SECTION 1

The Assessment of Effects of Climatic Variations on Agriculture: A Summary of Results from Studies in Semi-Arid Regions

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1.1. Introduction

In 1982 and 1983 there occurred the most pronounced El Niño event ever recorded. In Northeast Brazil the total gross product of agriculture in 1983 was almost 16% below normal. In this drought-prone region 1983 was the fifth successive year of below-average rainfall, which contributed to the progressive worsening of living conditions of about 12 million *nordestinos*. Although the Brazilian government spent the equivalent of US $ 1 778 m in emergency programs over 1979–1983, assisting about 2.5 million people with employment in public works, there was widespread hardship and extensive migration both from farms to towns in the region and out of the region itself.

In the same year (1983) there were extensive floods in Ecuador and Peru, persistent droughts in southern and eastern Africa and in north-central India, and widespread forest fires in Australia. Wheat production in Australia in 1982–1983 was only 63% of the previous five-year average and would have been even lower if Western Australia had shared the drought conditions of the eastern states (Gibbs, 1984). In the US cornbelt abnormally low rainfall reduced average US maize (corn) yields by 29% (relative to 1982) and this, combined with reduced planting due to government policy, led to a fall in total US maize production of 50% (Parry *et al.*, 1985).

Only some of these short-term events have been connected with the El Niño/Southern Oscillation phenomenon, a periodic fluctuation in the intensity of the intertropical atmospheric and oceanic circulation (Southern Oscillation) that is usually coincident with an anomalous warming of the eastern tropical Pacific

M. L. Parry et al. (eds.), *The Impact of Climatic Variations on Agriculture*

Ocean (El Niño). In all cases, however, they can cause substantial decreases in productivity, large aggregate falls in production and, in extreme though not infrequent instances, starvation and death.

In the longer term it is likely that changes in climate will result from increasing concentrations of carbon dioxide (CO_2) and other radiatively active gases in the atmosphere. Present assessments indicate that increases in global mean annual temperatures of between 1.5 and 5.5°C are likely to occur as a result of increases in CO_2, probably between 2050 and 2100 (Bolin *et al.*, 1986). Such changes are likely to affect the frequency of short-term extreme events, for example, through changes in rainfall regime in some semi-arid areas.

Thus both short- and long-term variations of climate will probably continue to be important factors affecting agriculture in the future. The present volume is the second of two concerned with the estimation of such effects and with the evaluation of appropriate responses to them.

1.2. Aims

This volume considers, firstly, the range of effects that short-term variations of climate may have on agriculture in semi-arid regions of the world and, secondly, the range of adjustments available to mitigate or exploit these effects. The core of the volume is six case studies of effects on agriculture in different semi-arid regions. A companion volume reports results of similar case studies in cool temperate and cold regions (Parry *et al.*, 1988).

The two volumes are the outcome of a research project based at the International Institute for Applied Systems Analysis (IIASA) and funded jointly by IIASA and the United Nations Environment Programme (UNEP) as part of the World Climate Impact Programme (WCIP). The WCIP is one of four components of the World Climate Programme (WCP), which was initiated by the World Meteorological Organization (WMO) in 1979.

The purpose of the project was twofold:

(1) To investigate the effects of climatic change and variability* on agriculture.
(2) To evaluate alternative responses to these effects.

An important premise behind the study was that, while we are not yet in a position to forecast how the climate may change (either in the short or long term), we *can* estimate the potential consequences of each of a number of *possible* climatic changes. By considering the range of impacts from and adjustments to

*Throughout the volume reference is made to three forms of climatic perturbation: climatic variability, climatic change and climatic variations. Following Hare (1985), *climatic variability* describes the observed year-to-year differences in values of specific climatic variables *within* an averaging period (typically 30 years). *Climatic change* describes longer-term changes *between* averaging periods either in the mean values of climatic variables or in their variability. These two descriptors form subsets of the third collective term, *climatic variations*, which embraces short-, medium- and longer-term changes with time in values of climatic variables.