CHAPTER 4

CLIMATE CHANGE: VULNERABILITY, IMPACTS AND ADAPTATION

4.1 INTRODUCTION

According to a survey conducted for UNEP's Global Environmental Outlook, environmental experts and research scientists perceive climate change as a dominant environmental issue for the current generation (UNEP, 1999). The survey, conducted among 200 environmental experts from over 50 countries, including several research scientists, found that 51% of the respondents considered climate change as the major environmental problem facing us today. 29% of those surveyed felt that fresh water scarcity was the major problem. Among other problems identified were: deforestation or desertification (28%), fresh water pollution (28%), loss of biodiversity (23%), population growth (22%), and waste disposal (20%). Recognizing the major threat presented by climate change, the parties to the UNFCCC agreed to take action to avoid dangerous levels of climate change by ensuring that food production is not threatened, and economic development is promoted in a sustainable manner.

Human activities, primarily burning of fossil fuels and land-use changes, are increasing the atmospheric concentration of greenhouse gases and aerosols. Greenhouse gases alter radiative balances and tend to warm the atmosphere, while aerosols have the opposite effect, i.e., they tend to cool the atmosphere. These changes in greenhouse gases and aerosols are together projected to lead to regional and global changes in temperature, precipitation and other climatic variables. Based on plausible changes in emissions of greenhouse gases and aerosols, climate models using the SRES (Special Report on Emissions Scenarios) scenarios, project a mean global warming of 1.4 to 5.8°C over the period 1990 to 2100.

There is adequate evidence to show that the changes in temperature and precipitation along with other related climate parameters could affect natural and socio-economic systems, but there is inadequate regional- and national-level information about the impacts of such climate change factors. Realizing this, the Third Assessment Report of Working Group II of the IPCC (Intergovernmental Panel on Climate Change) focused on regional level impacts of climate change in regions such as Asia, Africa and Latin America, unlike the First and Second Assessment Reports (in 1990 and 1996), which focused largely on global-level assessment of vulnerability and impacts. Prior to the publication of the Third Assessment Report, IPCC conducted a regional assessment of impacts of climate change and published the report in 1998 (IPCC, 1998). The critical natural and socio-economic systems that are likely to be affected by changes in temperature, sea level rise and precipitation are forests, grasslands, wetlands, agriculture, fisheries and coastal zones. The issues that are relevant to sustainable development are food production and security, wood production, fisheries yield, human health and coastal

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settlements. Some of the impacts, particularly on the natural ecosystems, are irreversible.

The effects of climate change are expected to be greatest in developing countries in terms of loss of life and relative effects on investment and the economy. The populations and communities have lesser capacity to adapt and are more vulnerable to climate change damages, as they are more vulnerable to other stresses (IPCC, 2001a). So, developing countries must fully understand the vulnerability of natural and human systems and the potential adverse impacts of climate change, and implement strategies to cope with and adapt to a changing climate.

This chapter first describes how climate change is projected and follows up this with a description of the observed and projected impacts on natural and human systems at global and regional levels. Adaptation strategies are then discussed and, finally, the need for a joint strategy of mitigation and adaptation is examined, along with a brief analysis of the barriers to the adoption of such strategies and the potential policies and measures to overcome these barriers.

4.2. PROJECTED PATTERNS OF CLIMATE CHANGE

4.2.1 Predicting Climate Change

Prediction of climate change requires, among many parameters, an estimate of the concentration of greenhouse gases resulting from anthropogenic emissions that affect the climate system. To distinguish anthropogenic climate changes from natural variations, it is necessary to identify the anthropogenic 'signal' against the 'background noise' of natural climate variability. This is a complex issue, since human-induced changes may be expressed through naturally occurring modes of variability (Shindell *et al.,* 1999). There is no dispute that the greenhouse gas concentration in the atmosphere is increasing and will cause warming. But the contentious questions are: How fast will warming occur? How serious are the likely consequences for the future? How soon in the current decade should human societies initiate action?

The IPCC's Second Assessment Report (SAR) presented six alternative scenarios to estimate greenhouse gas emissions based on population growth, economic growth, technological developments and energy supplies. These were known as IS92 a-f scenarios (Leggett *et al.*, 1992). In 1998, IPCC released a new set of SRES scenarios. The four "marker scenarios" - A1, A2, B1 and B2 - are representative of a full range of 35 scenarios. The four broad emission scenarios are given in Box 2.1 (Nakicenovic *et al.*, 2000). Using these scenarios, General Circulation Models (GCMs) have been developed to predict future concentrations of greenhouse gases, which in turn form the basis for estimating radiative forcing (in Wm^{-2}).

Climate models generate spatial patterns of changes in temperature and rainfall across the surface of the earth and through the depth of the atmosphere and the oceans. Projections of future climate change rely heavily on coupled Atmosphere-Ocean models, or Atmospheric and Oceanic General Circulation Models (AOGCM). These are mostly GCMs of the atmosphere and oceans developed as separate models and combined to give a coupled GCM. Comprehensive coupled atmosphere-ocean models are very complex and need large computers to run on.