climate change. The UNFCCC was adopted in 1992 at the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro. Informally, the conference was known as the Earth Summit. It adopted an international treaty binding countries together in a common effort to meet the challenge of global warming by reducing its effects, or at least by preparing for higher temperatures. The treaty specifically aimed to stabilize greenhouse gas emissions to prevent anthropogenic interference with the climate system.

The UNFCCC was opened for signing on May 9, 1992. By March 21, 1994, enough countries had signed that it became a part of international law. The treaty as it was originally written did not set limits on greenhouse emissions by individual countries, lacked an enforcement provision, and was not legally binding. However, it contained provisions that stated that updates, which were called protocols in the treaty, were to be issued that would set mandatory emission limits. The principal update was to be set at a new conference in Kyoto, Japan. The Kyoto Protocol was to become much better known than the UNFCCC. After each signatory nation conducted a greenhouse gas inventory, it was responsible for developing a plan for removing or reducing greenhouse gases to acceptable levels. The UNFCCC also named a secretariat that would be charged with supporting the work of implementing the treaty.

The COP 1 met in Berlin for its first session between March 28 and April 7, 1995. The participants concluded that the goals previously reached by those participating in the UNFCCC treaty were not sufficient to meet the challenge of global warming. Originally, the UNFCCC had a goal of returning greenhouse gas emissions to 1990 levels by 2000. It was decided that a process should be established for countries to take appropriate action well beyond 2000. COP 1 also called for legally binding standards and emissions limits to be set by international law. Participants in Berlin also created a separate body called the Ad Hoc Group on the Berlin Mandate (AGBM).

A second meeting of the Conference Parties took place at Geneva between July 8 and July 19, 1996. The meeting was styled COP 2. The meeting was a mid-point in the negotiations on greenhouse gas emissions that had begun with the Berlin Mandate. COP 2 acted in response to the IPCC Second Assessment Report issued December 1995, which stated that greenhouse gas concentrations had continued to increase, that the climate had changed since 1900, and that there was evidence that the change was anthropogenic. It also predicted that global temperatures would rise by 3.6 degrees F (2 degrees C) by 2100 and that the climate was expected to change in the future, adding that there were scientific uncertainties.

These Berlin Mandate negotiating sessions were held as follows: AGBM 1 (August 1995), AGBM 2 (October/November 1995), AGBM 3 (March 1996), AGBM 4 (July 1996), AGBM 5 (December 1996), AGBM 6 (March 1997), AGBM 7 (July/August 1997), and AGBM 8 (October/November 1997). The Berlin Mandate negotiations were concluded at COP 3 in Kyoto with the adoption of the Kyoto Protocol.

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**See Also:** Greenhouse Gas Emissions; Kyoto Protocol; United Nations Framework Convention on Climate Change.

**Further Readings**


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**Bhutan**

Bhutan is a landlocked state in south Asia, located in the eastern Himalayas and bordered by China to the north and India to the south, east, and
west. With a landmass of 14,824 sq. mi. (38,394 sq. km), its population density is one of the lowest in the world, at 46 people per sq. mi. (18 per sq. km). As a mountainous country, the elevation in Bhutan ranges from 492 ft. (150 m) in the southern subtropical foothills to 24,606 ft. (7,500 m) at the northern subalpine Himalayan heights. The country’s forest cover, at 70 percent of the total land area, is one of the largest in the world.

Bhutan held its first democratic elections in March 2008, transitioning toward constitutional monarchy. It is divided into four administrative zones called dzongdey, which are further subdivided into districts called dzongkhag. Although Bhutan’s economy is one of the world’s smallest, it has grown rapidly. In 2008, its average annual gross domestic product (GDP) grew by 6.6 percent—impressively high, considering that the world’s average GDP growth rate was 2.2 percent over the same period. Bhutan’s economy is primarily based on agriculture, with more than 80 percent of people practicing subsistence farming. In 2008, tourism contributed to 37.6 percent of the economy. The potential for hydropower generation is tremendous, at an estimated 30,000 MW. In fact, it is a major contributor to national economic fundamentals, mainly from the gross value generated from the sale of hydroelectric power to India.

Bhutan stands out as one of the few countries with net greenhouse gas emission sequestration, due to its vast forest cover, limited industrialization, and use of clean energy. Nevertheless, Bhutan considers climate change an important issue because of its potential impacts. The country signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and ratified it in 1995. The Kyoto Protocol was ratified in 2002.

According to a 2009 World Bank report titled “Shared Views on Development and Climate
Change,” the winter temperature is predicted to increase in Bhutan by 2.7 to 7.2 degrees F (1.5 to 4 degrees C) by 2050. With the majority of its citizens relying on agriculture, Bhutan’s crop growth and yields are very susceptible to climatic variations, pests, and diseases. Changing rainfall patterns and hydrological systems would also have significant impacts. Moreover, glacial retreat, including glacial lake outburst floods (GLOF), would be one of the most immediate, and dramatic effects of climate change in Bhutan that could result in swelling of its icy lakes, bursting of river banks, and torrents of water crashing into valleys. Of Bhutan’s 2,674 glacial lakes, 24 are at risk of overflowing. With some glaciers already receding at a rate of an estimated 100 to 200 ft. (30 to 60 m) per year, significant effects on important infrastructure, such as hydropower installations located downstream, could be devastating.

Bhutan has identified adaptation activities that are fine-tuned to address hazards such as GLOF, landslides, flash floods, and drought. Adaptation options include the installation of early-warning systems with associated awareness-raising activities, artificial lowering of glacial lake levels, assessment of threats to hydropower installations, soil conservation, land management, riverbank protection, slope stabilization, watershed catchment management, and community-based forest management.

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See Also: Abrupt Climate Changes; Adaptation; Carbon Sequestration; Climate Change, Effects of; Drought; Forests; Glaciers, Retreating; Global Warming, Impacts of; Kyoto Protocol; Land Use; Preparedness; Rainfall Patterns; Renewable Energy, Overview; Vulnerability.

Further Readings

Biogeochemical Feedbacks

Feedbacks are processes in a system that can either amplify or dampen the system’s response to external influences. When the concentration of a certain variable in a subsystem affects the behavior of the entire system, then changes in inputs or concentrations of that variable can result in multiple, coupled responses. Some of these responses enhance, while others mitigate the initial response of the system to the external forcing. In the case of the Earth system, if a change in the environment leads to additional and enhanced changes in that system, it is said to have resulted in a positive feedback. When a large, external forcing results in an even larger response from the affected system, the phenomenon is commonly referred to as a vicious cycle of positive feedback loops. In contrast, if a change in the environment leads to a process that mitigates the change, and results in smaller response from the affected system, it is said to be a negative feedback. Some systems have the ability to regulate their environment and maintain a stable condition by using multiple, interrelated dynamic mechanisms—a property of a system known as homeostasis. Feedback processes regulate the response of the Earth system to natural or anthropogenic forcings.

Biogeochemical feedbacks operate in the coupled biosphere–pedosphere–hydrosphere–atmosphere system. Biogeochemical feedbacks include changes in biological activity; atmospheric, water, or soil chemistry; and terrestrial and oceanic uptake of greenhouse gases (GHGs) that affect or are affected by changes in atmospheric dynamics. Some of the most important biogeochemical feedbacks include: changes in rates of plant productivity and carbon sequestration by soils because of altered patterns of air temperature and