GUIDELINES FOR COPING WITH NATURAL DISASTERS AND CLIMATIC CHANGE

Howard Kunreuther
Paul Kleindorfer

November 1980
PP-80-13

To be published in special risk issue of Zeitschrift für Umweltpolitik. (Journal of Environmental Policy, 1980. Vol. 3 No. 4).

Professional Papers do not report on work of the International Institute for Applied Systems Analysis, but are produced and distributed by the Institute as an aid to staff members in furthering their professional activities. Views or opinions expressed are those of the author(s) and should not be interpreted as representing the view of either the Institute or its National Member Organizations.

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

GUIDELINES FOR COPING WITH NATURAL DISASTERS AND CLIMATIC CHANGE

Howard Kunreuther and Paul Kleindorfer

1. INTRODUCTION

Today there is no prevailing wind as to how society should cope with the economic and social impacts of weather and related phenomena. A principal reason for this uncertainty is that the question has only recently been raised as to what the responsibility of the government and private sector should be. Thus, even though mankind always has been plagued by problems of extreme natural phenomena such as floods and earthquakes, it is only within the past ten years that efforts have been underway to evaluate an alternative set of adjustments for coping with these problems. (White and Haas, 1975.) When one focuses on the areas of climatic change and weather modification, then the historical time clock associated with research on the economic, social and political problems is even shorter. (See Schneider, 1976 and Cooper, 1978.)

The purpose of this paper is to propose a framework for evaluating alternative programs for dealing with weather-related risks. The framework emphasizes the impacts of limited information or misinformation on behavior. When the decision processes of the different actors are explicitly considered as a part of the problem, then alternatives which involve some form of government regulation may turn out to be more attractive than would otherwise have been the case.

2. FRAMEWORK FOR ANALYSIS

Figure 1 provides a schematic representation of a framework for analysis, indicating the descriptive and prescriptive phases of the process. The appropriate role of the public and private sectors ("the prescriptive" phase) can be better understood if

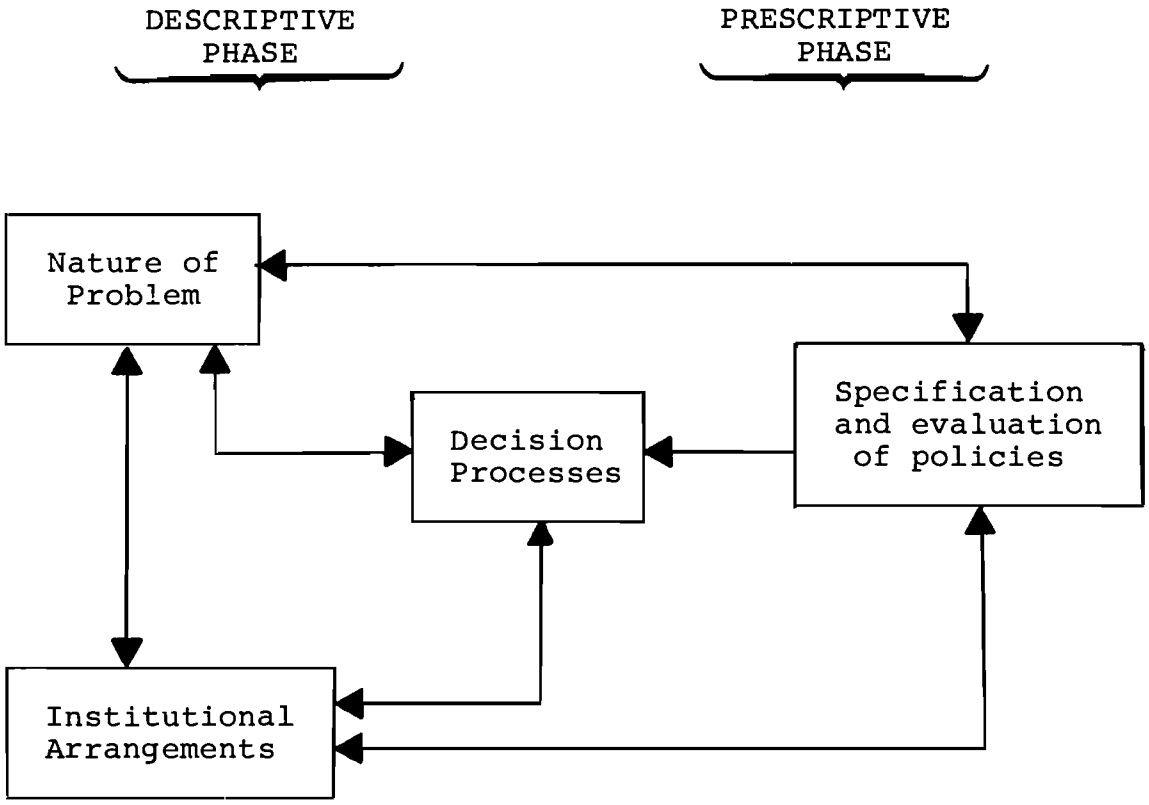

Figure 1 Framework for Analysis

the nature of the problem, institutional arrangements and decisions processes ("the descriptive" phase) are clearly spelled out. To illustrate consider two examples, one from the natural hazards area and the other associated with the impact of climatic change.

Nature of the Problem

At the outset one would like to have some understanding of the historical context of the problem and the types of questions that are being raised today.

Natural Hazards Example. Since 1953 the federal government has played an increasing role in providing disaster relief. Few individuals have protected themselves voluntarily with insurance against the financial consequences of disasters. Many of these uninsured victims have turned to the federal government after having suffered losses, and Congress has responded with an increasingly open hand. Should disasters be treated as a public responsibility or should residents of hazard prone areas bear the financial costs of living there? What are the appropriate programs to consider in making this choice and how should one evaluate them?

Climatic Change Example. In 1974 a number of scientists independently discovered that chlorine, one of the chemical elements in chlorofluorcarbons, CFC, was effective in destroying atmospheric gas ozone, although the magnitude of this change was highly uncertain. Ozone absorbs much of the ultraviolet radiation from the sun so that a reduction in its amount could cause skin cancer. Furthermore, a reduction in ozone could lead to climatic change but the actual effect could not be specified precisely. A problem facing the government is what action should be taken with respect to those manufacturers of aerosol spray cans which use CFC as propellants. Given the uncertainty associated with CFCs and ozone as well as the limited knowledge as to what its impact is likely to be on the human population, should spray cans be banned or are there other more appropriate policies?

Institutional Arrangements

In order to design appropriate policies for these and other problems we need to have an understanding of the institutional arrangements which define the informational and authority relationships among the relevant groups. Most problems normally involve the consumer sector, the production or service sector and the government sector as the relevant groups.

In the natural hazards example, we would want to understand the types of interaction occupants of a hazard-prone area will have with their insurance agents or companies regarding the purchase of disaster coverage. We also want to examine the possible interactions between the insurance industry and the government sector. For example, this may involve rate regulation at the state level (e.g. earthquake rates), reinsurance

at the federal level (e.g. flood reinsurance) or joint marketing efforts behavior in the private and public sector (e.g. flood coverage).

In the depletion of ozone example we would want to understand what alternative options are open to consumers and the affected businesses if aerosol sprays were taken off the market. We would also want to know what possible regulations could be issued by the government regarding the future use of CFC and what evidence would be required to justify each specific ruling.

Decision Processes. Perhaps the most important aspect of descriptive analysis, and certainly the most neglected, is an understanding of the decision processes of each of the different actors involved in the problem. We define decision processes to mean the collection, processing and dissemination of specific types of information in determining and promoting a specific course of action.

In the natural hazards example it is important to understand how residents of hazard-prone areas evaluate the probabilities and losses associated with such events as floods and earthquakes. In the same spirit we need to gain insight into what information is collected and processed by insurance companies in determining the anticipated benefits and costs of offering different types of coverage at specific premiums. We would then want to understand what steps are taken by agents to market coverage.

In the depletion of ozone example, it is relevant to know what information scientists have collected to determine the potential dangers of CFC to ozone and how certain they are of the future impacts on the population. In the same spirit one would want to better understand how these findings are interpreted by government regulatory agencies in handing down their pronouncements as to what action specific manufacturers must take.

Fortunately we know considerably more today about the decision processes of individuals than we did a decade ago. Recent empirical studies in field and controlled laboratory settings have shed light on the behavioral processes associated with collecting and utilizing information and the impact that these phenomena are likely to have on policy prescriptions. In particular, Tversky and Kahneman (1974) have shown that individuals exhibit systematic biases in their processing of information. One of these biases, availability, implies that individuals judge the probability of an event by the ease with which such instances are readily retrieved from memory. Such a heuristic implies that past experience will be a critical variable in individual decision-making with respect to certain events. This finding suggests that individuals are likely to underestimate their chances of being affected in the future by low probability events which have not personally affected them in the past. Calabrasi (1970) makes a similar point by observing that "such

things always happen to the other guy and no amount of statistical information can ever convince the individual that they can happen to him". (p. 56).

The importance of past experience in affecting information processing of occupants in hazard-prone areas is illustrated in a study by Kates (1962) who interviewed 110 individuals in LaFollette, Tennessee. On the basis of his findings he conjectured that:

> Men on flood plains appear to be very much prisoners of their experience. ...Recently experienced floods appear to set an upper bound to the size of loss with which managers believe they ought to be concerned. (p. 40).

In evaluating the decision processes of individuals and firms it is also relevant to learn from what sources decision-aiding information is obtained. The extensive literature on the diffusion of innovations (see Rogers and Shoemaker, 1971) indicates that the mass media are normally the initial source of knowledge about a product but the information from more personal sources is usually obtained prior to its adoption. This pattern of behavior is consistent with one of the classic studies in this area, Coleman, Katz and Menzel (1966), on the adoption of a new medical drug by doctors in four mid-western communities. The study indicates that salesmen and direct mail were the most frequent source of original knowledge about the drug, but just prior to adoption the doctor was most likely to seek out a colleague or consult a professional journal article. Another general finding in the empirical literature on innovations is that individuals are reluctant to spend much time collecting and processing information. The accuracy of their own data to a large extent will be dependent on those of their colleagues and friends. From a prescriptive point of view these findings suggest that informal contacts may play at least as important a role in providing information as the market system.

Finally, there is literature emerging which indicates that individual attitudes toward risk are impacted by the way information is diffused and processed. Kunreuther et al. (1978) in a field of survey of 3,000 homeowners in flood and earthquake prone areas found that people's decisions to purchase insurance were determined by past experience with floods or earthquakes and interpersonal contact with other policyholders rather than by a comparison of the risk involved in relation to the benefits of insurance. In a complementary set of controlled laboratory experiments on insurance Slovic et al. (1977) found that indivduals preferred to insure themselves against high probability-low loss events rather than against catastrophes which had a very small chance of occurrence. These findings imply that individuals may view uncertainty and risk in a different way than has traditionally been assumed by economists.

Prescriptive Analysis

The descriptive phase encompases problem formulation, institutional arrangements and decision processes of the different parties in response to different information. They are a fundamental input to the prescriptive phase, which is concerned with the specification and evaluation of a set of alternative policies. The options include relying primarily on market mechanisms so that individuals and firms have free choice as to what actions they pursue, or having the government intervene in the process through regulation, the use of incentives or the direct provision of specific services. Let us illustrate each of these alternatives within the context of the two specific examples presented above.

Rely on Market Mechanisms. In the case of disaster insurance, this alternative would consist of allowing individuals and businesses to locate in specific areas, take their chances with respect to a potential catastrophe and bear any losses themselves or through voluntary insurance coverage. The ozone depletion problem would be viewed as a concern of consumers and businesses. Information could be made publicly available through journals and the mass media that the use of certain types of aerosol cans may have harmful environmental effects. The responsibility for initiating any changes would be in the hands of consumers through their purchase decisions and with firms through their production decisions.

Institute Regulations. The government could play an active role in mitigating losses from natural hazards by imposing specific land-use controls and building codes on new structures slated to be built in hazard-prone areas. Home-owners applying for government-financed VA and FHA mortgages for new construction in these areas could also be required to purchase insurance as a condition for such a loan.

With respect to CFC emissions form spray cans, the government could impose a regulation which would ban the use of CFC as of a specified date. The choice of this deadline might reflect the tradeoffs between the costs of continuing to produce a "harmful" product and the economic and social disruption associated with preemporily banning its use.

Develop Incentives. The government could develop incentives for protecting home-owners against the financial losses from natural disasters by subsidizing insurance premiums on existing structures in order to make coverage more attractive. In the same spirit, property tax rates could reflect the degree of risk associated with locating in a particular area. Similar measures could be utilized with respect to coping with the CFC-ozone problem. Subsidies or tax credits could be provided to businesses who were capable of producing substitutes for CFC. In particular, the government might provide a lump sum transfer to the CFC industry to aid them in a reconversion process. As an alternative, the government could impose severe taxes on the CFC industry so that firms would have an incentive to develop alternative products which would not threaten to pollute the atmosphere.

Direct Provision of Services. One way to cope with the financial consequences of natural disasters would be to have the government provide liberal relief to victims in the form of grants and low-interest loans. By providing this type of aid, there would be less incentive for individuals to purchase insurance coverage than if the government were to do nothing. In the case of the CFC problem, the government could provide information services to the public as to the potential adverse effects of using aerosol sprays. If there were great uncertainty on the impact of CFC on the environment, then the government would have to determine carefully the form in which the message should be presented. How can one make a wise choice among these different options? There are two general criteria which should be explicitly considered in evaluating the different options.

A. Impact on Allocation of Resources

Each one of the possible courses of action will determine how individuals and firms will operate. For example, if the government decided to do nothing to protect victims against disastrous losses and no insurance were available, then some firms and households may prefer not to locate in certain hazard-prone areas. To the extent that these units aided our economic growth and development this might be considered a loss to society. Regulating hazard-prone areas would produce the same type of tradeoffs. On the other side of the coin, there are a set of negative consequences associated with the development of a hazard-prone area which society must pay for one way or another. If the public sector incurred the financial costs associated with the disaster, then society would be paying for the losses of a few.

The problem of resource allocation is considerably more complex when one moves from the financial consequences of natural hazards to the physical and economic consequences of environmental hazards such as the depletion of ozone due to CFC. In such cases, one has to balance the positive economic impact of these activities with the potential negative consequences, not only for the present generation, but also for future generations. We require considerable information on the short-run and long-run impacts of certain actions in order to make final judgments on resource allocation effects.

B. Impact on Equity and Distribution of Resources

A second measure which should be considered in choosing among alternatives is the impact of different measures on the welfare of members of society. If society feels that it is their responsibility to aid victims of natural catastrophes because that is a risk all of us should bear, then liberal federal disaster relief would be an inappropriate policy option for consideration. Such a decision may also be suggested because of income distribution concerns. If, on the other hand, there is a feeling that people should be responsible for the consequences of their actions, then some combination of the other options may be desirable.

When one moves out of the relatively simplistic world of natural hazards to the physical and economic impact of climate changes then the equity and distributional questions become intimately connected with legal issues of responsibility. If one takes the position that those who undertake specific actions must also bear the costs, then environmental problems associated with using CFCs may have to be handled by either some form of regulation or a tax imposed on firms. Without these measures, consumers and firms are unlikely to take preventive action. In economic terms, the benefit associated with restricting CFCs can be treated as a public good. In other words, the consumer gets so little perceived benefit to himself of not using aerosol sprays that he continues to do. Similarly, firms producing the good have no incentive to change their behavior. If CFCs were not produced, society might be better off with respect to a reduction in environmental hazards. If instead one feels that the private sector should monitor its own activities, then a laissez faire approach might be viewed as desirable.

The impact of different policies on resource allocation, equity and distribution of resources will be intimately related to the descriptive phase of the process. For example, the types of institutional arrangements will indicate how information is collected and disseminated among the relevant parties. An understanding of the decision processes will provide insight into how information is processed or misprocessed by the relevant groups. We will now elaborate on the specific natural hazards example to illustrate how one links the descriptive and prescriptive phases.

3. LINKING DESCRIPTIVE AND PRESCRIPTIVE ANALYSIS: THE CASE OF DISASTER INSURANCE

Descriptive Phase

Between 1973 and 1977 a multidisciplinary team supported by funds from the National Science Foundation, were determining the critical factors influencing the voluntary purchases of insurance aainst the consequences of low-probability events such as flood or earthquakes. Descriptive research methods included a field survey and laboratory experiments. The field survey permitted the discovery of differences between insured and uninsured home-owners in hazard-prone areas, while the laboratory experiments permitted us to identify causal relationships through controlled manipulation of relevant variables.

The basic sampling plan for the field survey involved face-to-face interviews with 2,055 home-owners living in flood prone areas through the United States, and 1,006 home-owners in eighteen earthquake prone areas of California. Approximately half of the sample individuals were insured against flood or earthquake.

The analysis of the field survey revealed that a significant number of home-owners in flood and earthquake prone areas either knew nothing about the availability and terms of insurance, or had inaccurate information. The survey also revealed that many

residents had little idea of the probability or potential damage from a future disaster. One of the most surprising results was the large number of uninsured home-owners who expected no federal aid at all in the aftermath of a major disaster. This indicated that neglect of insurance could not be attributed to expectations of generous government relief.

In the laboratory experiments, subjects were presented with a series of gambles, each of which involved a specified probability of losing a given amount of money. Losses and probabilities were varied across gambles. In one experiment subjects were permitted to buy insurance against the loss at an actuarially fair rate. Additional experiments varied the premiums so that insurance was offered at subsidized rates and commercial rates. In these experiments, subjects considered well-defined insurance problems in isolation and without real stakes at risk. To supplement this format, an elaborate farm management game was designed and run by a computer. While playing this game over a five-hour period, individuals had to decide for each year which crops they were going to plant, what fertilizers to use, and what insurance they would purchase against various natural hazards. Subjects' earnings in the game determined their salary.

The results from the experiments consistently showed that people preferred to insure against relatively high-probability, low-loss hazards and tended to reject insurance in situations where the probability of loss was low and the potential losses were high. These results suggest that people's natural predisposition run counter to what would be predicted by normative models of choice such as expected utility theory which assumes that risk-averse individuals should desire a mechanism to protect themselves from rare catastrophic losses that they could not bear themselves.

When asked about their insurance decisions, subjects in both the laboratory and survey studies indicated a disinclination to worry about low-probability hazards. Such a strategy is understandable in view of the fact that limitations of people's time, energy, and attentional capacities create a "finite reservoir of concern". Unless we ignored many low-probability threats we would become so burdened that any sort of productive life would become impossible. Another insight gleaned from the experiments and the survey is that people think of insurance as an investment. Making claims and receiving payments (by insuring against more probable losses) seems to be viewed as a return on the premium. Insuring against hazards that do not occur seems a waste of money.

Prescriptive Phase

The above study suggests that the primary cause of failure of the disaster insurance market is consumer disinterest. If insurance is to be marketed on a voluntary basis, then consumer's attitudes and information processing limitations must be taken into account. Policymakers and insurance providers must find

ways to communicate the risks and arouse concern for the hazards. One method found to work in the laboratory experiments is to increase the perceived probability of disaster by lengthening the individual's time horizon. For example, considering the risks of experiencing a 100-year flood at least once during a 25-year period, instead of considering the risks in one year, raises the probability to .22 and may thus cast flood insurance in a more favorable light. Another step would have insurance agents play an active role in educating homeowners about the proper use of insurance as a protective mechanism and providing information about the availability of insurance, rate schedules, deductible values, etc. Of course, these actions may not be effective. It may also be necessary to institute some form of mandatory coverage, perhaps having banks and other financial institutions require disaster insurance as a condition for a mortgage.

4. SUGGESTIONS FOR RESEARCH ON CLIMATIC CHANGE

A parallel type of analysis appears appropriate for evaluating the impacts of technological developments on climatic change. The descriptive and prescriptive phases of the analysis, however, are considerably more complex because we do not currently have a good understanding of the cause and effect relationship between human and natural processes and climatic changes. Furthermore, we are uncertain as to the long-range impact that specific atmospheric or other patterns will have on human society. We will discuss future research questions in the context of the conceptual framework presented in Figure 1.

Nature of the Problem

The large variation of past weather patterns from year to year make it extremely difficult both to project long-term trends in climatic change and to separate out changes due to human tampering (e.g., technology, population growth) from natural causes. Furthermore, there is disagreement among atmospheric scientists as to the impact that certain changes in climate will have on economic and social conditions in the world.

An interesting example illustrating the above points is the recent controversy concerning the impact of additional carbon dioxide in the atmosphere caused by the burning of fossil fuels (i.e., coal, oil and gas) and clearing of land (i.e., destruction of plant life and soil organic matter). The most generally accepted models all predict that an increased carbon dioxide will increase temperatures near the ground. However, these models neglect feedback mechanisms for clouds and ocean circulation so that a number of respected scientists feel that a global cooling trend still predominates. They support this hypothesis by citing the lack of warming during the industrial period since 1940 (Cooper, p. 504).

Other scientists feel that an increase in carbon dioxide will play a significant role in impeding the earth's emitted radiation, thus warming the atmosphere through the so-called "greenhouse effect." The process is called the "greenhouse effect" because carbon dioxide acts in the same manner as a

greenhouse. It is completely transparent to the wavelengths of light produced by the sun but absorbs the earth's emitted radiation, partly transmitting it back to earth and partly out to space. The resulting warming effect is similar to that produced by a greenhouse which is transparent to incoming solar radiation but impedes outgoing heat radiation.

There is thus uncertainty about how much temperature change will result from a given increased level of carbon dioxide in the atmosphere. Furthermore, there is great uncertainty on the impact that changes in temperature will have on agricultural productivity in certain parts of the world. Colder climatic zones could now become more productive if indeed there is a warming effect while other areas will suffer. The uncertainties associated with the problem create difficulties in designing meaningful policies.

Scientists also have limited knowledge on the interrealtionship between the impacts of weather modification in one part of the world and its effects on other parts of the globe. A graphic example of this climatic dependence is provided by Hurricane Inez which threatened the Gulf Coast in 1968. The storm never hit the U.S. but filled large portions of the Mexican altiplano with sufficient water to assure the area of favorable crops for a season (Schneider, p. 21). The analysis of benefits and costs of undertaking weather modification actions, such as seeding of hurricanes, has to reflect the potential impacts on a global rather than national level. Naturally the analysis becomes more cumbersome and uncertain as the outcome space is broadened in this way.

Institutional Arrangements. There is a natural bias in coping with problems, where long-term effects are uncertain and phenomena are understood only imperfectly, to concentrate primarily on the short-term impacts of specific actions. Normally any measure to ban or regulate human activities will produce negative economic and political consequences. Since politicians are elected at relatively short intervals they have little incentive to endorse specific bans which may adversely affect their constituencies. There is a need to understand in what ways the points of view of different interest groups affected by a specific problem--consumers, industries, governments, unborn generations--are impacted by current institutional arrangements. For example, in developing a program for coping with the impact of climatic change on food reserves the U.S. Department of Agriculture is the sole source of technical information for developing policy. Critics contend that the USDA favors the largest food producer and that information from other food experts should also provide advice to the executive branch as part of the policy making process (Schneider, p.43).

Finally, it is also important to understand the relationship between the institutional arrangements and the responsibility for certain actions. For example, if the federal government is

held responsible for negative outcomes of certain actions, such as weather modifications, then they will have an incentive to do nothing. As a case in point, consider the disastrous flood in Rapid City, South Dakota on June 9, 1972, which caused $163 million in property damage. Only a few hours before the flood the South Dakota School of Mines and Technology under contract with the Department of the Interior carried on a cloud seeding operation known as Project Skywater near Rapid City. A class-action suit has been brought against the Federal Government on the grounds that the cloud seeding operation was dangerous and hence should not have been undertaken (Scheider, p. 237). Meteorologists are uncertain as to whether the cloud seeding operation could have caused the flood. What is more certain is the reluctance of the Federal Government to undertake such experiments in the future even if the expected benefits exceed the expected costs. Being held financially responsible for negative outcomes and only gaining psychic rewards for beneficial results produces a strong bias towards not acting at all.

Decision Processes. We have already emphasized the imperfect information processing capabilities of individuals and the limited amount of data they use. In areas such as climatic change and weather modification, which are sufficiently complex and where the ways of evaluating different options lie beyond our individual knowledge and understanding, there is a tendency for us to rely on experts and authorities for guidance. Should there be considerable uncertainty and disagreement among scientists and policy makers as to the consequences of different measures, policy makers are likely to trust no one and maintain the status quo. This behavior will be reinforced by a natural bias to do nothing unless the organization is faced with a severe problem or crisis situation. There is substantial evidence from the organizational behavior literature supporting this point. For example, March and Simon (1958) in the analysis of organizational change have concluded that the individual or organization does not search for new alternatives unless the present course is perceived to be unsatisfactory. Only after a problem of crisis exists is there a need to take action. Lawless (1977) has documented the importance of public alarm in triggering remedial action with respect to social shock over technology. In a series of short case histories of recent episodes he documented the sequence of events leading to public alarm and the impact of this concept on specific regulatory actions. Schneider (1976) also provides a number of examples in the area of climatic change which illustrate the importance of a perceived crisis in order to generate change.

Prescriptive Phase

Guidelines for a prescriptive strategy in the area of weather modification and climatic change can be based on the nature of the risk and its outcome. The following concepts may be useful in beginning to reflect on the merits of alternative courses of action.

Degree of Reversibility. If the impact of certain atmospheric emissions cannot easily be reversed in the future then it may be necessary to undertake protective measures today even where the impact of the climatic change cannot be easily estimated. One reason that scientists are concerned with the concentration of carbon dioxide in the atmosphere is that it seems unlikely that even the most advanced future technology will make feasible its removal (Cooper, 1978, p. 510). Future research should be undertaken to understand better the degree of reversibility of different phenomenon.

Risk Associated with Certain Activities. As the probability and magnitude of loss associated with specific activities (e.g., use of CFCs) increases, then regulations will prove more desirable, other things being equal. Scientists need to obtain better data on the relationship between atmospheric emissions and climatic change before making a strong case for remedial action.

Adjustment Process. The more difficult it is for society to undertake effective actions at the onset or immediately after a severe crisis the more important long-range planning becomes. In the case of climatic change Schneider feels that the crises, which will occur if we do not plan now, will be catastrophic so that relatively little could be done in the short-run to cope with its impact. He proposes instead a stragegy on "prudence, negotiation and margins of safety in all our future planning so that we are adequately prepared for such probable misfortunes as extended periods of bad weather and their harmful effects on crops". (p. 39).

Responsibility. We need to clarify who will be responsible for the costs of undertaking changes prior to a crisis and who is responsible after a catastrophe occurs. The proposed policies will be very different if governmental agencies are held fully accountable for coping with problems of climatic change than if consumers and businesses are expected to share the risk.

The above concepts suggest the following five stage process for developing and analyzing prescriptive measures.

1. Specification of Adjustments. Experts individually or in groups should develop an alternative set of adjustments to cope with a particular problem. For example, in the CFC-ozone example one could consider the following set of adjustments: banning the aerosol can in 1981, waiting to ban the can until 1984, not banning the can, taxing the producers of aerosol cans, etc.

2. Scenario Generation. Experts should develop a set of scenarios outlining possible outcomes associated with different actions. They should carefully document what we know and do not know about specific phenomena and their potential consequences.

3. Group Discussions. Experts from relevant physical and social sciences should engage in a group discussion to determine

the probabilities and outcomes from each scenario. They should jointly recognize the uncertainty associated with certain events and provide a detailed specification of the multidimensional nature of the outcomes (e.g., economic impact, environmental impact, quality of life impact).

4. Evaluation of Scenarios. A procedure should be agreed upon for evaluating different scenarios with respect to pre-specified objectives. In this process there is a need to understand the potential conflicts among different interest groups (e.g., consumers, firms directly or indirectly affected by the adjustment, government, etc.). Some attention should be paid to the accuracy of information which each group has.

5. Implementation. The necessary changes in organization and institutional arrangements should be determined as a function of specific policies. For example, what governmental impact would certain regulatory measures or tax incentives have on governmental agency's responsibility in coping with a particular climatic change problem?

The above procedure is a general one which could be followed in coping with a wide variety of policy-related issues. In the case of climatic change and weather modification, the need for a systematic evaluation of alternatives and consequences by experts from different groups is particularly critical because of the potentially grave but uncertain consequences certain phenomena are likely to have on the world in the next few decades. Whether or not such a process will be followed for coping with weather remains to be seen.

REFERENCES

Calabresi, G. 1970. The Costs of Accidents. New Haven: Yale Press.

Coleman, J.S., E. Katz, and H. Menzel. 1966. Medical Innovation: A Diffusion Study. Indianapolis: Bobbs-Merrill.

Cooper, C. 1978. What Might Man-Induced Climate Change Mean? Foreign Affairs, 56: 500-520.

Kates, R. 1962. Hazard and Choice Perception in Flood Plain Management. Chicago: University of Chicago, Department of Geography, Research Paper No. 78.

Kunreuther, H., R. Ginsberg, L. Miller, P. Sagi, P. Slovic, B. Borkan, and N. Katz. 1978. Disaster Insurance Protection: Public Policy Lessons. New York: Wiley and Sons.

Lawless, E. 1977. Technology and Social Shock. New Brunswick, N.J.: Rutgers University Press.

March, J. and H.A. Simon. 1958. Organizations. New York: Wiley.

Rogers, E., and F.F. Shoemaker, 1971. Communication of Innovations. New York: The Free Press.

Schneider, S. 1976. The Genesis Strategy. New York: Plenum Books.

Slovic, P., B. Fischhoff, S. Lichtenstein, B. Corrigan, and B. Combs. 1977. Preference for Insuring Against Probable Small Loss: Implications for the Theory and Practice of Insurance. Journal of Risk and Insurance, 44: 237-58.

Tversky, A., and D. Kahneman. 1974. Judgment Under Uncertainty: Heuristics and Biases. Science. 185: 1124-31.

White and Haas. 1975. Assessment of Research on Natural Hazards. Cambridge, Massachusetts: MIT press.