Chapter 1
Scenarios used in the Report

Any changes which take place as the results of increasing emissions must be viewed against a background of changes which are already occurring and which will continue to occur as a result of other factors such as:

- Natural changes - these include long-term changes which are driven by solar and tectonic factors, and short-to-medium term changes which are driven by ocean and atmospheric circulation patterns.

- Population increase - the latest UN figures show that current world population is 5.3 billion, with a predicted growth to 8.5 billion by 2025 and then stabilising at more than 11 billion in the late 21st century; this growth will be unevenly distributed on a regional basis and will impact on already vulnerable areas, particularly in Africa and the Middle East.

- Land use changes - the clearing of forests for new agricultural production, together with more intensive use of existing agricultural land, will contribute to land degradation and increase demands for water resources.

In an ideal world, Working Group I would have had the time to produce scenarios for emission-induced climate change which could have been used as a basis for the analyses of this Working Group. However, this was precluded because work proceeded in parallel. As a result, and in order to complete its work in time, Working Group II has used a number of scenarios based on existing models in the literature.

The scenarios generally have the following features:

(i) an effective doubling of CO_2 in the atmosphere over pre-industrial levels between now and 2025 to 2050 for a 'business-as-usual' scenario, with no changes to present policy;

(ii) an increase of mean global temperature in the range 1.5°C to 4.5°C corresponding to the effective doubling of CO_2;

(iii) an unequal global distribution of this temperature increase, namely half the global mean in the tropical regions and twice the global mean in the polar regions;

(iv) a sea-level rise of about 0.3 to 0.5 m by 2050 and about 1 m by 2100, together with a rise in temperature of the surface ocean layer of between 0.2° and 2.5°.

These scenarios can be compared with the recent assessment of Working Group I which, for a 'business as usual' scenario, has predicted the increase in global temperatures to be about 1°C above the present value by 2025 and 3°C before the end of next century. However, it has estimated the magnitude of sea-level rise to be about 20 cm by 2030 and about 65 cm by the end of next century. Nevertheless, the impacts based on 1-2 m rise serve as a warning of the consequences of continued uncontrolled emissions.

The smaller rise docs not lessen the anxiety, for their continued existence, of the small island countries, particularly the Pacific and Indian Oceans and the Caribbean, or of the larger populations in low-lying coastal areas such as Bangladesh. It is difficult to predict the regional effects of sea-level rise with any certainty. Significant variations of sea-level already occur for a variety of reasons, while there are considerable shifts in land levels associated with tectonic plate movements which can also lead to rises and falls.

The scenarios of Working Group II are derived both from General Circulation Models and from palaeo-analog techniques. Palaeoclimate analogs are proposed by Soviet scientists as a means by which climate changes can be assessed. The methodology assumes that past warm geologic intervals provide insight into possible future climate conditions. The General Circulation Models, developed by Western scientists, are based on three-dimensional mathematical representations of the physical processes in the atmosphere and the interactions of the atmosphere with the earth's surface and the oceans. There is considerable scientific debate about the merits and demerits of each of these, as discussed in the report of Working Group I.

The palaeoclimate scenarios used by Soviet scientists are based on three warm geological periods with estimated future levels of concentration of CO_2

applied to them. The details of these are shown in Table 1.1. While these are superficially similar to the predictions of the General Circulation Model approach for different CO_2 concentrations, the factors which caused the climate changes in geologic times are not clear. Nevertheless, they have been used to make predictions of climate change of regions in the USSR.

The General Circulation Models are, in their current state of development, comparatively crude in their description of many of the processes involved. However they can be used to simulate regional changes resulting from a range of concentrations of CO_2 in the atmosphere. Working Group I has favoured the General Circulation Model approach in producing its predictions of temperature rise and precipitation changes. In its report, estimates for 2020 have been given for central North America, southern Asia, Sahel, southern Europe and Australia. These are reproduced in Table 1.2 and are broadly similar to those used by Working Group II.

Despite the current uncertainties, both techniques have been used by Working Group II in the development of regional impacts to assist policy makers. There are problems with prediction of regional precipitation since there is disagreement between various General Circulation Model outputs as a result of simplifications to the representation of complex physical processes. Current research is seeking to improve the General Circulation Model approach and to increase resolution to enable better regional predictions. There are also problems with the palaeoanalog approach which yields differing scenarios for precipitation from the General Circulation Model approach. This leads to different assessments of impact on water resources and agriculture. Soviet scientists are working to validate their techniques and improve regional scenarios.

It should be noted that, in many situations, the overall impact is determined more by the changes in the magnitude and frequency of extreme events than by changes in the average. This is especially the case for tropical storms and droughts. The assessment of Working Group I of possible climate changes suggests a low probability of increased frequency of extreme events. However, it is entirely possible that shifts in climate regimes will result in changes in frequency in certain regions.

An issue of importance not considered in any detail is the impact of possible response strategies (developed by Working Group III) on the scenarios used here. Thus, a major change in energy production from fossil fuel to nuclear or renewable energy sources could drastically alter our assessments. Further, changes in agricultural practice could dramatically alter yields of particular crops in certain regions. These impacts of response strategies require much additional work.

Despite all these uncertainties, it is possible to make assessments of potential impacts of climate change by considering the sensitivity of natural systems to significant variations. These are summarised in the following sections under: agriculture and forestry; terrestrial ecosystems; hydrology and water resources; human settlement, energy, transport, industry, human health and air quality; world ocean and coastal zones; seasonal snow cover, ice and permafrost.

Table 1.1 Palaeoclimate analogs used by Soviet scientists

Period	**Analog** (year)	**Temperature** (difference from present)	**Past CO_2 concn.** (ppm)	**Assumed CO_2 concn.** (ppm)
Holocene Optimum	2000	+1	280	380
Eemian Interglacial	2025	+2	280	420
Pliocene Optimum	2050	+4	500-600	560

Table 1.2 Estimates for regional changes by Working Group I
(IPCC Business-as-Usual scenario; changes from pre-industrial)

The estimates are based on high resolution models, scaled to give a global mean warming of 1.8°C consistent with the best estimate (2.5°C) of climate response to greenhouse gases. With the low estimate value of 1.5°C, these values should be reduced by 30%; with a high estimate of 4.5°C, they should be increased by 50%. Confidence on these estimates is low.

Central North America (35°-50°N 85°-105°W)
The warming varies from 2° to 4°C in winter and 2° to 3°C in summer. Precipitation increase range from 0% to 15% in winter, whereas there are decreases of 5% to 10% in summer. Soil moisture decreases in summer by 15% to 20%.

Southern Asia (5°-30°N 70°-105°E)
The warming varies from 1° to 2°C throughout the year. Precipitation changes little in winter and generally increases throughout the region by 5% to 15% in summer. Summer soil moisture increases by 5% to 10%.

Sahel (10°-20°N 20°W-40°E)
The warming ranges from 1° to 3°C. Area mean precipitation increases and area mean soil moisture decreases marginally in summer. However, there are areas of both increase and decrease in both parameters throughout the region, which differ from model to model.

Southern Europe (30°-50°N 10°W-45°E)
The warming is about 2°C in winter and varies from 2° to 3°C in summer. There is some indication of increased precipitation in winter, but summer precipitation decreases by 5% to 15%, and summer soil moisture by 15% to 25%.

Australia (12°-45°S 110°-155°E)
The warming ranges from 1° to 2° in summer and is about 2°C in winter. Summer precipitation increases by around 10%, but the models do not produce consistent estimates of the changes in soil moisture. The area averages hide large variations at the subcontinental level.