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Climate Change and International Politics: Problems Facing Developing Countries

Global climate changes caused by human activities have the potential to alter agricultural productivity, freshwater availability and quality, sea level, and many other factors of importance to society. Although the principal responsibility for the production of greenhouse gases lies with the industrialized countries, some of the worst impacts will fall on developing countries least able to prevent or adapt to the changes. This characteristic, together with the long history of political frictions and disputes worsened by environmental stresses suggests that global climatic changes have the potential to exacerbate existing international tensions. Severe risks facing developing nations from rapid climatic changes are discussed here together with actions that both the industrialized and developing world can take to prevent or mitigate the worst effects. The world is already committed to some climatic changes because of gases emitted over the last century. Slowing the rate of future change can increase the time available to understand and prevent the worst impacts and reduce the risks of international disputes and conflicts.

INTRODUCTION

For nearly two decades since the landmark 1972 United Nations Conference on the Human Environment in Stockholm, Sweden, the principal environmental worries facing most nations have concerned air and water quality, soil conservation, and adequate food supplies. Although some environmental progress has been made in recent years, notably in improving air and water quality in industrialized nations, enormous problems remain to be solved. In particular, environmental deterioration in developing countries continues at an alarming rate.

Equally alarming, new large-scale environmental problems have appeared that threaten to aggravate international relations, behavior, and security. These problems include acid precipitation, Arctic haze, the depletion of stratospheric ozone, species extinction, and global warming. Unlike previous concerns about 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. As a result, finding satisfactory solutions will be especially difficult.

The issue of global climatic change, the so-called "greenhouse effect," epitomizes these concerns. With the exception of the consequences of nuclear war, no other environmental problem has the scope or the potential for such widespread societal impacts. Recently, analysts and policy-makers have begun to express concern about the international implications of climatic changes. In 1987, the World Commission on Environment and Development (WCED) stated:

"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." (1).

Similarly, the Toronto Conference on the Changing Atmosphere concluded in June 1988:

"The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil-fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security... The best predictions available indicate potentially severe economic and social dislocation for present and future generations, which will worsen international tensions and increase risk of conflict between and within nations." (2).

Other signs that the issue of greenhouse warming has reached the international political agenda can be seen through statements by General Secretary Gorbachev, Prime Minister Brundtland, Prime Minister Mulroney, President Reagan, and President Bush and members of his cabinet (3).

Climatic change will affect more than just traditional East-West concerns. Indeed, while the principal responsibility for the production of greenhouse gases lies with the industrialized countries, some of the worst societal impacts will fall on developing countries. This discrepancy has the potential to worsen existing tensions and to raise new disputes between industrialized and developing nations and between poorer nations themselves. This article identifies severe risks facing both developed and developing nations from rapid climatic change and proposes actions to prevent or mitigate the worst international frictions that may arise. If nations act today to slow the rate of climatic change, it may be possible to increase the time available to understand and prevent the worst impacts, and to reduce the possibility of international disputes and conflicts.

THE ROLE OF THE ENVIRONMENT IN INTERNATIONAL DISPUTES AND CONFLICTS

Environmental stresses are both a cause and a consequence of political tensions and international disputes (4–7). Many factors affect the connections between environmental stress, poverty, and security, including inappropriate development policies, resource constraints, population pressures, and economic inequities. Although the links are complex and poorly understood, it is widely acknowledged that resource constraints or environmental degradation can lead to conflict when other pressures and tensions exist between states. In this way, resources act as *triggers* (e.g. Middle East oil), as *tools* (e.g. weapons links to energy, financing, access to materials), as *consequences* (e.g. targeting of dams, nuclear reactors, or oil fields), and as *roots* (e.g. economic competition, pressures, and tensions) of conflict (8).

Among all the major environmental threats, global climatic change appears to be the most likely to affect international politics because of its wide scope and magnitude. Climatic changes may cause either a direct shortage of a resource such as

Figure 1. Environmental routes to conflict. This diagram shows the relationship between global climatic changes, 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 exist between states.

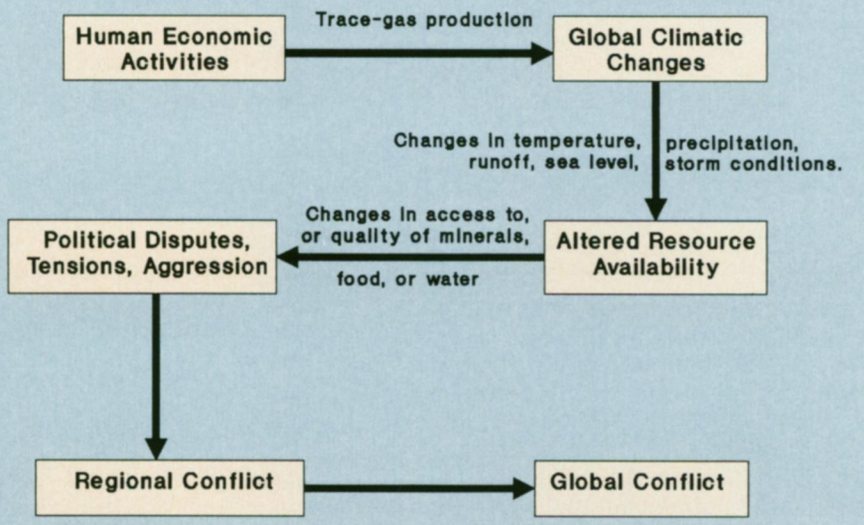
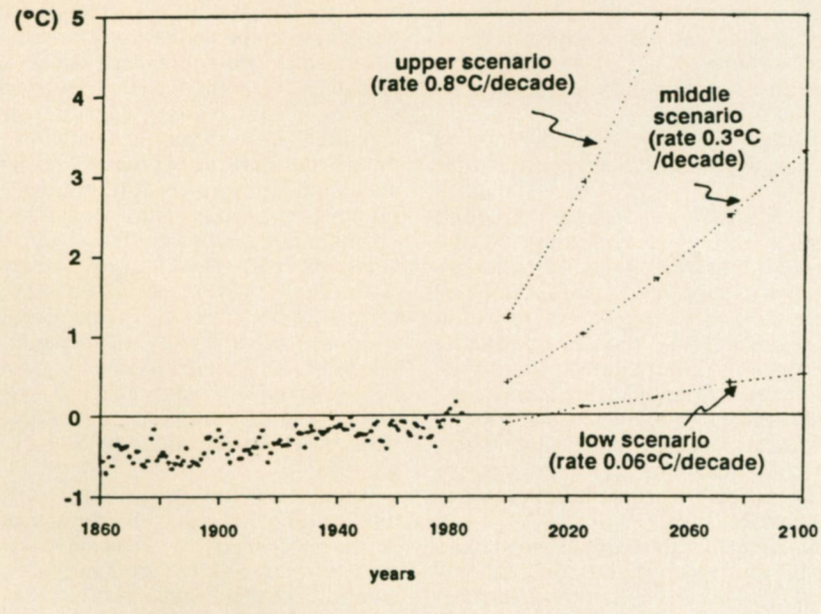


Figure 2. Three scenarios of global average temperature that might develop in response to growing atmospheric concentrations of greenhouse gases, plotted as differences from the average 1985 temperature. The middle scenario reflects present emission trends (except for limits on chlorofluorocarbons as agreed to in the Montreal Protocol). There is a 50% chance that the actual path of climatic change could lie above the middle curve. In the judgement of WMO (1988)[26] there is a 90% chance that the actual future temperature rise will lie between the upper and lower curves.



water or food, or they may lead to the degradation of resources held either in common or exclusively (9–12). In the first case, disputes and conflicts may arise through competition for a limited resource, by the perception that competition may arise for that resource, or by threats of action. In the second case, resource degradation may provoke a reaction by the holder of that resource or may lead to political or economic exploitation. These effects will have consequences for international relationships, behavior, and policy (3, 6, 13). Figure 1 shows the path by which global climatic changes, or other large-scale environmental problems can affect international politics and, ultimately, international security.

FUTURE CLIMATE: WHAT DO WE KNOW?

Atmospheric concentrations of carbon dioxide and other trace gases are increasing as a result of the combustion of fossil fuels, other industrial activities, and deforestation. These gases retain heat in the atmosphere that would otherwise be reradiated into space, thus raising the temperature of the Earth and altering major climatic patterns. State-of-the-art climate studies estimate that global average temperatures will increase between 2 and 5°C with an equivalent doubling of the atmospheric carbon dioxide concentration (14), a concentration that will be reached in the first half of the next century given present rates of fossil-fuel use and deforestation. In the fall of 1987, climate scientists and policy-makers met in Villach, Austria under the auspices of the Beijer Institute, the World Climate Programme of the World Meteorological Organization (WMO), the United Nations Environment Programme, and several other organizations to discuss plausible future climatic impacts and possible policy responses. Figure 2, from the final report of that meeting, shows the likely future trend of global average temperature together with the temperature record for the past 125 years.

The expected rise in temperature will be accompanied by many other climatic and geophysical effects, including changes in precipitation patterns, changes in the frequency and intensity of storms, and a rise in sea level due to both thermal expansion of the oceans and melting of land ice. Concerns have also been raised about the possibility of surprises—sudden abrupt shifts—in the way the oceans and atmosphere may respond to climate perturbations (15). State-of-the-art climate models can neither predict such surprises, nor rule out the possibility that they will occur.

Considerable uncertainties remain about the nature, timing, magnitude, and regional details of climatic changes. Although we could wait for more research and more detailed information on the environmental and economic impacts of climatic changes before taking actions, this approach has two serious flaws. First, the complexity of climate modelling means that the necessary research will be slow and difficult. Yet any delay in slowing the emissions of greenhouse gases commits the earth to greater

and greater climatic changes. Second, any international agreement to prevent major climatic change may be complicated by a desire of certain actors (countries, subnational groups, corporations, alliances) to capitalize on perceived regional advantages in the midst of larger-scale negative effects. Those actors who perceive themselves to be beneficiaries of a warmer earth—even if that perception turns out later to be wrong—may choose not to cooperate in international negotiations to address the issue of climatic change.

More recently, attention has begun to focus on the rate of climatic change. In 1987, the Villach and Bellagio climate conferees concluded that slowing the rate at which temperature and sea level will rise is as important for preventing severe societal and ecological disruptions as is an absolute limit on climatic changes. This focus arises because of constraints on the ability of natural and societal systems to adapt. Of particular concern are limits to how quickly natural ecosystems can respond to climatic changes. Inland migration of wetlands is limited by sedimentation rates; upward growth of coral reef islands cannot exceed rates defined by temperature, tidal action, and nutrient availability; forest and plant communities move at rates constrained by soil conditions, water availability, and vegetation succession dynamics. Because of these concerns, attention is now turning to identifying critical rates of change in order to set long-term environmental targets that may have some use as regulatory guides. Such targets could be supplemented with absolute limits to climatic change, since unlimited warming must eventually be prevented.

DEVELOPED AND DEVELOPING COUNTRIES: VULNERABILITIES AND RESPONSIBILITIES

Future tensions over climate changes are likely to result from changes in superpower relations (East-West concerns) and from disparities between developed and developing countries (North-South concerns). Several fundamental factors suggest strongly that North-South tensions will be the most problematic. First, the industrialized countries are primarily responsible for the production of greenhouse gases. Second, the consequences of climatic changes will be far more widely distributed among both rich and poor countries. And third, developing countries have far fewer technical and economic resources at their disposal for adapting to or mitigating the impacts of climatic changes than do the industrialized nations.

The industrialized world is primarily responsible for the production of greenhouse gases. Figures 3 and 4 and Table 1 show that the industrialized countries of the Northern Hemisphere are presently responsible for about 70% of the global production of carbon dioxide and nearly all chlorofluorocarbon production, while having only 25% of the world's population. Although rapid population growth in developing countries will lead to large increases in energy use, this disparity in per-capita production of greenhouse gases

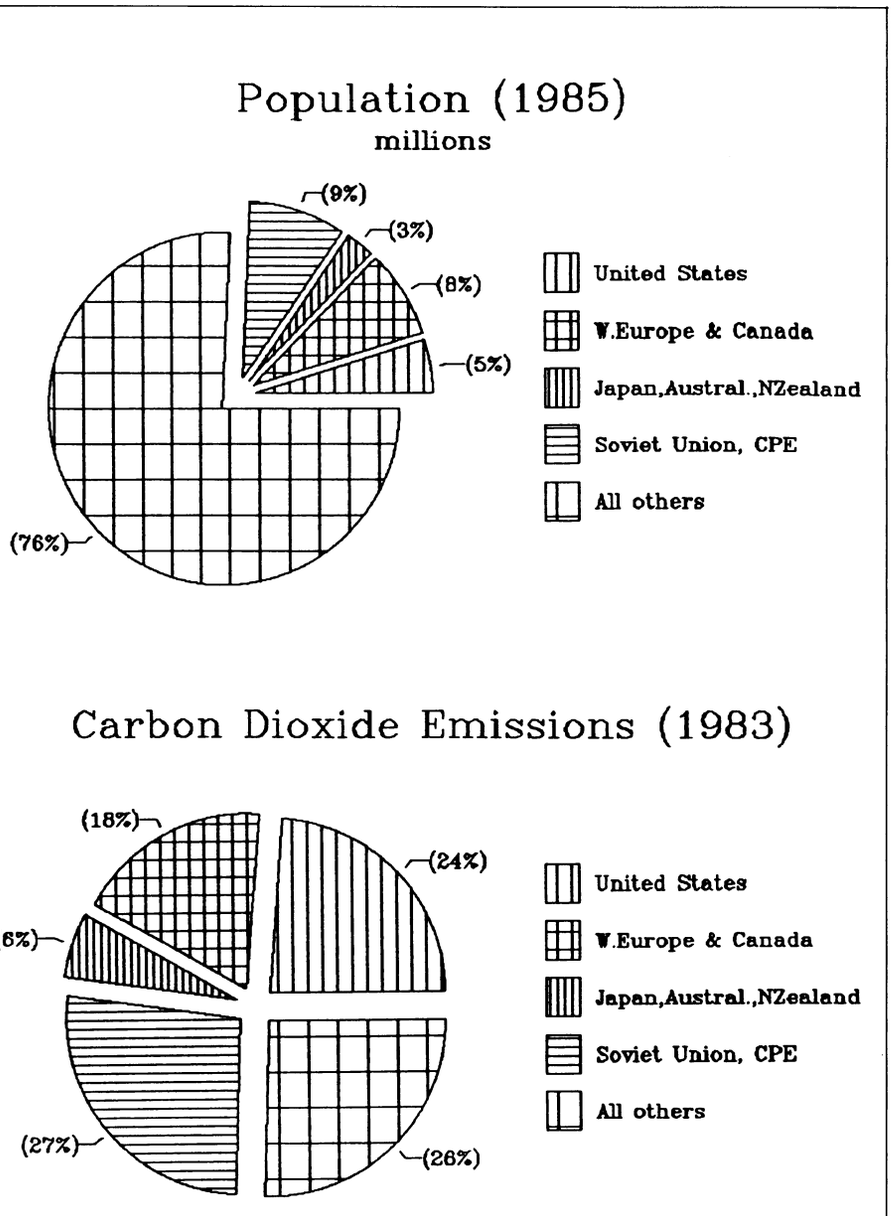


Figure 3a. Distribution of 1985 population by country and region. Note the low population of the industrialized countries, which make up only 25% of global population.

Figure 3b. Distribution of 1983 carbon dioxide emissions by country and region. The industrialized countries are responsible for nearly 75% of global carbon production. Although this may decrease as developing countries increase their energy use, the principal responsibility for greenhouse gas emissions will rest with the industrialized nations for a long time.

Table 1. Percentage of world production of carbon dioxide and chlorofluorocarbons (CFCs) (32–34).

	CO_2*	CFC-11	CFC-12
United States	24	23	30
Western Europe & Canada	16	49	33
Japan, Australia, New Zealand	6	20	15
Soviet Union and other CPEs	26	6	19
All others	28	2	3

* These figures include carbon dioxide from fossil fuel combustion and industrial fuel use, but do not include the contribution from biomass burning.

CPEs: Centrally-planned economies.

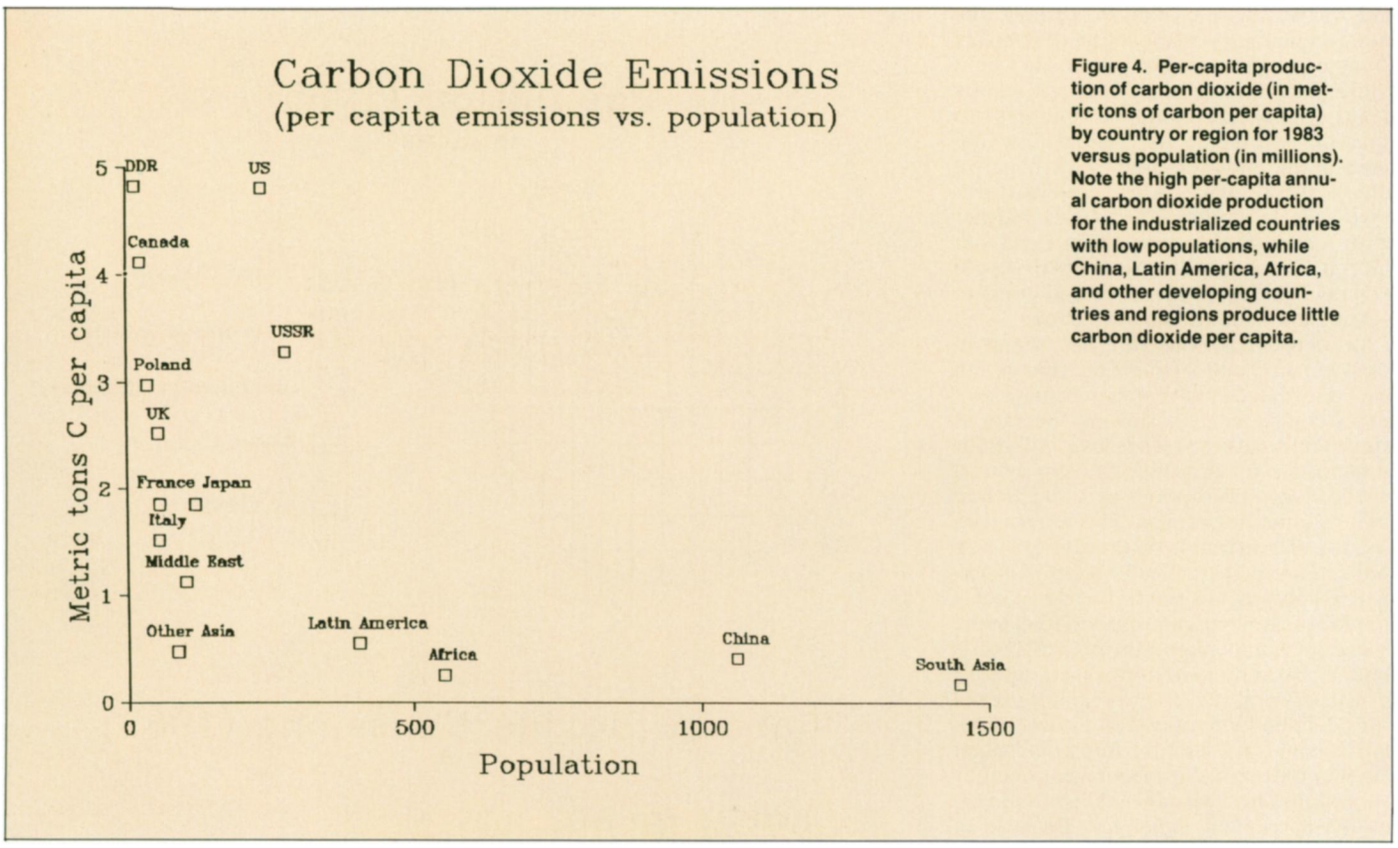


Figure 4. Per-capita production of carbon dioxide (in metric tons of carbon per capita) by country or region for 1983 versus population (in millions). Note the high per-capita annual carbon dioxide production for the industrialized countries with low populations, while China, Latin America, Africa, and other developing countries and regions produce little carbon dioxide per capita.

(shown in Fig. 4 for carbon dioxide) is likely to persist for a long time.

Unlike the distribution of responsibility for greenhouse gases, the distribution of impacts from greenhouse warming will be global in extent and delayed in time. Among the victims of climatic change will be those nations, and generations, least responsible for the production of greenhouse gases, least able to either adapt to or mitigate the changes, and with little international economic or political clout. Developing countries are particularly vulnerable to disruptions in the availability and quality of freshwater resources, changes in agricultural productivity and trade, and sea-level rise. Each of these problems is discussed briefly below.

Table 2. Rivers with five or more nations forming part of the Basin (19).

	#	Watershed Area (km²)
Danube	12	817 000
Niger	10	2 200 000
Nile	9	3 030 700
Zaire	9	3 720 000
Rhine	8	168 757
Zambezi	8	1 419 960
Amazon	7	5 870 000
Mekong	6	786 000
Lake Chad	6	1 910 000
Volta	6	379 000
Ganges-Brahmaputra	5	1 600 400
Elbe	5	144 500
La Plata	5	3 200 000

Water Resources

Historically, international political friction and tensions have arisen over the control of, access to, or the quality of freshwater resources (6, 13, 16, 17). Even in the absence of climatic changes, pressures on existing water resources are growing due to increases in population, industrial water demand, and development. As these pressures grow, the probability of conflict over remaining water resources will also increase.

Greenhouse climate changes will have extensive effects on both water availability and water quality (18). Rising temperatures will increase the demand for water for urban and agricultural uses, and elevated temperatures will alter snowfall and snowmelt patterns. Changes in precipitation patterns will affect the timing and availability of freshwater runoff, increasing flood risks in some regions and drought frequencies and intensities in other regions. Warmer waters and altered flows could worsen existing water-quality problems. And the hydrological changes anticipated will greatly complicate operating and managing our present system of aqueducts, reservoirs, and dams, which were designed for past climatic conditions, not future ones. In regions where water resources are widely shared, these physical effects will have important political implications.

Freshwater resources are often shared by two or more nations. Nearly 50 countries on four continents have more than three-quarters of their total land area falling within international river basins, while globally 47% of all land area falls within international river basins (19). Over 200 river basins are multinational, including 57 in Africa and 48 in Europe. Table 2 lists thirteen major rivers with five or more nations forming part of the watershed, although conflicts may occur when rivers are shared by only two countries. Regions with a history of international tension 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 and Rio Grande rivers in North America.

One measure of the greater risks facing developing countries is the extent to which they share freshwater resources. Of the thirteen river basins in Table 2, ten are shared mostly by developing nations. Indeed, many of the wealthier nations, like the US, Canada, the Soviet Union, Australia, New Zealand, and Japan have few or no shared river basins due to their size, location, or geography.

Climate-induced water-resources problems may be particularly severe in arid and semiarid regions, where water is already in short supply. Developing countries predominate in these regions. One measure for evaluating this vulnerability is per-capita water supply—the amount of reliable streamflow available per person. There have been several attempts to define these terms more precisely. Falkenmark (20), for example, discusses relative levels of "water competition" as the number of people that must be supplied per million cubic meters of water per year. Using her definition, problems of absolute water scarcity tend to arise when this value rises

above 1000 (i.e. 1000 people per million cubic meters per year). Another measure of water availability is "per-capita water availability". Table 3 lists the per-capita water availability of selected countries either dominated by international river basins or with existing tensions over shared water resources. Countries with low per-capita water availability are especially vulnerable to droughts, growing demand, and international competition for limited supplies. A third measure is the ratio of consumptive use to available supply (21). Where consumptive use is high relative to supply, annual or seasonal shortages are likely to be felt. While no single index can satisfactorily describe all hydrological vulnerabilities, such indices can help to identify regional or national sensitivities.

Another factor that highlights the vulnerability of developing countries to changes in water resources is their relative lack of facilities such as flood-control dams or water-supply reservoirs. Floods and droughts are mitigated by controlling excessive flows or storing water for extended dry periods. Most facilities for these purposes, however, are found in developed countries able to afford the large costs necessary to construct and operate them. While climatic change may well change the frequency and severity of floods and droughts, and hence the design and operating requirements of major reservoirs, countries with no or little physical water-resource infrastructure will be more vulnerable to adverse hydrologic events than industrialized nations.

Agriculture

Threats to food supplies and agricultural systems have been cause for past frictions and tensions between nations and may be cause for future problems as population growth puts increasing pressures on food production (6, 22). Mechanisms for such threats include trade embargoes, political manipulation of access to food, environmental degradation such as loss of soil fertility, or competition among conflicting land uses. The disparity in food needs and food resources between the developing and the developed world has long hinted at the possibility of future conflict over access to food resources.

Many countries are already acutely vulnerable to natural climatic variability that may cripple food production, reduce supplies, or raise the price of foodstuffs on the world market. Rainfed agriculture, the principal form of agriculture in many developing countries, is particularly sensitive to the vagaries of weather, especially the timing and length of the rainy season, the total amount of rain received, and the pattern and severity of storms. Rainfed arid and semiarid lands support nearly one billion people (1). These lands remain largely underdeveloped and agricultural investment is low. Rainfall in these regions is highly variable and unpredictable on both a seasonal and annual basis—indeed, some blame the recent decline in food production in Africa on recent, persistent adverse drought conditions exacerbated by development pressures (23). As global temperatures begin to increase and rainfall patterns begin to change, the food situation in these areas is likely to grow more precarious. At all latitudes, the most severe agricultural impacts may be located in marginal areas, although we know little about how climate will change in these areas (24).

Analysis of the net effect (both regionally and globally) of climatic changes on food production is greatly complicated by two factors: (i) the difficulty of estimating how climatic changes and higher CO_2 concentrations will affect yields; and (ii) the difficulty of estimating the effect of changes in yields on world agricultural markets. Food availability depends on a complex array of physical and institutional factors, including patterns and productivity of planting and harvesting, purchasing ability of nations, and the operation of food-distribution systems. Short-term reductions in yields alone are not necessarily bad for overall long-term productivity and food availability. Confounding factors include the size of stocks, subsequent investments in other regions, planting patterns, international prices, and the character and mechanisms of trading agreements (25, 26). Thus, changes in the comparative advantage of different international actors can play a greater role than absolute changes in agricultural productivity. The advantage, however, typically accrues to rich industrialized nations.

Sea-Level Rise

Rising sea-level due to both thermal expansion of the oceans and melting of glaciers and land ice will have severe direct effects on coastal nations. While the rise in sea-level will most likely be incremental, the damages caused by this rise will occur during extreme events such as storm surges, hurricanes, and typhoons.

Some observations can be made about the differences in vulnerability to sea-level rise of developing and developed countries. Most major cities in both developed

Table 3. Per-capita water availability in selected countries dominated by international river basins (35–37).

Country	10^3 m^3 per year per person*	Land area in international river basins (%)**
High Water Availability		
Bangladesh	12.1	86
Brazil	35.2	61
Burma	27.0	73
Cameroon	18.8	65
Colombia	34.3	64
Ecuador	29.9	51
Guatemala	13.0	54
Kampuchea	10.9	87
Lao People's Dem	59.5	94
Nepal	9.4	100
Venezuela	44.5	80
Low Water Availability		
Afghanistan	2.5	91
Belgium	<1	96
Botswana	0.8	68
Bulgaria	2.0	79
Czechoslovakia	1.8	100
Egypt**	<1	30
Ethiopia	2.3	80
Germany (Dem Rep.)	1.0	93
Germany (FRG)	1.3	88
Ghana	3.4	75
Hungary	0.6	100
India**	2.3	<30
Iraq	1.9	83
Israel**	0.4	6
Jordan**	0.2	6
Kenya	0.6	64
Luxembourg	2.8	100
Pakistan	2.7	>75
Peru	1.8	78
Poland	1.3	95
Portugal	3.3	56
Romania	1.6	98
Spain	2.8	57
Sudan	1.2	81
South Africa	1.4	66
Syria	0.6	72
Togo	3.4	77

* Data are for internally available renewable water resources. Some of the largest developed countries, such as the Soviet Union, Japan, Australia, New Zealand, Canada, and the United States have few or no internationally-shared rivers.

** Note that some regions with tensions over water may have only small areas that are in international basins, for example, Israel and Jordan (the Jordan River). India and Egypt are other examples. Some developed countries, such as the Federal Republic of Germany, Israel, and Belgium, have very low per-capita water availability, while some developing countries, such as Nicaragua, Ecuador, and Indonesia have high per-capita water availability. A realistic assessment of water availability must consider total water supplies, timing of water availability, quality, location, and political allocations.

Table 4. Major storm disasters in South Asian Coastal/Delta regions (38).

Year	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

and developing countries will be protected from sea-level rise, but at great expense. In developing countries, however, sea-level rise will be most severely felt by exposed coastal populations and by agricultural developments in deltaic areas. Three highly-populated developing countries, India, Bangladesh, and Egypt, are thought to be especially vulnerable because their low-lying coastal plains are already extremely vulnerable to storms. Since 1960, India and Bangladesh have been struck by at least eight tropical cyclones that each killed more than 10 000 people (see Table 4). In late 1970, storm surges killed approximately 300 000 people in Bangladesh and reached over 150 kilometers inland over the lowlands. Recent estimates suggest that a climatically-induced one-meter sea-level rise would cover scarce arable land in Egypt and Bangladesh presently occupied by 8 and 10 million people, respectively (27). A far greater fraction of the population of these countries would be threatened by the increased consequences of storms.

River deltas are also vulnerable to the activities of upstream states. Activities by India, Nepal, China, and Bhutan, for example, all affect the flow characteristics of the Ganges, which is felt downstream by Bangladesh. Disputes already exist between India and Bangladesh over the construction of dams on the Ganges, over the use of major upstream tributaries, and over river diversions (28). Upstream activities can affect both water availability in Bangladesh and the formation and ecology of the delta, which offers some protection from storm surges and sea-level rise. One solution—population migration away from the most threatened areas—offers a way of reducing human vulnerability, but at the high societal and political cost of relocation and absorption of those displaced.

The Ability to Respond or Adapt to Climatic Impacts

There is a fundamental discrepancy between the ability of developed and developing countries to adapt or respond to the impacts of climatic change. Adaption requires resources for building new infrastructure such as reservoirs and dams, levees and dikes, and aqueducts. It requires additional land onto which agricultural production can be extended or threatened populations can be moved. And it requires scientific assessments of what the most severe impacts will be and when and where they will appear.

In the absence of definitive advance evidence for prompt and severe climatic impacts, industrialized nations are likely to prefer the "wait and see" strategy of adaptation, which produces the fewest near-term costs. One risk of this strategy, of course, is that unexpectedly severe or rapid impacts may overwhelm a nation's ability to adapt, or that there are thresholds or nonlinearities in societal capabilities for adaptation (25).

Developing countries, however, have the most to gain by trying to force greenhouse gas producers to cut back on emissions. They have limited resources for responding to major climatic impacts and have fewer responsibilities for greenhouse gas emissions. Recently, the developing nations have begun to argue forcefully that the burden for prevention should rest with those industrialized countries that bear the greatest responsibility for the production of greenhouse gases (29, 30).

A further complication may be a desire of certain actors to capitalize on perceived regional advantages of climatic changes. 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—others may be forced into an adaptation strategy.

DISCUSSION

Of all the pressing large-scale environmental problems facing society, global climatic changes appear to have the greatest potential for provoking disputes, worsening tensions, and altering international relations between developed and developing countries. Two routes to conflict can be identified. First, the climatic changes associated with global warming will affect freshwater availability and quality, food productivity, and access to other resources, goods, and services. The societal impacts of these climatic changes will be widely distributed, but they are likely to be felt far more severely by poorer nations, posing important and still unresolved questions about equity, fairness, and international environmental ethics.

Second, the inequitable responsibility for the production of greenhouse gases has begun to provoke calls from developing countries for prompt actions to reduce these emissions. With few exceptions, developing countries are least able to mobilize the resources for adapting to severe and rapid impacts, while developed countries are more likely to prefer to adapt to climatic changes than to drastically alter their energy and industrial infrastructures. This fundamental dichotomy is likely to lead to international friction and disputes between developed and developing countries unless mechanisms can be worked out to more equitably share the cost of limiting climatic impacts.

Both technical and political solutions are available, although none appear capable of preventing at least some climatic changes due to greenhouse gases already emitted. Among the technical options are (i) slowing the rate of climatic change through increased energy efficiency, greater use of non-fossil-fuel energy sources, reforestation, controls on other greenhouse gases, and the sequestering of carbon dioxide away from the atmosphere, such as deep in the ocean; (ii) mitigation of the most severe impacts through larger grain shortage, better international distribution of agricultural production, more flexible water-resources systems, increased water conservation, and protection from sea-level rise; and (iii) adaption to climatic impacts such as through population migration, land abandonment, and shifts in agricultural practices. Indeed, the actual responses to climatic changes are likely to include all of the above.

Various political actions are also available depending on the perception of the severity of climatic impacts and on the economic and technological means available for responding. Unilateral actions can be taken by those countries that have a major responsibility for greenhouse gas production or that face particularly severe climatic impacts. Although unilateral actions are likely to be only marginally effective at slowing climatic changes, they set good ethical examples and some of them can be justified for other good reasons. For example, increased energy efficiency reduces the economic, political, and environmental costs of energy use while slowing the rate of emission of greenhouse gases. Similarly, increasing the robustness of existing agricultural and water-resource systems would ease many existing food and water problems, while helping to prepare for similar problems caused by future changes in climate. Restrictions on ozone-destroying chlorofluorocarbons protect human health and also slow the rate of climate change.

More effective are multilateral actions on the part of the industrialized world. Coordinated actions to control trace-gas

emissions should be the responsibility of these countries and would help address the questions about equity. Joint international research into alternative energy resources is another possibility, as would be an agreement by major coal consumers, such as the United States, the Soviet Union, and China to reduce their dependence on coal through an agreement to share natural gas resources and energy-efficiency technologies. Finally, comprehensive international agreements, such as the Law of the Sea, or the Montreal Protocol developed for protecting the ozone layer, would be most effective at slowing the rate of climatic change. Such agreements are, however, 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 to both improve our understanding of climatic impacts and to negotiate and implement equitable international responses.

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