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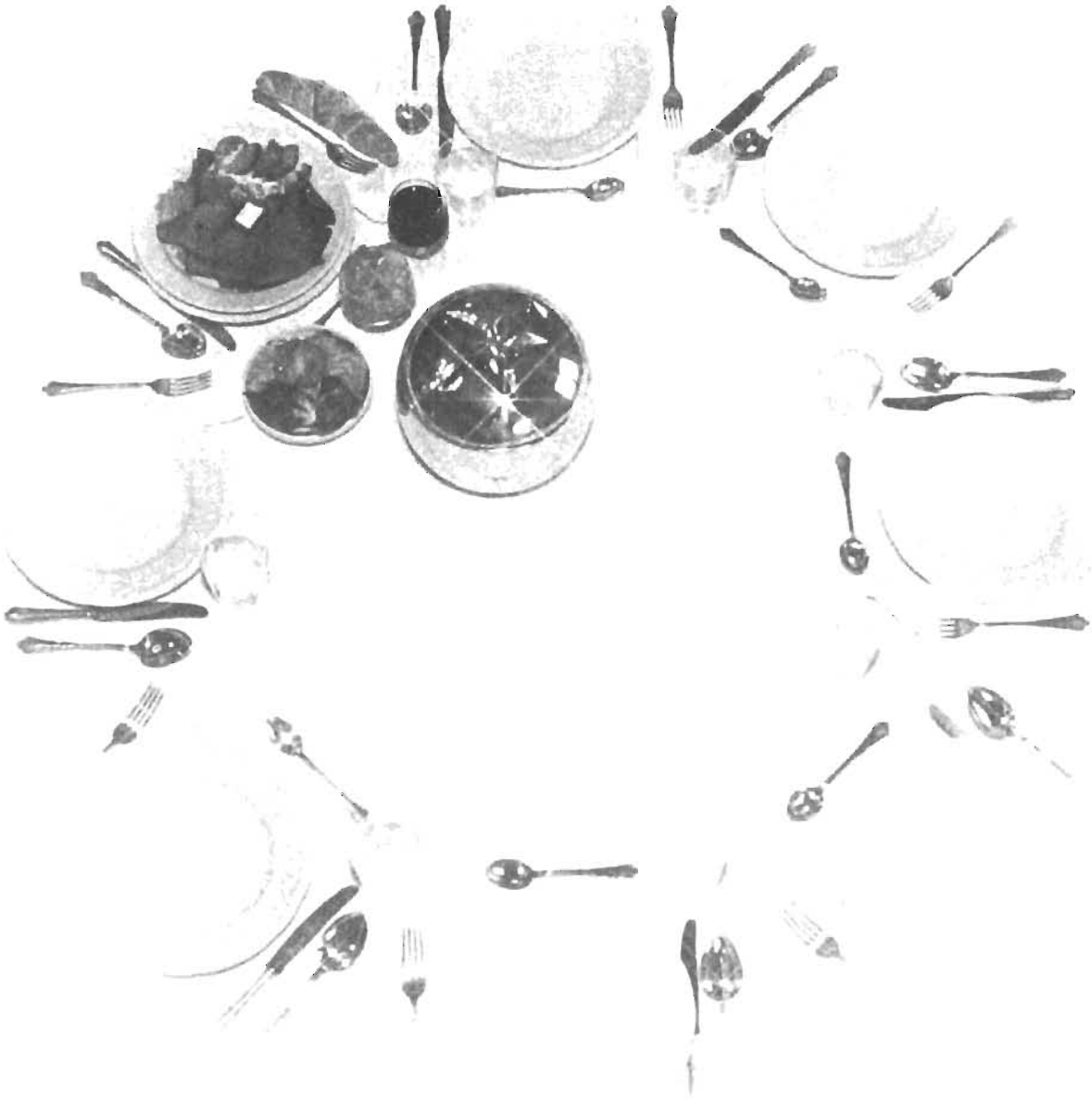

Searching for Ways to a Hunger-Free World

Kirit Parikh, Leader of the IIASA Food and Agriculture Program, explains in this interview with **Bradley Hitchings** how the Institute is searching for policies to help solve the problem of hunger.

Q *Professor Parikh, practically speaking, is the enormous problem of hunger in so many areas of the world really solvable?*

A It ought to be solvable, the popular view notwithstanding. We read about all the people now suffering from hunger and about projected population growth, and the layman assumes the case is hopeless. As scientists, we are convinced that the case is not so hopeless and policies can be found to ameliorate the problem.

Q *But the problem is in fact getting worse, is it not?*

A The latest projections of the Food and Agriculture Organization of the United Nations suggest the contrary, although such figures are always controversial. Their estimates seem to say that the undernourished proportion of world population will decline over the next twenty years but the absolute numbers will increase if the trends persist. With their optimistic projections, even the absolute numbers decline.

Q *And do you go along with such an optimistic view yourself?*

A It would be tempting to agree if one merely had to deal with the technical side of the problem. Some 30 million more tonnes of wheat every year, a mere 1.5 percent of current grain production, could eliminate hunger worldwide if distributed appropriately. But as an early run of IIASA's computer model has shown, if one country were to produce 30 million tonnes extra and sell the wheat on the international

Kirit Parikh

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market, it would never get to the people who need it. Wheat stocks in some countries would increase and some countries would lower their wheat production and increase feed production. More meat would be produced. The rich would then eat more meat – and the poor would stay hungry.

Q *So the problem is not technical, but political.*

A The problem is not one of agricultural productivity but one of agricultural distribution. Or to put it another way, it is not one of hunger but one of poverty. If the poor could afford wheat, an increase in production would eliminate hunger. Since no government wants its people undernourished, it is not strictly speaking a political issue, but policies must definitely change if hunger is to be eradicated in the world.

Q *In 1974, the Food and Agriculture Organization estimated that there were 462 million undernourished people in the world, excluding the centrally planned economies of Asia. The number included developed economies as well as Third World economies. How can a small number of scientists at IIASA expect to help solve such a vast problem?*

A That figure has been challenged, but the question is apt. Because of its broad international character, its familiarity with the most advanced modeling techniques, and its commitment to major worldwide problems, IIASA is well suited to such an extremely demanding task. We can help solve the problem by identifying suitable policies.

Q *You're saying that advanced modeling techniques will show the way to a hunger-free world.*

A Exactly. Better distributions of income – and food – are largely matters of national policy. However, such policy is deeply influenced by international trade in food. Agriculture actually dominates economic policy in most countries. But it is also affected by the policies of other countries. The world's food and agriculture system can best be seen as a set of national systems *embedded* in national economies that interact with each other. The modeling approach is an effective way to understand such interacting systems.

Q *How has IIASA gone about modeling the world's food and agriculture system?*

A First, we want to identify the factors that affect world food distribution. Then, with a view of how the worldwide system works, we will be able to suggest national and international policies to alleviate current food problems and to keep intermediate and long-term problems from developing.

Q *Do you have the resources for such an undertaking?*

A Admittedly, it is a large undertaking. Many diverse and seemingly incompatible systems must be simulated as national models that can be linked in an international model. Scientists at IIASA are not working in isolation on this linkage. IIASA acts as the central point for other scientists throughout the world. The whole network is developing a global "general equilibrium" model composed of national food and agriculture models that interact.

Q *What is a general equilibrium model?*

A Our model is in equilibrium because physical quantities of commodities are in balance. It is in "general" equilibrium because, in addition, monetary valuations of countries and of individual producers and consumers are in balance. The important thing here is that since all countries are included, there are no infinite sources or sinks of goods and currency. Therefore, the true effects of and feedback from policy decisions cannot be masked.

Q *Do you mean to say that IIASA is developing models of agricultural distribution for every country in the world?*

A National models that link with the IIASA international model are currently being developed in countries representing about eighty percent of the world's population, land area, and food production and distribution, including imports and exports. A few of these countries have been added

recently, and others may be coming into the IIASA program. To close the system, a rest-of-the-world model is included.

Q *Can you provide a rough estimate of how far toward completion the various national models are?*

A Yes. We have models for individual countries and for two groups: the European Communities, which, as you know, are composed of Western European countries, and the Council for Mutual Economic Assistance, which includes the planned economies of Eastern Europe. Individual country models are breaking out of the two groups in some cases. For instance, the CMEA model has now been completed and applied, and so has an individual model for Hungary. The CMEA model will soon split into three: Hungary, Poland, and the other countries.

Models for India, Brazil, Kenya, Sweden, and Thailand are now nearly complete. Models for the EC, Egypt, the USA, Poland, Austria, Japan, Finland, Canada, China, and Bangladesh are now being developed. Models for Australia, New Zealand, Mexico, and Indonesia are scheduled to start. We would also like to add models of Nigeria, Pakistan, and Argentina.

Q *Do you think other countries will become interested in the project and develop models, so that the rest-of-the-world model will comprise a smaller percentage of the total?*

A Definitely. Several countries have been added recently, and others may come in as scientists and others within those countries express interest in the IIASA program.

Q *Which countries are now about to join the program?*

A It is a little premature, perhaps, to mention them just yet. But we can say with some assurance that more models will be undertaken, not only in countries now covered by the rest-of-the-world model, but in EC and CMEA countries. Just this month, for example, we received an additional grant to support four more scientists for three years at IIASA to speed up development of the EC model.

Q *What sort of information must these models contain?*

A The answer to that is quite technical, but I think I can give you a general idea. The countries and groups of countries interact in reaching equilibrium. Each country is conceived to be made up of three basic components: production, exchange, and policy. The production component depends on government plans and policies, anticipated prices, and changes in resources, environment, and technology. In the exchange component, prices are determined under the influence of government policies as the various groups in the country trade what they have produced. The policy component concerns adjustments to plans and policies over time, in response to changes taking place in the model and the international environment.

Q *And the models of different countries must be expressed in the same terms for them to work together?*

A Yes, and that is what makes our program a rather ambitious one. To be linkable, the country models must have certain common characteristics. The country's net excess demand for each commodity must be a continuous function of world prices, although allowance is made for import and export quota restraints. Each country must use the same list of commodities and the same units of measurement, and they must all use an annual basis for reporting. Other requirements relate to modeling technique and are not particularly restrictive.

Q *How will the models of all these countries interact?*

A The models of the different countries interact through trade, aid, and capital flows. Given a set of world prices a country model can be viewed as adjusting its policies, such as taxes and tariffs, and responding with the amounts of exports and imports it would like. But the desired exports and imports of all countries must be compatible. We have to find prices that make them so. It is in this way that the models interact. The country models distinguish between the main staple foods, nonfood agricultural crops, and residual nonagricultural sectors. In short, they cover the whole economy of the country.

Q *Is it necessary to model the whole economy?*

A It is, for dealing not only with the country's food supply but also with its income formation and for relating food demand to income. Food supply and demand are treated according to income group. The grouping may range from landless farmers in a specified region to the whole nonagricultural rural sector of the country. These income groups are one type of actor in the system; national governments are the other type.

Q *What has the IIASA Food and Agriculture Program achieved so far?*

A First, we have created a network of participating institutions all over the world. They are developing models of their countries that will be mutually consistent and compatible for joint computer analyses. Whereas these are still being developed, IIASA has devised for all countries specifically included in the system simpler models, which we call the basic models and which, when connected, constitute the basic linked system. The IIASA basic models have been effective in bringing new countries into the project, providing starting points for detailed models. A country's detailed model may be more explicit on such matters as commodities, regions, classes, policy instruments, resources, and technology appropriate to the country.

The basic model is sufficient for use in the overall model; detailed models help countries concerned with bilateral agreements, the effects of one country's policies on certain other countries, and other matters of less than worldwide interest. The basic model developed by IIASA has served as a prototype for many of the country models taken on so far. In a few countries, scientists have developed their own basic models, in some cases using our standard Food and Agriculture Program country model as a point of departure and later replacing it. In other countries a less complex model has been used to gain experience before building the detailed model. One country, India, uses the detailed model as

its basic model.

Q *What is the appeal of the IIASA model system?*
A The benefit of linkage is the opportunity to relate a country's food and agriculture to the rest of the world. One can examine the impact of national policies as it is affected by reactions of other countries to such policies. Moreover, in the typical case a group of scientists within the country evaluates the structure of our Food and Agriculture Program's basic model of their economy. They may supplement the data provided by the Food and Agriculture Organization on which our basic model is built with their own country's food and agriculture data. They may make modifications that improve the basic model for use in their country. As familiarity with the structure nurtures confidence in it, the scientists may proceed with development of a detailed model of their own country.

Q *How soon will their efforts pay off?*
A Actually, countries developing food and agriculture models gain immediate benefits from a better understanding of their own food production and distribution and of how these relate to the systems of other countries. Participating institutions receive updated versions of the basic linked system, including the linkage superstructure, the set of basic country models, and associated data files, in return for updated versions of the basic model or the detailed model that each institution has developed.

Q *Are any of the models far enough along to be used at present, and do results so far stimulate interest in the program?*
A Yes, we are well under way. The model for Hungary continues to be used by that country's Ministry of Planning. The model for Thailand, developed by collaborators at the Centre for World Food Studies, is now installed and being put to use by the Ministry of Planning there. The World Food Council and the Food and Agriculture Organization of the United Nations have requested some new computer simulations. The Organization for Economic Co-operation and Development is interested in us, but our models are not yet developed quite enough for its needs.

A meeting at IIASA in December showed how the Polish model was a new tool for policy makers that could make contributions to economic analysis. Sweden is now developing a new, more elaborate model. We see increasing interest in the potential-user community now. Our supporters continue to be enthusiastic and we have not lost anyone.

Mexican and Japanese officials have named scientists to work on the models of their countries. The Japanese Ministry of Agriculture has provided funds to our Japanese collaborators. Our US model team has received funding from the US Department of Agriculture for 1982. This all indicates support for the general conception and expectation of its usefulness.

Q *Can the concept be expanded to other sectors?*
A We think the program has a lot to offer scientists involved in modeling and analyzing other sectors. Currently IIASA is considering its application to the forestry sector. It can also be applied to any other sector where international trade is important and where national policies should be analyzed in a general equilibrium framework that will not miss important feedback and other indirect effects.

Q *How do you see the future for the IIASA Food and Agriculture Program?*
A Our ultimate objective is to show the way to a hunger-free world. While such a task will take enormous effort and time, as you pointed out earlier, our system is designed to generate its own momentum. Our system offers its participants incentives from the start, and this does much to ensure its continuation and completion.

We have been discussing Task 1 of the program. Task 2 involves technological transformation in agriculture over a long term, up to twenty or thirty years ahead. Increasing pressure on land will present new and different problems, which the program must take into consideration.

Q *What are some of these long-term problems?*
A As the basic agricultural resources — land, water, and fertilizer — become scarcer and more expensive, a technological transformation of agriculture will have to take place. The higher yields needed and changes in the relative prices of land, water, fertilizer, and other cost factors will lead to changes in the techniques of production.

Q *How can the program help mankind to prepare for such a future?*
A It can determine the stable, sustainable production potential of the world, of nations, and of regions. Then it can determine whether mankind can be adequately fed by this production. It can suggest alternative transition paths and their resource requirements and then suggest sustainable combinations of techniques of food production. It can examine the policy implications of sustainable production at global, national, and regional levels.

Q *Will it be possible to apply some of the long-term policy implications of limited basic agricultural resources to the short-term policy implications now being developed in the models?*
A That is our intention. We began the program with a concern about policies over the next five to fifteen years, but we knew a long-term perspective was needed. So the solutions to current problems must be consistent with paths that lead to a sustainable, equitable, and resilient world meeting the food needs of a global population that may double by 2030. We believe that it is within man's abilities to achieve such a goal.

More information on the IIASA Food and Agriculture Program is available in a 250-page Status Report: *Food for All in a Sustainable World: The IIASA Food and Agriculture Program* (Kirit Parikh and Ferenc Rabár, editors), August 1981, SR-81-2. Single copies are available free of charge from the Distribution Section, Office of Communications, IIASA (tel. 02236 71521, ext. 483; telex 079137).

A Light in the Forest

One of man's oldest industries — forestry — is rapidly becoming one of his difficult modern problems, as trees are used for fuel and building material, and as a pervasive ingredient in the implements of living. Last December, in a town dedicated to preserving the past, scores of scientists converged to discuss that venerable industry in its twentieth century context.

They had come to Williamsburg, Virginia, USA to examine how a new technique could help managers see not only the forest and its trees, but also their environmental niche, the challenges they face from rising demand for land and fuel, and the industry and international trade they support. The forum for this evaluation was the North American Conference on Forest Sector Models, sponsored by IIASA, the US Forest Service, US Forest Industry, Canadian Forestry Service, National Forest Products Association, American Paper Institute, and Resources for the Future. It brought together some eighty scientists from universities, the forest industry, and government agencies in Australia, Austria, Canada, Finland, the Federal Republic of Germany, Japan, Sweden, Switzerland, and the United States.

"While some countries have used models of timber growth, harvesting, and land use, not much has been done to provide models covering the entire forest sector," explained IIASA's Professor Risto Seppälä at the Williamsburg meeting.

The term "forest sector," according to the Finnish scientist, refers to the composite of all aspects of forestry and the forest industry, from timber growth to end products, along with associated environmental and socio-economic factors.

This effort to see the forest sector whole, Professor Seppälä said, has been stimulated by the fact that the sector will face significant structural changes in the coming twenty to thirty years. This is primarily due to global shifts in the availability of wood raw material and processing facilities, and to changes in production costs and trade patterns. A broader view, using sets of national models linked to a global one, would permit managers to select policy options that lead to a benign future for the forest sector.

Professor Seppälä described an ambitious multinational modeling program proposed by IIASA that would conduct a worldwide survey of forest sector models, to make them available to managers from a central source. At the same time, the Institute would begin developing a set of prototype models. These models would include such dynamic elements as timber production, harvest and labor force, land conversion, erosion, firewood use, wood processing, wood product consumption, government policy (regulations and subsidies, for example), and the overall national economy, including the capital market for forest products. In addition, the prototypes could be changed to accommodate other differences, such as those between industrialized and developing countries.

Present participants in the IIASA study include: Australia, Austria, Canada, Finland, France, the Federal Republic of Germany, Hungary, Italy, Japan, the Netherlands, New Zealand, Norway, the Soviet Union, Sweden, the United Kingdom, and the United States; and the International Union of Forest Research Organizations (IUFRO), the Forestry Division of the United Nations Food and Agriculture Organization (FAO), and the Economic Commission for Europe (ECE).

Supply, demand, world trade

Still, models are just tools, Professor Seppälä emphasized. The ones being developed by IIASA will be used to improve understanding of those factors that affect changes in supply and demand, a critical element for long-range projections of forest production, but one about which "our knowledge is weak." Here, researchers will look at the very long-term resource potential, then weigh that potential against the consequences of various land-use policies.

Present patterns of global interaction, in the form of trade, can change rapidly. But there is no means of exploring the various effects of such developments systematically, and the mechanisms and structural features of world trade have received very limited attention thus far. The IIASA study, Professor Seppälä said, hopes to define those elements of world trade in forest products, and to discover the world, regional, and national perspectives on the future prospects of the industry in the context of a world trade system.

However, he noted, modeling and projecting national and global forest sectors deal with only part of the problems facing forests today. He sees IIASA and its national partners in this program turning also to protecting the forests as a renewable natural resource.

One of the most pressing problems of developing countries is the devastation of forests. Each minute thirty hectares of tropical rain forest vanish, and the pace is increasing. If it continues, by the year 2030 rain forests will be replaced by deserts or eroded areas. "Although this possibility is creating increasing concern," Professor Seppälä said, "we have very little precise knowledge about the real effects and dynamics of forest depletion. Separate studies concentrating on several special issues are being carried out by different institutions, but we lack a holistic, interdisciplinary research program. IIASA is an ideal location for such an effort."

The meeting in Williamsburg was not an isolated endeavor, but part of a sequence of regional conferences connected to IIASA's Forest Sector Project. The meeting after this took place in Finland for the project's Scandinavian collaborators. Similar conferences are planned for Central European and Pacific Rim countries.

Why Climb Everest?
A Critique of Risk Assessment

Cultural anthropologist **Michael Thompson** came down from Mount Everest with a new overview of risk assessment.

High-standard Himalayan climbing is a risky business. Indeed, it is quite possibly the riskiest there is. The fact that it is also an expensive business makes it difficult to understand why anyone should choose to engage in it and scotches right at the outset the explanation, favored by some, that people take risks because they are poverty-stricken. The fact that climbers often, in effect, pay heavily to put their lives at risk suggests that economics has not got *that* much to do with it. Of course, people sometimes are poverty-stricken because they are not prepared to take risks. It would be a curious sort of explanation that required us to hold that poverty was the cause of risk taking and that the avoidance of risk taking was the cause of poverty.

Such an explanation is curious not because it is wrong but because it is incomplete. A complete explanation would have to include some kind of delayed trigger mechanism to provide for switching from one set of conditions to the other.

How, then, do we account for these two regimes, risk taking and risk avoiding, and for the switching mechanism? As it happens, anthropologists have already described the regimes but to understand the switching mechanism we have to look at the aesthetics, not the economics, of risk.

Anthropological discussion of risk

The anthropological discussion of risk centers upon the fascinating phenomenon of Himalayan trade.

The Greater Himalayan Range, running roughly from east to west, separates two remarkably different regions. To the north is the high, dry, cold plateau of Tibet sparsely populated by Lamaist Buddhists. To the south are the low, wet, hot Middle Ranges quite densely populated by Hindus. The Greater Himalayan Range, though high, is surprisingly narrow and this means that anyone prepared to move into the uninhabited high valleys below the even higher passes into Tibet would be on to a very good thing. He would be in a position to generate wealth as effectively as a hydroelectric station with a massive head of water in both directions would be able to generate electricity. He could become the profitable channel through which wool and salt would flow down from Tibet whilst grain of various sorts flowed in the opposite direction. Once these flows were established he could expect the varied and sophisticated products of Mongolia and China to the north and of India to the south to be sucked in by the strong trade currents he had set in motion.

However, the price he will have to pay in taking up this tempting position is the acceptance of a high level of risk. Trade across passes of up to twenty thousand feet or more is a risky business. A sudden storm can wipe out not only his entire stock but him as well. If he gets safely across he may be robbed by Tibetan bandits, he may find that political changes (such as the Chinese occupation of Tibet) have made it difficult or impossible for him to sell his goods, that the market in these goods has been flooded, or that for some other unforeseeable reason there is no longer any demand for them. Moreover, all the while that he is away he may be worried about the arrangements back home.

There are two possibilities concerning the occupying of this tempting but risky middleman position. Either the Buddhists could move down or the Hindus could move up. In all cases, it would appear, it is the risk-taking Buddhists who have moved and it is the risk-avoiding Hindus who have stayed put. All attempts at explaining why this should be so have foundered in a classic anthropological whirlpool. Do they move or stay put according to whether they are "Buddhists" or "Hindus," or do they become "Buddhists" or "Hindus" according to whether they move or stay put?

All the evidence suggests not that one of these answers is right and that the other is wrong, but that they are both right. So let us have a look at risk taking and at the aesthetics of those who take the risks.

Aesthetics of risk taking

The real physical risks in Himalayan mountaineering — the avalanches, the frostbite, the verticality, the cerebral and pulmonary oedema, even the leeches and the Nepalese food — would probably be all too apparent to non-mountaineers even in the absence of the books and slide lectures, which, with their relentless and emphatic rehearsal of these horrors, are the favored means by which those climbers who have survived recoup the financial losses incurred in their latest exploit and accumulate something toward the expenses of the next.

Sometimes an expedition will entail, as well as these physical risks, financial risks that in their own way are every bit as great. When Barclays Bank agreed to back the 1975 British Everest Expedition there had already been six attempts by powerful teams, including one led by Chris Bonington who was also to lead our 1975 attempt, all of which had failed by a considerable margin to climb the Southwest Face: the formidable "last great problem" on Everest.

The full enormity of Barclays' financial risk becomes apparent when you see the same institution that is so reluctant to lend a customer just a few hundred pounds against the ample security of his freehold house calmly hand out a hundred and fifty thousand

pounds, completely unsecured, for a madcap scheme that they know has only a one-in-fifty chance of succeeding. Of course, Barclays will point out that this is not what they were doing and that the money, in fact, came entirely from that part of the budget allocated to advertising and public relations. Nevertheless, the fact that they were bombarded with letters from incensed customers suggests that the general public has difficulty in visualizing the Big Five banks as benign grannies with the cash they have earmarked for various purposes distributed among different tins and vases on their mantleshelves. Rather, they employ a simple input–output model: they see their money going into the bank and they see that same money being dished out to Chris Bonington, his friends, and a whole lot of opportunistic Sherpas on the other side of the world.

In the event the prophets were confounded, the Southwest Face was climbed and Barclays' great gamble paid off in the sense that they have now regained much more than one hundred and fifty thousand pounds. I hasten to add that these profits have not disappeared into their coffers but have all been carefully placed in a little tin on Grannie Barclay's mantleshelf and are to be devoted to the encouragement of youthful adventure.

There can be no doubt that Everest climbing involves massive physical and financial risks. The reason why Everest climbing, unlike, say, air travel, has not become safer with the passage of time is to be found in its uselessness. Once air travel became useful there were powerful economic incentives to increase the likelihood of a passenger being delivered live to his destination. Mountaineering has been mercifully free of such utilitarian constraints, until recently.

Every man destroys the thing he loves: the leader of the first ascent of Everest in 1952, Brigadier John Hunt, left the army and, as Sir John (later, Lord) Hunt, headed the Duke of Edinburgh's Award Scheme designed to channel the pure spirit of the great achievement to every schoolboy and schoolgirl in the land. Outdoor pursuits arrived in education and with them came a whole new profession: outdoor pursuits instructors: hideous Frankensteins, half teacher, half mountaineer.

One result of all this was that a small number of children who, left to themselves, might never have gone near a mountain, died. In vain did they hold official inquiries, introduce codes of safety, initiate mountain leadership certificates, and weigh down their charges' rucksacks with devices that would enable them to extricate themselves from every conceivable eventuality. Some children still died. The solution was simple and obvious: *mountaineering must be made safe.*

In this way, a program originally inspired by a great achievement is now poised to bring about a situation in which such an achievement will be impossible. Nearly all the "Buddhists" have been converted to "Hinduism": there are very few of us left. Before we become extinct, and before achievements involving a high level of risk become impossible, let me enter a plea for our preservation. I do not ask that we be recognized as yet another oppressed minority and granted the security of a Buddhist sanctuary. Rather, I would urge that we understand the "Hindu–Buddhist" cycle, and its switching mechanisms, before it finally breaks down. If we understand it we can rebuild it and so retain access to the full range of capabilities that it alone can generate.

The aesthetics of high-standard mountaineering are such that a proposed route is only felt to be worth while if there is considerable uncertainty as to its outcome. It is for this reason that we wished to climb the Southwest Face. Advances in equipment and technique, and the familiarity resulting from its many ascents, have rendered the original route by the South Col of little interest to the leading climbers of today. I was interested to discover that the Sherpas who accompanied us on the Southwest Face also entered into this aesthetic framework and disparagingly referred to the line by which Hillary and Tensing first reached the summit as "The Yak Route."

In sharing this little joke, European climbers and Nepalese Sherpas are both revealed as "Buddhists" poking a little malicious fun at some European "Hindus." For a moment, as we chuckle, the mists of cultural difference clear and we see through to the universal mountain that usually they obscure. These mists are formed by our personal processes of risk management. Risks, it turns out, come in several different forms and the way in which we emphasize one and play down another often clouds our understanding of what is going on.

As well as physical and financial risk there is intellectual risk. A person takes an intellectual risk when he sets out to provide an adequate explanation for something where previous attempts have failed, and he takes an intellectual risk when he sets out to question the validity of some explanation that most people believe to be perfectly adequate. In taking an intellectual risk a person stands to lose neither his life nor his fortune, but his credibility.

Intellectual risk taking is not usually much in evidence on Himalayan expeditions. A climber *knows* he wants to climb Everest and his main concern is to try to do it in as aesthetically pleasing a way as possible. If he were all the time asking himself *why* he wanted to climb Everest he would probably not get far beyond Base Camp, and might well fall down a crevasse if he did. Mallory's famous reply, "Because it's there," was not an answer to the question, "Why climb Everest?": it was a way of stopping people asking it for long enough for him to have a stab at doing it. The charm of the Sherpas' little "Yak Route" joke is that, by momentarily clearing those mists, it encourages me to take a large and exciting intellectual risk. In anthropological terms I want to try to formulate a general theory of risk. In everyday terms I would like to have a go at answering that perennial question: "Why climb Everest?"

Aesthetics, of course, have always been recognized as an important part of mountaineering. The aesthetic form may change, from the stiff upper lips of the prewar Everest climbers, through nature mysticism, esoteric skill, hard graft, or letting it all hang out, but there can be no doubt that more than just economic considerations motivate the mountaineer.

Yet, curiously, such aesthetic nice-

ties are not assumed to extend to the Sherpas who, throughout the history of Himalayan mountaineering, have carried the Sahibs' loads, and sometimes the Sahibs themselves, up their chosen peaks. True, virtually every expedition book is full of praise for the Sherpas' fortitude, cheerfulness, and dependability, but at the same time there is always something rather stereotyped about this handsome expression of credit. The Sherpa still remains the Cheshire cat of mountaineering literature: little more than a big smile at the opposite end of the arm to the Sahib's predawn mug of tea. The basic assumption is that the Sahib climbs Everest because it is there whilst the Sherpa climbs it for the money.

It is a convenient assumption. If climbing is mostly about aesthetics and if the Sherpas are concerned only with economics, then their contribution to any mountaineering achievement can be equated with that of, say, Barclays Bank. You need money to climb Everest, so the argument runs, and you need Sherpas to climb Everest, but both are simply the preconditions for Himalayan mountaineering: neither has anything to do with its essence, with what climbing is really about.

In other words, our personal risk management leads us to expand the aesthetic scope of our own actions and to contract that of the Sherpas: east is east, we say, and west is west and cultural difference explains all. All that this appeal to cultural difference does is set a limit to what we are prepared to explain. Sharing a joke with Sherpas overrides these distortions produced by our risk management and reveals that the frames of our aesthetic scopes are identical. Suddenly, appeals to cultural difference are of no avail: we can no longer call upon Kipling to bail us out when the intellectual risks become too great.

Probably the greatest achievement of anthropology has been to shatter the convenient assumption that, in the same sort of situation, people will tend to do the same sort of thing. Anthropologists have become so carried away by their spoilsport success that they have almost completely lost sight of the really interesting, and difficult, question: "Granted that different

Michael Thompson

people in the same sort of situation may do different things, why do they do the different things that they do?" This is the question that a general theory of risk will have to answer. It will have to offer some satisfactory reason why Mallory wanted to climb Everest, and why Mingma the Sherpa wants to climb Everest, and it will have to give some satisfactory reason why all sorts of other people do not want to climb Everest.

Risk taking and risk avoiding

For every proverb and catchphrase there is, it would seem, a contradictory counterpart: "Look before you leap" versus "He who hesitates is lost." If we were to collect these contradictory pairs and line them up with one another we could sketch out the world views, the sorts of predictive frameworks, that the risk taker and the risk avoider use in choosing, and justifying, the very different courses of action that each follows. The risk taker's world view corresponds to that of the adventurous Himalayan trader: the Buddhist. The risk avoider's world view corresponds to that of the cautious, stay-at-home cultivator: the Hindu. One grants credibility to one set of proverbs, the other to the opposing set. Once equipped with these very different perceptions of the world it is hardly surprising to find that, when confronted with uncertainty, they operate very different strategies.

The Buddhist is an optimist: his response to uncertainty is positive. He acts boldly, but not foolhardily, in the hope of reaping rich rewards. The Hindu is a pessimist: his response to uncertainty is negative. He prefers not to act for fear that one thing may lead to another. Why should one be led to adopt the risk-narrowing strategy, the other the risk-spreading strategy?

First of all, it is not because one is a Buddhist and the other is a Hindu. "Buddhist" and "Hindu" are simply convenient labels to identify a person's commitment to one or another set of proverbs. No, the answer to why a person accords credibility to one set of proverbs rather than the other is ridiculously simple, and has nothing to do with cultural difference.

The Hindu adopts a risk-sharing strategy, and subscribes to the pessimistic, all-embracing world view that justifies such a strategy, because he has someone to share with. The Buddhist adopts a risk-narrowing strategy, and subscribes to the optimistic, piecemeal world view that justifies such a strategy, because he has no one to share with.

Social context is enormously persuasive. If there is no one there to share your risks with you, you cannot go in for risk sharing and, conversely, only a mug would take a huge personal risk knowing that, if he were successful, he would have to share the rewards among all his cautious, risk-shunning fellows. Of course, a risk avoider may, in certain circumstances, be prepared to take certain risks: those that are not for personal gain but for the survival, the glory, or the honor of the group.

I can foresee two possible objections to this devastatingly simple answer to the question, "Why climb Everest?" The first is that, if my theory states that individualism encourages risk taking and collectivism encourages risk avoidance, then, in equating Everest climbing with individualism, I have it all wrong because Everest climbing is a collectivist activity wholly dependent for its success upon superlative teamwork and upon highly motivated and skilled individuals selflessly surren-

dering their personal ambitions (to be *the* man on the top of Everest) to the common cause (getting *a* man on the top of Everest).

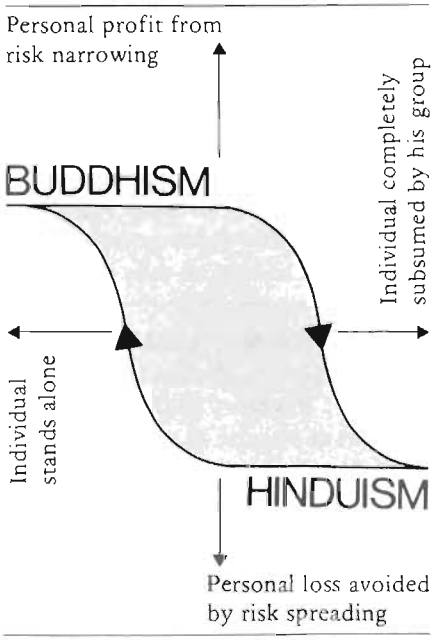
High-standard mountaineers are extraordinarily individualistic and are only prepared to form an expedition together in the first place because they know that, regrettably, they can't get to the top of Everest unaided. The steady progress of an Everest assault can only be maintained by continually changing the lead climbers, those who have done their stint returning to Base Camp for a rest whilst others, still fresh, take their place. Going down to Base Camp takes one or two days, coming back to the sharp end is at the rate of one camp per day. It is most fortunate that the total amount of time it will take to climb the mountain is unknowable. Having myself watched and been involved in these complex dynamics, I am quite certain that, if the optimum position happened to be that of the first pair to set out from Base Camp, all the members of the expedition would hurl themselves simultaneously at the mountain and that, if this were not the optimum position, not a soul would stir from his sleeping bag.

The second possible objection is that, if the answer to this perennial question really is so simple, how come somebody hasn't come up with it sooner? The reason is twofold. First, people are usually very strongly committed to their view of how the world is, and this commitment is partly maintained by denying the validity of other ways of seeing the world. Second, though the world view to which they are committed depends upon their social context, they are unaware of this dependence. As far as they are concerned, their world view is not some artificial construct, it is an accurate, factual account of how the world is. One might say that the collectivized context is to the "Hindu" what the earth is to the worm and that the individualized context is to the "Buddhist" what the air is to the bird. Each is as firmly and unquestioningly committed to his world view as are the worm and the bird to their respective eye views.

But there is a crucial difference. For worms and birds the environments are natural: for risk avoiders and risk takers the environments are social. No matter what actions worms and birds take they will never find themselves living in one another's medium but, for the risk avoider and the risk taker, there exist the possibilities equivalent to the worm sprouting wings and the bird slithering into the soil. Social contexts can change, either as a result of the actions of the individuals who constitute the totality, or as a result of external natural or social pressures. Risk avoiders can be transformed into risk takers and risk takers into risk avoiders. Yet the path to risk acceptance is not the reverse of the path to risk avoidance: there is a cyclical relationship between the two states: a Hindu–Buddhist cycle.

The Hindu in his collectivized context *learns* to avoid risk taking. He will have built up a considerable profit and loss account by the time he is firmly locked on to his set of proverbs. In the same way, the Buddhist will build up his distinctive pattern of investments that commits him firmly to the other set of proverbs. The consequence of all this work – all this aesthetic investment – is that, in order to let go of the Hindu world view and acquire a firm grasp on the Buddhist world view, you have to dismantle one investment structure and build another.

Such cycles can be depicted by a graph called a "hysteresis loop" in



which the area enclosed by the paths between the two states provides a measure of the work done in going round the cycle.

Apart from providing some sort of answer to the question, "Why climb Everest?", what does this diagram tell us that we do not already know? It tells us that:

1) Changing people's social contexts is a costly business.

2) Though risk-taking and risk-avoiding strategies are contradictory, little is to be gained and a great deal could well be lost by insisting that one is right and the other is wrong. Rather, each is appropriate in a particular kind of social context.

3) Though each is convinced that his view of the world is the right one, "Buddhist" and "Hindu" each stand to gain, as well as lose, from the activities of the other. This means that in all probability there will be, in the distribution of Hindu and Buddhist contexts, some optimum arrangement at which the gains minus the losses for the totality reach a maximum.

4) Since a modern industrial society inevitably generates both sorts of social context, and since the social policies that such societies implement inevitably result in the transformation of some individuals' contexts, there exists the possibility of evaluating these policies according to whether they will bring us nearer to, or take us further from, this optimum.

Having put forward these few suggestions, I am assailed by awful premonitions. Could it be that I am about to destroy the thing I love: have I gained something *useful* out of Everest climbing?

Michael Thompson works at IIASA on institutional aspects of risk management, and is also Senior Research Scientist with the Institute for Policy and Management Research at Santa Monica, California and Bath, UK and Lecturer in Urban Sociology at Portsmouth Polytechnic School of Architecture, UK.

What is Systems Analysis?

Edward S. Quade and
Hugh J. Miser

This is an abridged version of the first chapter in Volume 1 of the *Handbook of Systems Analysis* being published by IIASA. Volume 1: *Overview* is aimed at a widely varied audience; Volume 2: *Methods* is for specialists; while Volume 3: *Cases* will also be of wide interest.

Many of the problems facing society today emerge from systems combining people and the natural environment with various artifacts of man and his technology. Such problems and the sociotechnical systems of which they are aspects abound in modern society. For example, the problems of meeting the world's energy demands involve the energy system, which combines sources of energy, the means for converting these sources to usable forms, the distribution devices and procedures, the using community and the ways it employs energy, and the surrounding natural and economic environment that affects energy use and that is, in turn, affected by the energy system.

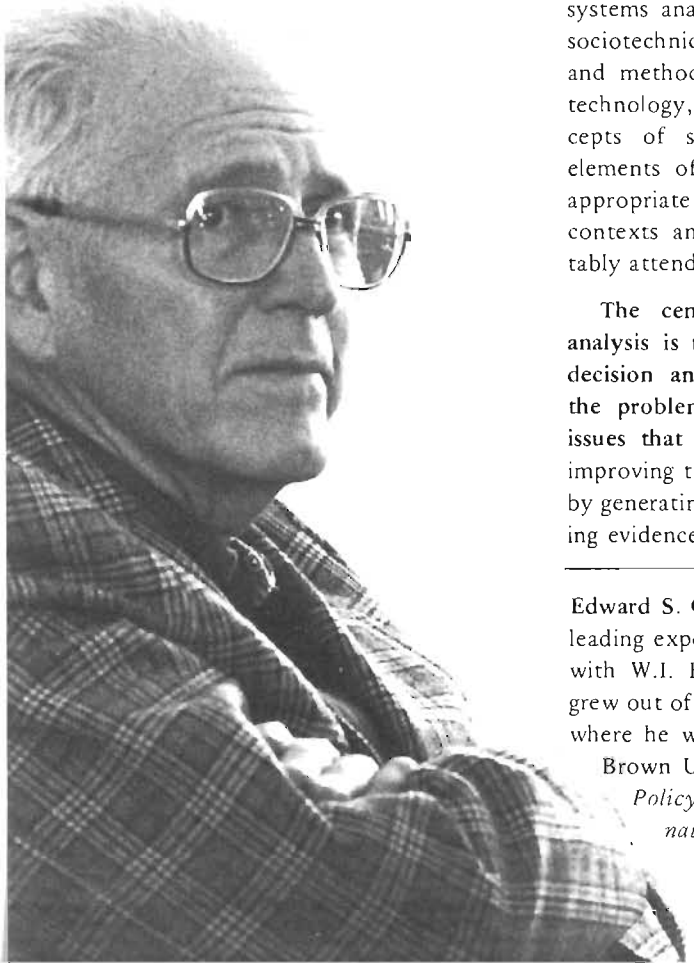
Many elements of such systems exhibit forms of regular behavior, and scientific scrutiny has yielded much knowledge about these regularities. Thus, many of the problems that arise in sociotechnical systems can be addressed by focusing such knowledge in appropriate ways by means of the logical, quantitative, and structural tools of modern science and technology. The craft that does this is called systems analysis; it brings to bear on sociotechnical problems the knowledge and methods of modern science and technology, in combination with concepts of social goals and equities, elements of judgment and taste, and appropriate consideration of the larger contexts and uncertainties that inevitably attend such systems.

The central purpose of systems analysis is to help public and private decision and policy makers to solve the problems and resolve the policy issues that they face. It does this by improving the basis for their judgment by generating information and marshaling evidence bearing on their problems and, in particular, on possible actions that may be suggested to alleviate them. Thus, commonly, a systems analysis focuses on a problem arising from the operations of a sociotechnical system, considers various responses to this problem, and supplies evidence about the costs, benefits, and other consequences of these responses.

Since systems analysis deals with diverse problems and different contexts, it assumes forms adapted to the problems, the systems, and their administrative contexts. To achieve its full growth and usefulness it must continue this process of adaptation and extension.

A complete systems analysis may involve as many as nine steps, although they may have only hazy borders and may occur either in parallel to some extent, or in an order other than the one listed. Applied systems analyses:

1) marshal both the evidence relating to the problem and the scientific knowledge bearing on it, when necessary gathering new evidence and developing new knowledge;
2) examine critically the social purposes — of both persons and institutions — relating to the problem;
3) explore alternative ways of achieving these purposes, which often include designing or inventing new possibilities;
4) reconsider the problem in the light of the knowledge accumulating during the analysis;
5) estimate the impacts of various possible courses of action, taking into consideration both the uncertain future and the organizational structures that must carry forward these courses of action;
6) compare the alternatives by applying a variety of criteria to their consequences;



Edward S. Quade: "Grand Old Man" of systems analysis — and one of the world's leading experts in the field. Professor Quade edited the first book on the subject, with W.I. Boucher, entitled *Systems Analysis and Policy Planning*. The book grew out of a course he gave in the early 1950s at the Rand Corporation, California, where he worked from 1948 to 1973. He had previously taught mathematics at Brown University and the University of Florida. Professor Quade was editor of *Policy Science* from 1969 to 1974 and Executive Editor of IIASA's *International Series on Applied Systems Analysis* from 1976 to 1979. Now retired, he serves as a consultant to the Rand Corporation; in addition, he is coeditor of the IIASA *Handbook of Systems Analysis*.

7) present the results of the study in a framework suitable for choice;
8) assist in following up the actions chosen; and
9) evaluate the results of implementing the chosen courses of action.

Although the list of steps refers to "the problem," for "problem" in many cases we must understand "problem situation." Systems analysis cannot hew to an accepted, predetermined outline, but must respond to the conditions of the problem context and exploit such opportunities for assistance to decision makers as it may offer.

Indeed, there is a case to be made that, in many situations, a systems analysis is part of a social process of problem solving in which many people take part.

Science and systems analysis

Science and its knowledge are the cornerstone of systems analysis, but systems analysis itself is not science. Systems analysis depends on science for its strength but systems analysis itself is a craft – and can be an art.

The domain of science is the phenomena of nature in the universe and the world. This context includes not only the phenomena described in the classic sciences with which we are familiar (astronomy, physics, chemistry, and so on) but also the less well understood phenomena of social and sociotechnical systems.

The scientist is an observer. He tries to describe in some generality what he sees, and what he expects to see in the future; this description is his theory, or model. Then he checks his predictions against further observations. Thus, the method of science is cyclic: it starts with observations and ends with observations, the ones ending one cycle being the beginning of the next one. A scientist always holds his theories tentatively, and is prepared to abandon or adjust them as observational experience accumulates.

We then define science as the body of knowledge (or collection of facts and theories – "models") assembled by the method of science. The individual sciences are distinguished by the portions of nature they are seeking explanations for, rather than by their techniques, tools, or methodological approaches, although these may have somewhat characteristic associations with particular sciences.

Workers setting out to apply the knowledge gained by science may find the way to use the knowledge is simple and direct; however, it is more usual for them to have to invent some sort of practical instrumentality to exploit their knowledge. In fact, for all but quite simple problems, they have to bring together much such knowledge and many inventions by designing a synthesis of a variety of items of knowledge and adapting the individual inventions to the new synthesis; almost any of today's high-technology artifacts (such as airliners) illustrate this point.

These invention and design activities aimed at applying the knowledge of the physical sciences are what is usually meant by the term engineering. It is important to note that many engineering artifacts are involved in the sociotechnical systems that systems analysis is concerned with.

Analysts looking over the scientific knowledge available during the last quarter-century and the efforts to use this knowledge to design solutions to large-scale sociotechnical systems problems saw the need for the classic and newer fields of science and technology to work together to solve these larger problems; this impetus led to systems analysis.

Against the background of this discussion, **systems analysis can now be described as the invention and design – or engineering – art of applying scientific knowledge to sociotechnical problems.**

Thus, while systems analysis contains many scientific components, it is not itself a science; rather, it is a new form of engineering being applied to the problems of large-scale sociotechnical systems. It is concerned not only with theorizing but also with choosing and acting. However, it uses the methods of science as far as possible and strives to uphold similar traditions. That is, good practice holds that:

- results emerge from processes that can be duplicated by others to obtain the same results;
- calculations, assumptions, data, and judgments are reported explicitly, and thus are subject to checking, criticism, and disagreement;
- conclusions are not influenced by personalities, reputations, or vested interests.

Certain sciences – economics, sociology, and physics, to name a few – are particularly relevant to the problems systems analysis addresses. Other disciplines – logic, mathematics, engineering, and computer science, for instance – provide the tools.

Among the latter, operations (or operational) research is particularly significant, because it is the discipline from which modern systems analysis emerged and because it shares a set of tools with systems analysis.

Systems analysis, as a name, may be relatively new, but it is not a new concept or activity. History records a number of past analytic efforts that, if carried out today, we would call systems analysis. The term was coined in the late 1940s to distinguish research being done to choose weapons systems from operations research. It differed from operations research in the need to introduce long-term economic factors and to consider interactions between means and objectives. Today, however, operations research has broadened to take into account these considerations and, along with systems analysis, to deal with equity and other political and social concerns. Systems analysis of this latter type is also being called *policy analysis*, particularly in the United States, partly to avoid confusion with the narrower office management and computer uses of the term systems analysis.

Systems analysis is NOT . . .

One way to help make clear what systems analysis means is to describe what it is not. For one thing, it has nothing to do with classifying systems or with discovering properties common to categories of systems. These are investigated in general systems theory or in systems science. In fact, systems analysis need have nothing whatsoever to do with any system other than the system defined by the

problem itself, made up of the things, concepts, and relations involved in the investigation.

Secondly, **modeling is not systems analysis.** A systems analysis is an attempt to discern and answer questions of importance in the choice of a decision or policy; a model is merely a useful device in helping to obtain answers to such questions.

Furthermore, systems analysis is not research for knowledge alone, nor is it causal analysis, concerned with discovering the nature and causes of social or environmental problems or the explanation of behavior, although such research may be necessary to a systems study. Systems analysis, in contrast, is concerned with analyzing and resolving issues arising in specific institutional contexts.

Finally, systems analysis is not a branch of applied mathematics – constrained optimization – or a branch of logic – the pure logic of choice – nor does it claim to be identical with what is sometimes called rational decision making or rational problem solving.

Applications

Systems analysis has been applied with varying success to a wide spectrum of problems, both in type and area. It can be put to many uses, routine (optimizing a system for assigning police patrols) or nonroutine (working out the main features of a housing maintenance plan). It can be used to raise questions about, and explore the consistency among, objectives of different programs (whether a petroleum company should look to further profits from an increase in exploration or from diversifying into other areas). It can point out directions for seeking new knowledge (using solar energy) and discover new uses for old products (adding a chemical to water to decrease friction through fire hoses). **Systems analysis provides this help by bringing knowledge, methods, ideas, and procedures from the academic, scientific, and research communities to bear on problems faced by business, industrial, and political decision makers.**

Systems analysis often works well with budgetary decisions. The first studies to which the name was applied were cost-effectiveness analyses. That is, they were studies that sought to determine a course of action that, for a fixed budget, would most nearly achieve some desired objective, or conversely, the alternative that would achieve a given goal for the least cost. Budgetary decisions typically involve choices among good things; the problem is to find out which are better. Actually, a good many questions, both public and private, that require analytic help are of this type. The situation often can be made to fit a well known model such as linear programming or queueing theory and a near-optimal solution obtained by means of a systematic computational routine.

Systems analysis has been most successful in helping with issues in which science and engineering dominate, as, for example, in many industrial and military applications.

In contrast, when political, organizational, and social factors dominate (as they do in most public problems, as for example, in designing a welfare system, or in setting standards for pollution control, or in defining an urban renewal policy), goals may be obscure and conflicting and authority diffuse and overlapping, with no confidence that analysis can help with the solution. In addition, efficiency and effectiveness may have no clear meaning in such problems; questions of equity, and "who benefits" and "who pays" may be more critical to the acceptance of a proposed solution than any question of which policy generates the greater surplus of benefits over costs.

The difficulties of deciding what ought to be done are likely to dwarf those of finding out how to do it. Nevertheless, systems analysis has helped here, even though it may not have offered a complete solution, by providing information, by isolating alternatives, and by yielding insights that have enabled decision makers to intuit better solutions. Systems analysis can almost always eliminate the really bad alternatives, leaving the decision maker a choice from among the relatively good ones. It can help with both acceptance and implementation of decisions by marshaling arguments and being used as a tool of advocacy for the better actions. Systems analysis can legitimize decisions and assemble support for proposed actions.

Systems analysis, even when it cannot prescribe the decision, has a number of virtues. Among other things, it

- introduces a certain amount of objectivity into a subjective process;
- can take uncertainty into account explicitly;
- considers specific issues in larger contexts and determines interactions and side effects;
- tends to shift debate from means to consequences;
- may reveal unanticipated consequences of policies and actions;
- evaluates and compares alternatives in a consistent and systematic way;
- may provide insight into issues and suggest better alternatives;
- reveals some of the linkages between objectives and feasible results.

Criticisms

There are also adverse features that may follow from dependence on analytic methods: for example, delays in decision making; increased centralization and concentration of decision making in top-level staff; increased dependence on complex processes (for instance, computerized information systems) that require continuous attention by expensive talent in order to work well; and elimination of inefficiency and redundancy, which, while costly, may have served to meet unexpected contingencies, resulting in greater dependence on processes and policies that, while finely tuned to specific situations, may not be robust or reliable under changing or "dirty" conditions.

Systems analysis, like every other human endeavor, has its limitations. One of these is that it is of necessity incomplete: time, money, and other costs place severe limitations on how thoroughly any topic can be studied. It simply cannot treat all considerations that may be relevant.

Since it is the nature of systems analysis to explore the difficult problems on the frontiers of our understanding of the workings of sociotechnical systems, the history of the subject has been strewn with difficul-

ties, and failures have occurred as well as successes. Sometimes the results of a study have been unusable and misleading.

Critics say that systems analysis is too complicated; that analysts are more interested in research than in solving real-world problems; that there is too much emphasis on cost; that it is a waste of money.

There are potential ways to misuse systems analysis. For instance, in addition to what the analyst may be told is the purpose, a decision maker may commission a study to provide himself with an "expert" facade for promoting his preconceived ideas or policies, an excuse for inaction and delay, or a shield for his actions that is hard to penetrate or challenge without rival analysis. Too, systems analysis may be misunderstood or produce misleading information, for example, by implying unwarranted degrees of confidence in oversimplified or partial results, or overemphasizing the readily treated (but often less important) quantitative aspects of problems while neglecting other attributes and values that are difficult to quantify and thus can be treated only by judgment.

However, criticisms of some cases of past practice must not be viewed as intrinsics of systems analysis; rather, they are pitfalls to be avoided in practicing the art of systems analysis.

So why systems analysis?

There are, of course, other means than systems analysis for helping a decision maker.

The policy advisor is the traditional source of advice. However, such an advisor is limited to what he can do by himself.

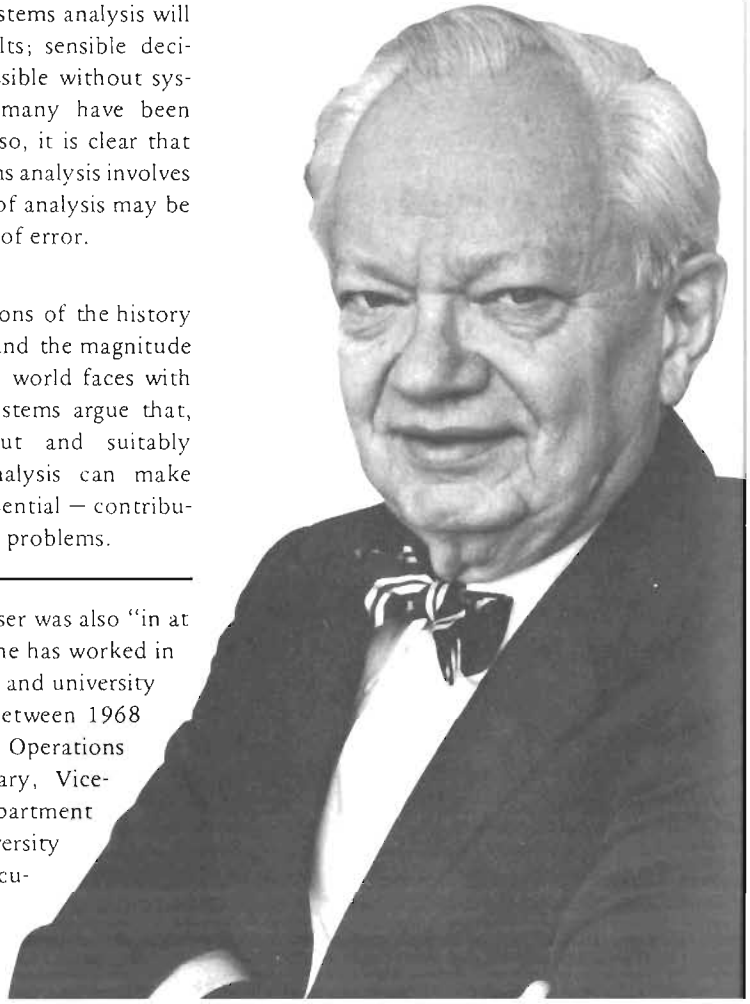
Committees are a second alternative. Unfortunately, the findings of many committees are obtained by bargaining rather than by reasoning and, on a committee, personality and prestige often outrank logic.

A third alternative is "muddling through," a sort of trial-and-error process in which naturally occurring feedback from what actually happens is supplemented by limited analysis. Administrators and policy makers have long gone about making decisions in this way — using analysis on parts of their problem, taking remedial steps rather than innovative ones, moving away from ills rather than toward definite objectives, seeking vague goals sequentially.

The argument that systems analysis, even though it may be incomplete, is to be preferred to the intuition of an expert, or to bargaining by a committee, is based on the belief that the results will be better, that is, that the decision maker will prefer the results he gets from analysis to what he would have done without the analysis. We cannot prove that systems analysis will produce better results; sensible decisions are clearly possible without systems analysis, for many have been made in the past. Also, it is clear that the practice of systems analysis involves a cost, and the cost of analysis may be greater than the cost of error.

However, the lessons of the history of systems analysis and the magnitude of the problems the world faces with its sociotechnical systems argue that, properly carried out and suitably applied, systems analysis can make important — even essential — contributions to solving these problems.

Systems analysis, as we have tried to make clear, is not a method or technique; nor is it a fixed set of techniques; but rather an approach, or way of looking at a problem and bringing scientific knowledge and thought to bear on it. It is a way to investigate how to aid a decision or policy maker faced with complex problems of choice under uncertainty, a practical philosophy for carrying out decision-oriented interdisciplinary research, and a perspective on the proper use of the available tools.



Hugh J. Miser: The other editor of the *Handbook*, Professor Miser was also "in at the beginning" of systems analysis. Trained as a mathematician, he has worked in systems analysis since 1949 in military, industrial, governmental, and university contexts. Professor Miser was editor of *Operations Research* between 1968 and 1974, and received the George E. Kimball Medal of the Operations Research Society of America after having served as Secretary, Vice-President, and President of the Society. He was head of the Department of Industrial Engineering and Operations Research at the University of Massachusetts, Amherst before joining IIASA in 1979 as Executive Editor for Institute publications. He is coauthor of two mathematics textbooks and has written numerous articles.

Patterns of Urban Change

Piotr Korcelli has been studying urbanization. He believes that the recently observed shifts of urban agglomerations are not a passing phenomenon and will have long-ranging socioeconomic effects.

The conventional wisdom of past decades held that the populations in major metropolitan areas throughout the world would continue to grow as they had in the past. Planners and scholars assumed that almost everybody would ultimately cluster in a megalopolis, one of the gargantuan cities spreading across the face of the earth. But as the census figures from the late 1970s came in, it was realized, with some surprise and anxiety, that the opposite was happening in highly urbanized, "postindustrial" societies. Large cities in Europe, North America, and Japan were not gaining in population as strongly as before, and many of the major metropolitan areas were even losing population. New York City and the Ruhr complex in the Federal Republic of Germany are among the urban centers that had more people in 1970 than in 1979.

This is urban contraction – not the suburbanization or the urban sprawl we had seen previously. Urban contraction primarily affects older industrial areas in the developed countries. Populations in the urban areas of the developing countries, on the other hand, are still expanding; in fact, their rates of growth have quite often accelerated. This marks a divergence between the developed and developing nations.

Various new ideas have arisen to explain the turnabout in urban population growth in the industrialized nations and these ideas could be tested with some empirical data already at hand at IIASA.

In 1977 IIASA started to develop detailed studies of population change in the seventeen countries of our National Member Organizations. Almost all of these are now published. All have the same structure and include comparable information, although each was written by a scholar native to the country being analyzed. The Migration and Settlement series used the new multistate theories and mathematics developed by Andrei Rogers first at Northwestern University, Illinois, USA and then at IIASA. The material accumulated for this series then enabled us to carry out a comparative international study, as part of a larger research effort to advance the application of settlement theory to urban and regional planning policy.

Our new study used 35 comparable metropolitan regions or functional urban regions from Japan and 12 European countries. Most of these regions have between 1 and 3 million inhabitants; a typical unit consists of a major city with its surrounding "commuting" area. In 1975 the fraction of the urban population in these countries varied between 50 percent in Hungary and 84 percent in Sweden. Natural increase ranged from 10.1 per thousand in Poland to −1.9 per thousand in the Federal Republic of Germany. Several regions are much larger than others as they encompass clusters of metropolitan areas, such as the North Rhine–Ruhr–Westphalia conurbation in the Federal Republic of Germany and the Osaka–Kyoto–Kobe region in Japan.

We used these urban regions as the reality against which we examined five hypotheses that attempt to describe the patterns of population change and migration to be expected when large-city population growth slows down. These include ideas of the relationships between urban population growth rates and how much of a national population is urbanized; the importance of migration to urban population growth; the tendency of urban residents to move more frequently; and how migration flows are directed, as well as how they change in terms of age groups.

One hypothesis states that the rates of population growth in urban areas are inversely related to the level of urbanization on the national scale and to the size of the city. The assumptions are that the rate of urbanization flattens out when over half of the population lives in urban areas and that the large cities are the first to experience this trend. This is tied to concepts of an aging population, characterized by low birth rates and diminishing migrations.

Data derived from our IIASA study basically support this concept. During the mid-1970s, 19 of the 35 urban regions experienced population growth that was slower than the national growth rate. Half of the remaining urban units in the study had higher growth rates than the national rate, but by less than 2 percent. Thirteen urban regions suffered absolute population losses and this figure is likely to increase to 16 by the year 2000 and to 21 by the year 2020.

The urban regions that have lost population include Vienna together with other northeastern Austrian provinces; Hamburg and the North Rhine–Ruhr–Westphalia area; Leipzig–Halle in the southern part of the German Democratic Republic; and, in the Netherlands, the northern areas based on Amsterdam and Rotterdam.

We found that generally there is also an inverse relationship between the rate of population growth and urban size.

Another hypothesis claims that the contribution of migration to the growth of large cities becomes of secondary importance in highly urbanized societies. What we have seen historically is that the natural increase of a population fuels urbanization in its early stages, and then migration – whether rural-to-urban or from other countries – becomes the dominant component of urban growth. It is suggested that as metropolitan areas "mature" and

decentralize, the natural increase of the resident population again becomes more important.

The evidence we have collected quite strongly supports this concept. Out of the 35 urban regions studied, 24 exhibit a positive natural increase with only 18 showing positive in-migration. About one-half of the urban regions with greater contributions from natural increase, including Paris, London, and Amsterdam, lost more migrants than they gained.

This drop in migration, both in absolute numbers and as a contributor to total population change, is a very recent phenomenon. The UN Economic Commission for Europe found that in the 1960s migration accounted for as much as 60 to 90 percent of the total urban population growth in a number of European countries, including Hungary and Sweden. This was also true of Japan. However, between 1960 and 1975, the ratio of natural increase to migration changed from 1:2 to 3:1 in Tokyo, and to 30:1 in Osaka.

It should be noted that the greater role that natural increase plays in urban population growth is not due to high fertility among the resident urbanites, but to the poor performance of many urban regions in attracting migrants from other areas. During the 1970s, traditional rural-to-urban migration streams became largely reoriented toward smaller cities and peripheral regions. Higher investments in social amenities and industry outside the major urban agglomerations translated into lower out-migration to urban areas.

A third hypothesis proposes that the population of large cities is distinguished by greater spatial mobility in comparison with rural and nonmetropolitan populations.

Our study shows the opposite. The large-city resident seems to be less mobile than the national migration rates suggest. One factor to take into consideration is that short-distance migration has been largely replaced by daily commuting between residence and work place as transportation systems have developed.

More information on mobility may be found by examining the probability

Robert A. Duis

that individuals, at different ages, will stay in their regions of birth. Our analyses of urban regions show that an individual born in a given urban area is more likely to stay there in the years between twenty and forty than others in this age group within the same country. Twenty is the most common age for migration. However, an urban resident is less likely to remain in a given urban region after the age of forty (usually tied to career movements) and even less likely to remain in the same urban center after sixty-five, the traditional age of retirement.

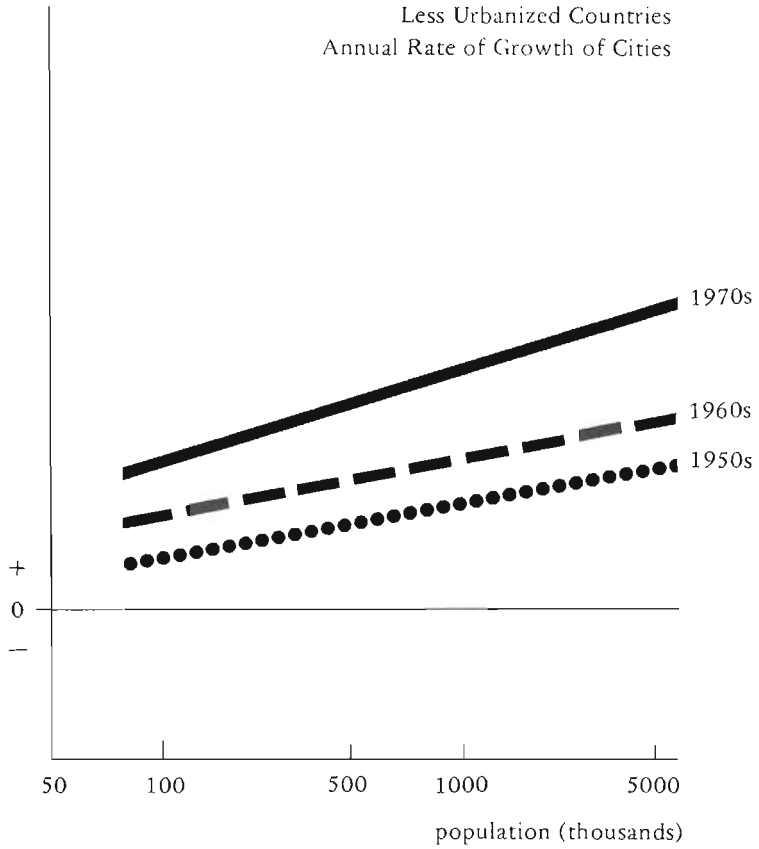
Another hypothesis suggests that the dominant migration flows within a highly urbanized country are those between the major urban regions and, within this category, from larger to smaller regions. The idea is that conventional rural-to-urban migrations — which generally go toward the biggest city because it is seen as offering the most opportunities for work, education, and services — are replaced by urban-to-urban flows. There is a hierarchical theory of migration that states that urban areas gain population from smaller communities and lose population to larger cities.

We arranged our data to show a comparison of moves between a given urban area and a group of other urban areas vis-à-vis "nonurban" areas within a country. The analysis falls short of providing conclusive evidence against the fourth hypothesis, but we found that migrations between major metropolitan regions within a country are less intensive than those between nonurban and urban areas. However, intensive urban-to-urban migration does take place between cities that are close to each other, such as in the Randstad region of the Netherlands and within the southern districts of the German Democratic Republic.

Looking at migration only between urban areas, we basically expected the smaller metropolitan areas to be gaining from the larger ones. However, our study showed the opposite. In relative terms (although not absolute trends), the number of people leaving smaller for larger urban areas was much greater than the number of people moving in the other direction. This was true for the flows between 30 out of 33 pairs of urban regions examined. Therefore, higher growth rates observed in the smaller metropolitan areas are the result of moves from still smaller urban and rural communities, rather than of moves away from the larger metropolitan regions.

The last hypothesis we examined discusses the change in the age profile of interurban migration, which makes it

Piotr Korcelli

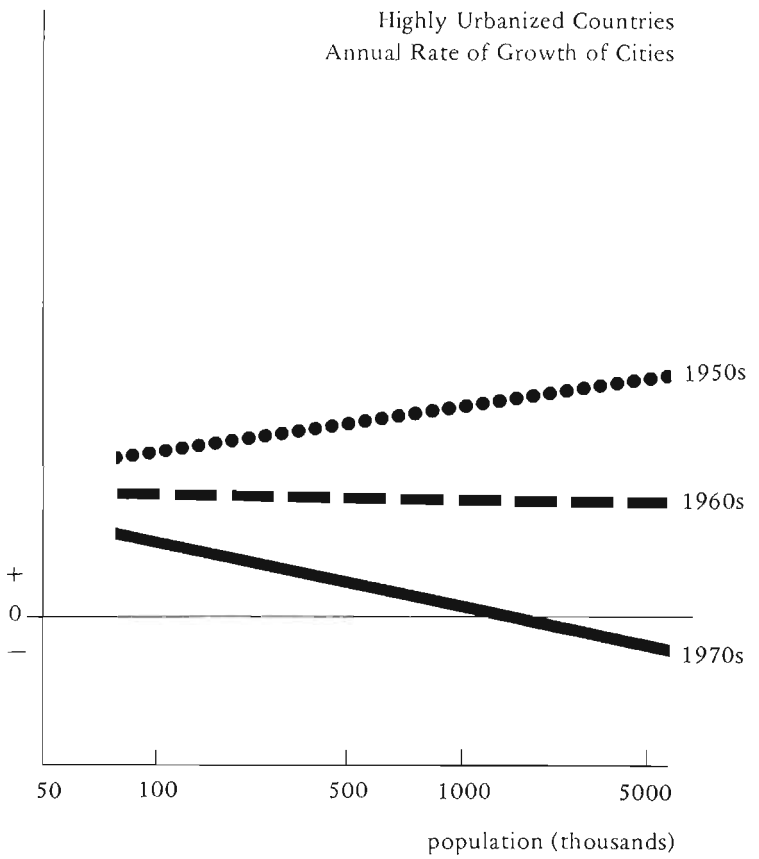


less labor-oriented than the traditional rural-to-urban flows. The age of migrants is very important as different age groups need different services. The typical migrant to an urban area was a young adult of around twenty. This meant that large cities benefited from a heavy influx of younger migrants to strengthen the labor force and reproduce, while their older inhabitants left for smaller urban and nonurban areas upon retirement.

We are learning that this is no longer as true for highly urbanized nations. Our material partially confirms this thinking. We used model migration-by-age schedules developed at IIASA by Andrei Rogers and Luis Castro. We intensively analyzed the urban regions of the Federal Republic of Germany, Japan, and Poland. The flows from, into, and between urban regions in these countries show a shift toward migration at higher ages than previously seen: from those between twenty and twenty-five to those between twenty-five and thirty. There is occasionally also a mid-career migration peak for those between forty and forty-five.

This hypothesis is probably correct, although it needs more extensive verification. This trend would have pronounced — and largely negative — long-term effects on the economic and demographic development of metropolitan areas.

Again, one should recall that this study used a group of countries, and urban areas within these countries, that are not uniform. This makes it more difficult to prove theories and to explain what is happening.



The patterns of urban settlement alter in time because of changes generally grouped about three main forces: economic, cultural, and policy-related factors. Causal links, however, go both ways. For instance, people move from a city because the environment is deteriorating, but because people are leaving the quality of life and the urban ecology deteriorate still further. What happens to settlement patterns when both spouses work, or when people live much longer because of social and health-related advances? What are the differences in resource and energy demands between low-density and high-density settlements? What are the effects on urban patterns of various governmental policies, for instance in communications?

These are still speculative questions. What we do have at this time are measurements that describe what is happening in highly urbanized countries, and some hypotheses and rather simple theories to explain what is happening.

An important point is that we can compare these recent turnabout trends with what is occurring in the developing nations. There the economic, cultural, and also, in most cases, policy-related factors are interacting to produce the current explosive urbanization patterns. This is a repetition, on a grander scale, of what we had seen in the cities of the developed nations until quite recently. We have seen how that has changed gradually since the 1970s; and we can look for analogous patterns of change arising in the Third World. Mexico City, for instance, is not likely to fulfill the now fashionable projection of a population of over 32 million in the year 2000. Still, many urban areas in the Third World will have higher peak populations than we have ever contended with. It is also true that we cannot pinpoint the time when explosive growth rates will drop. But we now know more about the forces involved in urbanization, how these change over time, and how they could be used to help bring about a slowdown.

Dr. Piotr Korcelli joined IIASA from the Institute of Geography and Spatial Organization of the Polish Academy of Sciences, where he was Head of the Department of Urban and Population Studies.

News from the Institute

Profile: IIASA Deputy Director, Dr. Allan Hirsch

Dr. Hirsch will focus on bridging the gap between research and decision making, which he notes "is a problem for every applied research institution, but more complex at IIASA because of its diverse clientele." His continuing concern is "the classic dilemma of maintaining a balance between the excellence of the research done and the transfer and application of the results of the research."

"Producing first-class applied research cannot be an end in itself; people must use it. On the other hand, no research organization wants to exist only as a consulting office."

He is "very excited, and glad" to join IIASA when it is entering its second decade since this means "the chance to think of the shape of the Institute for the future: in many ways a somewhat critical but also challenging time."

Dr. Hirsch says his "great admiration for the work of IIASA and Professor Holling," now IIASA Director, dates from his first link with IIASA – his participation in a workshop led by Professor Holling and his ecological colleagues in 1976, when Dr. Hirsch was establishing applied ecological surveys and analyses for the United States Fish and Wildlife Service.

Dr. Hirsch's professional experience while working at US governmental agencies was in research management, policy planning, and managing operational programs. He joins IIASA after having managed the research undertaken by the Environmental Processes and Effects Research Office of the US Environmental Protection Agency.

Book Review

Planning for Rare Events: Nuclear Accident Preparedness and Management. Proceedings of an International Workshop, January 28–31, 1980.
John W. Lathrop, Editor
Pergamon Press, 1981 (*IIASA Proceedings Series*, Volume 14)

IIASA assembled professionals with diverse responsibilities in nuclear accident preparedness from twenty countries, including key participants in the management of the 1979 accident at Three Mile Island (TMI). Frank accounts from the owner of the TMI plant, the regulatory commission, and the local emergency management agency demonstrate the contrast between the accident response system as it was intended to operate and the reality of having to make difficult decisions in confusing circumstances with incomplete information.

As editor John W. Lathrop notes, "Because of the outstanding safety record of commercial nuclear power, nuclear accident management experience has been assembled slowly. Accident management planners must rely instead on drills and procedures that lack authentic testing. The difficulty is compounded by the inability to anticipate all the ways a complex system can founder and by the development of obstructive 'mindsets' that are not validated by actual accident experience. It is quite [a] task to develop a plan that is resilient to confusion, that takes into account the likelihood that any accident will be accompanied by a certain amount of chaos and unplanned gaps in information." A major part of the book is devoted to the current plans and planning concepts of France, the Federal Republic of Germany, Hungary, the Netherlands, the UK, and the USSR.

One of the basic faults of organization that hampered effective response to the TMI accident was not only inadequate information but inadequate exchange of that information. This resulted in part from insufficiently predetermined roles and communication links for the numerous agencies who were called in once the accident occurred. Herman Dieckamp, president of the corporation owning TMI, stresses this point: "We underwent a day or two when the system was not only strained, but potentially overstrained, by having more people asking questions than answering questions . . . communications [giving information about something happening or something being done] must be very loud and clear and direct in order to minimize the opportunity for confusion and mistakes."

What happened at TMI was a sequence of events and impacts on the plant that had not been considered possible. In the aftermath of TMI, some of the accident management plans adopted by other countries appear too detailed to be wholly practicable. Most of those at the IIASA workshop agreed that the lessons to be learned from past incidents and accidents must be incorporated into current emergency planning.

Siegfried Bernhardt lists the accident management features that have been installed in the Neckarwestheim nuclear power plant in the Federal Republic of Germany as a result of learning from failures at other sites and of theoretical analysis. A nuclear alarm exercise, including evacuation, was undertaken from this plant in 1978, which Dieter Kaspar of the Ministry of Labor, Health, and Social Welfare of Baden–Württemberg describes as very useful.

Hiromitsu Kumamoto, Koichi Inoue, and Yoshikazu Sawaragi discuss their cause–consequence data base, which stores information on all types of incidents, wherever they occur. This practical aid could serve as a risk analysis tool and provide a mechanism for transmitting knowledge gained from previous accidents to new generations of technicians and to those who have to make decisions when an accident occurs.

The people in responsible positions have to deal with "the art, the skill, the science, and the prayerful aspects of decision making," says Robert D. Martin of the US Nuclear Regulatory Commission. "Decision making in the case of a nuclear accident differs from military planning and business planning. In a nuclear emergency I have to deal with an evolving accident that threatens human safety. I have to make

a combined technical, political, and health decision to risk the life of people by taking some sort of corrective or protective action that may in fact jeopardize them more than the thing I am trying to save them from."

Until very recently, regulatory bodies in many countries assumed that careful siting and design-engineered plant safeguards would provide adequate preventive measures. The probability of a serious accident was considered too low to warrant preparation and to justify concern about possible risk. Professor Harold P. Green gives a historical account, noting that emergency preparedness was downgraded because of the "concern that increasing emphasis on emergency planning would unduly alarm the public and contribute to the antinuclear movement." TMI dealt a massive blow to this way of thinking, as what had been regarded as incredible suddenly became stark reality. The way to regain public trust and acceptance of the nuclear industry, says Green, is through "relentless truth-telling about the risks of nuclear power" and the preparations made to counteract those risks.

The UN International Atomic Energy Agency's John R. Horan stresses that "There is no room for complacency. Today we have many more power plants coming on stream and much higher power levels. In addition, many of our plants are now aging . . . and the employees operating the plants are also aging." Based on the weaknesses identified during the discussions, the book makes several recommendations to improve preparedness for nuclear accidents. The book is one element of IIASA's continuing research in risk management.

Management of the TMI accident, as well as the 1977 Bravo blowout in the North Sea, is also discussed in *Lessons from Major Accidents*, IIASA Executive Report 6.

NMOs

The Hungarian Committee for Applied Systems Analysis has begun publication, in Hungarian, of the IIASA Executive Report series, noting the "great interest" shown by the National Bureau for Environmental Protection in Budapest for *Expect the Unexpected: An Adaptive Approach to Environmental Management* (ER-1), derived from the IIASA book *Adaptive Environmental Assessment and Management*, edited by C.S. Holling.

Visitors

Nobel Laureate Academician Leonid V. Kantorovich (on left) celebrated his seventieth birthday with IIASA colleagues in January. Known for many basic contributions to pure mathematics, particularly in the field of functional analysis, Academician Kantorovich sets the example of how to combine abstract approaches with most relevant, applied problems. Since the 1930s he has been developing mathematical economics and economic modeling in the USSR. He has been a scholar with IIASA's System and Decision Sciences Area, and was recently awarded his country's Lenin Prize.

Note to readers: Because *Options* is expanding in 1982, the fourth issue in the 1981 series will not appear.

New Titles

IIASA Proceedings Series

Volume 14 **Planning for Rare Events: Nuclear Accident Preparedness and Management**. Proceedings of an International Workshop, January 28–31, 1980. J.W. Lathrop, Editor. 268 pp.

Volume 15 **Scale in Production Systems**. J.A. Buzacott, M.F. Cantley, V.N. Glagolev, and R.C. Tomlinson, Editors. 248 pp.

Available from Pergamon Press Ltd., Headington Hill Hall, Oxford OX3 0BW, England, or Pergamon Press, Inc., Fairview Park, Elmsford, NY 10523, USA.

IIASA Collaborative Proceedings Series

CP-82-S1 Human Settlement Systems: Spatial Patterns and Trends. T. Kawashima and P. Korcelli, Editors.

Status Report

SR-82-1 1981 The Human Settlements and Services Area. A. Rogers.

Research Reports

RR-82-1 Validation and Physical Parametrization of a Gaussian Climatological Model Applied to a Complex Site. E. Runca, A. Longhetto, and G. Bonino. Reprinted from *Atmospheric Environment*.

RR-82-2 Migration and Natural Increase in the Growth of Cities. N. Keyfitz and D. Philipov. Reprinted from *Geographical Analysis*.

RR-82-3 An Approach to Distributed Modeling. A. Umnov and M. Albegov. Reprinted from *Behavioral Science*.

RR-82-4 Two Essays on Alonso's Theory of Movement. J. Ledent. Reprinted from *Sistemi Urbani* and *Environment and Planning A*.

RR-82-5 Migration and Settlement: 13. Japan. Z. Nanjo, T. Kawashima, and T. Kuroda.

Single copies of status reports and journal reprints are available free of charge. All other publications can be ordered from the Distribution Section, Office of Communications, IIASA.

Director's Corner: *What's in a Name?*

The greatest burden IIASA has is its name. Not in the word "international," for therein lies a strength, a reflection of its purpose of *collaboratively* addressing issues of disparity and conflict in a troubled world. Not in the word "applied," for IIASA's purpose is to identify and offer resolutions for problems and issues that threaten the well-being and survival of mankind. But the words "systems analysis" distort both the perception and the reality of IIASA's role and functions.

The practice of systems analysis often differs from outsiders' perceptions of that craft. This difference, in my view, stems from the fact that much of the practice of systems analysis is driven by a search for methods, a search that is on the one hand detached from issues and, on the other, detached both from those who make and from those who endure the resulting decisions.

Methods, of course, are important. Ten years ago, when IIASA was born, the great excitement among its scientific parents derived from the potential offered by systems analysis and computers. Then, for the first time, it seemed possible to bridge those crucial gaps that have delayed the solution to many complex problems — gaps between areas of knowledge, between people, nature, and technology; gaps between the expert, analyst, decision maker, and public. I have seen this hope expressed in my own discipline of biological ecology, where systems analysis has gone through a stage of exuberant enterprises. One of the grand possibilities of systems analysis has been that it increases efficiency. However, we find countless examples in which the more efficient system we help evolve is more fragile and vulnerable to unexpected events than its less efficient predecessor. Industries trained toward improved efficiency may simply evolve into efficient dinosaurs, and perish.

There are lessons here. The one I want to stress is that it is no longer necessary — it is now counterproductive — to be driven totally by methodological questions. The systems analysis work of the past that has had some consequence, both intellectually and in terms of application, was propelled by a clear and focused identification of a problem, and achieved that inspired insight I call "encapsulated understanding" in an environment where attention was paid to the way people used information and made decisions. It is time we decided not that we need techniques, audiences, and products, but that we should define what those must be, and toward what purposes.

We live in a troubled world — a world that seems to me to be in turbulent transformation. The most immediate and greatest threat to the well-being and survival of man is nuclear war. But suppose we could magically eliminate that threat, would we truly muddle through, faced with the fundamental problems of growth in a finite world? Answering that question gives us a guiding theme: we must concentrate on the problems of growth emerging from the intersections of man, technology, and nature.

But we wield a two-edged sword — we may be successful in driving intellectual advances and policies, but we can also become the victims of such success. We may point the way to the elimination of persistent diseases that cloud millions of human lives, only to find we have begun to destroy the immune responses of millions more. Systems analysis has often been a way of selecting a plan of action that lies between failure and marginal success — achieving something that, in the nature of the players, is perhaps not meant to be achieved.

Our search, then, is for issues that are generic, that cut across every effort in any IIASA menu. These, it seems to me, will have to be shaped by certain realities — the limits of our knowledge, of evolutionary transformation and structural change; and the need for a balance between prediction, regulation, and adaptation, between certainty and uncertainty. This search is not peculiar to systems analysis; one finds it everywhere along the leading edge of scientific theory. In evolutionary theory, for example, we see it in the debates concerning punctuated evolution. In chemical thermodynamics, we see it in the discovery of order from apparent chaos. In cultural anthropology and political science, we see it in the identification of cultural groups whose confrontations have developed rhythms of growth, disruption, and renewal.

Thus, we at IIASA must identify key issues that provide intellectual rigor for our scientists as well as the possibility of solving persistent human problems. Of course, we must examine the problem of food for the hungry. Of course, we must study the international redistribution of industries and jobs. Of course, we must assess the vulnerability and sustainability of resources, and the stabilities and instabilities of international trade. But we must have our primary focus on that broader, generic issue of growth, turbulence, transformation, and renewal.

In 1960, Leo Szilard wrote a novelette entitled *The Voice of the Dolphins*, in which he described an international organization called the Vienna Institute, which had been established at a time of rapprochement between the United States and the Soviet Union. The purpose of the Vienna Institute was to build bridges between East and West, around the focus of shared scientific questions. It survived and flourished until, at a time of growing political conflict, the US withdrew its support, followed by the USSR. But, happily for this fictional institute, it had developed a magical food substance that both nourished and reduced fertility. The returns from that patent allowed the institute to continue and work to its larger purpose of facilitating peace in the world.

For those of us in IIASA, the Szilard novelette seems extraordinarily prescient. Our Institute, like the fictional one, was established near Vienna at a time when it seemed appropriate for East and West to share scientific questions, and we have survived and flourished until now, when we are uncertain of continuing support from the United States. The difference, one might say, is that IIASA has no lucrative patents.

But our situation is not really a question of money. It is a question of shifting our perspective from what we have done to what we must do, from the lessons of the past to the central issues of the future. From this, commitments and resources must follow.

— C.S. Holling