CHAPTER 5

The Decision-Maker's Outlook

There are many kinds of decision-makers, and there are many levels of decision. The consequences of making a wrong decision can range from inconvenience through loss of income to hazards to property and life.

Daily weather forecasts provide a useful example of this, as nearly all of us use these as the basis for short-term decisions at one time or another. In doing so we fall into two broad groups. First, short-term decision-makers include:

(A) the layman, who may make a decision on how warmly to dress, whether to carry an umbrella, or even whether to go outside at all in some cases; and

(B) the operational manager, who may make a decision on whether to pour concrete, where to route aircraft, whether to spray orchards, or whether to cut hay.

All of the users in group (A), and some of the users in group (B), obtain their information through the communication chain illustrated in Figure 5.1. The forecaster does not know all classes of intended users. Through the years, however, he has identified the principal ones, particularly those in group (B), and he has developed special types of forecasts, e.g., for forest fire hazard, for air pollution potential, and for aviation and marine interests.

Figure 5.1 Flow of meteorological information

The consumers have learned to accept the limitations of weather forecasts and are prepared to overlook the occasional error. They realize that the odds will be in their favour, in an economic or some other sense, if they consistently base their decisions on the weather forecasts.

On a longer time-scale, climatological forecasts (in the sense of probabilities of particular sequences) may be used by other groups of decision-makers working on a larger scale: (C) planners, for purposes such as flood control; (D) national policy makers, concerned, for instance, with drought relief.

For the purposes of this report it is convenient to classify decisions into two distinct categories – *tactical* decisions and *strategic* decisions (U.S. Environmental Protection Agency, 1974). Tactical decisions are those decisions which are based on a single well-defined criterion and are made by people like those in groups (A) and

(B) acting within delegated terms of reference, or else according to their individual freedom of choice. Strategic decisions are those decisions which take into account several factors*, some of which may be of a qualitative nature or represent the interests of different groups. Most of the decisions by groups (C) and (D) will be of this type. As with tactical decisions, strategic decisions can be made by persons or groups in either the public or the private sector. They are not confined to the area of government policy.

Models used in tactical decisions have commonly been built and fully tested well in advance of the actual operational situation to which they are being applied. Because they have been 'tuned' with real data obtained over many repetitions of the decision-making process, their predictions can be trusted, in at least some statistical sense, by the decision-maker.

For the strategic decision-maker, this is often not true. The particular situation in which he finds himself may never have arisen before. As a consequence, he will often need a custom-built rather than an off-the-shelf model; he operates under numerous constraints, some of which involve time and money. Almost always, he must reach his decision within a limited time, and can only afford to spend a limited amount of money in doing so. If the time limitation is in hours or days, the building of a new model is excluded, and even the modification of an existing model is impracticable; only one which is fully established will serve. If the permissible time is measured in months or years and the funds in tens of thousands of dollars, then the scope for modelling assistance is much greater.

From the comments in the preceding paragraphs, a number of distinctions between the needs of tactical and strategic decision-makers become clear:

(1) By definition, strategic decisions must encompass a larger spectrum of considerations than tactical decisions.

(2) The strategic decision-maker is likely to be operating in a more difficult environment and under more contentious circumstances than the tactical decision-maker.

(3) Strategic decisions are more likely than tactical decisions to be made by groups and to involve people with conflicting view-points. The members of these groups will often have different perspectives and distinct responsibilities with respect to the various factors involved. Directors on boards of companies will represent the main divisions within their companies (e.g., marketing, personnel, finance, etc.). Heads of government departments will

*It is implicit in this definition that there is no generally accepted method of combining or aggregating the measure of the different factors so that together they can be considered as one. In cases where this is possible, the decision should be classified as tactical and not as strategic. The use of the economic order quantity in inventory control is an example of such a case (i.e., a tactical decision), since both of the factors (order cost and inventory carrying cost) have been aggregated in a well-accepted manner. On the other hand, most aggregated measures of net public benefits are by no means generally accepted; any decisions purportedly based on these should be classed as strategic and not as tactical decisions. In this context, it behoves the modeller to do his best to help in the development of compatible measures of different factors and the consequent establishment of tactical rules for decision-makers.

similarly tend to reflect the different interests of their constituents (e.g., conservation, employment, social welfare, etc.).

(4) The tactical decision-maker is more likely to seek direct access to the modeller than the strategic decision-maker, since his main concern is that the model provides an accurate measure of the specific criterion or factor involved. On the other hand, for the strategic decision-maker the model and its output are only a part of the information he has to take into account. He must indeed be aware of the various criteria in the model and the weights assigned to them, but he must also take due account of external interest groups.

(5) The tactical decision-maker is far more likely to understand the mechanism of the model and to spend the time necessary to become familiar with the details of its operation.

(6) The tactical decision-maker is likely to use well-defined models. The strategic decision-maker will generally require more aggregated and often more pragmatic information.

(7) The tactical decision-maker is more likely to seek specific single recommendations from the modeller, since single decisions are usually involved. The strategic decision-maker will generally prefer a list of options. Although both may require quantitative assessments of the influences on all the factors involved under a range of different assumptions, these detailed assessments are likely to be more important where the objectives are less well defined. The strategic decision-maker will also require an assessment of all the risks, including the likely consequences in the event of his making the wrong decision. Indeed, his main reason for using a model may be to assess the negative aspects of a decision; for instance, climatic air-dispersion models are most frequently used in this way (Andrews, 1975).

The importance of providing a list of options should not be underestimated. The modeller who does not present the strategic decision-maker with options runs the risk of being regarded as just another of the pressure groups and is likely to antagonize and erode the patience of the decision-maker.

Another useful distinction is between two types of strategic decision-making, which one may term respectively *technocratic* and *incremental* (Biswas, 1976). In the former, the decision-maker decides on a strategy at the outset, in the light of the best information then available, and persists with this through a considerable period without regard to temporary changes in the system which may be irrelevant to the final outcome. In the *incremental* approach, on the contrary, the decision-maker reassesses his strategy at frequent intervals, in the light of the current state of the system and of changes since his most recent intervention. Decision-makers are likely to prefer the incremental approach if either they are insufficiently confident of the reliability with which the effects of their management practices can be predicted, or they do not wish to commit themselves too firmly at the outset to a particular set of objectives.

Strategic decision-makers usually have in the back of their minds certain goals or objectives which influence their decisions, although they may not have formulated them in the quantitative terms which a modeller would prefer, and may even have left their long-range plans rather open. Even when their objectives are clear-cut and conscious, they are unlikely to disclose them for fear of committing themselves in the future (or of giving the opposition an advantage). Rather than a single objective, strategic decision-makers tend to have a number of different objectives which are frequently in conflict. Although they may rank their objectives, they often do not use these rankings consistently and generally try to avoid a negative decision with respect to any of their objectives*. This is particularly true when the objectives are 'on record' as in the case of official government policies. There are a number of ways in which strategic decision-makers can do this. They can delay making a decision; they can try to 'buy the problem away' by budgeting money in the hope that this act alone will provide a solution, satisfy the most active pressure groups, or at least ease their conscience. They can also attempt to satisfy their many objectives in an aggregative manner over a number of different decisions.

Although these tactics can be criticized, they may have advantages. As regards the delaying of decisions, political pressures change with time, with changes in the economy, with changes in people's attitudes, and with changes of decision-makers. A decision which was not politically feasible in one year might very well receive an urgent priority the next. The balancing of objectives over a number of different decisions also gives the strategic decision-makers a means whereby he can achieve some positive results. He can perhaps afford to concede on a few minor issues in order to achieve his major objectives. In effect, he is prepared to lose a few battles in order to win the war.

The 'incremental' approach to decision-making fits in with the fact that knowledge of environmental systems is often inadequate to enable useful predictions to be made over a long period ahead. A combination of short-term modelling, 'incremental' decision-making, and regular monitoring may therefore have real advantages over long-term modelling and 'technocratic' decision-making, even where the decision-maker is willing to adopt a 'technocratic' point of view.

Where the decision-maker admits that his objectives may change as time goes on – through pressures, or through improved understanding – a useful temporary objective may be the preservation of options. That is, it may be desirable to manage the system, not so as to maximize any specifiable objective function now, but so as to make it possible for him to react to future changes with minimum risk. This is akin to the concept of resilience developed by Holling and his colleagues (Holling, 1973, 1976; Walters, 1975). Accordingly it may be appropriate for modelling to be directed to the identification of management procedures which maintain system resilience (and thus give the manager the maximum elbow-room in the future) rather than those which contribute best to an objective perceived at the present time.

Clearly, the modeller can make a positive contribution to incremental decision-making and the preservation of options. By developing very broad planning

*This constitutes a good argument for the use of mini-max techniques. These involve the choice of the option which maximizes the measure of benefit of the most detrimentally affected factor (see Luce and Raiffa, 1957; Berry and Steiker, 1974).

scenarios which expose all realistic options and all the possible effects, and by keeping both the general public and the strategic decision-makers well informed, the modeller can help create an environment more conducive to long-term integrated planning, and to maintaining system resilience.

Often, many of the results obtained by using a model can, with hindsight, be obtained directly from the data by relatively simple analyses. Where this is true, the simple analysis may suit the needs of the decision-maker better than the model which suggested it. A presentation based on common sense, which may even be qualitative rather than numerical, is likely to be more acceptable than a complex simulation. This is not to say that the results will be intuitively obvious; in many cases they will not. For example, a novice skier intuitively puts his weight of the wrong foot; a good ski-instructor can give a perfectly reasonable explanation for the correct technique.

Where a strategic decision-maker has no direct contact with the modeller, he will generally tend to address all technical problems through an intermediary and involve himself in a minimum of detail. He will require a relatively simple analysis only to back up any figures provided to him. In such cases, the modeller should direct his major attention to the intermediary. This person is often one of the modeller's direct superiors, or possibly the person to whom the modeller is directly responsible for the conduct of the study; or he may be a subordinate of the decision-maker.

Intermediaries between decision-makers and modellers should not be thought of as a regrettable extra step in the chain of communication; often they may play a valuable part, particularly when the backgrounds of modeller and decision-maker are widely different. In countries where the civil service is independent of the political party in power, the role of intermediary is likely to be played by a permanent civil servant, while the decision-maker is an elected politician. In other countries, and in private companies and corporations, the situation will vary according to the seniority of the modeller in the administrative structure.

Questions of scale are important to the decision-maker, and modelling work must take this into account. A decision-maker concerned with a local environmental problem may have to consider strategies quite different from those within the purview of his counterpart at the regional or national level. Consequently, they are likely to require models at different scales in space and time. Moreover, the relations between cause and effect within, and among, the various disciplines involved in environmental problems may differ greatly in their spatial and temporal scales, and thus increase difficulties at the interfaces.

Decision-makers are often much more familiar with law, politics and the social sciences than with the physical and biological sciences underlying most environmental problems. This may lead to difficulties if they try to apply experience in the one field to the other. Misunderstandings of this sort can lead to mistaken deductions from scientific results – including those from modelling work. Physical and biological laws are far more immutable than legal or political rules; any expectations that the former can be modified as readily as the latter are doomed to disappointment.

The modeller should try to preserve a broad outlook on the possible options which the decision-maker might consider. Although the decision-maker may have specified a particular set of management strategies which he is proposing, he should

also be provided with any other options which mathematical methods may suggest and which may not be immediately obvious. Thus, in dealing with air pollution it may be possible to use some criteria permitting a selective use of the atmosphere for dispersal of pollutants. The use of the atmosphere for such a purpose could indeed be the most economical method of disposal – at least, for some pollutants. The evaluation of benefits due to the industries and the detriments associated with pollution they produce may have to be related to the basic needs of the population. The decision-maker may often wish to make his constituency and his administrative and political officials conscious of the fact that some of those benefits may have to be paid for with the nuisance and even the danger of atmospheric contamination, the inconvenience and costs of its control, or a slower growth of a community, a regional area, or a whole nation (AAAS Air Conservation Commission, 1965). The decision as to whether the cost is worth the benefits should not be decided by the scientist or the modeller, but the various options should be brought to the attention of the decision-makers.

The establishment of precedent and the creation of laws, rules, and regulations have the effect of reducing the number of factors which must be taken into account in strategic decisions. It is by these means that many strategic decisions can be reduced to tactical decisions. Indeed, this could be seen as the main aim of codification. The employee who asks his supervisor for some time off presents an example of this. If there are no rules or regulations, the supervisor has a 'strategic decision'; he must weigh lost production against the needs of the employee and the possible loss of employee morale. On the other hand, if there are company rules or regulations, the supervisor has a tactical decision. Regulations licensing the discharge of pollutants constitute a similar example in environmental decision-making.

Once again the modeller can make a considerable contribution. Models which explore the advantages, disadvantages, and risks of alternative sets of rules and regulations are often as important as those which explore the advantages, disadvantages, and risks of alternative options in other situations.

In regard to precedent, no one likes to be seen as inconsistent. For this reason, and for the reasons outlined above, the modeller should face the facts: decision-makers and especially 'politicians' do not like to make commitments; they prefer to keep their options open. Because of this, they often use a step-by-step (incremental) approach to decision-making rather than a planned strategy. Even when given a complete set of comprehensively assessed options, they may not wish to make a single positive choice. Frequently, they seek to subdivide the options into components and select only the components subject to the least contention or element of risk.

When the strategic decision-maker is not subject to very much external pressure, he is left in a far better position to plan ahead. Unfortunately, however, this also has its drawbacks, in that there is a considerable risk that such a decision-maker will treat all decisions as tactical, and not seek to examine all the options. While this will frequently help to accelerate development, it has undeniable risks, particularly where environmental issues are at stake.

Despite the differences outlined above, the tactical decision-maker and the strategic decision-maker share some common ground. In particular, they each have only limited resources at their disposal. The modeller must be prepared to compete

with other available techniques for these limited resources. This applies particularly to time, money, and manpower. As regards time, the modeller must accept that, like it or not, decisions will often need to be made under extremely severe time limitations. Moreover, the decision-maker cannot give all his attention to the modeller. As regards money, substantial funding is often needed to develop theory and data, to train personnel and to operate and maintain a model. Finally, as regards manpower, the use of a model requires personnel with the technical expertise to interpret model output, keep the model up to date, and adapt it to changing circumstances.

In these matters the onus lies with the modeller. He must be aware that the decision-maker will often try to cut corners and seek the cheapest answer. He must therefore take every step to ensure that he does not quote unrealistically short lead times, nor budget amounts insufficient for the job. There is little to be gained from ambitious modelling projects which produce results only after the decisions have already been made. There is even less payoff in substandard models which are incapable of furnishing any results at all.