Global Climatic Change and International Security*

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I. INTRODUCTION

International concerns with the implications of large-scale environmental problems have increased over the last few decades. The landmark 1972 United Nations Conference on the Human Environment held in Stockholm marked a critical juncture in international recognition of the problem of environmental degradation and the right to a healthy and productive environment, including adequate food, safe water, and clean air.[1] Although progress has been made in improving a number of environmental problems—notably air and water quality in industrialized nations—there is growing awareness in the international community of even more complex and widespread environmental concerns. These problems, including acid precipitation, Arctic haze, ozone depletion, species extinction, and climatic change, have the potential to threaten international relations, behavior, and security. Unlike the localized problems of air and water pollution, these threats have implications that are truly global in scope—they know no political distinctions and they obey no international boundaries.

The problem of global climatic change, or the greenhouse effect, exemplifies this class of environmental problems. Until recently, concern about climatic change was expressed primarily by natural scientists rather than the policy community.[2]

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1. Stockholm Declaration on the Human Environment, June 16, 1972, U.N. Doc. A/CONF. 48/14 & Corr. 1 (1973), *reprinted in* 11 I.L.M. 1416 (1972).

2. *See* NATIONAL ACADEMY OF SCIENCE, CHANGING CLIMATE: REPORT OF THE CARBON DIOXIDE ASSESSMENT COMMITTEE OF THE NATIONAL RESEARCH COUNCIL (1983); CARBON DIOXIDE REVIEW (W. Clark ed. 1982); SCIENTIFIC COMMITTEE ON PROBLEMS OF THE ENVIRONMENT, THE GREENHOUSE EFFECT, CLIMATIC CHANGES AND ECOSYSTEMS. A SYNTHESIS OF PRESENT KNOWLEDGE (B. Bolin, B. Döös, J. Jäger & R. Warrick eds. 1986); *Report of the International Conference on the Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gasses in Climatic Variations and Associated Impacts*, (WMO No. 661, 1985) (summary of conference held in Villach, Austria, Oct.

Political leaders and other government officials have finally begun to express an interest in the problem, at least in part because of the relationship between global environmental problems and international security. As suggested by the World Commission on Environment and Development (the Brundtland Commission):

> Environmental threats to security are now beginning to emerge on a global scale. The most worrisome of these stem from the possible consequences of global warming caused by the atmospheric build-up of carbon dioxide and other gases . . . Slowing, or adapting to, global warming is becoming an essential task to reduce the risks of conflict.[3]

This article discusses the implications of global climatic change for international relations and security. The effect of climate change on already scarce resources in developing countries is given particular attention. The different roles that may be played by the industrialized and developing world in preventing or mitigating the societal consequences of climate change are also explored.

II. INTERNATIONAL SECURITY AND THE ENVIRONMENT

Traditional notions of international security focused primarily on military threats. A more expansive conception of security issues is now needed, one that includes the role of global environmental problems with international implications. One writer has suggested that

> defining national security merely (or even primarily) in military terms conveys a profoundly false image of reality. That false image is doubly misleading and therefore doubly dangerous. First, it causes states to concentrate on military threats and to ignore other and perhaps even more harmful dangers. Thus it reduces their total security. And second, it contributes to a pervasive militarization of international relations that in the long run can only increase global insecurity.[4]

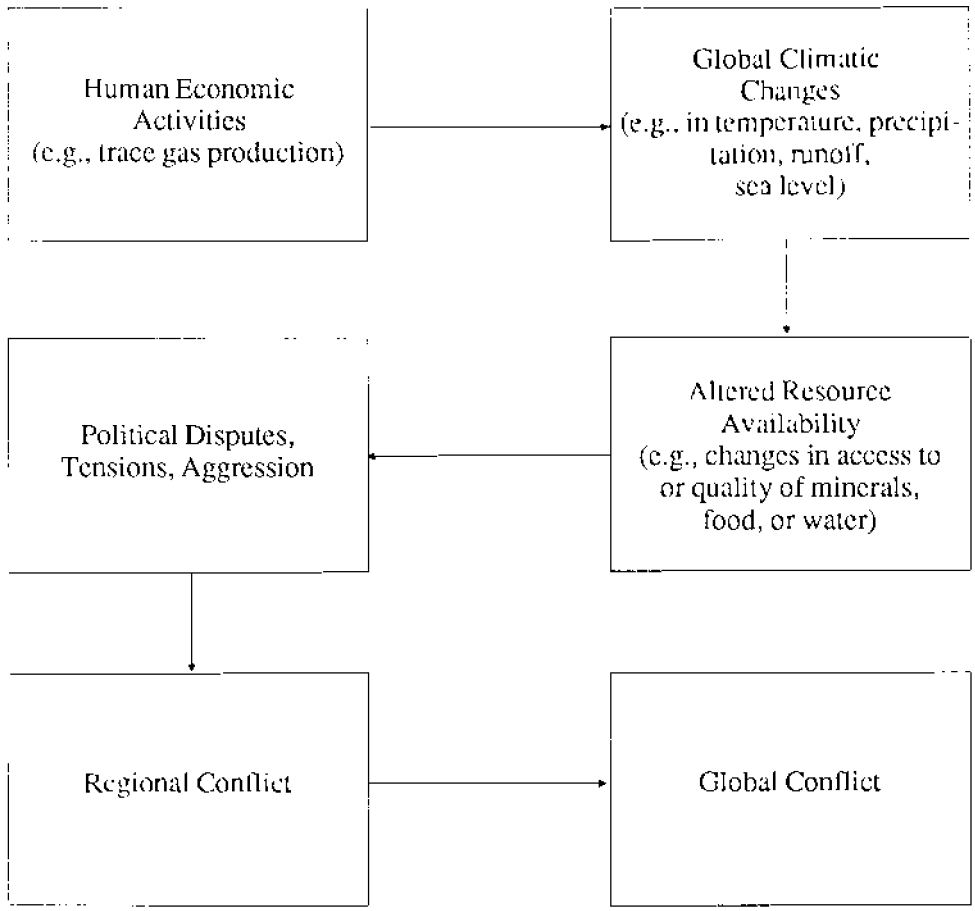
Among all the major environmental threats, global warming is most likely to affect international politics and security because of its wide impact on scarce resources. Human activities that produce carbon dioxide (CO_2) and trace gases are the primary cause of the atmospheric changes associated with global warming. Increased concentrations of these gases alter the heat balance of the atmosphere, thus raising Earth's temperature and modifying the global climate. By altering temperatures, precipitation patterns, sea level, and other conditions, these changes may affect the availability of scarce resources such as food and water. Changes in resource availability may, in turn, have implications for international security. Figure 1 illustrates the path by which global climatic change or other large-scale environmental problems can affect access to resources, international relations, and, ultimately, international security.

9–15, 1985, sponsored by the World Meteorological Organization, United Nations Environment Programme, and the International Council of Scientific Unions.

3. WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, OUR COMMON FUTURE 294 (1987).

4. Ullman, *Redefining Security*, 8 INT'L SECURITY 129 (1983).

FIGURE 1. Environmental Routes to Conflict



This diagram shows the relationship between global climatic change, impacts on resources, and international frictions and tensions. Climatic changes can act as the trigger to, or the roots of, international disputes and can lead to conflict when other tensions exists between states.

Resource constraints can be a cause and consequence of international disputes,[5] and they can lead to conflict when other pressures and tensions exist between states. Resources and their availability have traditionally been interrelated with interna-

5. *See* STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE, U.N. ENVIRONMENT PROGRAMME, GLOBAL RESOURCES AND INTERNATIONAL CONFLICT: ENVIRONMENTAL FACTORS IN STRATEGIC POLICY AND ACTION (A. Westing ed. 1986) [hereinafter ENVIRONMENTAL FACTORS]; Gleick, *The Implications of Global Climatic Changes for International Security*, 15 CLIMATIC CHANGE 309 (1989).

tional tensions in several ways by acting as roots, triggers, consequences, and tools of international conflict. For example, economic pressures and competition for scarce fuel resources have been underlying reasons or roots—of international tension for a long time. The need for Middle East oil has been a trigger for superpower intervention for decades; disruption of oil flow is a likely consequence of conflict in that region. International conflict also has direct consequences for resource availability when important structures such as oil fields, nuclear reactors, and dams are targeted for disruption. Certain scarce mineral resources such as cobalt raw materials that are critical to military production and operations—are also used as tools or instruments of conflict.[6]

Climatic change may directly cause a shortage of critical resources such as food by changing the conditions necessary for agricultural production. Productive capacities of different regions of the world may be influenced, for example, by modifications in rainfall or temperature brought about by climatic change. Actual or anticipated competition for essential foodstuffs may provide the foundation for international disputes or trigger conflict over this essential resource. Climatic change may also lead to a degradation of resources held either exclusively or in common, such as freshwater sources that may be contaminated by rising seas. Resource degradation may provoke protective reactions by the resource holder or may lead to political or economic exploitation. These behaviors may create tensions that have the potential to escalate into actual conflict on a regional or, ultimately, a global level.[7]

Despite the projected ecological and human consequences of climatic change, policymakers have failed to address the problem decisively; at least in part because of remaining scientific uncertainties surrounding the issue. Current studies estimate that global average temperatures will increase three degrees Celsius with an equivalent doubling of atmospheric CO_2 concentration.[8] In Figure 2 three scenarios for global average temperature change are shown together with the temperature record for the past 125 years. Some scientists feel that there is a 90 percent chance that global average temperatures will rise at a rate in between the "slow" and "fast" rates shown by the lower and upper curves in this figure.[9] As previously noted, scientists believe that changes in atmospheric temperature will be accompanied by many other

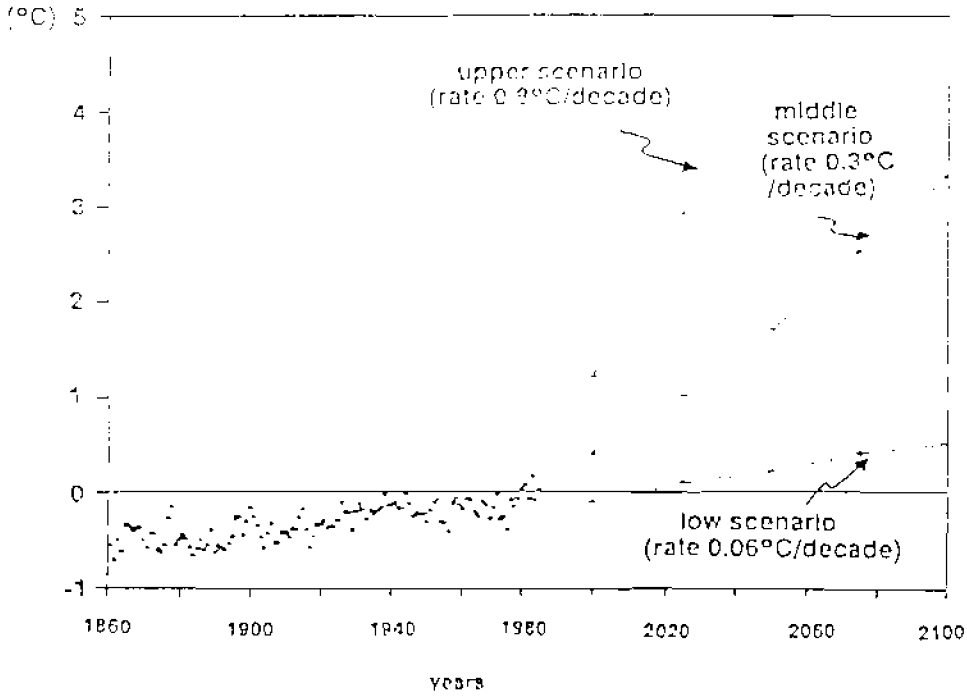
6. *See* R. LIPSCHUTZ, WHEN NATIONS CLASH: RAW MATERIALS, IDEOLOGY AND FOREIGN POLICY (1989).

7. *See* M. BUDYKO, CLIMATIC CHANGES (American Geophysical Union trans. 2d ed. 1977); W. ROBERTS & H. LANSFORD, THE CLIMATE MANDATE (1979); T. GUSTAFSON, REFORM IN SOVIET POLITICS: LESSONS OF RECENT POLICIES ON LAND AND WATER (1981); Wilson, *Global Climate, World Politics and National Security*, in WORLD CLIMATE CHANGE: THE ROLE OF INTERNATIONAL LAW AND INSTITUTIONS (V. Nanda ed. 1983); C. TICKELL, CLIMATIC CHANGE AND WORLD AFFAIRS (rev. 1986); Gleick, *The Effects of Future Climatic Changes on International Water Resources: The Colorado River, The United States, and Mexico*, 21 POL'Y SCI. 23 (1988); Gleick, *supra* note 5.

8. An "equivalent" doubling of CO_2 refers to the amount of CO_2 and other trace gases (methane, CFCs, nitrous oxide, and so on) that has the same radiative effect as doubling CO_2 alone. An "equivalent doubling" of CO_2 will thus occur before the actual CO_2 concentration in the atmosphere doubles, because of the role of the other trace gases.

9. *Developing Policies for Responding to Climatic Change* (WMO/TD No. 225, April 1988) (summary of discussions and recommendations of the scientific workshops held in Villach, Austria, Sept. 28–Oct. 2, 1987, and in Bellagio, Italy, Nov. 9–13, 1987, sponsored by the World Meteorological

FIGURE 2. Three Scenarios of Average Global Temperature Response to Atmospheric Buildup of Greenhouse Gases.[a]



a. Projected temperatures are plotted as differences from 1985's average temperature. The middle curve reflects present emission trends (excepting limits on CFCs agreed to in the Montreal Protocol). There is a 50% chance that the actual curve of climatic change will lie above the middle curve.

climatic and geophysical effects, including changes in the intensity and duration of storms and a rise in sea level. New concerns have also been raised about the possibility of surprises—sudden abrupt shifts—in the way the oceans and atmosphere may respond to climatic perturbations.[10]

Numerous uncertainties remain about the nature, timing, magnitude, and regional details of climatic change because of the limitations of climate modeling. In light of these uncertainties, many political leaders and other government officials may prefer to wait for additional research and information on the environmental and economic impacts of global warming before taking action. This approach has two serious flaws. First, the complexity of climate modeling means that the necessary research will be slow and difficult. Yet, unless actions to prevent the most signifi-

Organization and the United Nations Environment Programme) [hereinafter *Responding to Climatic Change*].

10. Broecker, *Unpleasant Surprises in the Greenhouse?*, 328 NATURE 123 (1987).

cant climatic changes begin soon, Earth will be irreversibly committed to substantial warming. Second, any international agreement to prevent major changes in climate will be complicated by perceptions of regional advantages in the midst of larger-scale negative effects. Thus, those nations, international alliances, or even corporations who perceive themselves to be beneficiaries of a warmer Earth will have an incentive to be uncooperative, even if that perception turns out later to be wrong.

Any idea that there may be any "winners" must be scrutinized carefully, because this view helps drive policy actions and decisions. Research has identified both regional advantages and disadvantages of greenhouse warming, but these impacts are likely to be only the more easily identifiable changes; they may not include some of the most important consequences. Furthermore, any assessment of changes in climate is enormously complicated by the different measures used to evaluate such changes, and by the nonquantifiable nature of important ecological and societal disruptions. Given the limitations and difficulties inherent in climatic change research, perceptions of winners and losers are as likely to be wrong as right.

III. ROLES AND RESPONSIBILITIES OF DEVELOPED AND DEVELOPING COUNTRIES

Three characteristics of the greenhouse effect will complicate the development of solutions to the problem and add to conflicts and tensions: (1) industrialized countries are primarily responsible for the production of greenhouse gases; (2) the consequences of climatic change will be widely distributed among both developed and developing nations; and (3) the ability of different countries or regions of the world to adapt to climatic change varies widely due to different levels of economic development. These characteristics will play an important role in shaping national perceptions and international reactions to the problem.

A. International Responsibility for Climatic Change

Most greenhouse gases are produced in the industrialized world. The high percentage of CO_2 and chlorofluorocarbons (CFCs) produced by the major industrialized countries in the mid-1980s is seen in Table 1. Industrialized nations of the Northern Hemisphere are currently responsible for about 70 percent of the global production of CO_2. The United States alone is responsible for nearly 25 percent of all CO_2 production, and 20 to 30 percent of CFC production. When these data are combined with population data, the discrepancy between the industrialized and developing worlds becomes more apparent. Figure 3 plots per capita CO_2 production for many of the world's countries and regions. It shows the enormous discrepancy between the emissions from low-population, highly industrialized countries and those from regions of the world with very high populations and very low emissions.[11]

11. Rotty, *Estimates of Seasonal Variations in Fossil Fuel CO_2 Emissions*, 39B TELLUS 184 (1987); Rotty, *A Look at 1983 CO_2 Emissions From Fossil Fuel (with Preliminary Data for 1984)*, 39B TELLUS 203 (1987); I. MINTZER, A MATTER OF DEGREES: THE POTENTIAL FOR CONTROLLING THE GREENHOUSE EFFECT (1987).

TABLE 1. Percentages of World Production of Carbon Dioxide and Chlorofluorocarbons

	CO_2[a]	CFC–11[b]	CFC–12
United States	24	23	30
Western Europe & Canada	16	49	33
Japan, Australia & New Zealand	6	20	15
Soviet Union & Other CPEs[c]	26	6	19
All Others	28	2	3

a. These figures include CO_2 from fossil fuel combustion and industrial fuel use but do not include the contribution from biomass burning. Data from Rotty, *Estimates of Seasonal Variations in Fossil Fuel CO_2 Emissions*, 39B TELLUS 184 (1987); Rotty, *A Look at 1983 CO_2 Emissions From Fossil Fuel (with Preliminary Data for 1984)*, 39B TELLUS 203 (1987).
b. Data from I. MINTZER, A MATTER OF DEGREES: THE POTENTIAL FOR CONTROLLING THE GREENHOUSE EFFECT (1987)
c. Centrally planned economies.

B. The Consequences of Climate Change

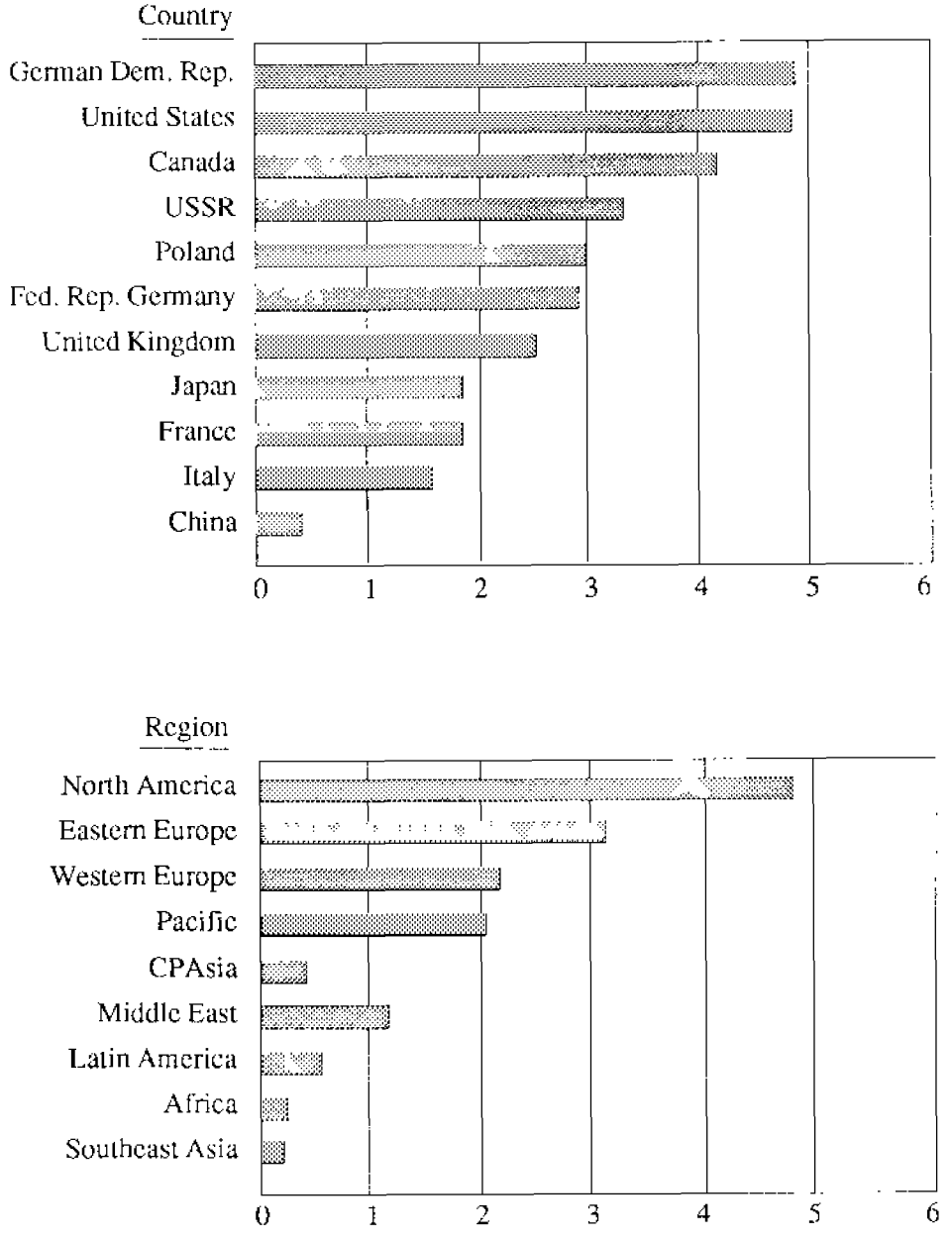
Although the industrialized nations bear the primary responsibility for the production of greenhouse gases, the consequences of climatic change will be worldwide and delayed in time. Among its victims will be those nations and generations least responsible for the production of these gases, least able to mitigate or adapt to the changes, and with little international economic or political clout. This equity problem will heighten international frictions and disputes.

Among the most important consequences for international security are effects on agricultural productivity and trade, the availability and quality of freshwater resources, access to energy resources, sea-level rise, and changes in ocean and ice conditions in the high latitudes. Changes in these areas will have implications for national and international relationships, behavior, and policy.

1. Agriculture. Threats to the basic food supplies of a country cause friction and tension between nations.[12] Such threats take the form of trade embargoes or other forms of political manipulation involving access to food, competition among conflicting land uses leading to loss of agricultural land, or environmental degradation

12. *See* Wallensteen, *Food Crops as a Factor in Strategic Policy and Action*, in ENVIRONMENTAL FACTORS, *supra* note 5, at 143; Gleick, *supra* note 5.

FIGURE 3. Carbon Dioxide Emissions by Country and Region, 1983 (in Metric Tonnes Carbon per Person)



such as loss of soil fertility. Scarcity is a fundamental condition for transmuting a resource into a political tool. Accordingly, a growing disparity in food needs and resources between the developing and the developed world may provide the basis for future conflict.

Food availability depends on a complex array of factors including patterns of production, purchasing ability, and the operation of food distribution systems. Many developing countries are acutely vulnerable to natural climatic variability that may cripple their own food production or substantially reduce the supply and raise the price of foodstuffs on the world market. Nonirrigated or rainfed agriculture is particularly sensitive to the vagaries of weather, especially the timing and length of the rainy seasons and the total amount of rain received. Conditions in many developing countries may grow more precarious under conditions of higher temperatures, changing rainfall patterns, and growing populations.

The consequences of global warming for large grain-producing regions are equally uncertain. As temperatures increase, agricultural production may be able to expand into northern regions of the United States, the Soviet Union, China, and Canada, yet such expansion is possible only if soil conditions, water availability, and other factors such as infrastructure permit. Output in regions that are currently productive, such as the central plains of the United States, and the Ukraine and Kazakhstan in the Soviet Union, could be reduced by higher temperatures and changes in water availability. Moreover, a near-term improvement in yield due to higher temperatures or greater water availability could be followed by a longer-term deterioration of yield as temperatures continue to rise or as beneficial rainfall patterns disappear.[13]

Analysis of the net effect of climatic change on food production is complicated by the difficulties of estimating the effect of changes in yields on world agricultural markets. Short-term reductions in yields are not necessarily bad for overall, long-term productivity and food availability. Confounding factors affecting national and international food stocks include the so-called comparative advantage—a combination of factors such as the size of food stocks and reserves, subsequent investments in other regions, planting patterns, international prices, and the character and mechanisms of joint international trading agreements.[14] Changes in these factors can often play a greater role in determining the degree of human suffering related to food availability than can absolute changes in agricultural productivity.

2. Water resources. There is a long history of international tensions related to freshwater resources.[15] Even in the absence of climatic change, pressures on existing

13. *See* THE IMPACT OF CLIMATIC VARIATIONS ON AGRICULTURE, VOL. 1: ASSESSMENTS IN COOL TEMPERATE AND COLD REGIONS (M. Parry, T. Carter & N. Konijn eds. 1987) [hereinafter IMPACT OF CLIMATIC VARIATIONS]; Pitovranov, Iakimets, Kiselev & Sirotenko, *Effects of Climatic Variations on Agriculture in the SubArctic Zone of the USSR*, in IMPACT OF CLIMATIC VARIATIONS.

14. *See, e.g.*, INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS, POLICY-ORIENTED IMPACT ASSESSMENT OF CLIMATIC VARIATIONS (R. Chen & M. Parry eds. 1987); Clark, *On the Practical Implications of the Carbon Dioxide Question*, International Institute for Applied Systems Analysis, WP-85-43 (1985).

15. *See* WATER IN THE MIDDLE EAST: CONFLICT OR COOPERATION? (T. Naff & C. Matson eds. 1984) [hereinafter WATER IN THE MIDDLE EAST]; Falkenmark, *Fresh Waters as a Factor in Strategic*

TABLE 2. River Basins Shared by Five or More Nations

River	Number of Countries	Area (km^2)
Danube	12	817,000
Niger	10	2,200,000
Nile	9	3,030,000
Zaire	9	3,720,000
Rhine	8	168,757
Zambezi	8	1,419,960
Amazon	7	5,870,000
Mekong	6	786,000
Lake Chand	6	1,910,000
Volta	6	379,000
Ganges-Brahmaputra	5	1,600,400
Elbe	5	144,500
La Plata	5	3,200,000

From: UNITED NATIONS CENTER FOR NATURAL RESOURCES, ENERGY AND TRANSPORT, REGISTER OF INTERNATIONAL RIVERS 3 (1978).

water resources are growing due to increases in population and development. Changes in precipitation brought about by climatic change will alter the availability of water and the frequency and intensity of droughts and floods; elevated temperatures will increase water evaporation from land and bodies of surface water; drier natural soil conditions may require a greater reliance on irrigation; sea-level rise will also alter water quality in freshwater aquifers.[16]

Where water resources are shared, existing international tensions related to water may be aggravated by climatic change. Large portions of the freshwater resources in the world are shared in areas such as international river basins or bodies of water bordering more than one country. Forty-seven percent of all land area on Earth falls within international river basins.[17] Over two hundred river basins are multinational, including fifty seven in Africa and forty-eight in Europe. Thirteen different major rivers with five or more nations forming part of the watershed are listed in Table 2. Regions with a history of international tensions or competition over water resources include the Jordan and Euphrates rivers in the Middle East, the Nile, Zambezi, and Niger rivers in Africa, the Ganges in Asia, and the Colorado

Policy and Action, in ENVIRONMENTAL FACTORS, *supra* note 5, at 85; Gleick, *supra* note 7.

16. *See generally* De Sylva, *Increased Storms and Estuary Salinity and Other Ecological Impacts of the Greenhouse Effect*, in 4 EFFECTS OF CHANGES IN STRATOSPHERIC OZONE AND GLOBAL CLIMATE [hereinafter EFFECTS OF CHANGES] 153 (J. Titus ed. 1986).

17. UNITED NATIONS CENTER FOR NATURAL RESOURCES, ENERGY AND TRANSPORT, REGISTER OF INTERNATIONAL RIVERS 3 (1978).

River and Río Grande in North America.[18] As demand grows, the probability of conflict over remaining water resources will increase. Institutional mechanisms for allocating shortages must be designed and agreed upon before climatic change begins to alter the hydrologic cycle. International water law, although immature in its development and application, must play a role.[19] By codifying these allocation schemes, mechanisms can be put into place to resolve water conflicts before they become acute.

3. Northern Energy Resources. Major energy resources, underlying Arctic continental and offshore regions, play a vital role in national economies and world economic markets. The willingness of policymakers to take steps to control climatic change will be affected by positive or negative changes in our ability to extract these resources. For example, changes in storm patterns and intensities will alter drilling and exploration expenses. Partial melting of the permafrost will make mineral exploitation more difficult. Conversely, climatic change may make oil and gas development in some parts of the region more accessible.

The oil and gas potential of the northern Arctic is great. Despite limited exploration, over 20 percent of the proved reserves of the United States are in Alaska; nearly 40 percent of Soviet proved reserves are in northern and western Siberia.[20] The Arctic proven reserves of the principal oil-producing countries of the region are shown in Table 3. Although access to northern oil and gas is already constrained by climate, cost, and technology, climatic changes are unlikely to prevent future development given the importance of these energy resources. Even today, the western Siberian oil fields produce about half of all Soviet oil,[21] and Alaskan oil provides 40 percent of US production. Future climatic changes may, however, have implications for the difficulty and expense of that production.

Although problems of access to northern energy resources do not directly affect developing countries, there are a number of indirect effects worthy of more-detailed analysis. In particular, how will world energy markets be affected by changed access to northern oil and gas? If exploiting these resources becomes easier, their cost will decrease and their use may increase. Perversely, this could further exacerbate the greenhouse effect by encouraging greater use of carbon-based fuels.

4. Sea-Level Rise. One of the most pressing direct effects of greenhouse warming will be rising sea-level caused by thermal expansion of the oceans and melting of glaciers and land ice. While this rise will most likely be incremental, the damage it

18. *See* WATER IN THE MIDDLE EAST, *supra* note 15.

19. *See generally Helsinki Rules on the Uses of the Waters of International Rivers*, in 52ND CONFERENCE OF THE INTERNATIONAL LAW ASSOCIATION 447 (1966); *Complementary Rules Applicable to International Water Reserves*, in 62ND CONFERENCE OF THE INTERNATIONAL LAW ASSOCIATION 275 (1986); Gleick, *supra* note 5.

20. *See* Garrett, *Conventional Hydrocarbons in the United States Arctic: An Industry Appraisal*, in UNITED STATES ARCTIC INTERESTS: THE 1980S AND 1990S 39 (W. Westermeyer & K. Shusterich eds. 1984); H. BERGESEN, A. MOE & W. OSTRENG, SOVIET OIL AND SECURITY INTERESTS IN THE BARENTS SEA (1987); BRITISH PETROLEUM COMPANY, BP STATISTICAL REVIEW OF WORLD ENERGY (1987).

21. Mote, *Environmental Constraints to the Economic Development of Siberia*, in SOVIET NATURAL RESOURCES IN THE WORLD ECONOMY 256 (R. Jensen, T. Shabad & A. Wright eds. 1983).

TABLE 3. Arctic Oil Reserves

	Arctic Proved Reserves (10^9 bbl)	National Proved Reserves (10^9 bbl)	Arctic Proved Reserves as a Percentage of National Reserves
United States	7	33	21
Soviet Union	22	59	37
Canada	1–2	8	12–24
Norway	a	11	a

a. Accurate Norwegian oil reserves data are unavailable, but estimates range between 100 and 300 million tonnes (or 0.7 to 2 billion barrels).

Data from Garrett, *Conventional Hydrocarbons in the United States Arctic: An Industry Appraisal*, in UNITED STATES ARCTIC INTERESTS: THE 1980S AND 1990S 39 (W. Westermeyer & K. Shusterich eds. 1984); H. BERGESEN, A. MOE & W. OSTRENG, SOVIET OIL AND SECURITY INTERESTS IN THE BARENTS SEA (1987); BRITISH PETROLEUM COMPANY, BP STATISTICAL REVIEW OF WORLD ENERGY (1987).

causes will occur during specific events such as storm surges that accompany hurricanes or typhoons. The impacts of this rise will vary depending on the geophysical characteristics of the region; nevertheless, some observations can be made about the differences between developing and developed countries.

Sea-level rise will be severely felt in coastal and deltaic areas, especially in regions where rivers are large and deltas heavily populated. It will cause particular problems for coastal populations and agricultural developments in developing countries. The highly populated coastal plains of India and Bangladesh, for example, are already extremely susceptible to storms. Since 1960, these nations have been struck by at least eight tropical cyclones that each killed more than 10,000 people (see Table 4).[22] In late 1970, storm surges killed approximately 300,000 people in Bangladesh, reaching over 150 kilometers inland over deltaic lowlands. Recent estimates show that a one-meter sea-level rise would cover land occupied by nearly 10 percent of Bangladesh's population.[23] Similar effects would be felt in many coastal nations throughout the world.

One suggested response to the problem of sea-level rise—population migration—offers a way of reducing human vulnerability in some areas such as the deltas

22. *See Responding to Climate Change, supra* note 9.

23. Broadus, Milliman, Edwards, Aubrey & Gable, *Rising Sea Level and Damming of Rivers: Possible Effects in Egypt and Bangladesh*, in 4 EFFECTS OF CHANGES, *supra* note 16, at 165.

TABLE 4. Major Storm Disasters in Coastal / Delta Regions

	Location	Estimated Death Toll
1963	Bangladesh	22,000
1965	Bangladesh	17,000
1965	Bangladesh	30,000
1965	Bangladesh	10,000
1970	Bangladesh	250,000–500,000
1971	India	10,000–25,000
1977	India	10,000
1985	Bangladesh	10,000

From World Climate Programme, World Meteorological Organization, Developing Policies for Responding to Climatic Change WMO / TD-No. 225 (Apr. 1988).

of Bangladesh, but the societal costs of relocating and absorbing these environmental refugees would be extremely high. Another remedy is to protect coastal cities and industrial sites by building structures to protect against rising seas. In the Netherlands, for example, over half the country would be uninhabitable if not protected against the sea.[24] Approximately 8 million people now living behind dikes and levees on land below sea level would be displaced. In the United States, a mixed strategy of abandonment and protection is being considered by the US Environmental Protection Agency, with attention being given almost exclusively to threats to cities.[25]

5. *Arctic and Antarctic oceans and ice conditions.* Conditions in the Arctic and Antarctic are beginning to play an important role in both strategic and commercial policy decisions. Questions about access to Antarctic mineral resources have re-emerged with the thirtieth anniversary of the Antarctic Treaty of 1959[26] and as capabilities for mineral extraction under severe conditions improve. Despite years of discussion, no treaty to regulate or prohibit the exploitation of Antarctic mineral resources has been completed. As climatic conditions begin to alter extraction

24. *See* Goemans, *The Sea Also Rises: The Ongoing Dialogue of the Dutch with the Sea*, in 4 EFFECTS OF CHANGES, *supra* note 16, at 47.

25. *See* U.S. ENVIRONMENTAL PROTECTION AGENCY, THE POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON THE UNITED STATES FINAL REPORT TO CONGRESS (1989).

26. Antarctic Treaty, Dec. 1, 1959, 12 U.S.T. 794, T.I.A.S. No. 4780, 402 U.N.T.S. 71, *reprinted in* 19 I.L.M. 860 (1980).

conditions in the higher latitudes, disputes could become more prevalent; especially in light of numerous unresolved claims of sovereignty over the Antarctic.

In the Arctic, commercial sea routes in the Northeast Passage are kept open at considerable expense by icebreakers. As the world warms, the Arctic could become ice-free for a large part of the year. The implications of this for commercial trade are unclear, but one important consequence could be the reliable opening of the Northeast Passage over the Soviet Union and the possible opening of a satisfactory Northwest Passage over Canada.

Changes in the Arctic may also have implications for the military balance between Northern Hemisphere superpowers. The United States and Soviet Union consider the area to be of strategic importance,[27] yet activities there are severely hindered by environmental conditions. This ice-covered region provides cover for the actions of nuclear-powered submarines of both nations, over the occasional objections of the other bordering nations–particularly Canada. While it is difficult to predict the importance of strategic submarines or superpower relations in twenty-five to forty years, the possibility of much less severe ice conditions in the Arctic could have important security ramifications.

C. The Ability to Cope with Climatic Change

Developed and developing countries differ in their ability to prevent or respond to climatic change. Unfortunately, the consequences of global warming may be most severely felt by developing nations that are the least able to adapt to the problem. For these nations, prompt preventive measures are strongly preferred, yet the burden of prevention rests with the industrialized countries that bear the greatest responsibility for the production of greenhouse gases. These nations are likely to lean toward adaptation rather than prevention because of the high costs of changing patterns of energy use. One risk of relying on adaptation, of course, is that unexpectedly severe or rapid changes may overwhelm the ability to adapt, or that there are thresholds in societal capabilities for adaptation.[28] For these reasons, reliance solely on adaptation may produce the greatest long-run costs to society.

In the absence of prompt and severe changes in climatic conditions associated with greenhouse gases,[29] industrialized nations are likely to prefer a wait-and-see strategy, which produces the fewest near-term costs to society. This was borne out at a 1989 conference in the Netherlands at which the United States, the Soviet Union, and Japan called for a delay in implementing measures to curb greenhouse gas emissions in the face of strong support for such measures from developing countries.[30] Developing countries with limited resources for responding to major changes

27. Johnson, Bradley & Winokur, *United States Security Interests in the Arctic*, in UNITED STATES ARCTIC INTERESTS, *supra* note 20, at 268.

28. Clark, *supra* note 14.

29. This is contrasted with the prompt action that accompanied the sudden appearance of the ozone hole over the Antarctic. Within a few years of the discovery, the Montreal Protocol was enacted. *See* Montreal Protocol on Substances that Deplete the Ozone Layer, Sept. 16, 1987, *reprinted in* 26 I.L.M. 1550 (1987) [hereinafter Montreal Protocol].

30. L.A. Times, Nov. 8, 1989, § A, at 1, col. 5; N.Y. Times, Nov. 8, 1989, § A, at 8, col. 3 (national ed.); Wash. Post, Nov. 8, 1989, § A, at 33, col. 1.

in climate have the most to gain by forcing the industrialized world to cut back on greenhouse gas production.

A further impediment to short-term solutions may be a desire of certain actors to capitalize on perceived regional advantages of climatic change. Those who believe–rightly or wrongly–that they will benefit from a warmer Earth will have no direct incentive to cooperate in any international agreement to prevent climatic change. If these actors are among those most responsible for greenhouse gas production and hence most able to affect the outcome–they may implicitly force others into a strategy of adaptation.

IV. CONCLUSION

Of all the large-scale environmental problems facing society, global climatic change has the greatest potential for provoking disputes, worsening tensions, and altering international relations. The direct consequences of global warming–changes in precipitation and storm patterns, and rising sea level–will be felt throughout the world. These effects will stimulate widespread indirect consequences for scarce resources that are critical to human survival and prosperity, including food, water, and energy. These changes in resource availability will have implications for international relations and security.

A disproportionate share of the responsibility for climatic change lies with the industrialized nations, yet its consequences will be distributed among developed and developing nations, posing important and still unresolved questions of equity and fairness. With few exceptions, developing countries–those least responsible for the production of greenhouse gases–are least able to adapt to severe consequences of climatic change. Thus these nations may prefer solutions involving prevention. Conversely, developed nations–those most responsible for the problem–are likely to prefer adaptive strategies because preventive measures may require drastic alterations in industrial infrastructures and patterns of energy use. This fundamental dichotomy of interests and preferences is likely to lead to international disputes unless methods can be found to share more equitably the costs of climatic change and prevention.

Although some climatic change appears inevitable, several solutions are available. Preventing or slowing climatic change can be accomplished through increased energy efficiency, greater use of non-fossil fuel energy sources, reforestation, controls on other greenhouse gases, and the sequestering of CO_2 away from the atmosphere. The most severe consequences can be mitigated through grain storage, water conservation, and new water resource systems. Adaptation through population migration, land abandonment, modifications in agricultural practices, and selective protection of coastal property is also an alternative. The actual international response to the problem is likely to include a mix of these options.

Political responses to climatic change will be shaped by perceptions of the severity of the problem and the resources available for responding. Unilateral actions can be taken by countries that are major producers of greenhouse gases and by those nations that may be most severely affected by climatic change. Options

available to these nations include increasing the robustness of agricultural and water resource systems to ease existing flood and water problems, while helping to prepare for problems caused by climatic change. Increasing energy efficiency would also reduce the economic, political, and environmental costs of energy use while slowing CO_2 emissions. Restrictions on ozone-destroying chemicals would help protect human health and slow the rate of climatic change.

A coordinated response on the part of the industrialized world in the form of a comprehensive international agreement would be most effective. Protocols such as those developed for protecting the ozone layer,[31] or the Law of the Sea,[32] might provide useful models for such an agreement. Although providing the most effective response, these actions would also be the most difficult to negotiate and implement.

There are no simple solutions to the problem of large-scale climatic change. Nevertheless, even slowing the rate of change by slowing the rate of production of the major trace gases can provide considerable "breathing room" to allow us both to improve our understanding of climatic change and to reflect on equitable international responses.

31. Montreal Protocol, *supra* note 29.

32. United Nations Convention on the Law of the Sea, Oct. 21, 1982, U.N. Doc. A/CONF.62/122 (1981), *reprinted in* 21 I.L.M. 1261 (1982) (*opened for signature* Dec. 10, 1982).