

used here to describe an analysis of the range of uncertainties encountered in an assessment study. These arise from two sources, here referred to as 'errors' and 'unknowns'.

Errors may arise from several sources, including measurement error, paucity of data and inadequate parameterization or assumptions. Unknowns include alternative scenarios, or the omission of important explanatory variables. The maximum range of uncertainty is the product of the individual uncertainties. The upper and lower bounds of these may be highly improbable, so more useful alternatives are confidence limits (e.g., 5 or 95 percentiles), which can be computed by studying the probability of uncertainties propagating (see, for example, Brklacich and Smit, 1992). These are often used as upper, lower and best estimates of an outcome.

3.5.6.2 Risk analysis

Risk analysis deals with uncertainty in terms of the risk of impact. Risk is defined as the product of the probability of an event and its effect on an exposure unit. It has been argued that future changes in average climate are likely to be accompanied by a change in the frequency of extreme or anomalous events, and it is these that cause the most significant impacts (Parry, 1990). Thus there is value in focusing on the changing risk of climatic extremes and of their impacts. This approach can then be helpful in assessing the potential risk of impact relative to predefined levels of acceptable or tolerable risk. It is important to stress, however, that while occurrence probabilities of hypothetical climatic events are relatively straightforward to compute, it is not generally possible to ascribe any degree of confidence to probabilities of future impacts.

3.6 Evaluation of Adjustments

Impact experiments are usually conducted to evaluate the effects of climate change on an exposure unit in the absence of any adjustments which might prevent, mitigate or exploit them, and are not already automatic or built-in to future projections. It is these adjustments which form the basis of measures to cope with climate change. Two types are described here: feedbacks to climate, and tested adjustments at the enterprise level. A third type, policy responses, is considered in Section 3.7.

3.6.1 Feedbacks to climate

The global climate system is influenced, in part, by interactions with the surface biosphere. To date, projections of future climate have assumed that the biosphere remains unchanged, but this is clearly unrealistic. As climate changes, so the pattern of vegetation and of other important organisms such as oceanic plankton, which feedback to climate, are likely to shift geographically. Impact models can identify these possible shifts, but they have not yet been linked effectively to climate models for simulating feedbacks to climate.

3.6.2 Tested adjustments at the enterprise level

Tested adjustments are experiments that can be conducted with impact models to evaluate alternative options for adjusting to climate change at the level of individual enterprises. To illustrate, a climatic scenario may indicate that the water requirements of a crop are no longer satisfied under a changed rainfall regime. In this case an adjustment that could be tested using a crop growth model might be the substitution of a less demanding, short-season crop variety. Here, the adjustment is

chosen by expert judgement, but evaluated using a model (for a similar example, see Box 7 on page 22).

It is important to recognise that any evaluation of potential adjustments necessarily makes assumptions about the way in which groups or individuals will respond when confronted with climate change. There is a whole area of research which examines the actual processes of adaptive response to changes in climate. This includes behavioural studies of actions taken during and after certain climatic events, as well as studies to identify thresholds of tolerance or constraints on adaptation to climate change and its effects (e.g., see Whyte, 1985; Smit, 1991).

When analysing potential adjustments, it is useful to distinguish between two types: anticipatory and reactive. Anticipatory adjustments are put into place in prospect of impacts occurring (e.g., the breeding of drought resistant crop varieties). Reactive adjustments are implemented after impacts have occurred (e.g., the adoption of drought resistant varieties). In many cases, adjustment experiments can assist in evaluating different options so that anticipatory, rather than reactive adjustments can be put in place.

Of course, not all adjustments can be tested. For some, an accurate evaluation may not be possible, and for others the required technology may not yet be available.

3.7 Consideration of Policy Options

Another method of responding to climatic change is through policy decisions. Aside from purely qualitative assessments, two methods of policy evaluation can be identified: policy simulation and policy exercises.

3.7.1 Policy simulation

In some assessments it is possible to simulate the effectiveness of alternative policy adjustments using impact models. Two types of policy response to climatic change are commonly simulated: mitigative and adaptive.

Mitigation policies refer to actions that attempt to prevent or to reduce changes in climate by altering the emission rates of greenhouse gases. These effects can be estimated and the costs evaluated using a range of models. Impact assessments can assist in identifying targets for mitigation policy with respect to minimising the effects of climate change (see Section 3.4.5.3). For instance, a target emissions policy might be set that limited the likely rate of change in climate resulting from increased GHG concentrations to one that natural ecosystems would be able to accommodate and adapt to, through migration or acclimation.

Adaptive policies recognize that climate changes will occur and that it is necessary to accommodate these changes in policy. For instance, the lifting of government subsidies on some food crops might be one policy method of offsetting overproduction due to a more favourable climate. Such a policy would rely on economic factors (i.e., reduced incentive) to bring about farm-level adjustments such as a switch to alternative crops giving a higher return.

3.7.2 Policy exercises

A second possible method of evaluating policy adjustments is the policy exercise. Policy exercises combine elements of a modelling approach with expert judgement, and were originally advocated as a means of improving the interaction between scientists and policy-makers. Senior figures in gov-