, at the same time, a distance problem, i.e., the potential is far away from the centers of demand. Kanoh proposed that an environmental tax be levied in the industrialized countries, part of which would be transferred to the developing countries as an assistance to improve their environmental situation.

Von Weizsäcker praised the Japanese system in which he observed slow gradual compliance with long-term goals. Learning from this example, he proposed the gradual introduction of an energy tax following a precisely defined path.

As a general word of warning, it was mentioned that often the positive aspects of new ways of doing things are compensated by unforeseen side effects. An example mentioned was the ideal situation of a "paper-less" office as a consequence of the computer as a writing and typing aide. In contrast to this hope, the paper consumption of the US has more than tripled between 1959 and 1986. Other examples can be found where more efficient energy end-use devices led to an increased consumption of the corresponding energy service, such as in the case of more fuel-efficient cars or energy-efficient light bulbs.

The discussants agreed that the total amount of materials moved worldwide grew in proportion to the GDP over the past years. However, the global energy system has decarbonized at a rate of 0.3% per year since 1960. Adding to this the decrease of energy intensity, carbon emissions per unit of GDP have even decreased at an annual rate of approximately 1.5%.

Kanoh said that a shift to electricity could be observed in all economic sectors but the transportation sector. It is therefore crucial to promote transportation means that are less carbon-intensive than today's. These include urban metro systems and CNG (compressed natural gas) cars – of which more than 100,000 have already been sold in New Zealand.

The discussion about CO_2 removal and storage centered on the environmental consequences of deep-ocean storage. To date, the effects on marine life of increasing CO_2 concentrations in the deep ocean is largely unclear. A problem with CO_2 removal by microalgae is the low density (or high land – or water surface – requirements) of carbon sequestration. It corresponds to an energy density of 10 watts per square meter. It was therefore agreed that microalgae can only be one of many partial contributions to the overall problem.

3. Sustainable Energy Development
Umberto Colombo

Discussions and comments by:

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East–West Center, Honolulu, Hawaii

Professor Clas-Otto Wene 73
Chalmers University of Technology, Göteborg, Sweden

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Dr. Arnulf Grübler
Environmentally Compatible Energy Strategies Project,
IIASA, Laxenburg, Austria

Foreword

As Umberto Colombo sees the future, in the Developing Countries there will be large increases in the use of fossil fuels as people shift from family-gathered fuelwood for cooking and locally extracted oils for lighting, to commercial sources for these and other purposes. In addition the beginning phases of industrialization have always required large inputs of energy.

In one theoretical model the trajectory of energy use is a bell-shaped curve, in which the rising phase continues until industrialization is well under way, and then a declining phase follows, with decline to a level as low as before industrialization began. Defining energy intensity as energy divided by GNP, a chart of the historical record shows something indeed similar to a bell-shaped curve from the beginning of the 19th century for the United Kingdom and the United States, and similar curves for other industrial countries during the 20th century. This suggests large increases for the Third World as it advances through the phases of industrialization.

Colombo reviews the issues of reserves and finds that shortage of fossil fuels is not likely to be the limiting factor on our use of them. On the other hand the effect of carbon dioxide emissions, especially climatic effect, could well bring to a stop a line of development that the West has followed ever since the start of its industrialization.

It is for such reasons that the decoupling of energy from the growth of income is promoted now in the industrial countries. It has one incidental disadvantage: it makes the forecasting of energy from a given income progression far less accurate. Moreover the large differences in per capita use of energy from country to country, as well as its changes within a country, make population forecasts poor guides to energy use.

Colombo's chief preoccupation on the environmental front is with efficiency of energy production and use. The First World is more efficient in energy use than it has been, but its affluence permits it to be more efficient yet. And that further increase is necessary if it is to allow for emissions from less advanced countries. Moreover it should set an example of economizing to the Third World, now starting to pass through the most difficult phase of the industrialization cycle. What the planet cannot support is to have more countries go through the energy-extravagant trajectory of the European and American 19th century in the course of their development.

Committee for IIASA '92

Discussion

Toufiq A. Siddiqi

Professor Umberto Colombo has provided us with a wide-ranging overview of the present energy situation, future prospects, and a number of concerns that need to be reconciled if our energy needs are to be met in a way that is sustainable. In the space available here, it is possible to comment on only a few aspects of the paper.

Since we are celebrating the 20th anniversary of IIASA, it might be useful to start with the energy situation as it was perceived during the year immediately after IIASA's establishment, i.e., 1973. As you recall, that was the year of the "First Oil Crisis", and our main concern was with the implications of there not being enough energy available at a reasonable price. Oil reserves were believed to have started declining, and a similar situation was believed to be imminent for natural gas. Two decades later, our principal concern is not with too little energy, but with the implications of using too much of it. The data provided by Professor Colombo in Table 3.2 have been used as the basis for constructing *Figure 1*.

From the table, we can see that the proven reserves of oil tripled during the last three decades, whereas the natural gas reserves increased by a factor of seven. Reserves of both fuels still appear to be increasing, in large part due to the reclassification of previously known resources. Our concern has shifted from adding to global reserves to a discussion of whether already known reserves of fossil fuels can be used for energy, without significantly changing the world's climate.

An important challenge for systems analysis in the nineties is to extend the scope of analyses of energy-environment models beyond

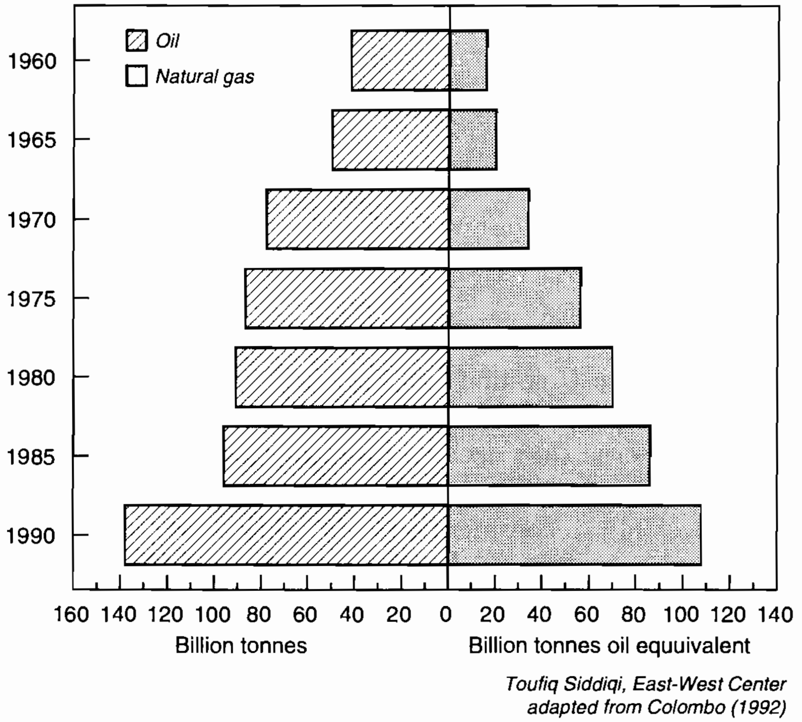

Figure 1. Proven global reserves of oil and gas, 1960–1990.

projections of aggregate supply and demand and pollutant emissions at national levels, and to examine the implications for various regions and groups within countries. In the context of global change discussions, the phrase "No regrets strategy" is often used. But the question *No regrets for whom?* is seldom asked. This may not appear important in relatively small, homogeneous, countries, but is a crucial question for many large, diverse nations be they industrialized or developing ones.

A strategy, for example, of switching from coal to natural gas or nuclear power in order to reduce carbon dioxide emissions is full of "regrets" for persons associated with the production, shipment, and use of coal in Australia, Canada, China, India, Poland, South Africa, USA, and many other large countries. In countries with a diversity of energy resources, the losses for the coal producers might be offset by gains for the producers of natural gas or manufacturers of nuclear power plants at a national level. However, the impacts on individuals and groups of a switch from coal to gas would be different. Policymakers are usually responsive to the needs of large groups. Thus the distributional impacts of specific policies need to be addressed more explicitly in systems analyses.

We are already witnessing the response of the large coal and oil producing countries in the climate change negotiations. They have not been at the forefront of those attempting to set deadlines for reducing emissions of carbon dioxide from fossil fuels. Of the six countries with the largest current and projected emissions of carbon dioxide, only Germany has a relatively strong commitment to reducing CO_2 emissions from present levels. In *Figure 2*, high and low scenarios are given for emissions in 2010. Emissions in Japan in 2010 may be close to present levels, and possibly in the countries comprising the former Soviet Union, if energy efficiency improvements are made.

The current debate on a global climate convention has focussed on issues of equity *between* countries. Occasionally, it has touched on equity between generations. Questions of equity *within* countries have seldom been raised. It is true that the average per capita consumption of energy in the industrialized countries is several times as high as that in the developing countries, as Professor Colombo has indicated in Figure 3.1. It is, however, equally true that a small percentage of the population in the developing countries, particularly in the urban areas, has levels of energy consumption comparable to that in the industrialized countries, and an order of magnitude higher than that of the rural populations in those countries. Systems analysts need to spend a great deal more time on scenarios for making more energy in environmentally acceptable forms available to these frequently underprivileged groups within countries.

The middle part of Professor Colombo's paper deals with nuclear and renewable energy. These appeared to be promising solutions to the problems of the energy shortages of the 1970s, and they again appear to be solutions to the problems of the energy impacts of the 1990s. In the meantime, two decades have passed in which only a limited effort has been undertaken to develop more

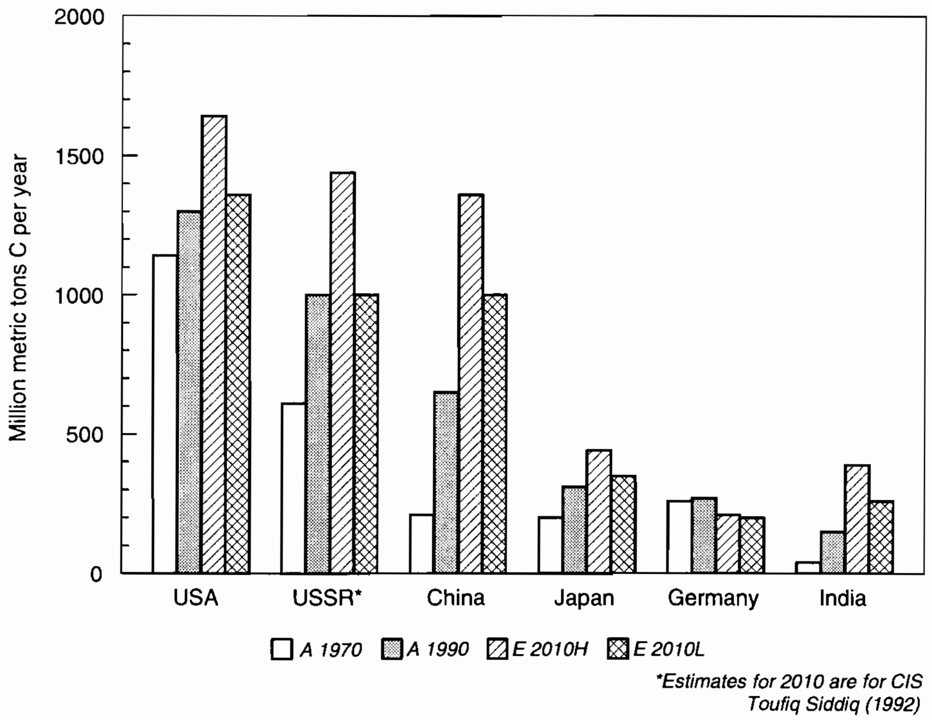

Figure 2. Recent and projected emissions of CO_2 from fossil fuel use in largest emitting countries.

socially acceptable and cost-effective ways of using these sources. Nations still have to figure out a way in which development of new energy technologies is not largely dependent on the current cost of the most widely used energy source (at present oil). One could make a more general statement and say that the concepts of "sustainable development" require that societies take a new approach to investment in research and development. Criteria such as "Payback Period" and "Internal Rate of Return" may have to be combined with other criteria to enable larger investments in technologies that would contribute to "sustainable development", but which might require two or three decades of development.

An important final point in Professor Colombo's paper deals with the ratio of energy consumption/GDP over time in a number of countries (Figure 3.8). He has suggested that countries undergoing industrialization at a later stage than others will have better technologies at their disposal, and will thus show lower peaks on the curve. This appears to be borne out for the United Kingdom, USA, Germany, France, Japan, and Italy. Peaks have not yet been reached in the less developed countries, and in Eastern Europe, as was to be expected, but there is concern that the energy intensity of GDP has already reached values higher than the peaks reached by Japan and Italy, the countries that reached industrialization most recently.

A partial answer lies, as Professor Colombo has suggested, in the general lack of availability of new technologies in the developing countries, and the reluctance of centralized governments in Eastern Europe to invest in modern technologies for the commercial sector. Part of the answer may also lie in the well-known difficulties of getting really comparable values of GDP in the developing countries. In many cases, the "real" GDP may actually be substantially higher than that used for these calculations, thus lowering the energy consumption/GDP ratio. Further, the cost (in dollars) of producing a ton of steel or aluminum is about the same in France or India, but the salary of a white collar worker in France may be 20–30 times as much as his counterpart in India. As the number of persons employed in the "service" sector in the industrialized countries increases, as it has during recent decades, the energy consumption/GDP ratio has declined faster than improvements in energy efficiency.

A challenge for system analysts during the 1990s and beyond may be to start measuring improvements in energy efficiency strictly in terms of physical output/energy used, and services supplied/energy used. Whereas we can expect the former to show steady declines as technology improves, there is no reason to expect the same for the latter. Depending on the particular mix of services in different societies, the latter might keep increasing, decline, or stay constant. It is comfortable to be able to use a single indicator like the GDP in energy analysis, but it may be hazardous to use it in situations where it is not the most appropriate variable.

References for Estimated Emissions Shown in Figure 2

USA:

High Scenario: US Department of Energy, 1991, *Limiting Net Greenhouse Gas Emissions in the United States*, report to the Congress of the United States, R.A. Bradley, E.C. Watts, and E.R. Williams, eds.

Scenario used as "National Energy Strategy Actions Case".

Low Scenario: Increase of 5% from 1990 levels by 2010.

USSR:

High Scenario: Makarov, A.A., and Bashmakov, I., 1991, An Energy Development Strategy for the USSR, in *Energy Policy*, special issue on *Climate Change: Country Case Studies*, J. Sathaye, ed., **19**:987–994.

Calculated from scenario used for "Reference case".

Low Scenario: Reference same as above, except scenario used is the one labeled "Interfuel Substitution".

China:

High Scenario: Siddiqi, T.A. *et al.*, 1991, Climate Change and Energy Scenarios in Asia–Pacific Developing Countries, in *Energy*, special issue on *Energy Policies and Global Climate Change*, S.S. Penner and T.A. Siddiqi, eds., **16**:1467–1488.

Scenario referred to as "Business as Usual".

Low Scenario: Reference same as above, except scenario used is the one labeled "Energy Efficiency + Fuel Switching".

Japan:

High Scenario: Kibune, H., 1992, Japan's Energy Supply-Demand Outlook for the 21st Century, in *Energy in Japan*, (114): 31–54.

Scenario referred to as "Trend Case".

Low Scenario: Reference same as above, except scenario used is the one labeled "Government Outlook".

Germany:

High Scenario: German Bundestag, ed., 1991, *Protecting the Earth*, a Status Report with Recommendations for A New Energy Policy, 2 vols. Bonn: Referat Öffentlichkeitsarbeit, Deutscher Bundestag.

Scenario using "Energy Policy" reduction criteria, but promoting use of hard coal, lignite, and natural gas imports.

Low Scenario: Reference same as above, except scenario used is the one labeled "Energy Policy" reduction.

India:

High Scenario: Siddiqi, T.A. *et al.*, 1991, Climate Change and Energy Scenarios in Asia–Pacific Developing Countries, in *Energy*, Special Issue on *Energy Policies and Global Climate Change*, S.S. Penner and T.A. Siddiqi, eds., **16**:1467–1488.
Scenario referred to as "Business as Usual".
Low Scenario: Reference same as above, except scenario used is the one labeled "Energy Efficiency + Fuel Switching".

Discussion

Clas-Otto Wene

I would like to comment on the option of energy efficiency in a "no regrets" strategy to manage the risk of a climate change. Is energy efficiency, especially on the demand side, a viable component of such a strategy? If so, how much can we trust improved energy efficiency to mitigate CO_2 emissions? Do we already know enough to recommend policy implementation?

1 Top Down

A "top down" analysis indicates that the energy intensity of GDP has decreased in the industrialized countries both in the long perspective and in the short perspective (see Figures 3.7 and 3.8 in Professor Umberto Colombo's paper). Before this analysis is carried over to the LDCs, Eastern Europe and the CIS one has to understand more about what is driving these changes. How much is due to supply side changes: fuel switching, improved and new supply technology? How much is due to demand side changes: improved and new demand technology, dematerialization of society? How do the two sides interact? For instance, since 1900, electricity generating efficiency has improved substantially. Cheap and abundant electricity has made it possible to design smart and efficient demand technologies. Comparative studies might be helpful in answering the question of whether the energy intensity over time will show the same behavior in LDCs as in the industrialized countries. It would be very interesting, for instance, to compare the ongoing electrification in an LDC with the corresponding historical period in an industrialized country. A project involving such a comparison between Ecuador and Sweden is currently planned (Maldonado, private communication).

Is the decrease in energy intensity between 1970 and 1990 due to autonomous conservation or is it the result of price effects? The analysis of MacKillop (1990), seems to indicate that there is an adjustment followed by a complete relinking between energy growth and GDP growth after each of the two oil price shocks in the 70s. This suggests that the decrease is mainly a price effect. For the short perspective, 5–10 years, the top down analysis indicates that considerable price increases are necessary to reduce the energy intensity of the GDP. However, such price increases do not seem consistent with a no regret strategy.

2 Bottom Up

The "bottom up" approach to energy conservation involves detailed calculation of engineering costs for different conservation measures. These estimates seem to indicate a large potential for conservation measures, cost-efficient already with today's prices. *Figure 1* shows calculations for electricity conservation for the community of Göteborg with 430,000 inhabitants (Björkqvist and Wene, 1992). With a real discount rate of 5% and at present prices, it would be cost-efficient to reduce the electricity demand by 25–30%. There are many attempts to explain why such a reduction is not observed in the real world. One is already suggested by *Figure 1*: the consumer tends to act as if he had a large discount rate. If he has a 25% discount rate, cost-efficient savings would be 5–7%, hardly visible above the noise level. Another explanation would be if there are other major costs not captured by the engineering calculations: costs for collecting information and costs for deliberations and risk assessments. As electricity conservation is the result of many small decisions by many consumers, these non-engineering costs may be a considerable part of the total costs. Both curves in *Figure 1* would then rise more steeply, leading to lower levels of cost-efficient conservation. Studies of non-engineering costs for the consumer are under way.

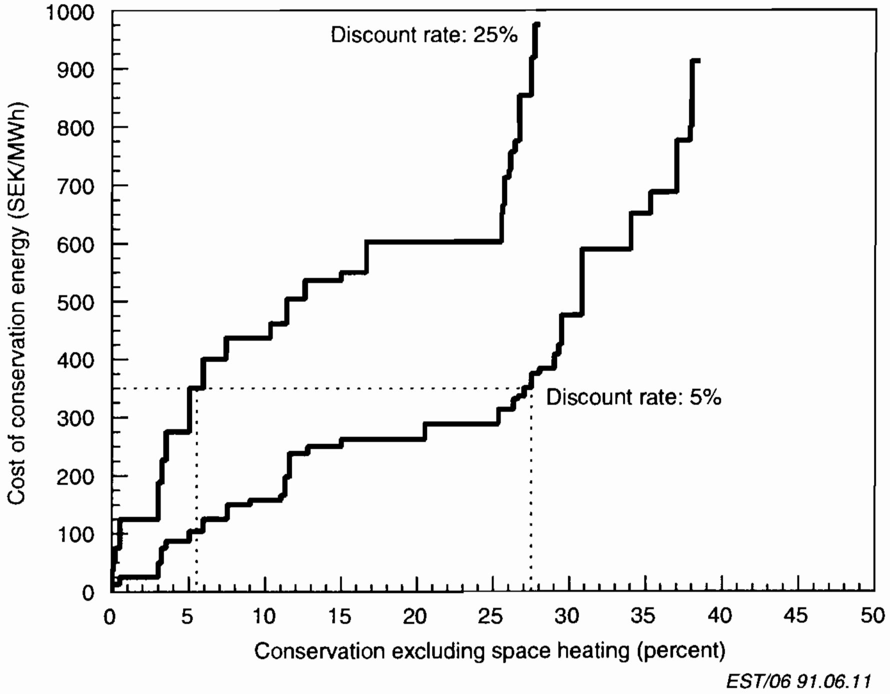

Figure 1. Supply curve for electricity conservation in Göteborg.

What conclusions can be drawn about the realization of estimated savings potentials from earlier conservation programs? In 1978 the Swedish Government started a major program for energy savings in existing buildings. In contrast to many of the electricity conservation options, this program could be targeted to relatively few, well-identified actors, and the effects of the technical measures for each object were substantial. An assessment of the effectiveness of this program indicates that up to 50% of the goals were achieved. This is an interesting benchmark for ambitious heat conservation programs. But conserving electricity is a more complicated task. How far can we rely on the success of an electricity conservation program?

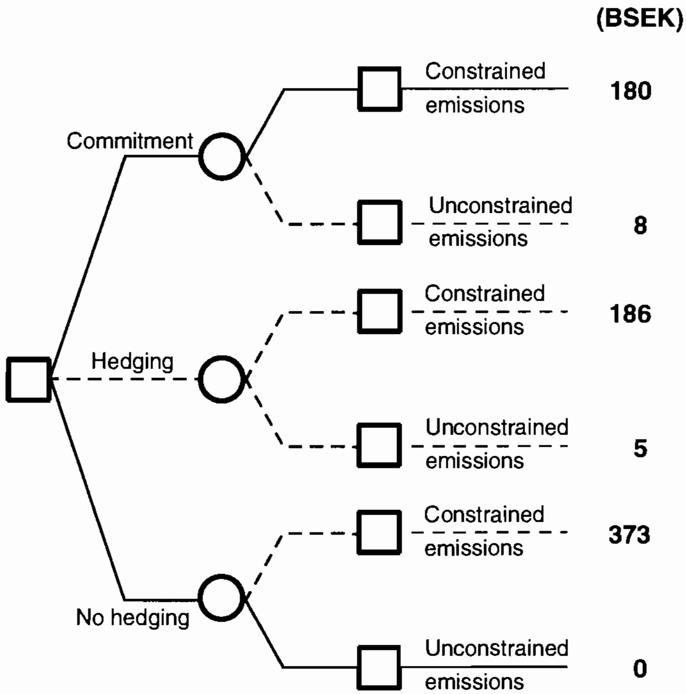

Figure 2. Decision tree for the Swedish energy system.

3 Minimum Regret

The reliability of the energy efficiency option in a no regret strategy has still to be proven. The previous discussion shows some of the reasons for this negative assessment. The possibility of rebound or "take-back" effects (Brookes, 1992; Frey and Labay, 1988) present other arguments. But the no regret strategy needs the energy efficiency option to show that it is possible to reduce CO_2 emissions at no cost or even reduced total cost for the energy system. Without a reliable energy efficiency option the no regret strategy becomes a misnomer.

Until the reliability of energy efficiency is proven it seems more correct to speak about "minimum regret" strategies. *Figure 2* illustrates a decision tree for the Swedish energy system (Larsson, in press). It includes a successful retrofit program in existing buildings, but no other "negative-cost" savings. CO_2 mitigation will have to rely on measures on the supply side: renewable energies, nuclear energy, fuel switching and improved efficiency for fossil fuel technology. Following a "no hedging", i.e., "business as usual", strategy, the regret may be as high as 193 BSEK (35 BUSD). Committing the energy system to constrained CO_2 emissions, but with the option to return to an unconstrained case, reduces the maximum possible regret to 8 BSEK. Applying a minimax regret criterion we see that a hedging strategy should be followed, because the maximum possible regret in this case is only 6 BSEK. Hedging implies a strategy where the energy system is allowed to develop as in the no hedging case, but detailed preparations are made for a swift implementation of CO_2 constraints. Note that commitment with constrained emissions cost 180 BSEK more than the no hedging with unconstrained emissions. This is far from a no regret situation.

References

Björkqvist, O., and Wene, C.-O., 1992, *Efficient End-use of Electricity in Göteborg – Potentials, Barriers and Organizational Needs*, Proceedings of the Conference on Next Generation Technologies for Efficient Energy End Uses and Fuel Switching, 7–9 April, Dortmund, Germany.

Brookes, L.G., 1992, Energy Efficiency and Economic Fallacies: A Reply, *Energy Policy*, **20**:390, May.

Frey, C.J., and Labay, D.G., 1988, An Examination of Energy Take-Back, *Energy Systems and Policy*, **12**:205.

Grubb, M., Reply to Brookes, *Energy Policy*, **20**:392, May.

Larsson, T., in press, Developing Strategies for Robust Energy Systems, II. Application to CO_2 Risk Management, *International Journal of Energy Research*.

MacKillop, A., 1990, On Decoupling, *International Journal of Energy Research*, **14**:83.

Maldonado, G., private communication.

Rapporteur's Report

Arnulf Grübler

Three (to an extent interrelated) issues were raised in the discussion of Professor Umberto Colombo's paper.

1. The role of markets and of market signals in promotion or as a potential barrier for energy efficiency improvements.
2. The social dimension of "no-regrets" options (like efficiency improvements) for mitigating adverse environmental impacts of energy production and use, in particular possible feedbacks and trade-offs.
3. On a more general line, the issues of how to define sustainable development of the energy system, and how such concepts could be integrated into prevailing economic thinking were also put forward for discussion.

1 The Role of Markets and Market Signals

There are no free markets in energy. Supply cartels and monopolies, (both at the producers' as well as the final distribution side), taxation, and subsidies to different branches of the energy production and consuming sectors exist in energy markets not only in reforming and developing economies, but also in "market" economies. The current market signals (low prices) as well as a more than comfortable resource situation provide incentives to *consume* energy, eventually to waste it. In addition, low energy prices can make the introduction of energy technologies at both the supply and end-use sides more difficult, whether one deals with demand-side management and conservation programs, solar energy, or a return of a new, safe generation of nuclear energy.

From an environmental perspective, however, one would prefer resource inputs like energy to be minimized per unit of output. Improved energy efficiency and resulting lower energy intensity is consequently seen as a central element of "no-regrets" precautionary strategies until scientific uncertainties with respect to global environmental change are reduced. As pointed out by discussant Clas-Otto Wene it may be more correct to speak of "minimum regret" strategies for the management of the risks of adverse global environmental change. An interesting "decision tree" analysis was presented by Wene offering the conclusion that an optimal hedging strategy at this point in time might particularly invest into R&D of possible response strategies and their detailed techno-economic assessments.

It was also pointed out that it is not clear yet analytically to what extent the impressive energy efficiency improvements achieved over the past 20 years are an intrinsic element of the overall "dematerialization" tendency of advanced industrial economies, or whether efficiency improvements are results of price induced conservation only. Furthermore, the relative influence of supply and demand and especially the interactions between the two in efficiency improvements need to be better understood in order to devise robust and effective policies for energy efficiency improvements.

Implementation of policies is a crucial issue. Significant improvements in energy efficiency cannot be expected to happen autonomously, instead they represent a tremendous task, e.g., in the reforming economies of Central and Eastern Europe. In this sense there is no "free lunch". Indeed, some have argued that the task ahead is even more burdensome. With most energy scenarios projecting a doubling of global energy consumption over the next couple of decades, and some CO_2 reduction scenarios calling for a 50 percent reduction of current emission levels, a factor four improvement in energy productivity ought to be achieved, clearly beyond the scope of "minimum" regret strategies or (incremental) energy efficiency improvements alone.

If not realized efficiency improvement potentials indicate market failure, some economists questioned why such market failures should be corrected for energy in particular. In addition, other resource inputs such as capital, labor, etc., may not be used most efficiently. Therefore, important trade-offs might be involved between efforts (costs) and policies geared toward improvements in the efficiency of utilization between different factor inputs. Such arguments raise, also, the more general issue of how to allocate limited resources to a multitude of burning issues facing humanity. Energy and possible global climate change are also currently at the center of attention in the communities of the analysts' and policy makers and, even of the public at large. Attention, analytical capability and policy initiatives have also to be devoted to other issues. These should certainly include the question, "What are effective development strategies for the South beyond the dimension of their environmental sustainability?"

2 Social Dimensions of Mitigation Options

Efficiency improvements or, more precisely, the lack of them point to important social forces and feedbacks at play. First, it was pointed out that consumers base their decisions on a much wider concept of costs than direct investment and operating costs, typically the subject of engineering-type studies. Costs also include information acquisition and decision costs. A wide gap opens between conservation potentials identified in detailed bottom-up studies and the actual potentials realized by consumer decisions, interpreted, in economic terms, as the difference between social and individual discount rates. Thus, we have to acknowledge a wide gap between societal and individual objectives.

Even in cases where efficiency improvement investments have been implemented, changes in consumers' behavior, i.e., how the more energy efficient technology or equipment is *used*, have taken place. With reduced "conservation pressure" less concern is placed on the usage pattern of the artifacts, leading in turn again to deteriorating efficiency. As an example of such a feedback mechanism it was mentioned that buying an energy efficient car can lead to driving it more. It was argued that such social feedback mechanisms are the essence of why theoretical conservation potentials may not turn out to be realizable. Understanding better from an analytical viewpoint such social feedbacks and gaining a better understanding of how consumers *perceive* the total costs of different options, including transaction costs, was concluded to represent an important future research direction.

Discussant Toufiq Siddiqi pointed out yet another important social dimension of global change mitigation strategies: their distributional consequences. Equity issues are not only involved between different countries or between different generations, past, current and future, but also *within* countries and generations. Siddiqi pointed out that, for instance, per capita resource usage within countries can vary up to factors of ten, being of similar order of magnitude as the disparity between the most and least affluent societies. Therefore, the issue of "no-regrets" for whom begs attention. As a conclusion for analysis, a general move from aggregate to more specific models was suggested.

3 Sustainable Development: Definitional Needs and Moral Issues

Perhaps the most controversial issue that emerged out of the discussion dealt with the definition and operationalization of the frequently too loosely used concept of "sustainability". One extreme view called the sustainability concept both morally repugnant and inherently undefinable. This because evaluation criteria between different actions such as a particular development project and the conservation of a species are considered impossible to define, and the trade-offs between different actions unknown.

On the other hand, it was argued that even economists acknowledge that market discount rates do not work in questions of intergenerational transfers. Perhaps therefore, to put it in Umberto Colombo's words, the *ethical discussion overshadows the market discussion*. Ethical questions and moral judgements need to be made explicit, for instance, what kind of environment with what irreversible changes we pass on to future generations, but also what kinds of knowledge and resources are transferred to future generations who must eventually cope with (solve, or adapt to) the problems inherited.

"Sustainability" also does not necessarily always imply the conserving of depletable resources for the future. Resources are, in principle, finite (although with an unknown physical or economic time horizon), but frequently they are also replaceable. Therefore conservation efforts to spread the lifetime of a resource base can "buy" time to develop substitutes. Perhaps this might be a pragmatic definition of "sustainability", quite consistent with economic concepts such as "no-regrets" strategies. Sustainable development paths are those which develop and maintain humankind's capability to adapt to changing boundary conditions, and enhance its responsiveness and the range of options available for such adaptation.

Examples in the energy area mentioned to substitute fossil fuels might be renewables, nuclear fusion, or in the very long-term even matter–antimatter. These are options which could sustain the energy needs of whatever level of global population will materialize over the next 100 to 200 years.

PART III

Present Trends Give Cause for the Most Serious Concern

4. Environmental Aspects of the Transformation of Centrally Planned Economies
Gueorgui S.Golitsyn

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Professor Siro Lombardini 91
Italian Society of Economists, Chiesi (TO), Italy

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Helsinki, Finland

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Professor Leonardas Kairiukstis
Lithuanian Forest Research Institute,
Kaunas, Lithuania

Foreword

Georgi Golitsyn gives a somber account of the residue left over from Communist rule in the ex-Soviet Union and in Eastern Europe. In the phase of transition to a market economy the numerous problems were quickly uncovered, but their solution is going to be slow.

A part of what brought the condition about was the extreme monopoly – for many commodities a single vast plant provided the needs of the entire Soviet Union. A demoralized labor force was not suited to that wholehearted intricate working together that modern production requires. In the pressure to achieve an adequate supply of goods, other considerations, and in particular those concerned with the environment, went by the board. And when there was but a single plant making a given machine part or other vital necessity, that plant just had to be kept going, irrespective of the quality of its product, or the damage it was wreaking. There has been much literature on multi-objective optimization, but in practice it seems difficult for managers to take more than one objective seriously when there is no pressure from the market to do so. The managers of the plants were rated on their recorded achievement of purely quantitative targets, and there was no corresponding bookkeeping for incidental conditions. Whatever the reason, it seemed impossible for the system effectively to embrace multiple objectives: safety, quality, environmental protection.

Part of the trouble was that in the Cold War goods for civilian consumption had to yield priority to military goods. Though the capital collected in what amounted to state taxes was considerable, there was a chronic shortage of capital in the civilian economy, and machinery was used two to three times as long as in the industrial countries of the West. With out-of-date equipment and undisciplined workers accidents in the workplace could be expected, and in fact they were frequent.

Golitsyn gives much attention to air pollution, that was inevitable in early stages of production, but could have been alleviated with modern methods. Many water reservoirs are in a state of eutrophication. There are far too many cases of soil degradation, deforestation, desertification, extinction of species. These side effects of production are not specific to Communism, but apparently it handled them less well than it might have. Man-made construction on a very large scale has been undertaken – the Aral Sea cotton development, the Leningrad Dam, nuclear power installations – without thought of their effect on the environment, that has turned out to be seriously adverse.

Poor management in warehousing and transport shows itself in the loss of product, especially in the food sector. One study showed 40 percent of eggs and 15 percent of fish lost between the farm or the harbor and the consumer. Much of what was delivered to the stores was in poor condition.

In this thorough and detailed evaluation of the condition of ex-communist states many other environmental problems and examples of waste are referred to. Golitsyn points out good reasons to deplore these. Inequity in the use of resources between North and South is exacerbated by wasteful practices in the North. These are not entirely absent by any means in the United States and Europe but those in the ex-Soviet Union were evidently more serious.

On a more general level, some of the limits of worldwide development are evoked by Golitsyn, and he ends with the basic query "To what extent should natural resources be expended on behalf of people in different places, in the north or south, east or west?" There has to be sharing; how should it be arranged? Interpreting natural resources in the broadest way, to include soils and the capacity of the atmosphere to absorb emissions without intolerable heating, some of what the North spends will not be available for the South, and some of what the world as a whole now spends will not be available to its grandchildren. Although for science to tell us the risks we run is far from adequate, the threat is there, and if the wider issue is not on the minds of people everywhere, it is not many years until it will be.

Committee for IIASA '92

Discussion

Siro Lombardini

As Professor Georgi S. Golitsyn has pointed out, the prospects for improving the environment during the next years may be good due to the decline of production. But that is not a sign of a positive evolution: it may be a premise for the further fast deterioration of ecological situations in the years to come.

To assess the long-term prospects, two initial considerations may help.

1. It is not true that one must always avoid pollution. There are technologies that by transforming polluting materials into secondary commodities may help achieve the goal of preserving the environment without cost. Whether these technologies will be adopted or not depends on the attention given to environmental problems.
2. The main factors accounting for environmental deterioration are the rate of growth of the population and "way of life". The first factor is relevant when dealing with Third World countries. The greatest danger for the environment in the Eastern European countries, moving from a command to a market economy, is the way of life that is likely to be stimulated by the transition process (think of the role of the car).

Two auxiliary considerations may help.

- There are different market economies. The Japanese market economy is quite different from that of the USA. The differences are mostly in the role of the financial sectors, in the State–firm relationship, in the institutional rules and praxis governing the games among firms. Some market economies are more favorable than others for implementing environmental policies.

- The first push for economic development does not come from the market (think of the US government's programs for military defense and space exploration that have contributed to technological development of key sectors of the economy). Then we must think of the objectives pursued by State policy. Why is environmental protection not a relevant objective in any State policy?

These considerations do not encourage optimism in assessing the prospects for improving the environment in the Eastern European countries.

1. They have accepted an ideological view of the market economy that does not allow for a proper consideration of the problems involved.
2. The Western countries – as well as the international institutions – do not help in improving the orientation of economic policy towards the goal of environmental protection. (It is certainly not sufficient to require the usual assessment of the environmental consequences of the programs to be financed. To face the environmental problems we need an appropriate general policy.)
3. It is precisely because of the economic crisis that the environmental requirements are likely to be practically ignored. Yet, the rebuilding of many industrial sectors could offer a unique opportunity to enhance an environmental policy. Golitsyn's remarks on the environmental deterioration after *perestroika* (that has, however, contributed to the opening up of new prospects from Eastern European countries and for the world in general) are illuminating.

Discussion

Lea Kauppi

There are several features in the political system of the former Soviet Union and other Eastern European countries which led to the present, and in many regions disastrous, state of the environment. Only by recognizing these facts and analyzing how they have changed or will change in the new situation can we try to describe the future.

1 Recognition of Environmental Problems

As the political system was considered ideal, consequently it could not cause environmental problems. Officially this opinion was valid for a very long time. This official neglect of the problems had many serious effects: monitoring of the state of the environment was not considered important and thus pollution could continue for a long period of time without any measures taken to prevent it. Still today, it is difficult to get a reliable picture of the present state. This has now led even to the overestimation of environmental problems in some cases in order to get more economic aid.

At the same time, environmental standards were, at least in some cases, unrealistically strict. For example, in the 1970s the Finnish water authorities had difficulty explaining to their Soviet colleagues that the color of the water in some virgin rivers flowing from Finland to the Soviet Union was caused by natural humus content. At the same time, the loading from Leningrad reported officially to the Baltic Sea Commission was heavily underestimated. The same was true for emissions from the smelters in the Kola Peninsula.

Today, the problem is not any more the neglect of problems, but still it can be seen that official statements and reality do not always meet. Recently Russia signed an agreement with Finland on environmental protection. According to the agreement a 90% reduction of phosphorus should be implemented in the sewage treatment plants of St. Petersburg in 5 years, which can be considered clearly unrealistic.

2 Responsibility

In the old system individuals had no responsibility. Since only the central administration was officially responsible, in reality, nobody took the responsibility. This cannot be changed in one night, but needs a lot of education at all levels. This may turn out to be a crucial question when implementing pollution control measures. The responsibility for the environment has to be understood as an integral part of all productive activity. One has to make sure that correct parameters are used for measuring productivity, i.e., the amount of products, not the amount of raw materials used. Improved efficiency means smaller losses to the environment as well.

3 Scales

One question is the scale of production. It seems that production on a very large scale is neither efficient nor environmentally sound. This is particularly true for agriculture where industrial production units have caused serious environmental pollution. However, in farms which aim at high productivity the losses have to be minimized. This means that nothing is considered as waste, but as a valuable resource.

4 The Future?

In the industrial sector aiming at higher productivity is often also positive for the environment. In a modern production system environmental protection is part of it. The best way is to prevent pollution generation in advance, although external measures are also needed. The main problems in industry are economical: where to get money for modernization. The modernization alone is not, however, enough. Just as important is proper management. If maintenance is not taken care of, modern factories can pollute the environment as well as the old ones.

In agriculture big structural changes are needed. The main trend should be the splitting of the huge industrial units into family farms, which cannot afford to waste manure, fertilizers or pesticides.

Private households, particularly in urban areas, may turn out to cause increasing environmental problems. The higher the material standard of living the higher the stress to the environment. Energy consumption and waste production, as well as traffic, increases. Particularly if this happens in a relatively short time, development gets out of control.

Common to all sectors is the importance of true responsibility at all levels.

The Environmental Situation in Lithuania during the Transformation of Eastern Europe

Leonardas Kairiukstis

1 Introduction

Environmental development history in Baltic countries during the late millennia can be characterized as colonization of woody land, decrease in forest cover, reclamation of landscape, increase in human population and agricultural industrial development. As far as it concerns Lithuania, the decrease in forest cover was estimated to have fallen from 54% (in the 13th century) to 19% (1950) (*Figure 1*). Therefore the long history until the second World War has still left quite a good, but rather fragile, environmental situation in Lithuania. Small industrial and agricultural development up to that time did not cause any remarkable environmental damage.

The annexation of Baltic countries in 1940 and, according to the Molotov–Ribentrops pact, incorporation in the former Soviet Union, as well as destruction during World War II, has completely changed the situation. In the late fifties Lithuania began to follow the development path of the Soviet Union. It was the path of industrialization. In the small area (65.2 th. km^2) of densely populated (3.6 mill.) Lithuania several gigantic industrial plants such as the Mazeikiai oil refinery, Akmene cement factory, Jonava and Kedainiai nitrogen fertilizer factory and finally the largest nuclear power station in Europe, Ignalina, were set up without

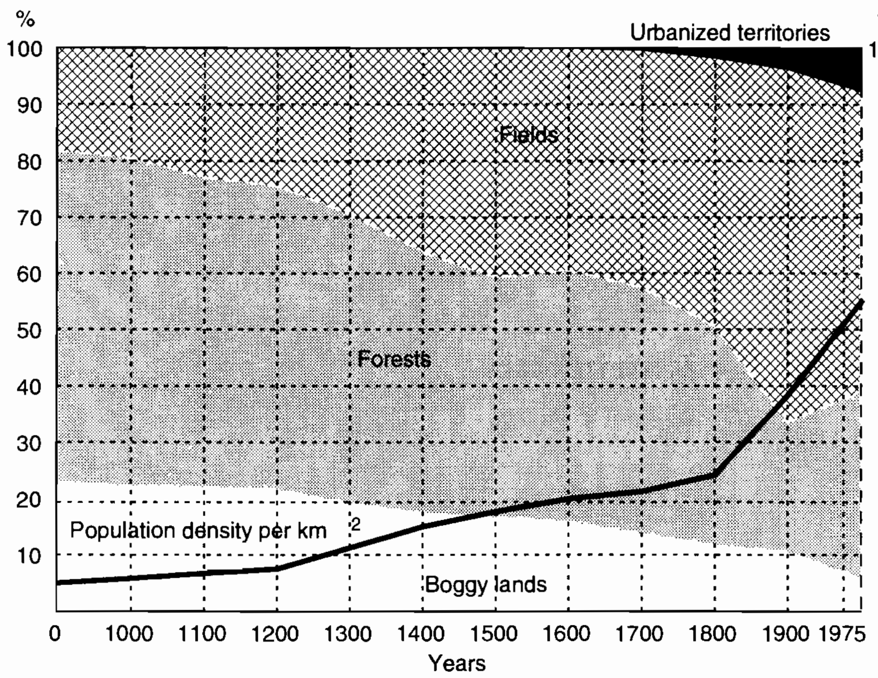

Figure 1. Diagram of landscape transformations in Lithuania (after Matulionis and Jankauskas with additions up to the year 2000).

proper ecological expertise (*Figure 2*). Among the other negative factors which also damaged environmental sustainability were irrational and unbalanced use of natural resources (building materials, peat, etc.) and overconcentrated agricultural activities with super-gigantic farms.

Technological colonization and the structural inadaptability of the economy to local demands, the Western market and the environment were peculiarities of the former totalitarian state which had and still have very grave consequences for the economy and the environment of Lithuania. The economy during the transition period has fallen into deep crisis. Over the last three years since Lithuania gained independence and step by step started to transform its so-called centrally planned economic system to a market system, economic decrease comprised 50% of the total national product. In

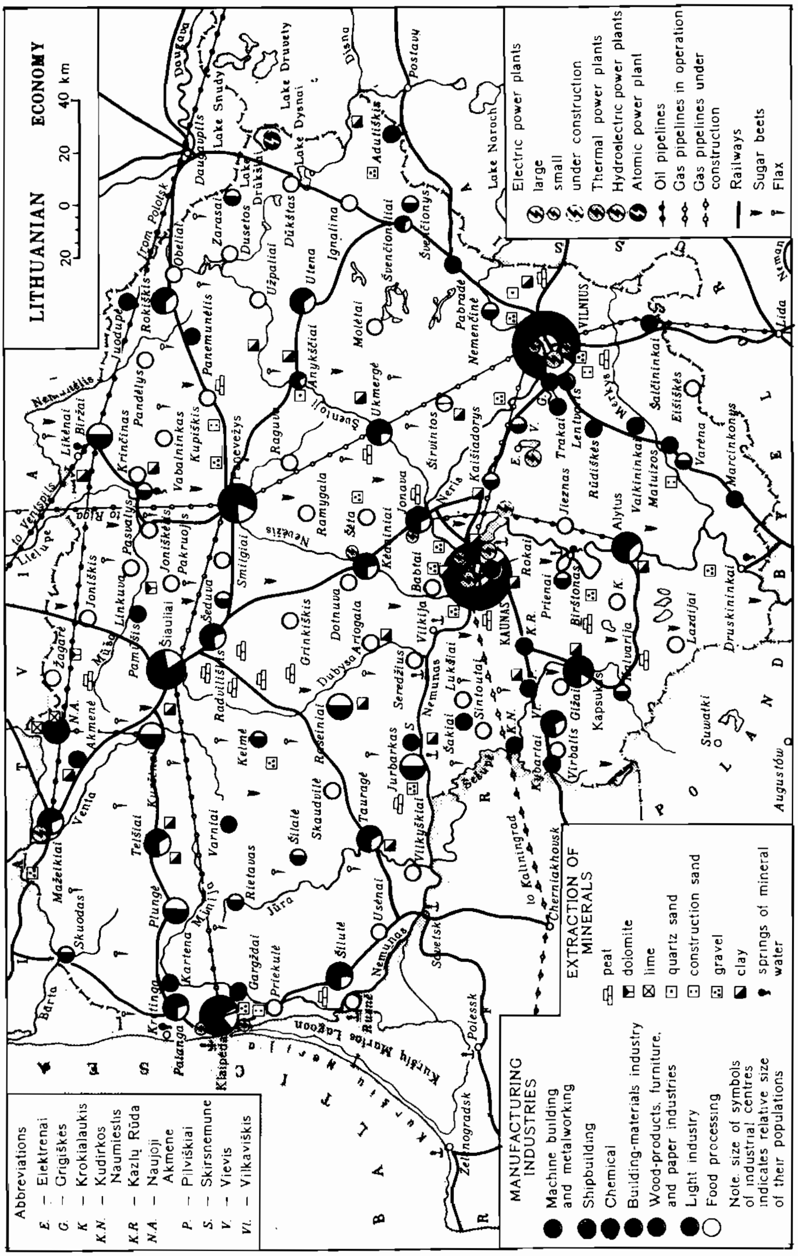

Figure 2. Industrial development of Lithuania.

agriculture the situation is alarming. In 1992 the prices and tariffs of consumer goods and services increased 13 times. The prices of food products increased 14 times, whilst the average monthly wage grew by a factor of 4. At the end of 1992 nearly 70% of all expenses were assigned for food. The renewal of technological processes nearly stopped, resulting in bad consequences for the environment.

Taking into consideration the situation above, Lithuanian scientists had been and are making some efforts to ensure ecological sustainability on a regional level (Kairiukstis, 1982, 1992). Using the main conceptual approaches worked out by W.I. Vernadsky (1926), the current UNESCO Program "Man and the Biosphere" and the State project "Ecological Sustainability of Regional Development", the dynamic territorial restructuring of anthropogenic activities in Lithuania are devoted to:

- Ensuring life support and well-being compatible with environmental protection.
- Neutralizing unwanted pollution and negative influences resulting from other noospheric disturbances.
- Stabilizing conditions for biota and providing spatial self-induced high productivity.

In this effort we experienced great methodological help from the International Institute for Applied Systems Analysis (IIASA), which launched a large program on ecological sustainability of the biosphere (Clark and Munn, 1986) and also from many other international programs (see Fritz, 1990).

Unfortunately, in practice, for sound environment management too little has been done, including in Lithuania. Therefore, in fact, environmental toxicosis has been aggravated. Environmental assessment has become one of the main tasks for scientists.

2 The Current Situation of the Environment

The current state of the environment in the Baltic region can be described by some "threats" characteristic to the whole European continent, namely:

- atmospheric pollution;
- acidification of water, soil and forest;
- nitrogen leaching as a result of agricultural practices;
- destruction of agricultural soil and food production potential due to chemical toxicants and erosion;
- decrease in biological diversity;
- long-term climatic changes and global warming.

In this report I would like to focus attention on several main stressors threatening human health and biological systems.

2.1 Atmospheric pollution

In the Baltic region there are widespread atmospheric pollutants such as CO, SO_2, C_nH_4, NO_x, HF,HC dust and O_3. Emissions from local pollution sources contain approximately 11.36 t/km^2 of pollutants per year in the East Baltic region. According to Amann (IIASA, 1990) the total sulphur and nitrogen deposition in the Baltic region exceeds the critical loads from 1–2 to 20–50 times.

Detailed investigation of pollutant sources and the state of pollution in Lithuania have revealed the following:

- There are about two thousand local pollutant sources, among them the 10 largest industrial enterprises which yearly emit more than 1 million tons of different kinds of pollutants (443 th. t CO; 188 th. t SO_2; 112 th. t C_nH_4; 65 th. t NO_x; 122 th. t of other pollutants). About half the pollutants are emitted by traffic (78% CO, 67% C_nH_4, 32% NO_x as a percentage of the total amount).
- To the greenhouse effect Lithuania contributes 0.16%. Emissions from pollution sources in Lithuania make up approximately 15.4 t/km^2 yearly. Additional input of pollutants from transboundary sources as calculated from the RAINS model constructed at IIASA (Hordijk, 1987) contains about 1/3 of the amount mentioned above.
- The concentration of pollutant ingredients (mg/m^3) in the atmosphere of the main industrial towns of Lithuania (Vilnius, Kaunas, Klaipeda, Shiauliai, Kedainiai, Jonava) were estimated

Table 1. The concentration (mg/m^3) of the main atmospheric pollutants in the largest towns and industrial centers of Lithuania (average 1984–1990), according to the Environmental Protection Department.

		Dust		SO_2		NO_2		CO		BP	
		av.	max	av.	max	av.	max	av.	max	av.	max
Vilnius	1986	0.1	0.7	0.01	0.08	0.02	0.33	1	14	0.9	6.0
	1987	0.1	1.0	0.01	0.10	0.03	0.23	1	12	2.1	8.2
	1988	0.1	1.0	0.01	0.06	0.03	0.30	1	12	0.9	2.5
	1989	0.1	1.5	0.01	0.08	0.04	0.45	1	20	0.6	1.3
	1990	0.1	1.4	0.01	0.07	0.03	0.27	1	22	1.3	4.5
Kaunas	1986	0.2	0.9	0.01	0.02	0.06	0.17	1	10	1.7	3.2
	1987	0.2	1.3	0.01	0.04	0.05	0.18	1	21	4.7	7.2
	1988	0.2	1.0	0.01	0.06	0.06	0.17	2	8	1.8	7.5
	1989	0.2	1.1	0.01	0.07	0.06	0.22	2	10	0.6	1.1
	1990	0.3	1.2	0.01	0.04	0.06	0.20	2	9	1.9	9.2
Klaipeda	1986	0.1	0.6	0.01	0.14	0.03	0.22	1	6	1.9	5.1
	1987	0.1	0.6	0.01	0.13	0.03	0.34	1	6	2.3	8.6
	1988	0.1	0.8	0.01	0.14	0.03	0.57	1	7	0.9	2.1
	1989	0.1	0.5	0.01	0.20	0.03	0.39	1	6	0.6	1.6
	1990	0.1	0.8	0.01	0.12	0.03	0.20	1	6	0.8	3.6

Shiauliai	1986	0.3	1.0	0.01	0.10	0.05	0.14	1	10	10.0	29.0
	1987	0.3	0.9	0.01	0.16	0.05	0.16	2	13	6.0	14.5
	1988	0.3	1.3	0.01	0.08	0.05	0.15	–	–	4.6	23.2
	1989	0.5	1.6	0.01	0.04	0.08	0.23	–	–	1.8	5.8
	1990	0.3	1.5	0.01	0.04	0.07	0.22	–	–	3.2	8.6
Kedainiai	1986	0.2	0.4	0.01	0.04	0.04	0.08	1	7	–	–
	1987	0.2	0.6	0.01	0.05	0.03	0.09	1	9	–	–
	1988	0.2	0.7	0.01	0.07	0.02	0.17	–	–	0.3	1.1
	1989	0.3	1.9	0.01	0.04	0.03	0.28	–	–	0.2	0.4
	1990	0.2	1.2	0.01	0.07	0.02	0.14	–	–	0.4	1.8
Jonava	1986	0.1	0.5	0.01	0.08	0.07	0.28	1	5	–	–
	1987	0.1	0.5	0.01	0.04	0.08	0.20	1	7	–	–
	1988	0.1	0.8	0.01	0.09	0.03	0.15	–	–	1.4	2.5
	1989	0.1	1.4	0.01	0.13	0.04	0.22	–	–	1.1	3.6
	1990	0.1	1.0	0.01	0.12	0.02	0.11	–	–	0.9	2.0

(in 1984–1990) as follows: dust averages 0.1–0.3, and its maximum amount is 1.9; SO_2 – 0.01 and 0.2; CO – 2–1 and 22; NO_2 – 0.02–0.08 and 0.88; NO – 0.02–0.07; phenol – 0.001 and 0.023; formaldehyde – 0.003–0.018 and 0.111; benzpyrene – 0.2–10.0 and 29 mg/m^3, respectively (*Table 1*).

- The mean annual dust concentration in many towns does not exceed the maximal allowable concentration (MAC). In Kedainiai and Shiauliai only, it exceeds MAC by 2 and 3.3 times or comprises 13 and 38% of the air samples investigated, respectively.
- The mean annual nitrogen dioxide concentration exceeds MAC in Kaunas by 1.5 times, in Shiauliai by 1.8, and in other towns was lower than MAC. Maximal NO_2 concentration in Vilnius was 5.3, in other towns it was between 2.6 and 4.6 times higher than MAC. Concentrations higher than MAC were recorded in: Shiauliai – 33%; Kaunas – 21%; Vilnius – 10%; Kedainiai and Klaipeda – 7%; in Jonava 6% of the air samples investigated were higher.
- The recurrent SO_2 concentration exceeding MAC in Kaunas comprised 15%, Shiauliai and Jonava – 14%, Vilnius and Klaipeda – 5%, Kedainiai 3% of the air samples investigated.

Benzpyrene is one of the most toxic admixtures in the air. Its mean annual concentration in Shiauliai exceeded MAC by 1.8 and in Jonava by 1.1 times. The highest benzpyrene concentration in Kaunas was 9, Shiauliai – 5.8, Jonava – 3.6, Klaipeda – 1.6 and in Vilnius – 1.3 times more than MAC.

The mean annual concentration of other specific atmospheric pollutants (fluorine hydrogen, formaldehyde, phenol) in towns did not exceed MAC. Occasionally, however, the maximal fluorine hydrogen concentration in Jonava was higher than MAC by a factor of 2.6 and the maximal amount of formaldehyde in Vilnius by a factor of 2 MAC.

A complex index of air pollution was estimated for each main town. It was determined that the worst situation (in 1990) was in Shiauliai, whereas in Kedainiai and Vilnius it was slightly better.

According to the absorption method in the forest environment of Lithuania (samples collected on a screen of 32 Rm × 32 km), the amount of SO_2 was 1.70 mg/m^2 per day on average and that of NO_x was −43.2 micro gr/m^2 per day. However, in about 10–20% of the forests the concentration of SO_2 was 3–6 mg/m^2 per day and that of NO_2 100–130 micro gr/m^2 per day.

- Nuclear radioactivity in the forest environment (after the Chernobyl accident), estimated according to caesium Cs137, can be characterized as follows: 6–3 th. Bqu/kg of the forest litter in the west, 3–1 th. in the southeast, and < 500–200 Bqu/kg of the litter in east Lithuania.

2.2 Water pollution

Along the surface of the territory of Lithuania about 4075 million m^3 (in 1989) of water flow. Of it 450 million m^3 of water are polluted. Purified water corresponding to the standards makes up 25.4%, insufficiently purified forms, 46.9%, and impure water forms, 27.6% of the flowing water. In addition, 44 million m^3 of impure water flow to filtration fields or are applied to irrigation. Only in Vilnius and Kaunas is the polluted water let out and comprises 40% of the polluted flowing water (data from the Department of Environmental Protection). The surface water is contaminated by the following substances resulting from the flowing water (figures are for 1989):

- Organic substances according to BDS – 64,110 tons.
- Suspended substances – 47,900 tons.
- Oil products – 540 tons.
- Mineral nitrogen – 7,770 tons.
- Mineral phosphorus – 881 tons.
- Iron – 464 tons.
- Copper – 32 tons.
- Zinc – 87 tons.
- Nickel – 34 tons.
- Chromium – 51 tons.

The quality of the surface water estimated according to the data obtained in 1987–1989 from 83 water quality observation points in 54 rivers, 5 lakes, and 2 water reservoirs is described by the following.

- Water quality observation points in which a normal regime of oxygen was recorded constituted 76% of all observation points: in the Nemunas, Shventoji, Merkys, Zeimena, Dubysa, Minija and in some lakes. The observation points in rivers in which oxygen concentration was diminished comprised 14% of all observation points (the Musha, Obele, Levuo, Shushve) while those in which oxygen concentration was less than 6 mg/dm^3 (the rate for water in which fishing is allowed) amounted to 6% (the Lankesa, Laukupe, Musha, Daugvene). An insignificant amount of oxygen (only 1.0–3.0 mg/cm^3) is found in the Kulpe and Sidabra. In the water layers near the bottom of the Kaunas sea oxygen concentration in the summer months decreases to 1.5–3 mg/dm^3.

  Observation points in lakes and rivers where the concentration (according to BDS_5) of readily oxidized organic substances is less than MAC (2 mg O_2/dm^3 is the rate for water in which fishing is allowed) make up 7.5% of all observation points: in the lakes of Lukstas, Tauragnas, Baluoshas and in the Zheimena, Minchia, Upyte. Water polluted by organic substances 1 to 2 times higher than MAC makes up 60%; that which is from 2 to 3 times higher than MAC – 21%; 3 to 6 times MAC – 10% and 35 to 50 times or 70 to 100 mg O_2/dm^3 – 3%. It occurs in small rivers such as the Kulpe, Sidabra, Obele and Tatula.
- Ammonium ions and nitrite concentration in the Nemunas is 1.5 to 2 times MAC, and in the Neris, Musha, and Sheshupe exceeds MAC by a factor of 7 to 10. In the middle-sized rivers and in small ones where the anthropogenic effect is insignificant ammonium and nitrite concentration in the water exceeds MAC by a factor of 1 to 2.
- Oil product (aromatic hydrogen) concentration is frequently less than 0.05 mg/dm^3 (I MAC); phenol – 0.001–0.003 mg/dm^3 (1–3 MAC); detergents – up to 0.02 mg/dm^3 (0.2 MAC). Copper does not exceed 0.003 mg/dm^3 (3 MAC); zinc – 0.004 mg/dm^3 (0.4 MAC); lead – 0.012–0.052 mg/dm^3 (up to 1.7 MAC).

- The concentration of chlororganic pesticides – DDT and its metabolites – is 0–40 mg/dm^3 and that of hexachloricyclohexan is 0–97 mg/dm^3.
- The most significant total pollution of flowing water by heavy metals is in towns: Kaunas, Shiauliai and Panevezhys (Krasilscikovas *et al.*, 1988). In the Shiauliai, Panevezhys, Alytus, Kedainiai, Kaunas and Vilnius regions well water is contaminated by copper ions to the greatest extent while in the Klaipeda, Pasvalys, Jonava, Vilkavishkis, Alytus, Shakiai, Kedainiai, Panevezhys and in the Vilnius regions it is contaminated by zinc. In the Akmene and Mazheikiai regions the pollution by Cr^{6+} exceeds the rate from 1.5 to 1.9 times, in the Skuodas region by 1.3 and in the Joniskis region by 1.2 times. High Cr^{6+} concentrations were detected in the Pasvalys, Birzai, Ukmerge, Vilnius, Shvenchionys, Utena, Vilkavishkis and other regions.
- According to the hydrobiological indications (phytoplankton and zooplankton, periphyton, zoobenthas) the surface water is polluted moderately. In lakes and water reservoirs eutrophication is intensive. This process is particularly significant in the lakes of Luksnenai, Simnas, Varenis, Mastis, Talsha and Shirvena. The concentration of biogenic substances and biomass of phytoplankton in the water are considered to be the most important indices of eutrophication. In accordance with these concentrations the lakes of the Republic are divided into three groups. The lakes affected insignificantly by anthropogenic activity – Plateliai, Akmena, Lavysas, Germantas, Tauragnas, Sventas, Ainis; the lakes affected moderately – Dringis, Pakasas, Vilokshnis, Vievis, Zarasai, Galve; and those affected significantly – Luksnenai, Simnas, Varenis, Mastis, Talsha, Shirvena.

All the water in the eastern part of the Baltic sea and Kurshiu lagoon (according to the data of 59 hydrometeorological stations in Lithuania) is well saturated with oxygen. In hollow parts deeper than 100 m oxygen concentration decreases up to 1 mg/dm^3, or is absent. Hydrogen is found here, the concentration of which in the central part of the sea and in the hollow parts of Gotland is 1.10–2.30 mg/dm^3 (1989). The water of the Kuršiu lagoon and near the coasts of the sea is polluted by ammonium ions exceeding MAC by 2.6 and 1.2 - 1.4 times, respectively, by nitrites exceeding MAC by 8.8 and 2.5 times, and by phenol exceeding MAC by 12–13 and 5–6 times. The mean phenol concentration in the deposition of the Kuršiu lagoon is 3.6– 14.67 mg/kg while near the coast and in the open sea it is 0.73–2.69 mg/kg.

The resources of the water reservoirs of Vilnius, Kaunas, Klaipeda and other towns are supplied by infiltrated surface water which is frequently polluted by organic substances and their combinations, oil products, etc. In comparison with the water of shaft wells, tap water is supplied by underground water of better quality. The quantity of all standardized ingredients, except iron, is less than the maximal allowable concentration (MAC). In the water of shaft wells calcium (Ca) and magnesium (Mg) are in abundance. Wells which have increased amounts of nitrites comprise 76% of all shaft wells in the Republic.

2.3 Soil pollution

Due to limited forest cover (27.8%), there is about 42% of the territory on which landscape resistance to chemical impact and ability for self-purification are comparatively insignificant (Pauliukevicius, 1989). A total of 350–400 th. ha of land need anti-erosion measures. In accordance with the data of the Ministry of Agriculture in Lithuania, approximately 4.06 kg/ha of pesticides are used, including 2.7 kg/ha herbicides. Simazin residue concentration in soil is about 0.01 mg/kg. The area in which the phytotoxic (PT) MAC is exceeded by 1.5 times constitutes 14% of the area investigated. In some regions maximal simazin residue concentration attains 45–94 PT MAC in arable fields and 48–90 PT MAC in gardens. In the Zarasai and Raseiniai regions the areas of cereal in which simazin concentration exceeds MAC by 2 to 9 times makes up 28–80% of the area investigated.

Along the highways polycyclic aromatic hydrogen and heavy metals accumulate in the soil. In some areas the quantity of benzpyrene exceeds MAC by 10–20 times. Lead amounts to 0.25 mg/kg. An increase in the quantities of Fe, Zn, Cu, Co and other metals has been detected. Acidification of rainfall causes considerable damage to water, soil and forests; the pH of precipitation from the west sometimes amounts to 3.3–4.0.

2.4 The long-term ecological background fluctuation and global warming

We have described above the main anthropogenic factors which have determined the environmental situation in Lithuania. The long-term ecological background deviations also have a noticeable impact on ecological systems and the lives of living creatures, either supportive or destructive.

Long-term tree-ring chronologies have shown that, in the Baltic region as well as in the Northern hemisphere as a whole, there are ecological background fluctuations of different duration which lead to different current productivity and sustainability of ecosystems (Kairiukstis and Dubinskaite, 1990). At this time, for example, we have lower tree productivity in cycles of 172 to 185 years, as well as 90–93, 58–62, and 46–53 year cycles. The average variables of cycles at present are also below the baseline of long-term tree growth. Let us consider these long-term cycles as they reflect the current general unfavorable climatic background conditions of the region under consideration. Short-term cycles (8 to 13, 20 to 25 years in duration) of growth processes, as well as forest decline (probably) and poor human health attributed to air pollution, will be revealed in the background of this unfavorable impact of long-term cycles.

The ecological background for productivity and viability of ecosystems, as seen in cyclic models, will remain lower in the following few decades. At the same time, following the cycles of short duration which are very typical of the Baltic region, namely in 1989 and the year 2000, we are expecting, also, minimal tree increment according to 11 and 22-year cycles, correspondingly.

The global warming process is also likely to decrease the sustainability of ecosystems, accelerate invasion of pests and disease, forest decline, etc. Most probably, changes in the composition of species will first occur in mixed ecosystems, as far as they represent transitional formations and their compositions are more dynamic.

This may lead to the transference of the southern borderline to the north for more species. In the southern part of the temperate zone, for example, spruce stands will be deprived of their position not so much due to the direct impact of climate changes, but as a result of reduced phytocoenotic resistance in new conditions.

The data illustrated above allowed us to conclude that environmental pollution in the East Baltic remains very severe. Actions taken by several countries to combat acid rain and a few relevant international agreements have proved to be very insufficient. Bearing in mind additional stress factors, such as long-term ecological background changes and global warming, scientists predict that the last decade of this century will witness a further aggravation of human health, forest decline, and other negative processes in ecological systems.

3 Indication of Current Environmental Aggravation

3.1 How trees can tell us about chemical and physical environmental stressors

It is a pity that not man, but trees have been among the first to tell us about dangers to life due to chemical and physical environmental changes. Forest die-off in Europe in the early 1980s was a trigger for new approaches to combat environmental pollution and to organize monitoring of forest decline and environment.

With the objective to estimate early indications of change in tree growth attributed to air pollution and physical environmental changes, the Lithuanian Forest Research Institute investigated physiological changes in cells and trees submitted to "stress" which was caused by physical and chemical environmental changes occurring due to atmospheric pollution. It was established that the "stress" situation occurs instantly (t_1), within several hours, days or months, and may be detected by biological, biochemical and energy changes in cells. The process of adaptation to stressors can continue for a long time, several years (t_2) or even decades (t_3), and lead to different consequences.

Our investigation on receptive indications of a tree as a system exposed to chemical stressors (Kairiukstis *et al.*, 1987) showed the following:

- Changes in membrane permeability to potassium ions enable the responses of trees to chemical impact to be observed 24 hours after the appearance of a stressor. Prediction of the quantitative changes in the structure of an organism as well as the trend toward forest decline is feasible after three months.
- Due to prolene accumulation in needles it is possible to evaluate qualitatively not only chemical stressors but the general state of the environment and steady stress induced to trees by it.
- The bioelectric potential of cell membranes and electric conductivity (active resistivity and polarization capacity) of the living tissues of a tree sensitively reflect both the adverse and affirmative impact of chemical substances in the environment.
- The mass of shoots with needles and that of needles are the most sensitive indices characterizing the overall reaction of trees to environmental change in the early stages.
- Finally, three dendrochronological methods for retrospective indication of forest decline attributed to air pollution have also been worked out. In the vicinity of local pollutant sources one of these methods has been applied. In the case of background pollution, including transboundary pollution sources, tree increment losses have been indicated by using harmonic analyses of standard dendrochronologies or reconstructed increment curves based on climatic indices.

The methods above were used in the monitoring of forest decline and environmental assessment in Lithuania as well as in other East Baltic countries during the years 1989–1992 on a screen of 4 km × 4 km.

The data on the regional monitoring have been obtained from the assessment of crown defoliation and other morphological, physiological and increment indices. These data disclose that due to atmospheric pollution forest decline, to one extent or another, affects 75.4% of all the forests in Lithuania (1991). It is found to be 7% more than in 1990 (68.4%) and was 62% in 1989. Moderately and severely damaged forests constitute 20.4%. Conifers

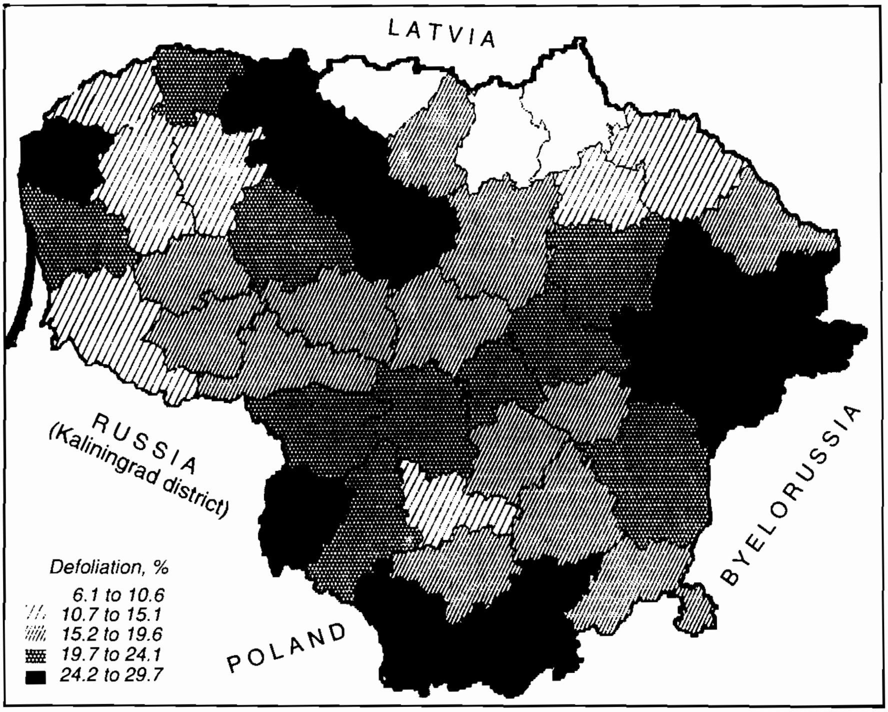

Figure 3. Distribution of Lithuanian territory according to atmospheric pollution and forest decline.

are damaged to the greatest extent: trees in which the impact of unfavorable atmospheric pollution is noticeable comprise 73.7% of all conifer trees, whereas the percentage in mature stands (aged 60 years) is 81.1%. Deciduous forests are the most resistant to air pollution. The trees affected by a negative impact to varying extents form only 49% of the total. The total data on forest damage suggests that the ecological situation has not improved. This means that the state of the environment did not improve either.

The greatest number of damaged trees is found in the Akmene (95.2%), Shvenchionys (95%), Kretinga (94.7%), Ignalina (94%), Utena (90.4%), and Shiauliai (89.6%) regions, while it is in the Birzai, Pasvalys, Kupishkis, Rokishkis, Shilute and Zarasai regions.

In accordance with several indices (crown defoliation, needle age, atmospheric pollution), four zones of forests damaged most severely (*Figure 3*) have been singled out:

1. Mazheikiai – Akmene, Shiauliai;
2. Klaipeda – Kretinga;
3. Zarasai – Utena, Ignalina – Moletai – Shvenchionys;
4. Vilkavishkis – Marijampole – Alytus – Lazdijai – Varena.

The best ecological situation remains in the zone of Birzhai–Kupishkis–Rokishkis.

The dynamics of the ecological state over the last two years were assessed by conditional scores. The areas where the state did not change constituted 40% of all regions, those where the state improved formed 20–25%, the regions where the state was aggravated amounted to 30–35%. Essential aggravation of the state of forests was observed in the Plunge, Telshiai, Ignalina, Kaishiadorys, Shakiai, Taurage, Shvenchionys and Shirvintos regions. In the Kupishkis, Panevezhys and Shilute regions, improvement was noted.

3.2 Threat of atmospheric pollution to human health

Pollution in the anthropogenic environment causes great danger for the existence of the Lithuanian population and the Baltic tribes as a whole. The threat moves slowly along two directions:

- First, it comes from the atomic power station in Ignalina. In case of an accident like the Chernobyl disaster, the Baltic tribes, and some of Urgo-Finns, Slavs in the south, Scandinavians, the present Lithuania, Latvia, part of Estonia, Finland, Poland and Sweden might disappear.
- Second, there is a threat of slow self-poisoning due to super-intensive industrial development which is technically unprepared and ecologically unbalanced. Air pollution is the concomitant of industrial development. Therefore, the towns of Shiauliai, Klaipeda, Jonava, Mazeikiai, Akmene, Vilnius, Alytus and districts, where currently over 1.3 million people live, are in danger. Besides this, nearly 1 million people live in other polluted zones in Lithuania.

The most awful diseases, such as cancer among human beings and animals, are associated with increasing amounts of polycyclic aromatic hydrogen (PAH) and nitrozamin (NM) in the atmosphere of the regions listed above. However, diseases are revealed very late since the latent period of malignant tumors is 15–30 years (Griciute *et al.*, 1987).

In accordance with the data of the Oncological Institute, due to atmospheric pollution the greatest morbidity of people with malignant tumors is in the Kedainiai region. Women and men are ill with lung cancer 2.4 and 1.9 times, respectively, more than the average, throat cancer 1.8 and 2.4, lip cancer 3.1 and 1.5, myelio-leucosis 2.3 and 3.8 times more frequently than the average in the Republic. Lip cancer among men exceeds the average of the Republic 3.9 times. Children living in the zone of the factory in Kedainiai inherit corporal defects: hemangioma dysplasia, syndactylism, etc. A similar situation can be observed in Jonava. The morbidity of people with tongue cancer exceeds the average of the Republic by 2.3–3.5 times, throat cancer by 2.6, cerebral cancer by 1.9, and lymphogranuliomatosis by 4.6 times. Children's morbidity due to pneumonia, laryngitis and bronchitis is nearly 10 times greater in the control zone (Murza and Juozukynas, 1989).

Due to the influence of emissions from the cement factory in Akmene and thermal electric power in Elektrenai, maladies of the respiratory organs are widespread. Children are ill with catarrh, conjunctivitis, and dermatitis more frequently than in other regions. Children's abnormality is more frequent too.

Professor Trainys, having thoroughly investigated the morbidity of domestic animals in the regions of heavy pollution, inferred that increased amounts of heavy metals accumulate in the fodder. For instance, in the Jonava region in the farms of Pauliukai, Neris, and Upninkai, nickel exceeded MAC by 15 times in the fodder, milk contained lead 2 at a level exceeding MAC by 2 times and in the muscles of cattle the quantity of cadmium was 5 to 9 times larger than MAC.

An increase in instances of chromosome aberration and sister chromatide exchange in the cells of cattle was noted. Aberration per cell is observed 3.5 times more frequently. Because of significant air pollution in the above farms, the total compulsory killing of livestock exceeds analogical indices in farms where pollution is slight (Kalnujai farm in the Raseiniai region).

This corroborates the inference (Kairiukstis, 1982) that in polluted zones it is not expedient to grow crops used for food and fodder, or develop cattle-breeding. On these areas technical crops and forests should grow.

4 Measures for Environment Protection

In order to decrease the negative consequences for the environment and human health caused by atmospheric pollution and climatic change it is necessary to increase the effectiveness of environment-protecting measures presented below, namely:

- To abate about 30% of the air pollution from local pollution sources by reconstructing the energy industry and transportation sectors, implementing sound and more efficient technologies; to attain international agreement on repayment of transboundary pollutants.
- To decrease by a factor of 2 the amount of pollutants getting into open waters, to construct or reconstruct 21 purification plants including large ones in Kaunas, and implement the requirements of the Convention of the Baltic Sea Protection; non-expansion of the capacity of the atomic power station in Ignalina and conservation of the first reactor.
- To increase forest areas by transforming non-forest land through reforestation, which must be augmented by a factor of 2. Wooded areas in the South-East Baltic regions should increase 2–3% and comprise 33% of the area.
- To create the Baltic shelter belts of protective forests across Lithuania, Latvia and the Kaliningrad district of the Russian Federation; nature-conservation territories should make up about 10–12% of the total land.
- To implement more environmentally oriented management and public policy to create new quality standards, to introduce taxes

for polluting the environment, to promote ecologically pure production, to organize ecological monitoring for the whole basin of the Baltic Sea by constantly observing air, water, soil pollution, the state of human health, forest decline, and genetic consequences.

Finally, one should stress the fact that the effect of emission control is transboundary, but, notwithstanding the general principal of polluter pays (we have, for example, air pollution exchange between East and West in a ratio 10 to 1), consideration should be given to supporting constrained resources in East Baltic countries – Lithuania, Latvia, Estonia – through cost-sharing between Scandinavian countries for their mutual benefit. Economic recession, which is taking place in all former socialist countries, will also create some immediate improvement of the environment in the Baltic region. However, looking at this process over a longer period of time, we should realize that this is only a precondition for environmental deterioration in the future.

References

Alcamo, J., Shaw, R., and Hordijk, L., eds., 1990, *The Rains Model of Acidification, Science and Strategies in Europe,* Kluwer Academic Publishers, Dordrecht, Boston, London.

Amann, M., 1990, *Using critical loads as the basis for abatement strategies in Europe*, EB. AIR/W65/R.I, United Nations Economic Commission for Europe, January 20.

Bartholin, T.S., 1978, Dendrochronology, Wood Anatomy and Landscape Development in South Sweden, in J. Fletcher, ed., *Dendrochronology in Europe*, National Maritime Museum, Greenwich, Archeological Series 4(2):125–130, Oxford University Press, UK.

Berglund, B.E., 1969, Vegetation and Human Influence in South Scandinavia During Prehistoric Time, *Oikos Suppl.* 12:9–23.

Clark, W.C., and Munn, R.E., eds., 1986, *Sustainable Development of the Biosphere*, Cambridge University Press, Cambridge, UK.

Ecological Sustainability of Lithuania (ECOSLIT), 1992, Annual Report (abstract), International Center for Scientific Culture, WORLD Laboratory Lithuanian Branch.

Fritz, J.-S., 1990, *A Survey of Environmental Monitoring and Information Management Programs of International Organizations*, first edition, 8042 Neuherberg b. Munchen.

Griciute, L., Dagiene, M., Shtripkuviene, N., and Gurevicius, R., 1987, *Impact on Human Health of Atmospheric Pollutions. First Aspects of Prophylactic and Hygiene*, Vilnius (in Lithuanian).

Hordijk, L., 1987, Integrated Assessment of Acid Deposition in Europe, in L. Hordijk, ed., *Report of the Second Task Force Meeting on Acid Rain and Policy Analysis in Europe, 14–18 April 1986*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Kairiukstis, L. *et al.*, 1987, *Assessing Climatic and Atmospheric Chemistry Changes through the Study of Trees*, Paper presented at the IIASA Task Force Meeting on Impacts of Climate Changes and Atmospheric Chemistry on Northern Forest Ecosystems and their Boundaries, 3–7 August, 1987, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Kairiukstis, L.A., 1982, *Environmental Optimization*, Vilnius–Kaunas (in Russian).

Kairiukstis, L., and Dubinskaite, J., 1990, Harmonic Analysis for Ecological Prognoses, in E. Cook and L. Kairiukstis, eds., *Methods of Dendrochronology: Applications in the Environmental Sciences*, Kluwer Academic Publishers, Dordrecht, The Netherlands.

Krasilscikovas, A., Jatuliene, N., Taraskevicius, R., Barysiene, R., and Michailenko, N., 1988, Environmental Situation and Illness of Children in Great Industrial Centres, *J. Sveikatos apsauga*, 11:12–15 (in Lithuanian).

Murza, V.A., Juozukynas, J., 1989, *Sveikatos apsauga*, 12:10–12.

5. Pluralism and Convergence in International Science Policy Sheila Jasanoff

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Foreword

Sheila Jasanoff is struck with the change in public attitudes to science that we have witnessed in the last few decades. Where once science seemed to offer truths beyond challenge and benefits without drawbacks, now doubts arise on the one side from some clear non-benefits like nuclear weapons and on the other side from various well-publicized events showing that scientists are subject to human failings. She refers to the change as the deconstruction of scientific authority. The process is evidently part of a wider distrust of institutions corresponding to our contentious modern world, but in the case of science it contrasts sharply with the previous implicit faith and acceptance.

One might have thought that science would be exempted from this critical spirit that is applied everywhere, on the grounds that its contributions have never been so great. It has supplied seemingly miraculous solutions to so many problems, and in so many distinct domains, that it ought to command respect as never before. Testimony to the persistence of an almost pathetic faith in science is the frequent complaint that there are problems – AIDS is most often cited – to which science has not provided an immediate solution. Yet this dependence on science does not protect it from public and political curiosity about its proceedings.

It is in accord with the new spirit that right-to-know laws are introduced. Yet science is the one institution that has always made openness a basic principle. Hostile to secrecy, its findings have always been published and subjected to challenge; in this has lain its strength. But with the increasing number of problems on which technical consultation is necessary we pass into a new phase in which the public will share not only in the published results of scientific work but in the consultation process. Scientific advisory committees are no longer to be allowed to deliberate in total privacy or their conclusions given any special respect; their advice is to be treated on what the press consider its merits, just as any other advice is.

Incidents that show the changed treatment of science occur weekly. As this is written *Science*[1] carries an article on the inspections that the National Science Foundation has started to make, under the title "NSF's New Random Inspections Draw Fire". The inspections are intended to ensure that the funds allocated to particular institutions are being used properly, but in one case those inspected were "disturbed by the breadth of the NSF team's enquiries". And Donna Shalala, Mr. Clinton's Secretary of the Department of Health and Human Services, responsible for another major science funding agency, the National Institutes of Health, complains:

> not that [Congress] are not willing to put in money, but they want to micro-manage that money.[2]

Scientists believe that the best results will be obtained if the right people are supported financially, and then judged by what they finally produce – without any intermediate requirements. That is no longer good enough for funding institutions under the eye of the legislature.

As an example of the problems with which international science policy has to cope she cites the views of Third World scientists and environmental activists on population and sustainable development, and how these differ from views held in the North. The North places far more emphasis on the control of population; the Third World on equitable access to resources. We need more knowledge on what will make development sustainable but in addition we must recognize that science alone has no way of resolving the broad issue involved. In fact scientists differ among themselves on the extent of the population and environment problems as well as on their nature, and one hopes that these issues among scientists will be resolved. But that is not sufficient, for values enter here; needed also are "communal norms about what kind of world

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[1] *Science*, Vol. 261, July 16, 1993.

[2] Mervis, J., 1993, Donna Shalala and the Future of NIH, *Science*, Vol. 26 (1), July 2, 1993.

we want and how human beings should relate to the world's other living and non-living systems".

Committee for IIASA '92

Summary of Helga Nowotny's Discussion

Nathan Keyfitz

Helga Nowotny summarizes some of the Jasanoff paper and in her comments concentrates on the boundary between science and society, no longer as sharply drawn as in the past. It once used to be said that science would make its greatest contribution if society interfered with it least. By trusting science and leaving it alone the public is in the end better off. That view is rarely expressed today. The demand is now for "public accountability of science and technology"; "science has become much like other institutions in modern society: in its organization and work setting, in its moral standing and the norms held by its members, and in its affinity towards (some would say corruption by) economic and political influence".

The process as Nowotny describes it has not yet been concluded. There is ahead another short step toward normality, in which science would not only be required to achieve results worth the money, "but could rapidly lose its claims to a higher form of rationality and the higher cognitive status and authority that goes with it". In fact two British physicists claim that this departure from the higher form of rationality previously attributed to it has already happened, and they blame it on four popular philosophers of science:

The discussion paper entitled *Redrawing the Boundaries between Science and Politics: Toward a Postmodern Version of Speaking Truth to Power*, by Helga Nowotny is Chapter 6 of *Science and Sustainability* (IIASA, 1992).

> Karl R. Popper who claimed that theories can never be proved but only falsified; Imre Lakatos, who contended that scientists ignore falsifying evidence; Thomas S. Kuhn, who argued that science is a political rather than rational process; and Paul K. Feyerabend ... who has insinuated ... that scientists develop and adhere to theories for what are ultimately subjective and even irrational reasons (see Horgan, 1993).

Many of the issues come to the fore in global environmental problems. In these "Knowledge cannot be separated from action any more", and it is possible that the scientists working in these fields are showing the way that science in general will follow in the years ahead. The plural roles of environmental scientists include their acting as advisors to their governments and forming part of their nations' delegations in international conferences; at the same time they are highly expert in their own right. They understand that problem definitions are contingent upon context, which includes the policy context. "They have learned to practice dual or plural loyalties – to science, which always means international, universalistic knowledge, and to their governments or employers as well.... The dexterity with which they change hats and cross boundaries makes them truly post-modern.... Some have also learned ... to speak the vernacular language of science, namely the ability to address lay people and to involve them in environmental science".

But Nowotny is very far from seeing the whole process as merely a part of a general social encroachment on science. "There are genuine concerns that come from realizing the global nature of the problems and the hazardous situation in which humanity is rapidly finding itself on this planet. There is the challenge of sustainability and the redefinition of our way of seeing the world that comes with it". The seeming encroachment comes because of the general public sensitivity to the importance of the issue to its own future.

References

Horgan, J., 1993, The Worst Enemy of Science, *Scientific American*, May, p. 16.

Rapporteur's Report

Rod Shaw

1 Introduction

The session consisted of short summaries by Professor Sheila Jasanoff of her theme paper and by Professor Helga Nowotny of her comments, followed by a general discussion. Rather than describe the discussion sequentially, the following report will deal with three main topics covered during the session. These topics progress from general problem definition to suggested approaches for the future, first in general and then with respect to IIASA in particular. They are:

(*a*) The Changing Public Perception and Role of Science in Policymaking.
(*b*) Coping With the Problem: "Speaking Truth to Power".
(*c*) Implications for Future Work at IIASA.

2 The Changing Public Perception and Role of Science in Policymaking

In her paper, Jasanoff brought our attention to the growing public unease and skepticism about the directions of modern scientific inquiry, the wisdom and integrity of the inquirers, and an overly intimate alliance between science and the state. She asks, "Is it appropriate for science to claim a cognitive authority superior to that of other social institutions because it alone is able to find out truths about nature?" Jasanoff calls this increased questioning of science and scientific evidence the "deconstruction" of science; Nowotny in her paper mentions how struck she was with how quickly the processes Jasanoff describes under the rubric of deconstruction have proceeded. Barely 20 years have passed from the time that A. Weinberg coined the term "trans-science", in which scientists inject order and discipline into examining questions in which the scientific information is inadequate. Weinberg envisaged an essentially linear relationship between science and policy whereby the former was something that could be cleanly done by scientists and factored as needed into policy. Today, this vision is seen as being too simplistic – scientific input into policy is being heavily scrutinized and often rejected. The old model of "science in, policy out" has been breaking down.

As Jasanoff described in her paper, Weinberg thought that the best way to factor science into policy was through the open and adversative processes of the law, at least in the legalistic decision-making culture of the United States. Yet, it has become evident in the past 20 years that, as science has become increasingly involved with public issues, it can no longer be considered to be independent of the social and cultural milieu in which it operates. Expert judgements about matters such as environmental degradation could differ widely, even with the same input data! Jasanoff feels that the experts' views were conditioned by underlying socially induced perceptions of the problem; the "facts" that the experts used were so context-bound that they were not descriptions of reality but could be labelled as "trans-science". She also mentioned research that has concluded that entrepreneurial cultures are generally most open to the risks and benefits of new technologies while, in contrast, egalitarian cultures are inherently risk-adverse.

In her commentary paper, Nowotny mentioned the entry of "junk science" into the courtroom, especially in the United States. She also described other factors in Europe that may have played a role in the decreasing skepticism about the role of science in public policy. The all-powerful welfare state in the three postwar decades coincided with the rise of powerful and effective alliances between modernizing elites and scientific establishments, all eager to advise policymakers. It was believed that the future betterment of humankind could be achieved with the help of science and technology, while negative consequences of policy decisions were denied or kept invisible. Nowotny states that today the former broad consensus of a societal project of major, future-oriented proportions has been shattered and that the once powerful state has lost much of its former capacity to control events and ideologies that favor the perpetuation of its control. This is especially so in the former Communist regimes in Eastern Europe, where science and technology run the risk of being conceived as having been deeply involved with the old totalitarian order.

It was brought out in the discussion that policy people get only a "snapshot" of science in progress, and a fuzzy one at that. We are still relying on a very inadequate means of assessing risk – statistics; furthermore there is a tendency to exaggerate what science really has achieved.

Despite growing public skepticism, especially with respect to domestic issues, science is still being called upon to provide input for policy debates. This includes international environmental issues such as global warming and the decrease of bio-diversity, where science still enjoys more public confidence than in domestic issues and has been used to define both problems and solutions, albeit general rather than specific. However, this acceptance of science in international issues may be short-lived if science is used more in the future to define solutions that invoke specific international obligations for nations. The problem of the credibility of science will be compounded by the fact that consensus with regard to a problem which is multi-faceted (as is the case with international environmental issues) is more fragile than in single discipline debates; we cannot expect to find simplistic solutions to global problems.

There is, therefore, a need to reconcile the destruction of science that has been described above with the still widely held view that science is still the best way to input knowledge into policy decisions.

3 Coping with the Problem – How to "Speak Truth to Power"

Because of the deconstruction of dominant expert opinions that occurs in open democratic environments and can lead to a paralysis of policymaking, some societies have opted for a policy framework that restricts the participation of potentially destabilizing critical voices. In her paper, Jasanoff described the use of external scientific advisory committees in the United States which help government agencies seek external peer reviews, solicit advice, and validate their own interpretations of uncertain science. Unrestricted access of experts to a jury was seen by some segments of the American public as an invitation for "bad science" to crowd out the "good". It was felt that a consensus on scientific evidence was more likely to evolve when scientists feel united in a shared ethos, such as the public service orientation of an advisory committee, than when they meet as representatives of competing social interests.

However, as Jasanoff pointed out, this approach may produce its own set of problems for science, since these advisory committees are themselves subjected to increasing public scrutiny. Scientists who are members of these committees have often been accused of being biased or of violating professional ethics. One way of addressing this problem is through a strategy known as technology assessment which has been institutionalized in the United States and in many countries in Europe. It uses the presumption that technology policy works best when all stakeholders are identified in advance and are drawn into the policymaking process. Central to the approach is the notion of scientific information that is shared among the proponents, rather than being withheld by one side as ammunition.

Nowotny stated that scientists need to play multiple roles in different communities: as scientific workers who interact with their peers; as scientific advisors to international organizations such as the UN, and as members of their national delegations in international negotiations. They need different vocabularies to communicate in these various roles; Nowotny stressed the need for scientists to learn to speak in the vernacular.

Nowotny's point was taken up by several participants who felt that scientists need to make clear to policymakers the limits to and uncertainty in their knowledge. Not only will the scientific input have more authenticity, but it will give the policymaker more power rather than less, because he will be able to anticipate and disarm at least some of the arguments about scientific uncertainty his opponents may use. The participants also made the point that it was crucial for the scientist, including those using systems analysis, to identify the interested parties in the debate. Identification of parties is important because they have different knowledge bases and abilities to respond to scientific input; effective communication with them demands that various forms and vocabularies be adopted. Although this point may seem elementary, it is often ignored, to the detriment of the whole process.

On the receiving end of the communication process between scientists and the public, it was felt that scientific literacy is steadily increasing among the latter. Nowotny mentioned a study which showed that the public's ability to understand articles in publications such as *Scientific American* has been increasing steadily since the 1920s. However, has this been due to an increase in the public's scientific literacy or to an improvement in the clarity of the writing?

Several participants described the increasing use (because of the increase in public scientific literacy) of "focus groups" – selected lay people who were assigned to tackle public policy issues involving scientific information. It was found that these groups could arrive at a profound understanding of the issue – an example was given of the city of Vienna using this approach to solve traffic problems.

As pointed out by other participants, however, the use of such intermediary groups also has its shortcomings. If several such groups disagreed with one another, the public could be confused and doubt the objectivity of both groups. In Europe, a scientific committee for the European Parliament has been largely ignored. Nevertheless, in India such groups (often NGOs) have been relatively influential.

The point was also made during the discussion that the role of science is not only to provide answers to problems but to better define the questions and determine the agenda with which the policymakers have to deal. It can also be useful for conflict-mapping which may reveal the reasons for differences arising from divergent scientific opinions and differences in the values held by the various parties. It was stated that this could be a potential area for future work at IIASA, a point which will be dealt with in the next section.

4 Implications for Future Work at IIASA

The strength of IIASA in the past has been both substantive and symbolic. Substantively, it has provided a place for good scientific work to be carried out. Symbolically, it was practically the only place where scientists from East and West could meet and work together. Although IIASA has been extremely successful in the past, it was the consensus in the discussion that the former role of IIASA as an East–West bridge has largely disappeared (although Nowotny stated that East–West problems persist). IIASA needs to find another role for itself. The bridge remains – what river should we have it cross?

Some participants felt that in the future IIASA should concern itself with substantive issues such as global change and economic transition and apply its past experience, expertise and networks to these problems. It was recognized that IIASA can be only a small player in the crowded field of global change. However, there are few institutions in the world which might be prepared to address the problems of global change in a holistic way by considering the societal, economic and ecological factors. Jasanoff suggested that there are two alternatives open to IIASA:

1. Prediction of physical and social impacts of global change, through various systems analysis tools such as modeling which would, necessarily, have to be relatively large ones. Jasanoff stated that, because of present attitudes, the prospects for short-term gains for IIASA from such a strategy could be substantial.
2. Use of systems analysis tools (such as conceptual models) to better define the real problem, its underlying causes and the reasons why people perceive problems differently. This could

be more risky and difficult – we would have to examine heterogeneous systems made up of people, practices, and social rules as well as the laws of nature. It is obvious that such an endeavor would have to involve both natural and social scientists.

It was felt by the participants that the second approach holds more promise. IIASA has had considerable experience in the 1970s and 1980s in examining issues in a holistic way. Few institutes have our particular experience and expertise. It was suggested that we should examine the results of past IIASA workshops which dealt with topics similar to the present one.

Finally, the participants felt that it is important to analyze these problems not only in the macro (global) scale but in the micro (regional) scale and to determine the linkages, both between the two scales and among various regions in the world. This could be another niche for IIASA in using systems analysis to act as an intermediary in resolving policy issues.

7. Decision Analysis and Support, and the Study of Developmental Challenges Andrzej. P. Wierzbicki

Discussions and comments by:

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Rapporteur's Report: 143
Professor Jaap Wessels
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Foreword

Decision support came into the world of practice along with the computer. At first it used computers to assemble data and miscellaneous information that would delineate the options open to the decision makers. Now, as Wierzbicki explains, it goes much further. It not only helps organize the decision process, but it also processes information customized for the situation, and enables the decision maker to draw on expertise and knowledge encoded by the program, and to use various algorithms for the evaluation of options and alternative decisions.

IIASA has been an especially congenial home for such work. Its substantive, applied projects are a unique source of expertise on environmental and economic processes. Though quantified and computerized with mathematical models, they transcend such models, and are a more diversified type of knowledge than is contained in expert systems or artificial intelligence. IIASA's decision support systems use multi-objective optimization as a tool for the flexible analysis of models and for organizing efficient interaction between the user and the decision support system. Applications have been to future energy supply, the natural gas trade in Europe, and economic policy.

New conceptual challenges resulted from the dispute about the role of human intuition in decision making. Now work is being done on ways of enhancing the intuition of the user. But at no stage does the program take over the decision making; at all stages the user is sovereign.

The work is applicable to conflict resolution. The equilibrium in a single-objective game requires that the preferences and payoff functions of each player are known to the others. But such information is carefully guarded in real life situations. If any of the players guess the objectives of the others incorrectly then their decisions need not lead to any equilibrium. On the repetition of the game, assessments of the other players' preferences would be revised and a higher level of sophistication attained by the players. In successive repetitions of the game each would come to realize that the earlier poor functioning was not due to the hostility of the other players but to incorrect assumptions about their motives.

Committee for IIASA '92

Discussion

Jaroslav Doležal

The contemporary understanding of a *decision support system* (DSS) encompasses a fairly broad variety of information systems designed and implemented with the aim of facilitating the decision-making process controlled by the user of such system (decision-maker). The available generality and flexibility of the DSS concept guarantees, in a certain sense, its future importance and further development. Needless to say, in spite of the numerous activities in this area during the last decade, many general ideas and concepts have been formulated only recently (Wierzbicki, 1992). On the other hand, it can be concluded nowadays that the DSS framework is often used in many branches of science, technology or even production without explicitly denoting it in this way.

Design and implementation of DSSs merge several diverse scientific disciplines ranging from system theory and decision analysis, via mathematical modeling and optimization to information theory and computer science. As pointed out by Wierzbicki (1992), the crucial point is and should be *independent* role of a DSS user, who is solely responsible for the issued decisions. Important practical impacts of model-based, aspiration-led DSS implementations are summarized by Makowski (1991). He documents the dominant position IIASA has achieved in this field by providing a complex and systematic study of a conceptual, methodological and implemental framework for a DSS designer. It should be noted that the so-called command and control (C2), and command, control, and communication (C3) military systems (Athans, 1987), investigated in the late seventies, represent an extremely complex kind of DSS. However, one should not underestimate, in addition, the importance of more simple decision support tools of a more general character often developed to promote usage of theoretical achievements in applied science and education. As an example in this respect let us mention the **OptiA** environment for nonlinear mathematical programming (Doležal *et al.*, 1990).

Connections of decision analysis and support methodology to developmental challenges (Wierzbicki, 1992) open additional application possibilities for DSS techniques, having in mind, especially, *information society* aspects. Either global or regional sustainable development will be hardly achieved without the extensive and systematic exploitation of various decision support tools. In addition, the fact of ever growing computer power and its overall availability cannot be overlooked in this respect and this will promote implementation of more sophisticated DSSs in diverse areas.

However, in most practical situations the development of highly specialized, problem-oriented DSSs cannot be avoided and the dilemma of *general* versus *specific* DSSs is usually closely related to the mathematical model involved. As a rule, it is not an easy task to design and develop a generic, hopefully reusable DSS, and the alternative preparation of several specific DSSs might be a more appropriate step instead, as documented for an aircraft engine simulation system (Doležal *et al.*, 1991).

References

Athans, M., 1987, Command and Control (C2) Theory: A Challenge to Control Science, *IEEE Trans. Automat. Control*, **32**:286–293.

Doležal, J., Fidler, J., Pacovský, J., 1990, *Dialogue System* **OptiA** *for Minimalization of Functions of Several Variables. Version 2.8 – User's Guide*, DFG Report No. 243, Universität Bayreuth, Bayreuth, Germany.

Doležal, J., Schindler, Z., Matoušek, O., 1991, **GolEM** – A Decision Support System Prototype for the Analysis of Aircraft Power Units Behavior, in *Advances in Methodology and Software in Decision Support Systems*, Abstracts, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Makowski, M., 1991, *Selected Issues of Design and Implementation of Decision Support Systems*, WP-91-16, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Wierzbicki, A.P., 1992., *Decision Analysis and Support and the Study of Developmental Challenges*, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Rapporteur's Report

Jaap Wessels

1 Models and Understanding

From the presentation by Professor Andrzej Wierzbicki it became clear that the relation between formal tools for decision analysis and their prospective users is a relatively neglected aspect. In this respect it became clear that the acceptance of formal tools is strongly correlated with the trust prospective users have in the tools and that the effectiveness of formal decision support is strongly determined by the measure to which the use of the tools stimulates the imagination and creativity of the users. As a consequence, a straightforward road to acceptance and effectiveness seems to be the construction of tools in such a way that the underlying mechanisms are understandable for the users. This road is less straightforward than it seems to be, since, in the first place, different types of users have different types of intuitive concepts and, in the second place, one need not understand the mechanisms of a car completely in order to drive it. Actually, several of the newer approaches to decision support are based on the idea that the underlying mechanisms should be specified in such a way that the concepts of the specifications conform with the concepts of the user about the situation. In most cases this implies paying more attention to detailed processes and inherent uncertainties than to elegant mathematical structures on a highly aggregate level.

One conclusion might be that it would be worthwhile to secure a more systematic view of the intuitive concepts in the minds of users and their impact on acceptance and effectivity of decision support tools.

Another conclusion might be that the development of decision support tools based on dynamic concepts with inherent uncertainty and lack of information has been started but is still in its infancy.

2 Instrumental Versus Explicative Models

A closely related issue emerging from the discussion at the workshop is the following. In accordance with the importance of understanding by the users, the most usual approach in developing decision support tools is to construct explicative models based on intuitive concepts or accepted assumptions about underlying mechanisms or rational behavior. Although this approach works well in many situations, there are also many situations where it does not work because of the extreme complexity of the underlying mechanisms or just because of a lack of understanding of the processes involved.

A way out of this difficulty is to stop aiming at "physical" understanding of the mechanisms and accept the use of parameterized black-boxes or instrumental models for which the parameters are determined in such a way that the black-box mimics reality to an acceptable degree. The most well-known example of such an approach is the introduction of a linear model for the generation of a time-series with the parameters estimated from historical data. Recently it became apparent that it might even be possible to use an instrumental model for the generation of prospective decisions directly based on the impact data without any explicit modeling. As candidates for such black-boxes, one suggests applying neural nets for which the parameter values may be determined by a learning process based on historical data for which the desirable decision can be usually chosen a posteriori without any knowledge of the underlying mechanisms. So, apparently, one may choose black-box models on different levels: on a low level for generating external influences in the form of a time series, on a high level for generating decisions directly based on the problem input or, virtually, in different ways on intermediate levels.

From this observation one might conclude that it would be important to have a systematic view of the indications for deciding on the use of an instrumental model on a certain level when designing decision support tools for a particular type of situation.

PART IV

Models to Say What the Future Holds

8. A Linear Model for Environment and Development
Lawrence R. Klein

Discussions and comments by:

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Rapporteur's Report: 161
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Foreword

Economic models in the past have tended to be confined to narrowly economic variables, with political, social and demographic information fed in as exogenous. Klein argues that that places unnecessary restrictions on the applicability of the results. For instance if births are assumed constant, and in fact they go in cycles as described by Easterlin, then one has foregone an improvement readily made. If national defense expenditure is controlled by Lewis Richardson's action–reaction model of an arms race, then that ought to be incorporated in the model, as was done by Klein in his LINK model. If fossil fuels are going to hit a ceiling imposed by the greenhouse effect, that too could well be entered; once it is entered, then the model would serve to study the effects of a carbon tax to reduce emissions.

Even political variables need not in principle be left as exogenous. Monetary policy is established by a central bank. Whether or not that bank is independent of the political system, it is likely to set interest rates lower when unemployment rises. Unfortunately for its incorporation in the model the precise determination of monetary policy depends on the objective function of a limited number of people.

Klein's LINK model is large, with 25,000 variables, and correspondingly vast data files that are updated monthly. More individual countries are being added on a regular basis. The commodity detail in the country-by-country trade matrix is being expanded; international capital flows and services are being introduced; debt accounting has already been introduced.

But large as it is the model does not answer all questions, and to it are appended satellite models intended for specific purposes that both act on the main model and receive changes from it. The satellite model covering demographic variables, as these act on the Japanese economy, serves as an illustration of the procedure.

For the last 30 years the population dependency ratios [ratios to the labor force ages (say 15 to 65) of those under 15 and 65 and over] for Japan have been lower than those of Germany and the United States, its two main competitors: but they are starting to rise, and in the next 20 years will rise above their competitors. But labor force participation will undoubtedly respond to the change in the ratio, and many of those over 65 will continue working. When this is taken into account and an economic dependency ratio calculated Japan will be no worse off than in the past. There will still be labor shortage, and the model will show the effectiveness of various policies to counter this, including permitting immigration, raising the retirement age, encouraging more women to enter the labor force, and further raising productivity levels. Saving is likely to decline as another consequence of aging, and the model will also show the effect of this.

Although the title states that the model is "linear", it is important to extend its use to the nonlinear case. Many nonlinear transformations and social accounting balances are included, in an additive fashion so that there may be linear combinations of nonlinear functions. Research has been underway for some time to introduce more inherent and complicated nonlinearities into economic models.

Committee for IIASA '92

Discussion

Hugh J. Miser

1 Introduction

The purpose of these remarks is to sketch the broad outlines of systems analysis work, so that the place of modeling of the type described by Professor Lawrence Klein can be viewed against a general background.

2 The Concept of Systems Analysis

Fortunately, the concept of systems analysis is very broad, so that activity under this rubric can encompass theory development at one end of the scale and severely applied work at the other.

- The theory work is aimed at understanding phenomena related to potential systems analysis problems.
- The other end of the spectrum encompasses work devoted severely to specific issues of choice: program, policy, or action. Such work obviously must have clearly identified clients for the results.

And, of course, systems analysis work can occupy any intermediate position on this spectrum.

3 The Domain of Inquiry

Similarly, subjects for systems analysis inquiry can be chosen from a very broad domain consisting of the phenomena exhibited by man/machine/nature systems, where the term machine is construed very broadly to include any disciplined structure.

4 The Focus of Inquiry

The usual focus of systems analysis inquiry within this domain is some problem seen either by analysts or interested parties as occurring in such systems. Since these problems always arise in a broad problem situation, this situation becomes the focus of the systems analysis inquiry aimed at understanding the undesirable effects being observed, and possibly seeing ways of ameliorating them.

5 Some General Principles of the Systems Analysis Approach

There are many such principles that could be cited (see, for example, Miser and Quade, 1985), but I mention only the four that are central to this discussion:

- It is necessary to understand the behavior of the variables in the problem situation that seem to be contributing to the problem. If existing theories or models can capture this behavior adequately, they can be used. If not, then models may have to be developed as part of the systems analysis effort.
- It is essential to recognize that systems analysis problems almost never emerge in a form that can be dealt with adequately by the tools and procedures of a single discipline. Thus, cooperative work by representatives of different relevant disciplines is essential. It is seldom adequate for a representative of the central discipline involved just to coopt on his own terms something from another discipline; the subtleties of systems analysis work demand interactive human intelligence from representatives of all of the cooperating disciplines. It is this fact that makes institutions such as IIASA so important for systems analysis, whereas academic departments usually are inappropriate.

- Practicality insists that the area to be investigated be given suitable boundaries.
- Economy of effort – not to mention the timely achievement of results – insists that, while models must be adequate for the problem, they also must be kept within practical bounds.

6 How to Address Systems Analysis Problems: Some Contrasts

My purpose here is to suggest some procedures at the extremes of systems analysis practice, in order to suggest the variety that can occur. Most work, of course, falls between these extremes.

6.1 Starting points

Having a general area of problems in view, an analysis team can start in either of two ways:

- It can design and build a large model encompassing variables relating to prospective problems. (The Klein paper that formed the theme of this session proceeds in this way.)
- Before the model building begins, considerable effort can be expended in exploring the problem area to define the problem to be treated, so that it will be clear how to build and exercise models that are adequate but also as economical as possible.

Most large-scale, systems analysis studies do some of both, but they usually lie between these extremes.

6.2 The purview of the work

The two extremes here are these:

- The analysis team builds a model with as wide a coverage as possible, incorporating the most accurate representations of the variables that are available.
- The models are restricted to coverage that is appropriate to the problem that has been defined, and accuracy is limited to

that needed to shed appropriate light on the problem and what might be done to ameliorate it.

6.3 Audiences for the work

The extremes here are these:

- Other scientists and systems analysts.
- The many parties who have an interest with respect to the problem being addressed.

Clearly, most work to some extent addresses both of these audiences: the scientists and systems analysts because they are the peers who will make judgments of its technical quality; the parties who have an interest because they want to know what light the work can shed on what might be done to ameliorate the problem being addressed.

6.4 How to reach these audiences

Experience with systems analysis shows that many media will be needed to communicate with the varied audiences that need to be informed about the results of the work, depending on the audience being addressed and the occasion:

- Other scientific peers may be addressed through publications in scientific and technical journals and papers read at technical meetings.
- Other audiences need to have publications focused carefully on their interests, background knowledge, prior experiences, and responsibilities.
- There are many occasions on which oral communication is necessary.

The craft skills needed in preparing these communications are often neglected – or left to be dealt with as an afterthought. However, since the success of the work hinges on how well the communications succeed, they deserve a great deal of thought and care.

Finally, it should not be overlooked that selling systems analysis results effectively is often done by quite informal means. Even though these may seem casual, the prudent analyst has the material so well structured in his mind that even these informal communications emerge in a highly disciplined form, in spite of appearing in informal garb.

6.5 Implications about methods

What has been said so far contains some implications about methods a study should use. The extremes are these:

- Complications in the modeling work are welcomed if they seem to extend the explanatory capability of a modeling effort, regardless of how essential they may be for treating the problem adopted as the basis for the work.
- Only the complications are allowed that are clearly related to the problem.

The difficulty with either extreme is, of course, that one does not usually know *a priori* what variables have important effects until the work begins to show results; nevertheless, most analysts can make important central judgments, with trial-and-error procedures then undertaken to discover where the boundaries should be for complications to be introduced.

7 Some Examples

Here are four simple examples that offer some variety in making these choices:

- The Klein paper in this session offered a central, very large model yielding results for economic variables that could be varied by adding models on its borders, thus showing what effects formerly exogenous variables might have on the central model's outputs. This was done against a general appreciation of broad problem areas, but not the refinement of specific problems within those areas.
- IIASA's lake eutrophication work developed general approaches to this problem employing a variety of disciplinary models; then

the entire structure was tested against a specific example: Lake Balaton (Somlyódy and van Straten, 1986).

- A systems analysis aimed at improving the distribution of blood from the central blood bank in New York City to almost 300 hospitals showed how effective models had to be tailored to the problem situation and the users of the work's results for a short overview account, see Miser (1981).
- The choice of a closure for the Oosterschelde estuary in the Netherlands (after the historic storm destroyed the coastal protection a quarter of a century ago) was made after a major systems analysis study in which both government and institutional scientists participated. There was no central model; rather, there were many models for the important variables, most of which were incommensurable. The final judgment (which led to the most expensive solution) was made by government officials and the Dutch parliament working together in the light of over six dozen major outputs for an equal number of important variables [for a brief account, see Miser and Quade (1985)].

8 Conclusions

The major conclusion is that the circumstance of the systems analysis study alters the case: in sum, the approach used must be adapted to what the problem area involves, what the problem is found to be, and what phenomena must be understood. This process involves many choices in at least these categories:

- the approach,
- the methods (including the modeling approach),
- the products that will be needed,
- the audiences to be addressed,
- the communication instruments that will be needed,
- the responsibilities of the various interested parties,
- and so on.

The major lesson of this discussion is that all of these matters deserve informed and principled consideration as part of designing and carrying out systems analysis work. It involves not only scientific knowledge but also a wide variety of craft skills.

References

Miser, H.J., 1981, *Operations Research and Systems Analysis*, RR-81-9, International Institute for Applied Systems Analysis, Laxenburg, Austria. (Reprinted from the July 4, 1980, Centennial Issue of *Science*.)

Miser, H.J., and Quade, E.S., eds., 1985, *Handbook of Systems Analysis: Overview of Uses, Procedures, Applications, and Practice*, Wiley, Chichester, UK.

Somlyódy, L., and van Straten, G., 1986, *Modeling and Managing Shallow Lake Eutrophication: With Application to Lake Balaton*, Springer-Verlag, Berlin, Germany.

Rapporteur's Report

Sture Öberg

The discussion in Workshop 6 was lively. It was mainly devoted to an exchange of ideas on how researchers could solve practical problems when they work with applied systems analysis tools.

A point of departure for the discussion in Workshop 6 was a paper by Professor Lawrence Klein, *A Linear Model for Environment and Development*. The paper showed how ideas from non-economic disciplines, such as demography, could be introduced in formal models of the economic system, either as endogenous parts or as satellite modules. Several examples were presented in the paper, but some were only mentioned by the author in the discussion. One was the implications of an energy tax in the US. A second one was the effects of a piece pipe line for water transport from Turkey to Syria/Iraq. A third example was trade war games between Europe, North America and the Pacific Basin.

It was not explicitly expressed, but it became clear during the discussion that the participants assumed that systems analysis with its formal models is an efficient way to:

- Summarize knowledge within scientific disciplines, or better.
- Develop a knowledge survey for interdisciplinary systems.
- Make forecasts, prognoses or impact analysis.
- Structure information for applied use, as a decision support tool.

Different types of systems analysis models were mentioned. There was an agreement that there is no simple answer to the question of which approach is the best. First, the solution depends on the problem and available resources for the analysis. Second, new statistical theories, new data sources, more harmonized data collection procedures, better computer facilities, and other changes would soon make any answer obsolete.

However, it was clear that there were two general opinions among the participants, one favoring a large, basic model that could be extended to deal with new problems, and another (which seemed to be more appealing) that one should create a new model for each new problem.

According to the first conception, which is one of the main ideas behind the LINK model mentioned in the paper by Klein, the more variables that could be handled in the model, the better. This is a way to communicate between disciplines. It is also a way to use existing knowledge in a coherent way, thus reducing uncertainty. If it is not possible to introduce new variables endogenously, then they should at least be used in a satellite model with defined variables at the connection points.

The advantage with a large, carefully designed model is that it will be used over many years. When it comes to models which take a long time to construct, e.g., natural science models on climate or social science models on quality of life, both types needing large data collection systems, then it is natural to use the systems tools also for questions they were not originally designed for.

Those in favor of tailored models meant that the problem should dictate the model, not vice versa. Usually data are poor, knowledge about links is also poor (e.g., statistics on economic performance are hardly ever right), and thus an approximate model will usually be good enough for politicians and businessmen. What is lost in detail is gained in relevance.

Of course, if every new problem is a unique one, then the second approach seems better. If the new problem is similar to earlier ones, then it is easier to use a base model and add relevant information.

Several technical details in quantitative models were touched upon, such as feedbacks, problems of scale, bifurcation, chaotic behavior, length of time periods, noise, stochastics, linearity or nonlinearity and stability. This discussion added clarification and was very informative for the participants with backgrounds in different modeling traditions. However, for the experts within each tradition it did not add anything new.

Considering stability, it was argued that the performance of economic systems, at least within a decade (which probably is the longest period a user is interested in), could be modeled with linear models. History shows that economic systems are surprisingly stable. This has to do with their base in physical and human capital, which can only be changed over a long period. There was too little time to elaborate on this topic. It is one of the main causes of misunderstanding between researchers from political science, economics and geography. They usually have quite different views on the amount of time needed for a structural change.

References

Klein, L.R., 1988, The LINK Model and its Use in International Scenario Analysis, in H. Motamen, ed., *Economic Modelling in the OECD Countries*, Chapman and Hall, London, New York, pp. 1–10.

Klein, L.R., 1992, *A Linear Model for Environment and Development*, in *Science and Sustainability*, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Miser, H.J., and Quade, E.S., eds., 1985, *Handbook of Systems Analysis: Overview of Uses, Procedures, Applications and Practice*, Wiley, Chichester, UK.

Quade, E.S., 1989, *Analysis for Public Decisions*, A Rand Corporation Research Study, 3rd Edition, North Holland, Dordrecht, The Netherlands.

PART V

How to Disseminate the Knowledge that Will Create a Constituency for Sound Policies

9. International Environmental Governance: Building Institutions in an Anarchical Society
Oran R. Young

Discussions and comments by:

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Institute for USA and Canada Studies,
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Foreword

With all the international institutions that have been constructed in the postwar period the society of nations is still anarchic. The best that has so far been achieved is organizations that serve particular and limited purposes, mostly existing as a place where negotiation among sovereign states can take place. There is not even a pretence of overall international government, nor does this seem to be wanted. Europe is finding it difficult even to set up a common currency, let alone a more basic unification. The way that national governments become bureaucracies, and are captured by special interests, suggests that even if there was a political will everywhere to establish a single rule, the outcome might be far from that desired.

That states the problem of governance without government. If we give up on establishing a world government for the foreseeable future, what is the alternative? After all there are a host of problems facing us that no country can handle alone. Acid rain will be generated freely by countries upwind in disregard of the decay of forests in their downwind neighbors. Upstream countries will not take into account the interest of those downstream in their water diversion engineering. Nuclear plants will be set up on the borders of states, so that at least half of the danger will be shared by unwilling neighbors. No management of the ocean commons is possible without a central authority that can truly enforce an agreed long-term harvesting plan.

We have to get along without a central government, but we have taken many steps toward governance. Agreements on particular matters from checking the thinning of the ozone layer by cutting the use of CFCs to international whaling conventions have had considerable effect. What we need is governance in the form of social institutions, unencumbered by governments, and we should be thinking of ways of strengthening such of these as we already have.

The variety of cases that have to be handled is surprisingly great: not only international rivers, but pools of oil that underlie the territories of more than one state; not only marine creatures and birds but migratory stocks of wild animals on land; even artifacts that are within the territory of one country can be part of the heritage of mankind, like the temples of Angkor Wat or the ancient buildings of Dubrovnik; or biological diversity in the forests of Brazil with the potential drugs that might be developed on the basis of their species. In all such instances countries would be required to go against their immediate interests as a service to the international community; if they are poorer than the average they cannot reasonably be expected to do this without some *quid pro quo*. "The polluter pays" as such does not work as between poor countries and rich.

All this describes the problem, but how far does it advance us toward a solution? Oran Young does have a procedure that could lead to a solution that would institutionalize in a more basic way activities already initiated. That is to "establish a transnational network to foster communication among those working on issues of international environmental governance. Such a network would benefit from having an administrative node located in a nonprofit setting but it should also encompass a sizable collection of participants working in different parts of the world and drawing on a variety of intellectual traditions". It would take advantage of modern communications technologies, like computer conferences available on electronic networks. The function of the network would be circulation of well-founded ideas available to all those concerned with environmental governance at the international level. It would be a powerful instrument for bringing new insights to bear on current environmental concerns, for monitoring the performance of existing environmental governmental systems, and adding to our overall understanding of international governance.

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Discussion

Walter Lichem

I thoroughly enjoyed reading Professor Oran Young's stimulating paper. It seems to be fully in line with the "Zeitgeist" of "more government" being rightly seen as not necessarily meaning "better government". The search for structures of governance is a worthwhile proposition. I would like to offer eight short points on some of the issues raised in Professor Young's paper.

(1) Institutional issues are of key importance with regard to the challenge of "environment and development". This is so because, as scientists repeatedly tell us and increasing information evidences, the current use of environmental and natural resource systems is not sustainable. This lack of sustainability is due, to a considerable degree, to a lack of schemes of governance sufficiently effective to assure sustainability.

The real program for implementing "environment and development" is to attain institutional change. This is probably the most complex challenge to societal organization in the history of mankind.

(2) It is increasingly difficult to separate internal structures for governance in "environment and development" from international governance structures. I attribute this phenomenon to "a new verticality". Such verticality refers to the multitude of effects of local resource use on global systems, as well as to the effects of international resource use on local resource systems. "Verticality" also refers to the identity of actors at different jurisdictional levels; the

same actors are affecting local, regional and global resource conditions.

(3) It seems to me that all governance schemes are mixed systems of more or less formalized codes of conduct on the one hand and governmental organization on the other. The question of which aspects of environmental resource use are left to self-regulating processes of interaction and which are subjected to governmental regulation is a question to be determined in each historical moment in accordance with the respective institutional functionality.

To illustrate this let me refer to Emperor Joseph II's attempt to regulate by law and enforce by police measures a change of underwear twice a week and the prohibiting of unhealthful corsets for the ladies of his time. Maybe in the 1780s such a governmental approach was necessary for issues that today, for many obvious reasons, are considered unworthy of governmental regulation and enforcement.

(4) A practitioner's experience suggests that informal governance (without government) is more effective under static conditions of social interaction. Let me illustrate this by referring to the governance schemes for regulating the sustainable use of open access common property resources among nomadic tribes. These systems have been effective as long as the basic conditions have remained static, i.e., the size of population, the quantity of resources available and the technology applied.

As current reality suggests rather the contrary, i.e., the size of our population is growing fast, the quantity of resources is dwindling and technologies are undergoing rapid change, we would have to seriously ask ourselves whether and where self-regulating schemes of governance are an appropriate response to the challenges at hand.

Let me give you another concrete example from my current work in the Ministry. The CSCE, with which I have been associated for some time, has all the characteristics of an informal governance scheme. It makes decisions by consensus; its organizational set-up has a very simple structure; it does not even have legal personality under international law. And yet, under the East–West stalemate the CSCE performed a very useful function in international relations. Nevertheless as conditions in Europe became dynamic and the CSCE was challenged by concrete crisis situations in Yugoslavia or in Nagorno Karabakh, it seems to lose all its credit and appears unable to respond to the challenges of our time.

(5) The multiplicity of actors and transfer schemes seems to obliterate somehow the traditional concept of "international". Territorial sovereignty is becoming relativized not only by the interference of the "international" or "global" actors on the national level, but also by the great variety of geographical reference areas of the different sectoral or resource-related interests; e.g., river basins, air quality areas; economic integration schemes; ethnic, linguistic reference areas, etc.).

(6) Recent experience suggests that initial responses to the challenge of "environment and development" were prompted, to a great extent, by an interesting interplay of non-governmental, national and international actors (such as Greenpeace or the World Wildlife Fund, but also international science) on the one hand, and of international organizations (and their secretariats) on the other. Many of the current conceptualizations, including the concept of "environment and development", in particular, are the result of this cooperation. National decision-makers who still carry the brunt of responsibility for global relationships were put under pressure from both sides: NGO movements at home and international organizations abroad. Observing the negotiating process in the preparation of UNCED 92 seems to reveal the result of this double-squeeze on national diplomacy.

(7) The ability of national actors to respond to the challenge of "environment and development" seems inadequate. Under current conditions the limits of negotiating capabilities have been reached. This is due, particularly, to the phenomenon of "dual polity" which has been addressed by Young in his paper. I mean by dual polity the dual response mechanism of national decision-makers to demands

resulting from the substantive issues of global change requiring national action and from the national clientele (of voters and interest groups).

(8) The mix of governance schemes and organizations (government) seems to be determined by two criteria:

- The requirements for crisis management (and here the global issues of "environment and development" with continuing massive environmental capital loss take increasingly critical proportions); and
- the effective establishment of informal and formal normative systems regulating in a decentralized way individual and institutional behavior within the units of sustainability.

Let me add a final remark. I like to recall the Harvard sociologist Carl Wildfogel and his thesis about the origin of the state. Wildfogel maintained that the challenge of rationally harnessing river resources in the basins of the Nile, in Mesopotamia, of the Indus and the Yellow River, made formal societal organizations necessary. Wildfogel called them "Hydraulic Societies".

We no doubt are moving toward the age of the "ecological society". Environmental preservation is not a constraint any more to our economic endeavors. Environmental conservation and development are becoming the most basic societal objectives.

My caveat: Wildfogel (as you may remember) also saw the Hydraulic Societies as the origin of Asian totalitarianism. Keeping this in mind, Young's appeal for governance without government seems very much worth considering.

Discussion

Victor A. Kremenyuk

Professor Oran Young has chosen a very important topic for discussion. His analysis concerns some of the issues being discussed in philosophical as well as sociological research and has a direct relation to the organization of the global society. Reflecting the realities of the current state of affairs in the world, and, specifically, the realities of interdependence, post-industrial society and global communications, the idea of governance has inevitably come to the forefront of discussions both among researchers and political figures. The new feature of these discussions is that the world has really reached a stage where a global society is not regarded as a dream or a far perspective but has become a part of reality which demands necessary conclusions regarding its order and structure.

However, the fact is that this world, which is a global society, still consists of sovereign nations, each of which is jealously adhering to the concepts of independence and sovereignty and are reluctant to share them with other nations. So, what we have as a result is a global society built upon the realities of interdependence and global communications, but structurally consisting of nation-states which are overwhelmingly concerned about their independence and sovereignty. The picture is not simply paradoxical. It is inherently controversial and may very easily become both an obstacle and a threat to further development.

Young is looking for a solution which could either solve this controversy or help to avoid it. Hence, his idea of institution building in the area of environment protection, which may be regarded as a part of the whole effort to achieve some sort of international governance. The idea is quite sound and deserves both support and some critical (or skeptical) contribution.

Generally, the idea is good and sounds realistic, mainly because it is attributed to the area of environment protection. A healthy environment has become a part of the human values shared by almost all nations in the world. These days one can hardly imagine a politician or a thinker who would either ignore or reject the ideas of environment protection, and the importance of these issues is one of the most powerful factors which may force governments to share their powers with other nations even at the expense of sovereignty.

However, it is well known that sovereignty is inalienable. When a nation agrees to share its individual right to independence with others in order to provide a more secure and healthy environment for its population, it will inevitably try to find other means which would compensate for its sovereignty and provide the national government with the same unchangeable amount of powers which is regarded by the government or the whole nation as indispensable for the survival of that nation and its institutions. In times of a high level of interdependence, the events in Yugoslavia or the former Soviet Union show rather conspicuously that nationalistic feeling may disrupt even the societies which for many years were integrated and lived on the basis of interdependence.

So, the *first* thing which comes to mind when reading Young's paper is the necessity to find a balance between progress in the area of institution building for governance of environmental issues and the preservation of the existing world structure of nation-states. The *second* observation, which also may be regarded as crucial for the analysis of Young's ideas, is the evaluation of the governance itself. He mentions the evils associated with the creation of the present system of governance but does not follow completely this line of analysis. The important thing which deserves attention here is the weakness of the majority of the power institutions, both national and international, which have, as their main task, to govern their nations through some international regimes.

The outbursts of violence in the USA and Canada following the acquittal of the policemen in Los Angeles, the violence in Russian provinces or in other republics of the Commonwealth of Independent States, violence in the former Yugoslavia, and many other cases, show quite sufficiently the extent to which governments may claim they govern their societies. The same may be attributed to the international conflicts: the Persian Gulf, Cambodia, and Afghanistan. In all these situations the governments and international agencies may pretend that they govern the state of affairs but each outbreak of violence underlines the fragile extent to which these cases are really controlled and beyond which governments are helpless to do anything to impose their wills.

So, in this case the question is: are we really serious about governance? If the answer is "Yes", then to what extent can we hope to control affairs and what will happen if that control, due to some unforeseen events, gave way to uncontrolled, unpredictable developments? Where should the line be drawn which would provide us all with a sense of security? Understandably, it is difficult to answer this question directly but at least we should bear in mind that "governance" has its limits and this must be remembered.

The *third* point which deserves attention while reading Young's paper concerns "anarchical society". Yes, it is quite true that international affairs very often have proved to be the area where anarchy is the dominant trend, and the more democratic and less hierarchical this area becomes, the more anarchical it seems. However, students of international relations know, at the same time, that there are certain implicit rules, very often invisible, which are followed by the majority of actors in international affairs.

Take, for example, the case of the Cold War. To many people this is a case of a direct military-ideological confrontation, a zero-sum game where a gain by one side (real or perceived as real) was a direct loss for the other: but in the whole Cold War relationship there was another, less visible, side which included cooperation. Both superpowers cooperated in avoiding a "hot" war and succeeded. Both cooperated in non-proliferation of nuclear arms and to a large extent also succeeded, though they could not prevent France and China from becoming nuclear powers. Both superpowers cooperated in keeping the whole UN system intact, and it survived the years of bipolarity. They cooperated in many other areas (including the Austrian State Treaty, 1955) but all these elements went unnoticed, or were given much less attention than they deserved.

This example explains that even in seemingly anarchical societies, such as the international scene, there are still some hidden, or unseen, laws and rules which are adhered to by any actor: the law of survival, the rule of "don't rock the boat" ("life boat ethics"), the rule of enforced coexistence (you don't choose your neighbors), and some others which help the nations survive in an unfriendly environment and optimize their gains from the international system – import of technology, investments, services, etc. Some of these rules work even under the most critical conditions, as for example, during World War II when Germany had to pay tribute to Swiss or Swedish neutrality, adhere to international norms for POWs, abstain from using chemical weapons, etc.

So, as a conclusion to this part of my argument, it is necessary to understand that even "anarchical societies" have to follow some ironclad rules and laws of the environment in which they live. This adherence, which basically may be explained by an interest in survival, gives hope that approaches and ways may be found to comply with these rules and laws for more sophisticated and civilized norms and to create a system of governance which will at least rule some areas of international relations.

In this respect, the *fourth* comment needs to be added since the questions is still open: how do we create those institutions and how do we bring the laws and procedures which will govern them closer to the rules and laws which govern the "anarchical societies"? One of the answers to this question is the expansion and optimization of the system of negotiations. It would be naive and unrealistic to hope that there will be another Messiah or a group of wise people who would get together and draw the new commandments for more than 150 nation-states. No one can work out the rules which would satisfy all the members of the global society and no one can enforce those rules even if the suggestion were made that they be drafted.

It is only through an expanded and balanced system of negotiations – bilateral and multilateral, single- or multi-issue, formal and informal, institutionalized or one-shot conferences – that some rules of governance may be drafted, discussed and adopted. It is only through such systems that the mechanisms of their implementation may be worked out and accepted: regimes, international agencies or organizations, permanent conferences (like CSCE), and others. Only such mechanisms as negotiations may provide opportunities to find sound solutions through lengthy and sometimes awkward procedures, but it is the only way which would permit every participant to explain his view of the situation and the desirable remedies, to have the feeling that no one is imposing his will but, on the contrary, each nation-state would be a direct participant in the creation of new institutions to govern the environment. How such a system of negotiations could be created and how it should operate is another question and may be discussed separately.

Rapporteur's Report

Bertram I. Spector

This workshop debated the issue of how compliance with international environmental agreements can be governed successfully *without* the trappings of formal government. Several interesting themes were raised in the discussion.

The first theme focused on the role of *economic and political motives* in effective governance of environmental accords. Politicians tend to be motivated to avoid short-term economic costs. These considerations directly influence the degree to and reliability with which environmental agreements are implemented and complied with on national and local levels. Since environmental improvements are often only visible in the long term, typically beyond a politician's tenure, there is minimal political willingness to act and ensure effective implementation and governance of agreements when all the public will incur are short-term costs. Most politicians associated with such agreements have to bear the burden of short-term costs, but never the longer term benefits.

Unfortunately, the outcomes of international environmental negotiations often reflect weakened solutions – the lowest common denominator – which all are willing to accept, but which cannot effectively resolve the fundamental environmental problems. Another common outcome of negotiation is a strong solution to which only a few nations can agree, but which offers potent approaches that truly resolve the environmental problem at hand. While economic and political motives may really be at the root cause of negligent implementation, leaders often resort to arguments that blame poor and uncertain science as the rationale for delay or noncompliance with agreements.

Compliance with treaty provisions is often directly traceable to the power and influence of domestic economic stakeholders. The ozone depletion agreement has worked well and has been complied with voluntarily – without recourse to extensive external persuasion – for instance, because there are few industries that produced the CFCs which were being limited by the treaty. Moreover, entrepreneurs in the industrialized countries viewed the ban on CFCs as an opportunity to develop new and larger markets for substitute technologies.

A second theme highlighted the importance of *grass roots social movements* in the processes of implementation and governance. The effectiveness of environmental governance certainly depends on the structure of the scientific solution in the treaty, but even more heavily on public interest groups – the nongovernmental organizations (NGOs) – which can provide the necessary will, motivation, and popular leadership to implement agreements successfully at a local level. These NGOs are often in a unique position in terms of their grass roots legitimacy to demonstrate to the public at large the benefits that can accrue at community level from compliance, even if the agreement imposes many costs and hardships that must be borne by individuals. In fact, the ultimate success of environmental governance at an international level may be determined by the willingness and activity of such NGOs at the local level, involved in a bottom-up process of implementation.

At the same time, even the most vigorous and successful NGOs may have problems mobilizing public support for certain types of issues that are abstract and difficult to visualize, for example, the effect of CO_2 on global warming and the impacts of ozone layer depletion. The more concrete symbols of undefended, helpless animals, i.e., dolphins, whales, panda bears, somehow appeal to public sentiment and often result in sympathetic reactions to accept the costs of conservation. This suggests that NGOs must play a critical role in educating the public to help increase the understanding of the scientific implications, costs, and benefits of action and inaction in order to gain public acceptance of compliance with treaty provisions.

The third theme targeted *the role of creativity* in the process of developing systems of governance that are likely to be adhered to. One approach is to creatively frame the problem to identify integrative win-win solutions in a self-evident fashion. Here, the issues must be defined and scoped in such a way that the principal parties formulating an agreement through the negotiation process gain a sense of ownership with regard to the prominent solutions. Another approach is to design a formula, a solution package, that successfully trades off the interests of all the players. This requires that the rules of governance are so crafted that the needs, interests, and objectives of each principal party are well balanced against the needs, interests, and objectives of the other parties.

In the end, though, the design of rules and regulations that govern compliance with environmental agreements – often generated with the advice of the scientific community – is viewed to be overly categorical and one-dimensional. The approach is to restrict this or cut that, taking account only of the scientific dimension of environmental problems. More creative and constructive options for governance are required that take into account the important social and economic needs and interests of the key parties to the agreement, that balance and trade off these needs and interests so that environmental problems get resolved while other national objectives are attained simultaneously.

Finally, several important questions were raised concerning effective governance of environmental agreements.

- What is the appropriate interface between science and mechanisms of governance? What is needed from science in the governance of agreements?
- Most environmental issue are interlinked and inseparable from many other environmental and other issues (development, trade, economics, life-style, etc.). Are separate mechanisms of governance relevant, given the mutual interdependence of issues? Can mechanisms of governance be developed which meet the requirements of this issue complexity?
- Is the study of chaotic systems in the natural world analogous to the anarchy of international politics and governance? Are the terms, concepts, and relationships transferable and useful?

PART VI

Population Growth and Aging: A Burden on Development

10. Population Growth in the Third World
Léon Tabah

Rapporteur's Report: 191
Dr. Gerhard K. Heilig
Population Project, IIASA, Laxenburg, Austria

Foreword

Much of the call on the environment is proportional to population. Increase of population in Third World countries requires household water and cooking fuel very nearly in proportion. It requires agricultural land and water, though how depends on whether at the same time agricultural technology can change to make more effective use of the existing cultivated land and the water in use. When technology changes toward the use of fertilizers and insecticides these generate other environmental problems, while more intensive working of the soil can speed its deterioration.

Two points stand out from the literature on these matters: population is not the only cause of environmental degradation, but technology does its share both in perpetrating and in protecting against degradation. Beyond that, the three factors, population, level of consumption, and technology, interact in a multiplicative fashion.

How far are Third World countries proceeding in the protection of their environments? Not very. "The decision makers consider that the costs of environmental protection are too high, and ... [their introduction would constrain] development strategies.... Preventing soil degradation at the village level has less priority than increasing food production to feed a growing population". "Exerting pressure on developing countries to shift to environmentally sound technologies is putting a burden on the economies of those countries".

Meanwhile a major change in the world's demography has been taking place, in that the transition from high to low birth and death rates is well on the way to becoming universal. Not many years ago it was confined to the rich countries of America, Europe and Japan, embracing no more than one quarter of the world's population; now it is conspicuous in East Asia and Latin America. Yet there is a considerable distance to go; Africa is still to begin the transition and though much progress was made in the 1960s, since the 1970s the fall in rates in Latin America has been hesitant.

The literature on the reasons that are bringing about the fall is vast. Most obvious is that the fall goes along with increase of income among countries, but this obvious explanation need not be the real one. Kerala is one of the poorest of the Indian states, and yet it is advanced in the control of both mortality and fertility. The oil countries of the middle east are among the world's richest in per capita income, but their birth rates remain high. Among Third World countries Ceylon is by no means one of the wealthiest but its rates are low. The explanation could be that it is not wealth as such but something else that comes with wealth, and especially education, of which the education of women could well be the most important.

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Rapporteur's Report

Gerhard K. Heilig

The discussion in Workshop 11 was carried out with great enthusiasm and covered a broad spectrum of questions, ranging from demographic and social to political and economic aspects. Five issues seemed to be of particular interest to the participants:

- the validity of population projections;
- the efficiency of family planning programs;
- the macro–micro dilemma;
- the question of sustainable technologies; and
- the motives for political action.

1 The Validity of Population Projections

There was broad consensus in the workshop that population growth is *one* of the key factors of future trends in environmental degradation. Hence, the methodology and validity of population projections were considered of great relevance.

Several participants criticized the current United Nations population projections. A discussant called the UN assumptions "implausible", and argued that contrary to UN assumptions most likely fertility and mortality will be higher in Africa and lower in Latin America. The mortality assumptions for Africa were especially considered as rather unrealistic. The spread of AIDS and the persistence or reappearance of other serious health problems (malaria) were mentioned as obstacles to a further mortality decline in Africa. There were also doubts that African fertility could decline to near-replacement level (TFR 2.3) by 2020–25, as assumed by the Low Variant 1990 UN projection (UN, 1992).

2 The Efficiency of Family Planning Programs

The discussion of possible future trends in population growth led to the question of whether current family planning programs have any significant effect on fertility. Participants at the workshop indicated the mixed empirical evidence:

- India's forty-odd year old Family Planning Program was characterized as one of the most ineffective. Its concept has changed several times (economic incentives, forced sterilization, health orientation) and still does not adequately address key factors of reproductive behavior in India, such as the weak social position of women and the lack of an old age security system. One participant described the Indian situation as follows: "nothing has happened in family planning since 1952 – it is shear inefficiency and confused motivation".
- On the other hand many Third World countries have implemented rather successful family planning programs. China, Mexico and Indonesia were briefly mentioned as examples.

There was consensus that "contraception in poverty" is necessary and possible. A participant pointed out that in Mauritius the fertility decline began long before the island experienced rapid economic growth. Female education and labor force participation were identified as major factors of this demographic transition. However, there were questions as to whether the experience of an island population of one million can be transferred to other developing countries.

The workshop also agreed that the key question of family planning is the "grass root efficiency" of the program. While nearly all Third World governments have expressed high-level recognition of the problem, a much smaller number have actually implemented effective policies. There are still developing countries that just pay lip-service to international pressure for curbing population growth.

3 The Macro–Micro Dilemma

Lacking "grass roots efficiency" in family planning programs is only a symptom of a much deeper difficulty in population policy, which can be called the macro–micro dilemma. It emerges with the rise of modern societies and the division of labor.

Modern societies and economies are structured hierarchically. They are no longer loose associations of family clans and production units, such as tribal societies, but tightly organized systems, based on functional differentiation and delegation of power. Each level in the hierarchy has different interests, time scales, and resources. What is good for society is not always good for the families – and vice versa.

Indian families, on the one hand, have few reasons to restrict the number of children, while the Indian government has expressed a strong interest in curbing population growth. On the other hand, Italy's government is concerned about the consequences of extremely low fertility, while from the perspective of Italian females there are few reasons to increase the number of children. The dilemma is not restricted to discrepancies between societies and families. There is often a wide gap between the interests of individuals and the expectations of their family groups. Many African women would probably prefer to restrict the number of births due to health considerations, but their reputation and social positions in the family are linked to producing a large number of children. Finally, there is often conflict between national and global interests. Brazil's development strategy in its northwestern rain forests (such as the construction of the "Amazonica") clearly contradicts global interests in stopping deforestation.

The working group discussed these questions in some detail. There was general agreement that scientists should not adopt the perspective of a specific hierarchical level, but study how the interests of individuals and the society, as well as national and global interests, could be made compatible.

4 The Question of Sustainable Technologies

What kind of technology is required for the sustenance of a world population of 10 to 14 billion? Can we apply the present-day technology of today's industrialized world, with its high consumption of energy and natural resources and its potential for environmental destruction? Transferring this technology into the developing world would most likely destroy the global life support systems (soil, water, atmosphere) beyond the point of possible recovery. Do we then need completely new technologies in industry and agriculture, such as genetically engineered production of food plants and livestock, or a decarbonized energy supply system based on solar/hydrogen technology? These "future" technologies might avoid some of today's environmental hazards, but bear a high potential of unknown (environmental) risk. Or should we go back to "old" technologies of traditional societies in the Third World and explore their potential? These technologies have proved sustainable for many generations, but their productivity is low.

The participants of the workshop disagreed on the question of which technological strategy should be adopted. The spread of "Western" know-how and technology to the Third World was criticized as a new form of colonialism. It would destroy the "ancient knowledge" about natural medicine, traditional food plants or ecologically adapted technology, such as the use of clay in house construction. We should learn from the Third World how to make our technology more sustainable.

On the other hand the workshop participants argued that under current demographic conditions traditional technologies either tend to become environmentally hazardous, or lose the capacity to support the population. A case in point is traditional agriculture and cattle breeding in Africa, which was sustainable at low population densities, but became a threat to the environment as the population doubled and tripled. In addition, the failure of agricultural modernization has contributed to the stagnation of the African food supply.

5 Motives for Political Action

What will motivate Third World families to restrict the number of children? What could urge European and North American governments to legislate strict measurements for reducing environmental destruction caused by industries and households? What might change energy-wasting lifestyles in "Western" societies? Which factors could initiate the development of environmentally sound technologies? There were several statements concerning these issues – some of them directly contradicting each other:

- One of the discussants, for example, stressed the "power of markets to influence people's behavior" while others argued that coercive measures, such as restricting the use of cars or airplanes, could force people to change their lifestyle.
- Several participants argued that developed countries will realize that the demographic pressure from the Third World can only be stopped by a massive financial transfer to the less developed world. On the other hand, there were doubts that "fear of mass immigration" would be a strong motive for European governments to increase development aid. As one of the discussants said, "There is much less dialogue between the North and the South today than 20 years ago".
- The participants of the workshop also disagreed on the question of responsibility, on which political action has to be based. While some stressed the responsibility of Third World countries for their unprecedented population growth, which in the long run would cause enormous environmental problems, others argued that consumption and production patterns of the rich are the major source of environmental degradation.

There was, however, agreement on some other critical aspects of political action. Several participants in the workshop were critical of the politicians from both the developed and the developing world who shy away from the key questions of global change. A case in point was the United Nations Conference on Environment and Development (Rio summit) where the delegations obviously avoided the two most important issues: population growth and economic development.

There was consensus in the workshop that the role of women still does not receive sufficient attention in development policies. Their social and economic position has to be strengthened and their opportunities for education have to be improved in many countries of the Third World, if family planning should succeed. Unfortunately, prospects are not too good for this integration of social and economic development. On the contrary, there is a conservative setback in many Islamic countries (most notably in some former Soviet republics), which might again restrict the lives of millions of women to raising children and keeping their households.

Finally, a majority of the participants seemed to be convinced that "new accounting principles" for the costs of environmental destruction have to be introduced to put the discussion on global environmental change on a rational basis.

6 Comments of the Rapporteur

The participants of Workshop 11 raised many of the arguments that fuel the current debate on population growth and environment. A broad spectrum of scientific positions and political orientations was presented in the discussion. However, the discussion omitted a few aspects which the rapporteur considers relevant to the topic of the workshop.

First, there was not much discussion about the fundamental political and economic changes in the former Soviet Union and Eastern Europe. (As mentioned, however, one of the discussants argued that "the power of markets should be used to influence people's behavior".) This disregard of a unique historical event surprised the rapporteur, since it was the imitation of the Soviet model of central economic planning which significantly contributed to the development debacle in quite a number of Third World countries (such as Ethiopia, Mozambique, Angola, Tanzania, etc.) – and this economic stagnation contributed to the failure to curb population growth. In addition, it was the system of socialistic command economy and collective irresponsibility which caused some of the most serious environmental disasters of our time, such as the Chernobyl explosion, the ecological catastrophe at Lake Aral, the devastation of whole regions in Eastern Germany due to brown coal exploration, or the destruction of large forests in former Czechoslovakia by massive industrial emissions. (For example, the per capita CO_2 emissions of Poland, Czechoslovakia or East Germany during the communist era were well within the range of the United States of America.) While several participants in the workshop criticized the unsustainable patterns of consumption and production in North America and Western Europe, no one mentioned the disastrous environmental effects of socialistic economies. The adoption of these economic systems by Third World countries (which is less likely at the moment) would be at least as devastating for our planet as the worldwide adoption of Western lifestyles and production methods.

Second, there was not much interest in "success stories". While the (near) failure of India's Family Planning Program was discussed to some extent, the success of China's and Indonesia's Family Planning Systems was mentioned only briefly. Several participants criticized the environmental consequences of Western "high-tech" agriculture in the Third World, such as groundwater pollution, soil degradation and deforestation – but no one mentioned the fact that the "Green Revolution" based on agro-chemistry, high yield seeds, irrigation and mechanization has more than *tripled* cereal production in China and *doubled* the rice output in India, which sustained the *additional* hundreds of millions by which these populations increased during the past three decades. There was broad consensus that consumption patterns and lifestyles in the developed world contributed most to global environmental problems – but no one mentioned that a number of industrialized countries in Europe have already eliminated or substantially reduced the environmental impact of many industrial processes, such as air pollution due to sulfur emissions of power plants. In the near future these countries will completely phase out the production of CFCs, which are the second most important greenhouse gases. (It should also be mentioned that China plans a massive increase in CFC production.)

Third, it was surprising to the rapporteur that "fear of immigration" was seriously considered a driving force for rational policy. Chances are high that fear of immigration will fuel a barricade mentality among European (and North American) populations and politicians. Most likely the slogan will be "close the borders", rather than "let's help the Third World". The rapporteur would prefer an attitude of shared responsibility ("we are all in the same boat"). This would require that both the developing and developed countries accept their share of responsibility for global environmental change. Third World governments must realize that the combination of high population growth and (expected) economic development will have a massive environmental impact in the not too distant future. Governments of industrialized countries must admit that the wealth of their populations has already caused partial degradation of the global commons, such as the atmosphere, the oceans, the soils. They are responsible for cleaning up the environmental heritage of their economic success. Political "confrontation" and "fear" would be poor motives for this kind of shared initiative in rational policy.

References

United Nations, 1992, *Long-range World Population Projections. Two Centuries of Population Growth 1950–2150*, UN, New York, USA.

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