The Climate Change Debate and Its Implications for Megacities

by

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ABSTRACT

In the past decade or so, global warming has become the most contentious of all international environmental issues. This is due to many factors including scientific uncertainties, a separation of the costs and benefits of mitigation, and diverse national pollution histories. For the most part, the debate centers between the developed world, which has historically been responsible for the majority of the world's greenhouse gas emissions; and the developing world, which is primarily interested in reaching a standard of living equitable to the developed world, irrespective of the pollution that will be produced in the process. Some of the issues of contention are as follows: the responsibilities of the developed world; the needs of the developing world; the policy mechanisms for addressing climate change; and the use of technological solutions for climate change abatement.

This thesis attempts to address those concerns over climate change as specifically pertaining to megacities, those urban areas of 10 million or more inhabitants. Along with populations of 10 million or more, exist immense needs in terms of food, water, shelter, and employment. Although they are built on only 2% of the world's land surface, urban areas use over three-quarters of the world's resources and discharge similar amounts of waste. Pollution, overcrowding, and unsanitary conditions plague many of the megacities of the world, especially those in the developing countries.

By addressing and analyzing those political, economic, and environmental concerns of megacities in the climate change context, this thesis finds that these urban areas have much to be concerned about. The urban areas of the developed world will likely find ways to decrease their per capita greenhouse gas emissions through more efficient energy uses and technologies. In doing so, they are likely to experience the ancillary benefit of reduced, localized air pollution. Urban areas in the developing world, however, may make the mistake of sacrificing their local environments in order to promote economic growth. However, if they are willing to cooperate with the industrialized countries of the world, they may be able to reap the benefits of international financial aid and technology transfers.

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TABLE OF CONTENTS

List of Tables

List of Figures

CHAPTER 1 INTRODUCTION & OVERVIEW

Concerns about Global Warming have only truly come to the international political forefront within the last decade or so, chiefly due to the establishment of the Intergovernmental Panel on Climate Change (IPCC), a creation of the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). Nonetheless, the topic has created an astounding amount of controversy, debate and tension both within and between nations. Although it is now widely accepted that the Greenhouse Effect and the associated Global Warming are true scientific phenomena expected to occur over a long time period, significant controversy and uncertainty continue to surround the consequential climate change resulting from these phenomena. Because global warming is inherently global in nature, actions taken (or gases emitted) in one part of the world may contribute to positive consequences, such as increased agricultural growth periods, in a second part of the world and negative consequences, such as increased flooding, in a third. Subsequently, it is this lack of equal delegation of the costs and benefits of global warming over both time and space that has led to a multitude of political, economic, and social debates over what has been done to cause, and what could and should be done to mitigate global warming. The largest ideological division has been drawn between the developed world, which has historically been responsible for the majority of the world's greenhouse gas emissions, and the developing world, which is most interested in reaching a standard of living equitable to that of the developed world. However, the debate is certainly not limited internally within the two sectors, developed and developing.

This thesis is intended to provide an analysis of the multitude of issues surrounding global warming. In doing so, the author aims to truly articulate the drivers – political, social, and

economic – behind each issue and their implications for future progress towards climate change mitigation. The paper is structured so as to address those issues and predictions of climate change specifically pertaining to Megacities. Megacities are formally defined as those cities with populations greater than 10 million. However, rather than by a specific population number, megacities may also be defined as those cities and urban areas, which are regional focal points due to their accounting for the majority of the population; municipal, industrial, and governmental services; and economy contained within that region. In either context, megacities vary widely across regions, specifically between industrialized and developing nations. Some important features to note:

- Urban areas currently accommodate approximately 47% of the world's population[1]. In 1995, the ten largest cities – Tokyo, Mexico City, Sao Paulo, New York, Bombay, Shanghai, Los Angeles, Calcutta, Buenos Aires, and Seoul - encompassed 155 million people. The trend of increasing urban populations is expected to rise even further, to an estimated 57% of the world's population by the year 2020. (UN, 1996)
- As of 1995, there were fourteen cities with populations exceeding 10 million, half of them in Asia. By 2015, ten more cities are expected to reach or surpass the 10 million mark, all of which are in Asia. (WRI, 1998)
- Cities generate more wealth than do nations as a whole; on average, city level output is more than 10 percent higher than national level output. This divergence is more evident in the lower income nations of Africa, Asia, and Latin America, where urban output surpasses national output by 30-40 percent. (Urban Age, 1998)

[1] The percentage of urban population refers to the census population of areas defined as urban in each of the countries of the world. Because each country sets its own definition of "urban", there is a wide range of definitions around the world. (WRI, 1998)

- Cities are major consumers of fossil fuels with over 80% of global consumption. (Girardet, 1996)
- A 1992 WHO/UNEP study of megacities showed that the most severe air pollution is monitored in cities in developing countries, but that air pollution is a widespread problem in megacities with at least one major air pollutant exceeding health guidelines in all of the 20 megacities studies. Seven of the megacities had three or more pollutants which exceeded WHO health protection guidelines – Mexico City, Beijing, Cairo, Jakarta, Los Angeles, Sao Paulo, and Moscow. (WHO & UNEP, 1992)

That said, it is clear the important role that megacities play and will continue to play in the future within the global warming context. However, many of these urban areas, especially those in the developing countries have done little to mitigate global warming, mainly due to a lack of information, resources, long-term goals, and political power. Nonetheless, climate change and climate change policies will have significant implications on megacities. Therefore, the main goal of this thesis is to address the political, economic and social concerns of climate change and relate them to megacities and other urban areas.

Overview

The remainder of this chapter consists of a quick summary of the major findings and conclusions made within this research project in order to introduce the reader to the important issues of the paper. Chapter 2 discusses the somewhat ambiguous concept of megacities and its relation to global warming, citing many of the important statistics related to the climate change issue. Chapter 3 then addresses the scientific and social dimensions of global warming,

including the uncertainties associated with and the anticipated effects of climate change. Chapter 4 provides a review of the institutional political components of climate change, such as the IPCC and the Kyoto Protocol. Chapter 5 then discusses the international interests of specific countries, regions, non-governmental groups and industries within the climate change debate. Chapter 6 then looks at the various policy options applicable to climate change and the anticipated advantages and disadvantages of each. Chapter 7 combines all the work of the previous chapters in order to address and evaluate the anticipated effects of, and policies for climate change, as pertaining to megacities. It will discuss the positive and negative consequences that regulations and incentives may entail for these urban areas and draws attention to their concerns. Finally, the conclusion will tie together the findings of the paper by summarizing those issues, which are vital to the megacities in the context of climate change.

Summary of Findings

Having completed this research, the ideas that are now most clear to me are the following:

- in a business-as-usual scenario, megacities will be more prevalent in the future than ever before, specifically in the developing world countries,
- as of yet, specific urban interests have played a minimal, if any, role in the climate change debates, due to a lack of resources and long-term political foresight within municipal governments,
- as the world's largest consumers and producers, megacities and other urban areas potentially have much to gain and lose from both climate change and climate change-

related policies including disproportional economic burdens and ancillary environmental benefits and sacrifices,

- climate change prevention must be synonymous with megacity/urban development that is both sustainable and strategic, and accounts for the needs of its hinterland, which in many cases is the entire world.

CHAPTER 2 MEGACITY ATTRIBUTES

As mentioned in chapter 1, megacities are the focal point of this paper. In order to articulate the concerns of megacities in the climate change context, I have chosen nine cities, which will function as examples (pictures and information on each city are on the last three pages of this chapter). These nine cities - Lagos, Bombay, Shanghai, Tokyo, Mexico City, Moscow, Paris, New York, and Sao Paulo – were chosen for two main reasons. Firstly, they are distributed throughout the globe, in both industrialized and developing countries, therefore providing an adequate degree of representation. Secondly, most are either national or state capitals, facilitating data collection. None of them is an exact depiction of the term megacity, since they are all very diverse. However, they are used to illustrate both the similarities and the diversities, which resonate throughout urban regions across the globe. Two of these cities, Moscow and Paris, do not fit the formal definition of the megacity with 10 million or more inhabitants, however, they are the closest examples Europe has to offer. In this chapter, population, economic and environmental indicators are used in order to draw comparisons and contrasts between the example cities. In addition, the same cities will be continuously used as illustrative examples throughout the remainder of this thesis, to physically connect the concept of megacities to the concept of climate change.

Population & Growth

The most common denominator of the megacity is its astounding population. However, as you can see in Table 1, the population numbers vary significantly across the example cities.

Whereas Lagos, Nigeria is just over 10 million in size, New York City is over 16 million in size, and Tokyo, Japan is at almost 27 million.

TABLE 1. POPULATIONS OF EXAMPLE MEGACITIES

REGION	COUNTRY	CITY	1950 POPULATION (000)	1995 POPULATION (000)	2015 POPULATION[1] (000)
AFRICA	NIGERIA	LAGOS	288	10,287	24,640
ASIA	INDIA	BOMBAY	2,901	15,138	26,218
	CHINA	SHANGHAI	5,333	13,584	17,969
	JAPAN	TOKYO	6,920	26,959	28,887
CENTRAL AMERICA	MEXICO	MEXICO CITY	2,885	16,562	19,180
EUROPE	RUSSIAN FED.	MOSCOW	5,356	9,269	9,299
	FRANCE	PARIS	5,441	9,523	9,694
NORTH AMERICA	U.S.	NEW YORK	12,339	16,332	17,602
SOUTH AMERICA	BRAZIL	SAO PAULO	2,423	16,533	20,320

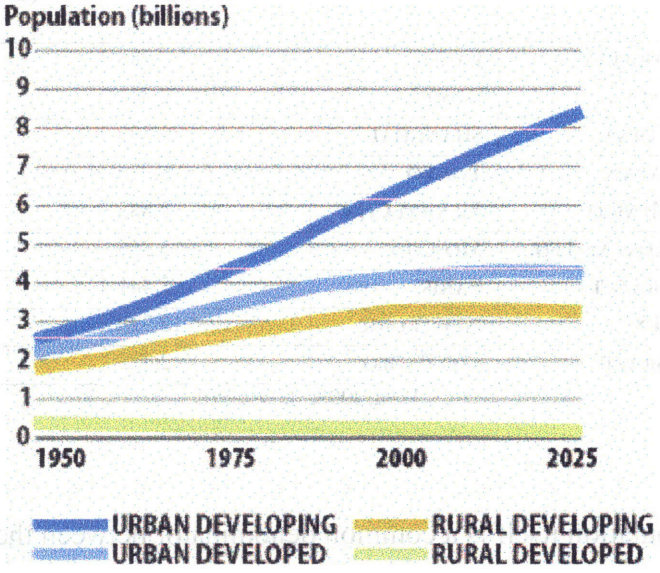
WRI, 1998. 1. Projected.

Although population itself is a common denominator between these megacities, the population growth trends of the past and present are widely disparate amongst the examples. In 1950, New York City, at almost twice the size of the next largest city, Tokyo, was the only example, which qualified as a megacity. In the next fifty years though, Tokyo nearly quadrupled in size, surpassing New York City by more than 10 million people. The steepest urban growth rates by far, though, have been and will continue to be witnessed by the developing world. As Figure 1 shows, developed world as well as rural developing population growths are expected to reach a plateau just after the year 2000. On the other hand, urban populations in the developing countries are expected to continue their precipitous ascension well into the next millenium.

There are many reasons for this trend of increasing urbanization within the developing world. Expectations of higher wages, better sanitary and utility services, and increased

educational opportunities are all motivations for rural to urban migrations. These are especially true in developing countries, where the divergence between rural and urban areas, in terms of opportunities and services, is more extreme than in industrialized countries.

FIGURE 1. WORLD URBAN POPULATION GROWTH, 1950-2025



UN, 1996

Living Standards

Differences between the developed and developing urban areas become overwhelmingly apparent when comparing living standards, such as purchasing power parity (PPP), utility services, and mobilization. Table 2 illustrates these divergences between the example cities. Going by wealth (PPP) alone, an individual living in New York City is more than 32 times better off than his counterpart in Lagos. That same New Yorker is basically guaranteed water, sewerage, and electricity services, whereas the Lagosian has a good chance of receiving water and electricity services, but almost nil for sewerage. According to the data, those in the

developing cities of Asia and Africa are significantly less likely to receive water and sewerage services than the corresponding Westerners. Although important in terms of climate change, mobilization is a less valuable living standard statistic than the others are, because it does not control for choice and alternatives. For example, individuals living in cities with excellent public transportation facilities may not require or even desire car ownership. New York City is a good example of this. On the other hand, in cities such as Bombay, and Shanghai, other forms of mobility, such as mopeds, motorcycles, and three-wheelers are very popular. In India, for example, 73% of the vehicles are two stroke, which includes the two and three-wheelers (CSE, 1999).

TABLE 2. ECONOMY, SERVICES & MOBILIZATION IN EXAMPLE MEGACITIES

		% OF URBAN HOUSEHOLDS CONNECTED TO			
CITY	PER CAPITA PPP[1] (1997 INT$)	WATER	SEWERAGE	ELECTRICITY	MOBILIZATION (CARS/1000 PEOPLE)
LAGOS	880	65	2	100	4
BOMBAY	1,650	55	51	90	130
SHANGHAI	3,570	100	58	100	32
TOKYO	23,400	N/A	N/A	N/A	552[1]
MEXICO CITY	8,120	N/A	N/A	N/A	140[1]
MOSCOW	4,190	100	100	100	138
PARIS	21,860	100	98	100	426
NEW YORK	28,740	100	99	N/A	232
SAO PAULO	6,240	N/A	N/A	N/A	79[1]

WRI, 1998. 1. By Country, World Bank, 1998.

Financial and Political Power

Relative to the nations that encircle them, cities tend to be responsible for a disproportional amount of financial and political power. Many of the megacities of the world function as both state (or national) capitals and financial megalopolises. The megacities of

Tokyo, New York, Sao Paulo, and Mexico City house the headquarters of banks and multinational corporations, which dominate over the global economy. With the continuous introduction of newer, faster communications technologies, international capital and power have become increasingly more transient. Political and financial decisions and trades made within the megacities of the world in one day can define the future existences of far-off nations. (Girardet, 1996)

Environment

The final categories of indicators addressed here are those relating to the environment. Environmental degradation can come in two different, yet usually related, forms - pollution and resource depletion. Countries at varying levels of development are likely to exhibit differing levels of degradation. The less developed countries (LDCs) tend to be resource intensive, utilizing resource depletion (deforestation) and sales as a means of income. LDCs are also more likely to suffer from a larger amount of localized air and water pollution than the developed countries. The industrialized countries, on the other hand, are better equipped to manage their resource stocks and control their local pollution, but are larger contributors to global air pollution, especially on a per capita basis. This is evident in the statistics presented in Tables 3 and 4. The lower income countries of Brazil, Nigeria, and China have very high deforestation rates, whereas the United States and France have increased their forest cover over time. India is the anomaly here in that, as a lower income country, it also increased its total forest area by almost 7 million hectares from 1980 to 1995. Species extinction, however, does not seem to be correlated with income and is occurring to varying degrees amongst all of the nations examined.

TABLE 3. RESOURCE DEPLETION IN EXAMPLE COUNTRIES

COUNTRY	TOTAL FOREST CHANGE (HA,1980-1995)	MAMMAL SPECIES # KNOWN	MAMMAL SPECIES % THREATENED	HIGHER PLANT SPECIES # KNOWN	HIGHER PLANT SPECIES % THREATENED
NIGERIA	-3,155,000	274	9.5	4,614	2.0
INDIA	6,746,000	316	23.7	15,000	8.4
CHINA	-6,925,000	394	19.0	30,000	1.1
JAPAN	-66,000[1]	132	22.0	4,700	15.0
MEXICO	-45,000	450	14.2	25,000	4.2
RUSSIAN FED.	0	269	11.5	N/A	N/A
FRANCE	804,000[1]	93	14.0	4,500	2.6
U.S.	2,943,000[1]	428	8.2	16,302	11.3
BRAZIL	-49,623,000	394	18.0	55,000	8.4

WRI, 1998. 1. 1990-1995 Only.

The air pollution data presented in Table 4 is indicative of the urban pollution trends discussed earlier. The localized concentrations of pollutants are much higher in the developing cities, where vehicles and power producers tend to use antiquated technologies and have few pollution controls in place, than the developed ones. According to the data, Mexico City has the worst aggregate air quality, with the highest concentrations of total suspended particulates and nitrogen dioxide, and the second highest concentration of sulfur dioxide. Paris has the best overall air quality, with the lowest concentrations of particulates and sulfur dioxide, and the second lowest concentration of nitrogen dioxide. The primary sources of these pollutants are power stations, motor vehicles, and heating. However, geographic factors also come into play in determining pollutant concentrations. Mexico City for instance is surrounded by a ring of mountains, which enclose the metropolitan area and also reduce the flow of winds and hence, pollution dispersion. The city is also situated at an altitude of 2,240 m, which means the

atmospheric oxygen content is low and contributes to incomplete combustion processes, causing higher concentrations of some pollutants.

TABLE 4. AIR POLLUTION IN EXAMPLE MEGACITIES

CITY	COUNTRY	TOTAL SUSPENDED PARTICULATES ($\mu g/m^3$)	SULFUR DIOXIDE ($\mu g/m^3$)	NITROGEN DIOXIDE ($\mu g/m^3$)	CARBON DIOXIDE EMISSIONS[1] (000 TONS)
LAGOS	NIGERIA	N/A	N/A	N/A	8,230
BOMBAY	INDIA	240	33	39	15,138
SHANGHAI	CHINA	246	53	73	36,677
TOKYO	JAPAN	49	18	68	242,631
MEXICO CITY	MEXICO	279	74	130	64,592
MOSCOW	RUSSIAN FED.	100	109	N/A	113,082
PARIS	FRANCE	14	14	57	56,186
NEW YORK	U.S.	N/A	26	79	334,806
SAO PAULO	BRAZIL	86	43	83	26,453

WORLD BANK, 1998 (DATA FOR 1995). 1. WRI, 1998.

Unfortunately, it was impossible to find carbon dioxide emissions on a city basis, so the CO^2 data presented in table 4 has been extrapolated from national to city emissions by way of per capita emissions and population. It is likely, however, that these estimates are conservative since urban areas tend to have higher per capita carbon dioxide emissions than rural areas. Using these indicators, we see that the developed, highly industrialized cities of New York, Tokyo, and Moscow are the largest emitters – all with emissions greater than 100 million metric tons. Of the developing world cities, Mexico City has the highest emissions - greater than those of Paris, and Lagos has the lowest.

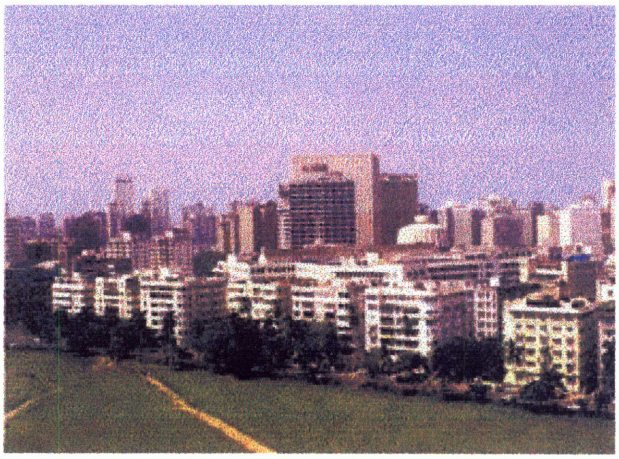
The statistics presented in this chapter illustrate the widespread disparities between urban regions across the globe. These deviations are most apparent when comparing developing to developed regions. The similarities and differences presented here are extremely important in

the climate change context when contemplating the issues of national sovereignty, equity, and sustainability, all of which will be addressed in the upcoming chapters.

CITY SNAPSHOTS

LAGOS, NIGERIA

Location – Western Africa
Population – 10,287,000
Country Status – Low Income
Climate – Equatorial



BOMBAY, INDIA

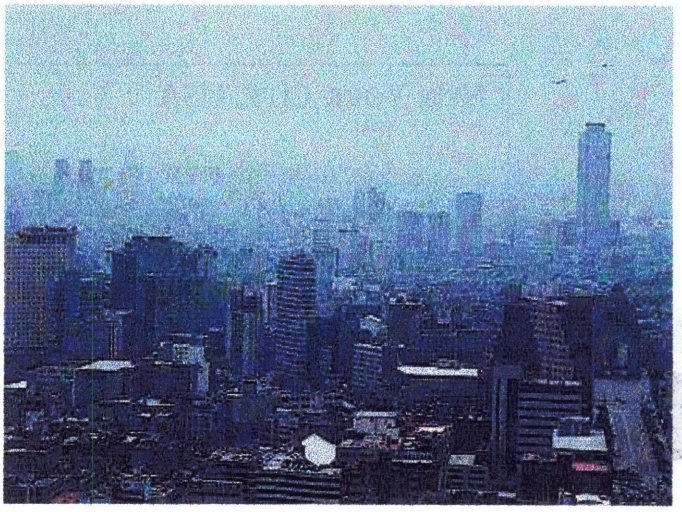
Location – South Asia
Population – 15,138,000
Country Status – Low Income
Climate – Tropical Savanna

SHANGHAI, CHINA

Location – Southeast Asia
Population – 13,584,000
Country Status – Lower Middle Income
Climate – Tropical

TOKYO, JAPAN

Location – East Asia
Population – 26,959,000
Country Status – High Income
Climate – Temperate



MEXICO CITY, MEXICO

Location – Central America
Population – 26,959,000
Country Status – Upper Middle Income
Climate – Marine West Coast

MOSCOW, RUSSIA

Location – Eastern Europe
Population – 9,269,000
Country Status – Lower Middle Income
Climate – Continental Cool Summer

PARIS, FRANCE

Location – Western Europe
Population – 9,523,000
Country Status – High Income
Climate – Temperate

NEW YORK CITY, USA

Location – North America
Population – 16,332,000
Country Status – High Income
Climate – Temperate

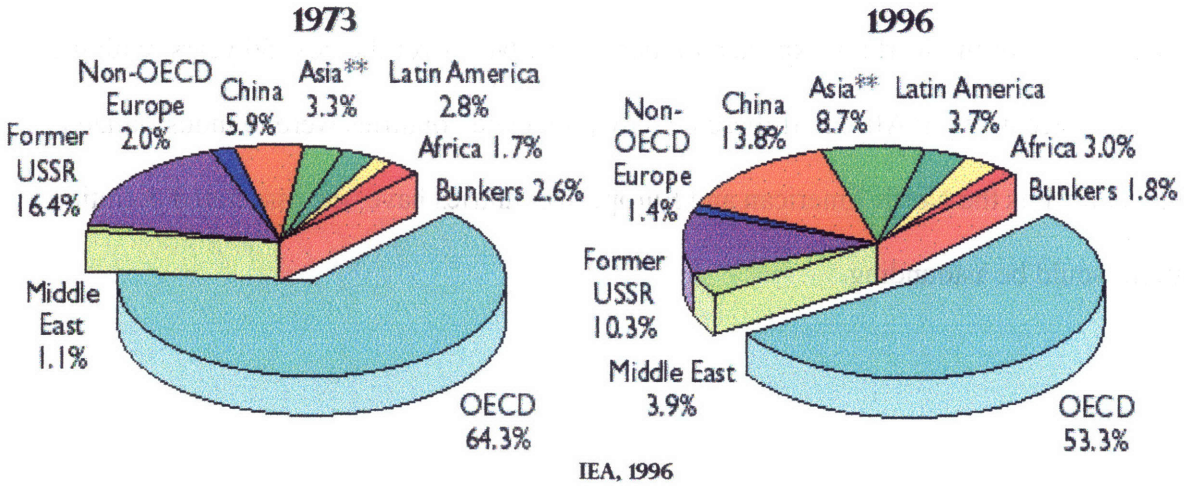
SAO PAULO, BRAZIL

Location – South America
Population – 16,533,000
Country Status – Upper Middle Income
Climate – Tropical

CHAPTER 3 SCIENTIFIC & SOCIAL DIMENSIONS OF GLOBAL WARMING

The Industrial Revolution and the invention of the automobile have irreparably changed our lives forever. They contributed to rapid socioeconomic changes by reducing the time required for travel and the production of goods, inherently making our lives easier. However, mechanization and mobilization were not the only outcomes of this time period. Also associated with the industrialization of America and the other developed nations is the widespread pollution, which escalated during this time period. In particular, the concentrations of greenhouse gases (GHGs) in the atmosphere have increased by over 30 per cent since the beginning of the Industrial Revolution (1850s). This rate is unprecedented in geologic time and is expected to continue increasing as the global economy expands, lesser-developed countries (LDCs) industrialize, and populations skyrocket. Although the industrialized world is still responsible for the majority of the world's carbon dioxide and other greenhouse gas emissions, the developing world is quickly catching up.

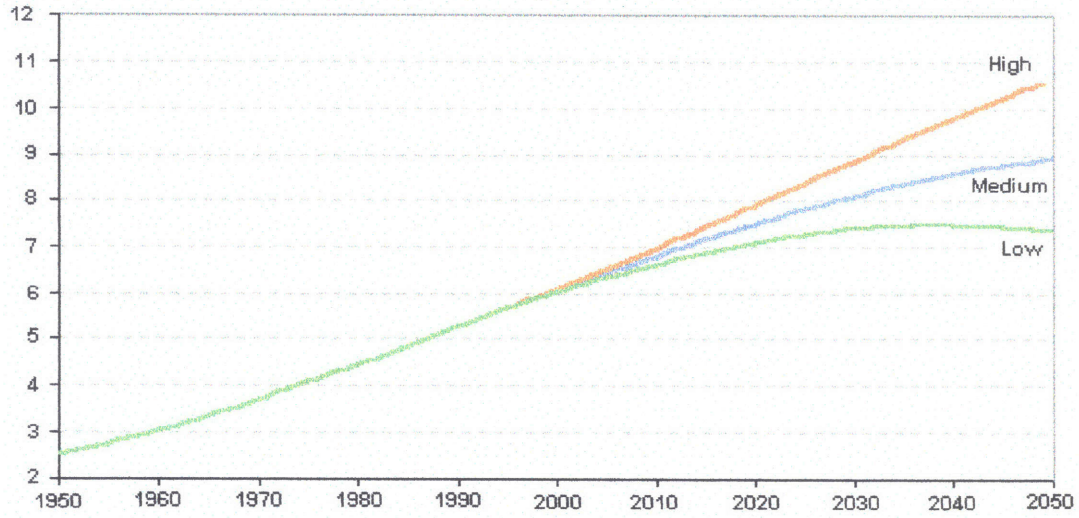
FIGURE 2. REGIONAL SHARES OF CO_2 EMISSIONS



IEA, 1996

Population & Emissions

FIGURE 3. WORLD POPULATION SIZE: PAST ESTIMATES AND MEDIUM-, HIGH- AND LOW FERTILITY VARIANTS, 1950-2050 (BILLIONS)



UN, 1998

Between 1950 and 1998, world population grew from 2.5 billion to 5.9 billion, a 234% increase. It is expected to reach the 6 billion mark sometime this year (1999). However, world population is not only increasing, it is essentially changing its structure. In mid-1998, eighty per cent of the world lived in the less developed regions and twenty per cent in the more developed regions. According to the United Nations Population Division, the population of the less developed regions of the world is expected to increase by 64% over the next 50 years, with the fastest growth occurring in Africa. If these heavily populated countries were to industrialize in the same manner as the North American and European countries have, the associated pollution generation would be astounding.

TABLE 5. 1995 CO_2 EMISSIONS FROM FOSSIL FUEL BURNING AND CEMENT MANUFACTURING

	TOTAL (000 METRIC TONS)	PER CAPITA (METRIC TONS)
WORLD	22,714,561	3.9
AFRICA	745,595	1.1
EUROPE	6,247,094	8.5
NORTH AMERICA	5,904,312	19.9
CENTRAL AMERICA	477,045	3.6
SOUTH AMERICA	747,331	2.4
ASIA	8,270,648	2.3
OCEANIA	322,535	11.3

WRI, 1998

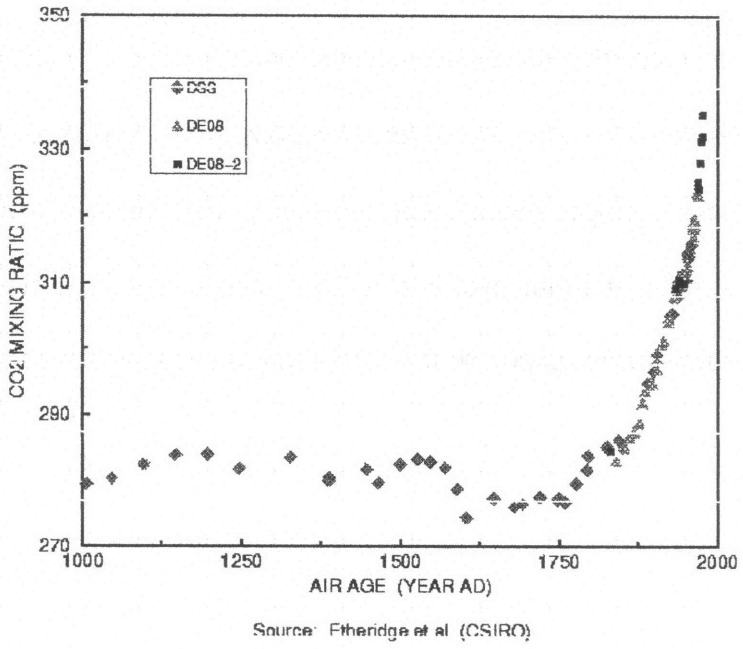
As it stands now (Table 5), the African countries emit about 1 metric ton carbon dioxide per capita, compared to North American emissions of 19.9 metric tons per capita. Hypothetically, if the entire population of Africa were to emit 20 tons of CO_2 per person, 15 billion metric tons of CO_2 would be released into the atmosphere. This would be equivalent to 66% of the world's total carbon dioxide emissions in 1995. Imagine what this number would be if the entire world were to emit at the same rate as North America.

These statistics demonstrate the gravity of the situation that the world is facing. After their contemplation, two thoughts should become increasingly clear. The first is that the per capita emissions differentials between the different regions of the world are astounding. The second is that the lesser-developed regions' decisions about development will have widespread implications on the world's environmental health. These concepts will be more thoroughly addressed in later sections of this paper, so it is important to keep them in mind.

Emissions & Global Warming

What does this all mean in terms of climate change? Well, that question is debatable, but some facts remain. First, increased levels of fossil fuel combustion, agricultural activity and deforestation have led to significant increases in the concentrations of greenhouse gases in the atmosphere. The GHGs which are directly influenced by anthropogenic activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO), chlorofluorocarbons (CFCs) and ozone (O_3) (Houghton, 1994). Second, greenhouse gases are named so due to their heat-trapping ability. As these gases collect within the earth's atmosphere, they prevent heat (long wave terrestrial radiation) from radiating back out to space, eventually leading to a warming of the earth- "the greenhouse effect". Unfortunately, the precise relationship between the amount of GHGs in the atmosphere and the temperature rise on Earth is unknown.

FIGURE 4. ATMOSPHERIC CARBON DIOXIDE CONCENTRATIONS (MEASURED FROM ANTARCTICA ICE CORES)



All in all, the combination of emissions and deforestation has led to an increase in atmospheric carbon dioxide concentrations from a pre-industrial level of 280 ppm (parts per million), to 363 ppm in 1996. Other greenhouse gases are not nearly as prevalent as CO_2, but are also on the rise. For example, methane, mainly produced through farming, has increased by 670 ppb (parts per billion) to 1670 ppb between 1986 and 1996 alone. Whereas industrial and agricultural activities lead directly to GHG emissions, deforestation is an indirect source of carbon dioxide. Forests contain a multitude of natural acceptors of carbon dioxide. Therefore, as they are cleared, the earth's natural absorption capacity is decreased, resulting in an increase in the amount of CO_2 present in the atmosphere. The majority of the world's deforestation has occurred in the tropical regions of South America, Africa, and Asia, which lost over 59 million hectares between 1990 and 1995. Since 1990, tropical forest regions have decreased by over 10%, 196 million hectares. (WRI, 1998)

To complicate the situation further, there are other factors, which indirectly affect global warming. For instance, gases such as carbon monoxide (CO) and nitrogen oxides (NO and NO_2), instigate chemical reactions with other GHGs, further augmenting the global warming phenomenon. On the other hand, atmospheric particles, know as aerosols, can actually have the opposite effect on global warming, by absorbing solar radiation and scattering it back to space. Aerosols are produced in much the same manner as GHGs – through fossil fuel combustion and biomass burning. At present, in some locations, the cooling effects of aerosols can be large enough to more than offset the warming due to greenhouse gases. However, since they do not persist in the atmosphere for long periods of time, aerosols are not expected to offset the global long-term effects of greenhouse gases, which are more long-lived (IPCC, 1997).

Expected Effects of Climate Change

Although the scientific specifics are unclear, there are estimates as to the amount of warming that can be expected in the future. The most noted (and debated) of which is the Intergovernmental Panel on Climate Change's (IPCC) estimation of a 1-3.5°C rise in temperature by the year 2100. To put this into context, during the last major ice age, which ended about 10,000 years ago, temperatures were only about 5°C colder than today (Hill, 1997). Scientists are also unclear as to what exactly the effect this temperature rise will have on the Earth's ecosystem. Predicted effects include rises in sea level, due to glacial melting; increased weather variability, including extremes such as floods, hurricanes, and tornadoes; changes in terrain, including desertification; modified agricultural yields; enhanced air pollution; and the spread of disease (Hill, 1997). Although the actual warming will be experienced globally, due to the current differentiation in regional temperatures and latitudes, the associated effects of warming will not be the same across the globe. Because they mainly inhabit the warmer parts of the world near the equator and in the Southern Hemisphere, and they are more dependent upon natural resources for sustenance, many developing countries and island states are expected to incur the more brutal consequences of climate change. For instance, rising sea levels will diminish the total landmass of many of the smaller island countries by a much larger percentage than the continental countries. For example, in the case of the Majuro atoll in the Marshall Islands, it is estimated that for a 1 meter rise in sea level as much as 80 per cent of the total land would be vulnerable (IPCC, 1997). Therefore, we can see that along with the sources of climate change, the symptoms are likely to be severely unequally distributed.

The effects of climate change will by no means be equally distributed across the globe, only adding to the current unequal distribution of population and wealth. Currently, 2 out of 5

people in the world live in either China or India the world's most populated countries, and less than 18% live in Europe and North America. Yet, in terms of purchasing power parity, China ranks 72nd and India 101st, whereas, the United States is 1st (World Bank, 1998). Based on the international poverty line of less than 1Int$/day, 1.4% of the United States, 29.4% of China, and 52.5% of India live in poverty (WRI, 1998). Although these statistics are constantly changing, the comparisons are clear. Global warming and its disparate consequences are likely to only worsen the situation. According to the IPCC, climate change represents an important additional stress on those systems already affected by increasing resource demands, unsustainable management practices and pollution, which in many cases may be equal to or greater than those of climate change (IPCC, 1997).

Environmental and ecological destruction induced by climate change will be much more devastating to the poorer economies of the world for several reasons. First off, many developing economies depend on (and in many cases take advantage of) their natural resources for means of income. If those resources were to be destroyed, few prospects would remain for wealth generation. Secondly, with less capital and technological abundance, developing countries will be less equipped to deal with the negative effects of climate change by means of adaptation. Whereas, industrialized countries may be able to use technological means and methods to adapt to climate change, developing countries will most likely have to depend upon foreign aid and technology transfers. Finally, because the lesser-developed countries (LDCs) play home to the majority of the world's biological diversity, their environmental assets tend to be unique, highly valuable, both intrinsically and financially, and irreproducible.

Although most developing regions are particularly vulnerable to changes in climate, widespread poverty, increasing population rates, and overwhelming natural resource

dependencies are likely to make Africa the region most defenseless to climate change. Even without climate change, many of the countries in Africa are already classified as water-stressed, their tropical forests and rangelands are under threat, biomass energy resources are being depleted and much of the population does not have access to adequate food, water, or sanitation services. Rural to urban migrations are on the rise and many urban areas are already feeling the strain on their inadequate infrastructure. Possible changes in the African climate due to global warming include increased incidences of vector-borne diseases, such as malaria and dengue fever, and droughts, which could make agricultural lands less productive, further increasing the trend of urbanization. In addition, many of the larger African cities and megacities, such as Lagos, are located on coastal areas, which will be more threatened by sea-level rises than inland areas. Without any financial resources and increasing pressure on its natural resource base, Africa is severely limited in terms of its ability to adapt - more so than any other region. (UN, 1997)

The Latin American countries are likely to be most threatened by changes in water availability, losses of agricultural lands, and flooding of coastal, riverine, and flatland areas. Particularly vulnerable groups in these areas include those living in the outskirts of large cities, especially in flood-prone and unstable hillside areas. Other regions, specifically the more temperate climates of China, Japan, Europe, and North America are likely to be most effected by the migration and or disappearance of large ecosystems, due to the shift in temperatures. Coastal loss is a significant threat, not only for island states, but also for areas with active ports – Tokyo and New York for instance. The resounding finding in much of climate change research is that the effects of climate change will be most significant in those areas in which the environment

and natural resource endowments are already under stress due to mismanagement, pollution, and unsustainable use – many of the same dilemmas that already affect urban areas.

Sustainability

Although global warming is an environmental concern, it is part of a larger array of social/environmental issues under the title of sustainability. Sustainability and sustainable development have become fashionable words in the realm of environmental protection, but their true meanings are somewhat ambiguous. The obvious interpretation of sustainability or sustainable development is that it entails sustaining something. That 'something', however, is highly controversial. For those of us in the industrialized world, we are looking for ways to sustain our current living standards, which for many include 3 televisions, 2 VCRs, and 2 cars per household; while simultaneously finding ways to minimize the damage we inflict upon the environment through living in this manner. Our idea of increased living standards would be a newer car, a faster computer, and another trip to Honolulu. However, there are those in the so-called "South" for whom living means inhabiting a one-room mud hut with seven other family members and without any sanitary facilities, never mind running water, electricity, or television. What are they looking to sustain? This is where development comes into play. Sustainable development then must be development that minimizes this gap without sacrificing the environment in the meantime.

The most widely used definition of sustainable development is that of the Brundtland Commission, which calls it 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). Figure 5 illustrates this definition as it specifically relates to cities.

FIGURE 5. THE MULTIPLE GOALS OF SUSTAINABLE DEVELOPMENT AS APPLIED TO CITIES

(MITLIN AND SATTERTHWAITE, 1994)

MEETING THE NEEDS OF THE PRESENT....

- *Economic needs* – includes access to an adequate livelihood or productive assets; also economic security when unemployed, ill, disabled or otherwise unable to secure a livelihood.
- *Social, cultural and health needs* – includes a shelter which is healthy, safe, affordable and secure, within a neighborhood with provision for piped water, sanitation, drainage, transport, health care, education and child development. Also a home, workplace and living environment protected from environmental hazards, including chemical pollution. Also important are needs related to people's choice and control – including homes and neighborhoods which they value and where their social and cultural priorities are met. Shelters and services must meet the specific needs of children and of adults responsible for most child- rearing (usually women). Achieving this implies a more equitable distribution of income between nations and, in most, within nations.
- *Political needs* – includes freedom to participate in national and local politics and in decisions regarding management and development of one's home and neighborhood – within a broader framework which ensures respect for civil and political rights and the implementation of environmental legislation.

....WITHOUT COMPROMISING THE ABILITY OF FUTURE GENERATIONS TO MEET THEIR OWN NEEDS

- *Minimizing use or waste of non-renewable resources* – includes minimizing the consumption of fossil fuels in housing, commerce, industry and transport plus substituting renewable sources where feasible. Also, minimizing waste of scarce mineral resources (reduce use, re-use, reclaim). There are also cultural, historical and natural assets within cities that are irreplaceable and thus non-renewable – for instance, historic districts and parks and natural landscapes which provide space for play, recreation and access to nature.
- *Sustainable use of renewable resources* – cities drawing on freshwater resources at levels which can be sustained; keeping to a sustainable ecological footprint in terms of land areas on which producers and consumers in any city draw for agricultural crops, wood products and biomass fuels.
- *Wastes from cities keeping within absorptive capacity of local and global sinks* – including renewable sinks (e.g. capacity of river to break down biodegradable wastes) and non-renewable sinks (for persistent chemicals, including greenhouse gases, stratospheric ozone-depleting chemicals and many pesticides).

The definition introduces two conceptual parts of sustainability: intragenerational equity and intergenerational equity. Intragenerational equity refers to equal treatment within a generation, meaning between the 'North' and the 'South, whereas, intergenerational equity refers to equal treatment between this generation and the next and so on. It is obvious that there is not currently intragenerational equity throughout the world. For instance, in Luanda, Angola, an urban area with a population in excess of 2 million, only 13% of the population is connected to a sewerage system, 41% to water, and a mere 10% to electricity networks (WRI, 1998). This is a far cry from the 100% connection rates, which pervade the developed world. For some, it is difficult to discuss intergenerational concerns when there is such a colossal intragenerational divergence. This is the most pervasive reasoning behind the developing world's resistance to participate in climate change mitigation. They are fearful that it will inherently lead to developmental sacrifices. Therefore, much of the debate over the social issues of climate change boils down to one concept – sacrifice.

Will the rich, industrialized world have to sacrifice its comfortable way of life, or will the developing countries be forced into permanent poverty? This is obviously a somewhat simplified, exaggerated, hypothetical question, but it encompasses the fears of both the developed and developing regions. To truly address the problem of global warming though, it must first be viewed under a more optimistic light. When viewed as a fight between the sovereignty of nations, it will never be solved. Unfortunately, this is much of what has occurred in the political forefront of climate change negotiations.

CHAPTER 4 CLIMATE CHANGE POLITICS

Although scientists had been studying global warming since the 19th century, climate change didn't surface on the international political agenda until the late 1980s. It became a "hot" topic in 1988 when, on a 98° day, United States Senator Timothy Wirth called a hearing to express his concerns over global warming. At the hearing, experts including James Hansen, then director of NASA's Institute for Space Studies, testified as to the seriousness of the issue, saying that the world was warmer than at any time in this century and that it was 99% certain that the cause was man-made gases and not natural variation. Hansen's stature and initiative gave credibility to the subject and led to a snowball of political actions and negotiations amongst the industrialized countries. (Anderson, 1998)

Negotiating Bodies

Negotiations officially began later that year, when the World Meteorological Organization and the United Nations Environmental Programme formed the Intergovernmental Panel on Climate Change (IPCC). The IPCC was established in order to address the rising concerns and questions about increasing worldwide anthropogenic emissions and their relation to the greenhouse effect. The IPCC's 1990 report, which called for more research and attention to the climate change issue, led to the establishment of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC). The mandate of the INC/FCCC was to prepare an effective framework convention on climate change that would provide some sort of consensus of the broad majority of participants.

Finally, in 1992, after many negotiating sessions, the UN Framework Convention on Climate Change (FCCC) was opened for signature at the Earth Summit in Rio de Janeiro, and subsequently entered into force in 1994. Also negotiated here was the Rio Declaration on Environment and Development, which contains twenty seven principles for state and interstate behavior, including such concepts as the eradication of poverty, recognition of the special needs of developing countries, and the responsibility of states not to cause environmental damage beyond their borders. The Convention called for the founding of the Conference of the Parties (COPs), the supreme body of the FCCC, whose purpose is to implement and continuously review the Convention. The members of the COP are divided into two groups – Annex 1 (A1), which accounts for 38 developed countries and economies in transition, and Annex 2 (A2), which only includes the 25 developed countries. According to the Convention, the A1 countries are committed to adopting policies and measures aimed at returning GHG emissions to 1990 levels by the year 2000, and the A2 countries, which consist mainly of the OECD countries, are to provide financial resources and technology transfers. Decisions as to the specifics of adoption were left up to the COPs and their annual negotiation sessions.

Kyoto Protocol

The third COP took place in Kyoto, Japan in December of 1997. The goal of this session was for the negotiators to finally agree upon a protocol containing binding emissions reductions. All countries involved went into the conference with different ideas of what was an ideal commitment.

Although concerns over climate change had originally been brought to the Congress in 1988, the US, the world's largest emitter, was fighting the climate change battle hardest on the

domestic front. Months before the conference began, the Senate had already passed a unanimous resolution telling the president not to sign a treaty unless it would apply to all nations, specifically some "key developing countries". The US finally went into the conference with a proposal of a reduction to 1990 levels. The Europeans, who had proposed a reduction of 15% below 1990 levels were very critical of the US's stance and exerted much pressure upon Clinton to take on a larger commitment. Japan, as host of the conference and the world's second largest energy consumer, was intent upon making the meeting a success and therefore, suggested an intermediary proposal of 5% below 1990 levels.

The final result, the Kyoto Protocol, contains country-specific emissions reductions for the Annex 1 nations, which would aggregately lead to worldwide emissions reductions of 5.2% below 1990 levels. The reductions incorporate six of the major greenhouse gases (CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) and the target reduction period is 2008-2012. The specific reduction obligations are listed below in Table 6. The Protocol and its associated quantified emission limitations or reduction obligations (QELROs) will only become legally binding when at least 55 of the Annex 1 countries, representing 55% of the developed world's emissions, have signed and ratified the document. Notably, no developing country actions are stipulated within the Protocol framework, except for potential involvement in CDM projects. Table 7 illustrates the carbon dioxide emission trends of those countries, which are home to the example megacities, including the Kyoto limits of those that are Annex 1 countries. This table is particularly indicative of the emission differences amongst the example nations, specifically between the U.S. and the rest of the world, and the divergence between the US's emission limitation and its unlimited emission trends.

TABLE 6. PARTY QUANTIFIED EMISSION LIMITATION OR REDUCTION OBLIGATION (QELRO) WITHIN KYOTO PROTOCOL

PERCENTAGE OF BASE YEAR (1990)		
AUSTRALIA 108	GREECE 92	NORWAY 101
AUSTRIA 92	HUNGARY 94	POLAND 94
BELGIUM 92	ICELAND 110	PORTUGAL 92
BULGARIA 92	IRELAND 92	ROMANIA 92
CANADA 94	ITALY 92	RUSSIAN FEDERATION 100
CROATIA 95	JAPAN 94	SLOVAKIA 92
CZECH REPUBLIC 92	LATVIA 92	SLOVENIA 92
DENMARK 92	LIECHTENSTEIN 92	SPAIN 92
ESTONIA 92	LITHUANIA 92	SWEDEN 92
EUROPEAN COMMUNITY 92	LUXEMBOURG 92	SWITZERLAND 92
FINLAND 92	MONACO 92	UKRAINE 100
FRANCE 92	NETHERLANDS 92	UNITED KINGDOM 92
GERMANY 92	NEW ZEALAND 100	UNITED STATES 93

TABLE 7. NATIONAL CARBON DIOXIDE EMISSIONS & LIMITATIONS

Anthropogenic CO^2 emissions (million tons)								
Country	1990	1991	1992	1993	1994	1995	1996	Kyoto Limit
Brazil	55.3	58.4	58.7	61.1	64.2	68.3	74.6	
China	655.5	688.4	722.2	753.6	818.4	876.8	918	
France	96.4	102.6	97.4	94.4	89.1	92.4	98.8	88.7
India	184.3	197.5	210.2	219.5	233.3	246.0	272.2	
Japan	292.2	298.2	301.5	294.7	308.6	310.3	318.7	274.7
Mexico	80.5	84.7	90.6	90.3	94.8	88.2	95.0	
Nigeria	24.2	25.1	30.3	30.6	27.2	24.8	22.7	
Russia	600.2	579.3	533.4	503.3	439.0	366.2	431.1	600.2
USA	1316.6	1309.9	1325.4	1370.8	1402.1	1408.8	1446.8	1224.4

CDIAC, 1997

Flexibility Mechanisms

In addition to reduction variations among countries, multiple methods of reductions, which increase the flexibility of compliance, have also been approved. Emissions trading allows two countries (or companies), one above its limit, one below, to buy and sell emissions amongst each other. This mechanism was vital for the US agreement. The United States already has a successful history of emissions trading, originating from the domestic Acid Rain Program, which allows for emissions trading amongst electric utility plants. Without trading, the US would be forced to make all reductions domestically. With such a large energy production industry, this would be detrimental to the US economy. In order to provide a net decrease in emissions, trades can only be made between two regulated countries. Therefore, it only applies to Annex 1 countries. Joint implementation (JI) also yields net reductions amongst Annex 1 countries, by allowing one country to manage its emissions by paying for emissions reductions in another country. Because future emissions reductions will be least expensive in developing countries where fossil fuel usage is very inefficient, many developed countries were eager to include them in the agreement. The Clean Development Mechanism (CDM) allows for this by permitting Annex 1 countries to reduce emissions by making investments in non-Annex 1 countries. However, in order for any of these emission management programs to function efficiently, there must be emission monitoring capabilities, and funding and enforcement procedures in place. As of yet, the infrastructure necessary to utilize these mechanisms has yet to be agreed upon and constructed. In addition, many developed and developing countries still view these mechanisms as a "way out" of domestic actions by developed nations, even though they may be more economically efficient than domestic reductions. The European Union, for instance, in contradiction to the United States has argued that domestic measures must be taken first,

previous to the use of trading. The EU also advocates the imposition of a cap on the total amount of the quantified emissions limitation or reduction obligation (QELRO) that can be achieved internationally, rather than domestically. This conflict over domestic versus international reductions is just one of the multitude, which has delayed action towards emissions reductions.

Many of the opponents of emissions reductions use cost as a reason for delaying action towards climate change mitigation. In analyzing President Clinton's plan to reduce greenhouse gas emissions to 1990 levels, the WEFA Group, a Philadelphia-based economic consulting firm, predicts a loss to the U.S. economy of $3.3 trillion between 2001 and 2020 accompanied by the disappearance of millions of jobs (Srodes, 1998).

There is some degree of truth to the cost argument depending on the way in which the associated environmental policies are structured. For instance, the U.S. currently spends approximately $150 billion each year to comply with existing federal regulations, mostly based on command and control measures. This accounts for over 2% of U.S. GDP. (Palframan and Tank, 1998) However, command and control measures, such as technology or emissions standards, are not the only forms of regulatory policy. "Apart from command and control, another way to protect the environment is by trying to repair the market for environmental endowments such that the energy and innovation that markets can unleash is mobilised to conserve the environment rather than colluding in its destruction. The idea is to get people to automatically conserve the environment as a result of the signals they receive from the marketplace" (Palframan and Tank, 1998).

Many economists have demonstrated that by incorporating flexible, economically driven policy mechanisms such as emissions trading, carbon taxes, and joint implementation into the

global warming policy mix, excessive costs may be avoided. Paul Portney, President of the Washington, D.C. based Resources for the Future, has argued that 'the cost-saving potential of incentive-based approaches compared with command and control is at least 10 percent and possibly as much as 75 percent' (Palframan and Tank, 1998).

As mentioned earlier, allowances for emissions trading between Annex 1 countries, joint implementation between Annex 2 countries, and clean development of developing countries have already been incorporated into the Kyoto Protocol. However, the means by which each nation chooses to meet its emissions limitation are solely up to that nation's own discretion. According to Portney, the available economic incentives that can be used in environmental policy include taxes, marketable permits, subsidies, liability assignment, information provision, and product return. He says that these economic incentives 'are attractive for one reason: They economize on administrative staff and information requirements' (Palframan and Tank, 1998).

Experience with Market Mechanisms

Throughout the climate change negotiations the U.S. has been a staunch advocate of the inclusion of permit trading and other economic incentive programs into the Kyoto Protocol. The primary reason for this is that the US has achieved success with incentive-based programs, specifically in the form of a tradeable permits system for sulfur dioxide (SO_2) emissions from electric utilities. Savings from this program have been estimated at $1 to $6 billion annually, when compared to the alternative command and control approach. (Palframan and Tank, 1998) However, the success of the US sulfur dioxide permit trading scheme does not necessarily mean CO_2 permit trading is the only or even part of the answer to climate change.

There are several factors that made permit trading appropriate to sulfur dioxide emissions in the US that may not apply to carbon dioxide emissions worldwide. The first reason for the program's success is that SO_2 emissions were easily quantifiable and limited to a finite number of sources – the electric utilities. In the case of carbon dioxide, emissions do not originate within only one industrial activity, such as electricity production, but across all sectors – household, government, and industry, and from all types of sources – energy production, transportation, forestry, etc. A second differentiation between sulfur dioxide and carbon dioxide is that whereas CO_2 is a global pollutant, SO_2 is more regional and its effects are less widespread. For example, sulfur dioxide emissions in the Midwestern United States may lead to acid rain in New England, but not Bangladesh. Therefore, a reduction of sulfur dioxide emissions within the US was expected to lead to air quality benefits within the US. A third component that makes trading of the two pollutants different is national sovereignty. Inasmuch as the SO_2 program led to conflict and called for cooperation amongst the States, the US government was still the sole decision-maker in its development and implementation. On the other hand, in order to generate carbon dioxide reductions, all nations must be involved in the process and find ways to cooperate. In this case, there is no single government body, which yields the power to implement and enforce the way that the US government could over the electric utilities within its borders. Still, these are not reasons for the dismissal of permit trading as an option, just an indication of the difficult nature of the problem.

Buenos Aires Plan of Action

The fourth COP took place in November of 1998 in Buenos Aires, Argentina. The purpose of the meeting was to iron out the issues left ambiguous by the Kyoto Protocol. After

two weeks of negotiations, the outcomes were deadlines set at late 2000 for adopting rules and regulations necessary for implementation of the flexibility mechanisms of the Protocol – Permit Trading, Joint Implementation, and the Clean Development Mechanism. What may be even more important than this Plan of Action, however, are the events, which took place during the conference.

Before many issues were even addressed, the US and Argentina both took serious political actions. Argentina, as host of the conference parted ways with the other developing countries, known as G77/China, by offering to take on voluntary commitments at COP5 in Amman, Jordan. Kazakhstan soon followed suit by also vowing to take on a binding reduction commitment. The US also took a stand when the Clinton Administration signed the Kyoto Protocol, without the support of the Congress.

Throughout the conference, the negotiators continued to air their concerns over voluntary commitments by non Annex 1 countries, financial mechanisms and funding related to the Clean Development Mechanism, and the transfer of clean technologies from the developed world to the developing. The European Union, along with many developing countries continued to insist that emissions trading caps, which limit the amount of a nation's QELRO that can be attained through permit trading and other mechanisms, be established. They view the US's adherence to permit trading as an indication of a lack of long-term commitment to reducing GHGs at home. However, advocates of a permit trading system have asserted the fact that, when viewed from an economic standpoint, caps only work to limit the effectiveness of this type of mechanism.

Outstanding Issues

Although many important issues were addressed and commitments made in Argentina, the plan of action, when boiled down, represents nothing more than another imposed deadline. The fate of the Kyoto Protocol still ultimately hinges upon a number of issues including implementation, enforcement, and fees, which up until now have failed to be agreed upon. The most important of which is the fact that the deadline for reductions (2008-2012) is fast approaching. Continued delays and negotiations coupled with increasing emissions only work to make the inevitably necessary reductions more expensive and difficult to implement. The US Department of Energy estimates that, if nothing is done, emissions will be more than 30 percent above 1990 levels by the year 2010 (Anderson, Morgenstern, and Toman, 1999).

Another undressed, yet significant concern is that for the need of the international institutions, which will measure, monitor, and verify claimed emissions reductions. The existence of so-called "hot air", which represents unused emissions from countries such as the former Soviet Union, who currently emit less than in 1990, has also led to much debate. On the one hand, is the US, as a buyer of emissions permits, likely to pay Russia for its formerly untamed emissions? On the other, is this even a sound proposal? In aggregate economic terms it is; by buying Russia's unused emissions, the US may incur lower costs than it would domestically. In addition, the Protocol calls for a share of the CDM proceeds to be donated to those countries most vulnerable to climate change. The size, mechanics, or bearers of this fee are still undecided. The CDM is also vague on the terms for making qualified reductions and their applicability to national quotas. And maybe most important, how will reductions be enforced, and what are the penalties for non-compliance?

Even if the issues of implementation, enforcement, and governance were to be resolved the Kyoto Protocol is not a long-term strategy. It only represents a first round attack on climate change. Developing country emissions are on the rise and expected to supercede those of the developed world in less than a decade. If this is the case, in order to prevent climate change, they must be included within any long-term emissions reduction strategy. How this will occur, and how the Protocol will be reviewed and adjusted over time are also uncertain.

CHAPTER 5 A DIVERSITY OF INTERESTS

Because greenhouse gases and climate changes cross international borders, lack distributional equality, and have the potential to cause extensive environmental and economic damage, many people have been led to associate climate change policy with a loss of national sovereignty and the potential for economic ruin. Around the world, radical environmentalists are predicting an ecological apocalypse, whereas right-wing conservatives predict an economic one. Radical views have led many to fear both action and inaction on the political front. Scientific uncertainties have been used by different groups as both reasons for and against political, specifically international, actions. Many governmental and non-governmental groups maintain vested interests in the outcome of any political agreement, specifically in terms of natural resource and capital commitments. Because of this, debates between industrialized and lesser-developed countries, conservative and liberal think tanks, and democrats and republicans persist over what, if anything should be done to mitigate climate change. Within all the chaos, there are specific drivers behind each viewpoint. Some are historical and/or cultural, others strategic. Specifically missing from the debate, however, have been the interests of urban areas. Because of this, this chapter does not explicitly address their concerns. However, chapter 7 will identify and analyze those issues and concerns, which should be of primary interest to cities in the climate change debate.

Domestic Concerns

The European Union (as a whole) and the United States are the two largest members of the Annex 1 group of nations under the Framework Convention – using either economic or

emissions measures. In order for the Kyoto Protocol to go into effect, 55% of the A1 countries, accounting for 55% of the A1 emissions, must ratify the document. Since the US accounts for 35% and the EU for 20%, implementation can not occur without one of these nations' ratification. However, their aggregate views on climate change and other environmental issues are distinctly different and sometimes at odds. Their differences stem from deep-rooted cultural preferences and governmental policies. As of yet, neither nation has ratified the Kyoto Protocol.

The United States

There is no single dominant US position concerning climate change or climate change policy. There are unique differences between the positions held by the Clinton Administration, the US Congress, and the American Public. Although the three groups are exposed to similar collections of information, their positions diverge over the scientific, economic and political facets of climate change.

The Clinton Administration has, since its inception, maintained that "climate change is a serious threat to natural systems and human well-being that requires a serious response", while simultaneously accepting both the scientific uncertainties and the continued need for economic development (Toman, Tebo, and Pitcher, 1997). The three-pillar approach of the administration includes the following: 1) policies based on sound science, 2) policies based on partnerships with the private-sector industry and non-governmental organizations, and 3) international solutions. The first pillar of the official position accepts the conclusions of the IPCC and the US Global Change Research Program (USGRP) and therefore, states the need for policies that provide insurance to reduce the risks posed by climate change. This reliance on science extends beyond the findings of natural science to include those of the social science disciplines, such as

economics and sociology - meaning that non-environmental considerations are equally important. The second pillar stresses the need for cooperation between government, industry, and society in order to reduce greenhouse gas emissions. Thus far, manifestations of this cooperation are evident in the Administration's voluntary Climate Change Action Plan (CCAP), which includes grants and tax exemptions aimed at promoting energy efficiency improvements and waste reductions. Finally, the third pillar of this position – international solutions, accounts for the need to involve the developing countries in the Framework Convention and implement both joint implementation and technology transfer policies.

The Administration's position has come up against strong criticism both domestically and internationally – specifically from the European Union. "Meaningful participation" of key developing countries (China, India, Mexico), which Clinton originally included as a necessary component of US actions, has become the guiding light behind Congressional inaction towards Kyoto. The fiscal year 1999 budget actually disallowed the EPA to use any funds "to propose or issue rules, regulations, decrees, or orders for the purpose of implementation, or in preparation for implementation, of the Kyoto Protocol". Because of this, the Clinton Administration has been unable or unwilling to implement any type of non-voluntary GHG emission reduction policies. This need for developing country participation is also potentially at odds with another facet of the administration's position – the cry for differentiated reduction responsibilities, based on national circumstances. Developing country representatives also argued for differentiated responsibilities based on national circumstances, but the circumstances being referred to by the US are not necessarily living standards, rather they are the potential costs of emission reductions.

The US's Republican-majority Congress is even more staunchly devoted to the inclusion of the developing countries than the administration and has several times vowed not to ratify any

treaty without it (1997 Byrd-Hagel Resolution). Although the US added its signature to the Kyoto Protocol during COP-4 at Buenos Aires, it was done so against congressional wishes. Senate Resolution 98, which was passed unanimously, previous to the Kyoto Conference, declares that the US should not sign on to any global climate change treaty that either omits binding reductions for developing countries or results in serious harm to the US economy (Antonelli and Schaefer, 1998). Like the administration, the Congress holds the belief that significant emissions reductions can be accomplished through increases in efficiency of energy end uses and increased research and development, and that reductions should only be made in a cost-effective manner. Some members of Congress, including Senator Charles Hagel (Republican – Nebraska) have also voiced concerns over national sovereignty, maintaining that the creation of a multilateral international organization, such as that proposed by the Framework Convention, could undermine US control over its own industries.

The American Public has demonstrated mixed feelings towards Climate Change. According to a 1997 Pew Research Center phone survey, the American Public was less concerned about the greenhouse effect in 1997 than in 1990. Other environmental issues, such as river and lake pollution and toxic waste contamination rank higher on their list of environmental concerns. Regardless, the same poll found that the American public strongly supported higher gasoline

TABLE 8. PHONE SURVEY OF AMERICAN PUBLIC

Worry About Environmental Problems % who worry a "great deal"	1990+ %	1997 %
Pollution of rivers, lakes, and reservoirs	64	61
Toxic waste contamination of soil and water	63	59
Air pollution	58	47
The loss of natural habitat for wildlife	51	46
The loss of tropical rain forests	40	44
Damage to the earth's ozone layer	43	40
Commercial development of open space	na	29
The "greenhouse effect" or global warming	**30**	**24**

+ Gallup trend.

prices and the majority also supported international environmental standards. However, much of the public also demonstrated confusion over the differences between regional air pollution, stratospheric ozone depletion, everyday weather changes, and global warming.

A second survey, commissioned by the D.C. research group Resources for the Future, was conducted quiet differently than the first and found significantly different results. The RFF survey, conducted at the end of 1997, asked an extensive range of questions relevant to global warming, rather than all environmental issues. The survey found that 77% of Americans believed that the world was warming and 61% though this was bad. In addition, 59% of the participants said the U.S. government should "do a great deal" or "quite a bit" to combat global warming and 77% said they would be willing to pay more money each month in order to reduce air pollution resulting from electricity generation. Seventy one percent of the respondents also thought the U.S. should require foreign aid recipients to also reduce their air pollution. (Krosnick, Visser, and Holbrook, 1998)

The European Union

Similar to the United States, the European Union, which compromises fifteen sovereign states, negotiates as a single bloc with a common position. The EU follows specific guidelines relating to any Union-wide environmental policy, which were built into the Treaty of Rome by the Single European Act of 1987 and extended by the Treaty on European Union of 1992. While leaving room for member states to take on tougher protection measures than those to agreed to at a Union level, EU environmental policy theoretically must contribute to the pursuit of:

- preserving, protecting and improving the quality of the environment;
- protecting human health;

- ensuring a prudent and rational utilization of natural resources;
- promoting measures at the international level to deal with regional or worldwide environmental problems.

The Treaty also requires Union policy to aim 'at a high level of protection', at rectifying environmental damage at source, and to be based on taking preventive action and making the polluter pay. (www.europa.eu.int/pol/env/info_en.htm, 1999)

These sentiments are evident in EU climate change policy. Throughout the climate change COPs, the EU members continued to stress their support for domestic GHG reductions and common policies and measures, showing more interest in energy taxation than emissions trading. These preferences are consistent with their policy of rectifying damage at the source. The EU also debated and opposed the use of differentiated reduction targets amongst developed nations, even though the Union always intended to differentiate its target amongst its member states. After much dispute, the EU accepted the differentiated targets and the inclusion of permit trading in the Kyoto Protocol, but continues to push for a cap on the amount of the national QELRO which can be achieved through emissions trading.

International Hostilities

The most significant political divide in the climate change arena exists between the developed and developing nations. However, disagreements also abound internally within the two political sectors. Amongst the developed nations, the United States and the European Union have continued to work towards different, usually opposing, policy ends. Development and interest divergences amongst the developing nations have led some to voluntarily offer their participation under the Kyoto Protocol, to the dissatisfaction of the stronghold countries such as China and India.

Developed-Developed Relations

The most evident example of disagreement amongst the developed, Annex 1 nations exists between the United States and the European Union. Although both nations agree that global warming is an important issue that must be discussed in the international arena, they have been at odds on all points beyond this. From the beginning, the US has been very adamant about specific treaty necessities – diversified national emissions targets (based upon compliance ability) and allowances for permit trading and joint implementation. Although climate change is an environmental concern, US participation has been hinged upon an economy-first attitude. As discussed earlier, this is mainly due to congressional opinion, not necessarily public or administrative decisions, but is not necessarily unsubstantiated. Congressional (and administrative) fears are that if the US and the other Annex 1 nations do sign on to Kyoto and reduce their aggregate emissions either domestically or through permit trading; and the developing countries don't, the global environment will be none the better due to a restructuring of trade balances. The concern is that the energy-intensive, polluting industries that help to bolster the US economy will simply relocate outside of the borders of the Annex 1 nations, continue to spew greenhouse gases, yet no longer provide profits and jobs to US citizens. In addition, as the world's most powerful country – economically and militarily speaking, many nations and international organizations depend upon the US for support and, envy aside, could also be harmed by a slump in its economy and export purchasing powers.

The EU has also demonstrated similar tactics and concerns in the negotiating processes. Like the US, the Union has continuously gone into the climate negotiations with specific treaty ideals in mind – differentiated emissions targets amongst its states and harmonized reduction

methods (i.e. carbon taxes). Interestingly enough, although the European Union has maintained itself as primarily environmentally-concerned, as opposed to the United States, it continues to lie in wait as to ratification of the Kyoto Protocol. EU participation and ratification seems to hinge primarily upon US participation, since the Union voices less concern about initial participation by the non-Annex 1 countries. Now that reduction targets have been distributed amongst the Annex 1 nations, the EU's main priority in negotiations has been to resist US pressure for full use of emissions trading, insisting upon a necessary percentage of domestically-induced reductions.

Developed-Developing Relations

Of the Non-Annex 1 nations, China and India have been the most vocal opposition to US (and other Annex 1) calls for developing country limitations. However, because China and India rank 1 and 2, respectively, for population size (UN, 1998), and 2 and 5, respectively, for total carbon dioxide emissions (WRI, 1998), they are prime targets for proponents of developing country participation. As recent as COP-4 in Buenos Aires, China refused to even discuss its own participation in the Kyoto Protocol, stressing that at 2.7 tons carbon dioxide per capita, their emissions constitute "survival emissions", unlike the "luxury emissions" of the United States (20.5 tons/capita).

Interestingly enough, these "survival emissions" have become so concentrated in some urban Indian and Chinese areas that of the 10 cities in the world with the worst air pollution, nine are in China and one is in India. According to a report by the Washington-based World Resources Institute, as a consequence of industrial emissions from fossil fuel combustion, one Chinese City (Lanzhou, China) rarely experiences a clear day. The report also said that children

living in large developing world cities breathe air that is the equivalent of smoking two packs of cigarettes per day. (Fox, 1999) A second report by the Centre for Science and Environment claims that in two decades, while the Indian GDP more than doubled, vehicular pollution increased eight times over and industrial pollution by four times (CSE, 1999).

It has become evident in the debates over climate change that the developing nations are fearful of sacrificing development in order to reduce global greenhouse gas emissions. However, it has also become evident that the emissions of GHGs are also associated with uncontrolled emissions of local and regional pollutants such as particulates and sulfur dioxide. Because of this, it is becoming apparent that much of this development has and will continue to come at the cost of human and environmental health.

Developing-Developing Relations

In opposition to the stronghold nations of China and India, some other developing countries have been less adamantly opposed to participation in the climate change arena. For several reasons, some developing countries have found it to be in their best interest to be included in the global effort for greenhouse gas reduction. Argentina, for example, broke ranks with the other developing nations by volunteering to also take on a reduction commitment under the Kyoto Protocol during the next conference of the parties (COP-5). Maria Julia Alsogaray, the Argentinean Secretary of Natural Resources and Sustainable Development and President of COP-4, was quoted as saying that while Argentina did not hold "historic responsibilities" for the climate change problem, it wished to belong to the group holding future responsibilities for commitment leading to a solution. This action gained much praise from US representative Stuart Eizenstat who called the decision historic and signaled that Argentina's undertaking constituted

the kind of meaningful participation by a developing country that is a precondition for US ratification. (IISD, 1998)

The Clean Development Mechanism and its potential for financial assistance and technology transfer also provide potential benefits to those developing countries willing to participate. However, China has also been opposed to the CDM's association with the private sector, saying that technology transfer should be "on non-commercial and preferential terms" (IISD, 1998).

Interest Group Involvement

Interest groups, ranging from non-governmental organizations to national consortia and industrial lobbies have also become heavily involved in the climate change debate in the US and abroad.

Non-Governmental Organizations

Non-governmental organizations, or NGOs, -specifically American ones - have become significant players in the climate change debate, especially in trying to influence public opinions one way or the other through print and television advertisements and the internet. They have also both participated in and protested during the Framework Convention conferences. NGOs concerned with climate change issues can basically be stratified into four groups, with political leanings ranging from left to right. One look at these groups' web pages demonstrates the seriousness with which they view the science and politics of climate change.

The first NGO group includes the radical activist groups, such as Greenpeace, which defines itself as "an independent campaigning organization that uses non-violent, creative

confrontation to expose global environmental problems, and to force solutions that are essential to a green and peaceful future". This type of group believes in environmental protection at all costs and tends to promote an almost apocalyptic view of the environmental implications of climate change. For instance, Greenpeace estimated that we must phase out the use of coal, oil, and gas within the next 30 to 40 years in order to cut GHG emissions 50 to 70 percent. Because of their radical motivations, they tend to find themselves consistently working against many political decision-makers and experience difficulty implementing their proposed policies. Over the years, Greenpeace has become more renowned for the protests it stages than the policies it shapes.

The second group is made up of the comparatively more moderate environmentalists, such as the World Wide Fund For Nature (WWF) and the Natural Resources Defense Council (NRDC). These groups function mainly by distributing climate change information in order to build public awareness and consensus, and increase political pressure for their proposals. They also urge individual consumers to be more aware of the environmental implications of their consumption choices and the "green" alternatives available to them. Both the NRDC and the WWF promote the use of targeted policies aimed at stimulating the market introduction of clean technologies and fuels in both developed and developing countries. WWF research concluded that if these policies were implemented nationally in 1998, the US could reduce its annual carbon emissions to 10 percent below 1990 levels by 2005 and to 22 percent below 1990 levels by 2010, and the EU could reduce their emissions by 14 percent below the 1990 level by 2005.

The third group, which I denote as the environmental economists, includes research groups such as Resources for the Future (RFF), based in Washington, D.C., which advocate environmental policies that account for both environmental benefits and economic costs. These

groups are advocates of a balancing between the need for environmental protection and the need for economic growth. RFF has become a significant advocate in the development of market mechanisms, such as permit trading, as a means for environmental protection. Members of RFF have also made several alternate policy proposals aimed at greenhouse gas reductions.

Accepting the differences in opinion over the gains and costs of reducing GHG emissions, RFF proposed a hybrid system coupling an emissions target with a relief mechanism for unexpectedly high costs. In particular, the policy would establish a fixed number of tradable permits based on a specified emissions target. It would also provide for additional permits at a pre-specified trigger price. As long as the control costs remain below that trigger level, the target would be attained. With so much argument over the true costs of GHG reductions, this type of flexible policy balances the concerns of both environmentalists – an emissions target – and industries – costs. (Kopp, Morgenstern, Pizer, and Toman, 1999)

The other end of the NGO spectrum includes staunchly conservative groups such as the Heritage Foundation, also based in D.C., which are primarily against the use of government policy for environmental protection. The Heritage Foundation promotes doubts about the existence of global warming, its relation to human activity, and its relative harm/benefits. They are adamantly opposed to the Kyoto Protocol for all of the following reasons:

- The Kyoto agreement clearly violates the terms of Senate Resolution 98;
- Considerable uncertainty surrounds the existence of global warming;
- The treaty will harm the U.S. economy seriously;
- The Kyoto Protocol is unfair;
- The treaty will subject U.S. citizens, businesses, and the states to the dictates of international bureaucrats.

In contradiction to cost predictions made by the environmentalist NGOs, the Foundation spouts statistics that the Protocol "portends dire economic consequences for Americans—as much as $30,000 in lost income per family and up to 2 million lost jobs each year".

National Consortia

AOSIS, or the Alliance of Small Island States, has a particularly unique interest in climate change and the Kyoto Protocol. Because of their size and geography, these forty-two islands are especially vulnerable to the potential effects of climate change, specifically rises in sea level – some members are only 1 meter above sea level at their highest point. As mentioned earlier, a 1-meter rise in sea level would lead to the disappearance of 80% of the landmass of the Marshall Island's Majuro Atoll. Fear for their future existence has motivated this group of small nations to become amply involved in the Framework Convention. Although none of these countries is a member of the Annex 1 or 2 groups, they are very much concerned as to what actions and time periods these groups commit themselves. Going into COP-3 in Kyoto, AOSIS advocated a proposal that called for a 20 percent emissions reduction from 1990 levels by 2010.

Another highly influential, but less concordant group is JUSSCANNZ, the non-EU, developed nations of Japan, the US, Switzerland, Canada, Australia, Norway, and New Zealand. They tend to share an interest in flexible means for emissions reductions and the inclusion of developing country commitments, but were originally based on information sharing and not bloc negotiating stances.

The Group of 77 and China, or G77/China, is made up of all the developing countries of the world and includes the AOSIS members. As a whole, they are against taking on emissions commitments until the developed countries have already committed themselves. However, a

lack of unanimity has detracted from their capability as a negotiating bloc. Regional interests have continued to undermine their alliance – the African countries are most concerned about vulnerability and impacts; the Chinese and Indian are concerned about economic development; and the Asian Tiger countries are concerned with losing their industrial attractiveness in the case of emission restrictions. (UNEP, 1997) Some developing countries have also broken off or shown interest in taking on their own commitments, as Argentina did at the last conference in Buenos Aires. With much to gain or lose from the negotiations, the G77/China has been notably more reactive than proactive and has thus been unable to promote policies, which may be or primary interest of benefit to themselves. Up until now, their operating stance has been to resist developed world proposals.

One group with the potential to gain economically from the Kyoto Protocol or other treaties is the Economies in Transition, or EIT, which include the former USSR countries of Central and Eastern Europe. Their movements away from communism to democratic capitalism have been accompanied by economic crises, which have translated into large decreases in GHG emissions. Under the Kyoto Protocol, Russia holds a 100% emissions limitation, which translates into over 600 million tons of carbon dioxide. Russia's 1996 emissions however, were 431 million tons – leaving room for 170 million tons of carbon dioxide for use or sale.

On the other side of the coin, with much to lose, is the OPEC group, the Organization of Petroleum Exporting Countries. Many of these countries, such as Kuwait, Nigeria, and Saudi Arabia depend almost solely upon petroleum for national income. Nigeria, for example, consumes only 465 of the 4,050 petajoules of commercial energy it produces, of which 95% are liquid fuels (WRI, 1998). These countries are obviously concerned about the potential impact on their economies of a reduction in world oil use. However, as it stands now, the Kyoto Protocol is

unlikely to do so – without emissions limitations on developing countries, world oil usage will continue to grow in these regions.

Industrial Lobbies

The industrial lobbyist groups most concerned with the climate change debate are composed of those business groups, which may have the most to lose via emissions reductions – e.g. petroleum companies. The American Petroleum Institute is the lobbying group, which represents the US petroleum industry, and has many of the same concerns as the OPEC group. As does the conservative Heritage Foundation, API quotes the WEFA consulting firm study, which estimated a loss of over 2.4 million U.S. jobs and an average cost per household of $2,700. In API's view three considerations – uncertain science, certain costs, and the availability of time – dominate the decisionmaking process and should dominate the debate. It is rather ironic that API defines the estimated costs, based on two studies quoted, as certain, but defines the science behind climate change uncertain. Rather than calling themselves opponents to the Kyoto Protocol, they define themselves as proponents of other actions – scrapping old, high-emission autos, removing regulations that discourage capital stock turnover; fostering the export of emission-control technology. All of their proposed actions radiate around the idea of loosening governmental grips on US industry at home and increasing governmental assistance to bring US industry abroad.

Additional business groups affected by climate change negotiations and regulations include electric utilities, railroads, transportation, and manufacturing. The Global Climate Coalition is an organization of business trade associations and private companies established in 1989 to coordinate business participation in the scientific and policy debate on the global climate

change issue, which aims to represent all of these U.S. industries. The GCC's position is that "existing scientific evidence does not support actions aimed solely at reducing or stabilizing greenhouse gas emissions". It does however, support these actions for other economic or environmental reasons. The GCC also supports increased technology transfers to developing nations, and Central and Eastern Europe. Evident in this position is the GCC's belief that international concern over climate change could potentially lead to new business lines.

Although many industrial groups continue to deny the existence of climate change, many are also eager to get involved in reductions now, rather than later. Working with the Pew Center on Global Climate Change, companies such as BP Amoco, Dupont, United Technologies, and Entergy have all interpreted the climate change debate as a signal that eventually, action will be necessary. Understanding this, they see it to be in their best interest, economically, to reduce and receive credit now, which can be used later on down the road when reductions become more difficult and more costly.

CHAPTER 6 APPROACHES & SOLUTIONS TO CLIMATE CHANGE

"Global warming poses a particularly difficult challenge for our economic and political institutions because the stratosphere is a public good. Its scarcity is not reflected in rising prices; it is not automatically rationed only to the highest valued uses. The damage cause by greenhouse pollutants is an externality in both space and time."

- Tom Teitenberg, *Environmental and Natural Resource Economics*, 1996

Strategies

Difficult as the problem may be, there are four distinct strategies that can be applied unilaterally or multilaterally in the struggle against global climate change – climatic engineering, adaptation, mitigation, and prevention (Teitenberg, 1996).

The first, and most dubious, strategy is that of climatic engineering. More like something out of a science fiction novel than government policy, climatic engineering offers combative solutions to climate change, such as shooting particulate matter or mirrors up into the atmosphere to counteract the sun's rays and reduce the warming trend.

Adaptation is somewhat of a last resort measure if the world is unable to prevent climate change beforehand. By finding ways to adapt to and function within a changed climate, we could postpone or altogether avoid actions in the here and now. However, given a significant magnitude of warming, unbearable heat or sea level rises could leave adaptation impractical or even unfeasible for some nations. Therefore, relocation would have to be a significant portion of adaptation measures.

The third possibility is that of mitigation. Mitigation offers means of increasing the planet's absorption capacity by methods such as reforestation. However, it is prevention, which has really been the aim of climate change negotiations up to this point. Prevention entails finding ways of reducing the emissions of those greenhouse gases that lead to global warming. Since fossil fuels are the largest contributors to greenhouse gas emissions, the most obvious ways of doing this are to either 1) use less energy or 2) use alternate (less-polluting) energy sources. Although the first three strategies all may offer potential for dealing with climate change they are not within the scope of this paper. Therefore, I will only discuss probable climate change policies as related to measures of prevention.

Economic Principles

Because the costs of prevention have become such a significant portion of the climate change debate, it would be impractical to evaluate any policy proposal without considering the associated costs and benefits of implementation. Therefore, before addressing the specific policy options available for combating climate change, I will discuss four economic principles that are applicable to this type of international environmental problem and can provide the necessary foundation for policy development and analysis– the Full Cost Principle, the Cost Effectiveness Principle, the Property Rights Principle, and the Sustainability Principle. (Teitenberg, 1996)

Based on the presumption that humanity has a right to a reasonably safe and healthy environment, the full cost principle states that all users of environmental resources should pay their full cost, including use, restoration, and damage compensation costs. Applied to the global warming situation, the full cost principle would call for the elimination of existing subsidies, which promote unsustainable resource use, and the implementation of resource use charges,

payments for pollution (emissions), and compensation to individuals harmed by pollution. (Teitenberg, 1996)

The cost-effectiveness principle is a step or two down in stringency from the full cost principle. It asserts that those policies, which achieve their stated objective at the lowest possible costs, are considered to be cost-effective. (Teitenberg, 1996) However, there must be a clearly stated objective in place. For global warming, this would entail finding a common global goal (i.e. total allowed global greenhouse gas emissions) and then utilizing the policy that will achieve this goal as inexpensively as possible.

Stemming from the tragedy of the commons theory, lack of fulfillment of the property rights principle is the reason for many international environmental problems. When property rights are unassigned or misspecified (i.e. the atmosphere and the biodiversity contained within rainforests), perverse incentives towards overuse are created and resources are depleted and degraded. It is believed that by assigning property rights, incentives for economically efficient use are created. (Teitenberg, 1996) In order to solve for global warming, atmospheric property rights would have to be assigned and distributed. Then the owners of those rights would be free to preserve or sell them as they saw fit – inherently creating a market for shares of the atmosphere.

The sustainability principle calls for resource use in a manner that respects the needs of future generations. In order to fulfill this principle, policies must be structured without a bias for current resource use against future use. This would entail either payments to future generations for current use or preservation of those invaluable resources. (Teitenberg, 1996)

When viewed from an international perspective these principles are very difficult to implement, some more so than others. The full cost and sustainability principles call for

monetary valuation of and accounting for all the world's natural resources. Lack of information and administrative resources, and diverse cultural valuation systems can make these feats impossible on an international scale. The property rights and cost-effectiveness principles are more internationally feasible because they allow market forces to determine resource values, but still call for initial property assignments and policy objective determinations. Up until now, climate change policies, including the Kyoto Protocol, have not truly followed any of these principles. Negotiations have addressed the need for resource valuation and sustainable development, but have failed to define them in policy terms and objectives. Of the four principles, cost-effectiveness is the one with the most potential for implementation. However, it still calls for full participation of the global community, which, as of yet, has been unachievable.

Traditional Policy Options

Command and Control

The most dated and widely used policies for environmental protection are those that take on the command and control (CAC) approach in which a standard is set with stiff penalties for non-compliance. The United States and the European Union have historically utilized policies such as this to control air and water pollution domestically. Standards defined under a CAC approach are usually done so based on human or species health protection, with no regard for the costs of meeting them. Unfortunately, they also tend to incentivize measures of evasion. Therefore, they are best utilized in situations or with forms of pollution where there is no margin for error (Palframan and Tank, 1996).

Under the auspice of global warming prevention, these standards could apply to inputs (fuels), processes (technologies), or outputs (emissions). What makes this approach palatable to

some is the definitive environmental control it involves - CAC policies say that pollution is bad and will not be tolerated. However the disadvantages associated with command and control climate change policies abound. The largest deterrent is that it would basically be impossible to implement and enforce these measures on a global scale. Without credible punishment for non-compliant nations, there would be no incentive for compliance by any nation. Domestic uses are possible, but would put regulated nations at an economic disadvantage to non-regulated nations.

The application of domestic CAC policies also has other problems. In order to apply and enforce emissions standards, monitoring devices must be in place at the emissions sources. However, greenhouse gas sources include not only power plants and refineries, but also personal motor vehicles, fireplaces, rice paddies, and even cows – making monitoring extremely difficult. Technology standards are also an option, but since there are not currently any GHG emissions control technologies in existence, they could only apply to the use more efficient or alternative production technologies – wind power, solar power, etc. The biggest problems with technology standards are that 1) unless they are retroactive, they tend to discourage against new sources (which are usually more efficient than old ones) and 2) by forcing the use of newer (usually more expensive) technologies, they tend to stifle innovation or encourage deception. The final CAC option, fuel standards, could include regulations on the composition of fuels used – possibly specifying a maximum level of carbon content per unit energy produced. However, without international regulations of this sort, this type of policy could potentially lead to the domestic use of low carbon fuels and the export of high ones.

Voluntary Programs

A second environmental policy approach is to establish voluntary programs. These voluntary approaches are agreements whereby an individual firm (or group of firms) makes a commitment to operate in a certain way, and/or achieve certain objectives in order to improve environmental performance (Palframan and Tank, 1998). Voluntary approaches to environmental protection have been used throughout Europe, Japan and the US. However, these types of agreements can only be successful when viewed by the participants not as a way around regulations but as another form of governmental policy. In order for this to occur, watchdog organizations need to be in place and have a clear understanding of the differences between the business-as-usual pattern and legitimate measures of abatement. Incentives for firm participation include cost reductions and public recognition of environmental concern. (Palframan and Tank, 1996)

One instance of volunteerism related to GHG reductions has occurred in the US recently in the form of a proposal for early reduction credits. Several US-based, multinational corporations, such as BP Amoco, Dupont, and Entergy, along with the Pew Center on Global Climate Change are currently working towards approval of Senate Bill 2617. If passed, the bill would credit early, voluntary emission reductions with an equivalent volume of emission rights under any future, permitting scheme. Theoretically, if these companies will eventually be forced to make these reductions, it is in their best interests economically to do so sooner than later. However, without the future permitting scheme in place, this type of early crediting may lead to the distribution of too many or too few permits and may provide credit for business-as-usual actions. (Kopp, Morgenstern, Pizer, and Toman, 1999)

Because of their misuse potential, voluntary programs are not the solution to an environmental problem with the significance of climate change. However, they could act as a catalyst for future regulations, by easing firms or nations into the habit of taking steps towards reducing greenhouse gas emissions, regardless of the incentives to do so.

Market Mechanisms

"Apart from command and control, another way to protect the environment is by trying to repair the market for environmental endowments such that the energy and innovation that markets can unleash is mobilized to conserve the environment rather than colluding in its destruction. The idea is to get people to automatically conserve the environment as a result of the signals they receive from the marketplace."

- Frank Covery, "The Types and Roles of Market Mechanisms", 1998

The most significant advantage of market mechanism policies, as opposed to command and control policies is the creation of an incentive to improve over time. With a market-based policy, no matter what the level of existing performance, there is always a direct (financial) benefit from improvement. On the other hand, the CAC approach tends to impose a level of performance and, once it is achieved, there is little incentive to improve. (Convery, 1998)

Tax Levies & Rebates

Although not very popular in the United States, the tax/fee approach to reducing greenhouse gas emissions has been suggested several times over - specifically by the European Union. Taxes or fees could be implemented on either the fuel or emission level in order to

reduce GHG emissions. Fuel taxes could be levied based on the amount of carbon or energy content contained within a specific fuel. They can also be exacted on emissions produced. However, given that the number of fuel sources is much smaller than the number of emissions sources and that fuel content is almost directly correlated with emissions produced, fuel taxation would be a much simpler proposal than emissions taxation.

According to economic theory, the appropriate tax level would depend on each fuel's per-unit contribution to the global warming problem – translating into higher tax rates for those gases with higher per-unit risks (Teitenberg, 1996). Efficient fuel taxes would function by signaling the consumer of the damage inflicted upon the environment through fuel use, leading to behavioral changes. However, taxes are only efficient when they are set to the level that equalizes the costs and benefits of emissions reduction. Since it can be extremely difficult to monetize the benefits associated with emissions reductions, cost-effectiveness could instead be achieved by predetermining an overall emissions reduction and then setting tax levels to reflect that goal.

Although theoretically cost-effective, taxes are most politician's worst nightmare, especially in the US. International tax mandates are even less popular because they surrender some degree of national sovereignty to an international body. Because the US already has low energy taxes, it would face a disproportionately large share of any international tax burden (Eizenstat, 1997). One way to make energy taxes more palatable though, would be to ensure tax neutrality – lower other taxes, such as income taxes, in response to a rise in energy taxes. In other words, tax the "bads" (pollution) and not the "goods" (productivity).

Tax rebates or subsidies offer another form of behavior modification, by providing economic incentives to individuals and firms who use certain technologies or processes. They

also provide a means of introducing newer, more expensive technologies onto the market at a reduced cost. As with other taxes or fees, they tend to be most politically acceptable on a domestic, not international, basis. For the fiscal year 2000 budget, the Clinton Administration has proposed a Climate Change Technology Initiative, which would contribute $3.6 billion in tax incentives over five years for renewable energy and the purchase of energy-efficient homes, cars and appliances. When evaluated from an economic perspective, this type of policy, however, is not a least cost method of reducing greenhouse gas emissions. It is instead a demonstration project designed to provide information about the commercial potential of certain technologies. (Edwards, Rousso, Merrill, and Wagner, 1998)

Subsidies

According to David Roodman, of the Worldwatch Institute, "Few public policies are as unpopular in theory and popular in practice as subsidies." Subsidies are those policies, which devote public resources to alter risks, rewards, and costs in order to favor relatively specific groups or activities (Roodman, 1998). Subsidies have been used worldwide to support new technologies and investments, provide social services, and construct infrastructure. Many of the tax incentives in President Clinton's Climate Change Initiatives are actually subsidies in the form of tax breaks, which lower the cost of specific, energy efficient technologies.

Subsidies may offer a temporary contribution to climate change prevention strategies by fostering clean technologies, but they are riddled with negative externalities. A more productive strategy for climate change may be to reduce or remove those existing subsidies, which actually encourage greenhouse gas emissions. Worldwide, current subsidies that support natural-resource-intensive industries and activities total at least $650 billion. In the US alone,

infrastructure subsidies exist in excess of $111 billion in tax breaks and road spending over what drivers pay in fuel taxes and other fees. This in turn encourages low-density, car-based land use patterns, contributing to excess oil use, greenhouse gas emissions, and traffic congestion. According to Roodman, "Trying to block change through subsidies indeed resembles the building of dikes against a rising sea. Even if the dikes are well made, which they usually are not, they can only work if they are continually built up". (Roodman, 1998)

Permit Trading

The trading concept is an extension of the property rights principle. Participants in this type of program may be nations, firms, or even individuals. Depending on the structure of the policy, the total number of permits allocated will represent the total amount of resource to be used or pollution to be emitted. The participants are then assigned permits that specify the amount of a resource to be used or pollution to be emitted. Shareholders are then allowed to buy and sell the permits amongst themselves until their reduction costs are equivalent to the permit costs. Because the permit prices are determined within the market, there is no need for government determination as there is in the tax approach. As opposed to the CAC approach, this system allows the government to meet its policy objective while allowing greater flexibility in how that objective is met (Teitenberg, 1996). Other advantages of the permit system include reduced bureaucracy (once the system is in place) and governmental revenue generation (if the permits are auctioned).

This type of system has been most fully adopted in the United States, where it has been used to control air pollution both regionally (RECLAIM – Regional Clean Air Incentives Market, in Los Angeles) and nationally (the 1995 Clean Air Act Amendments' Acid Raid

Program), (Convery, 1998). Because of their success with tradeable permits domestically, the US has been the largest proponent for permit use internationally to reduce greenhouse gas emissions. Although emissions trading has been the most talked about permit system, there is also potential for an atmospheric or fossil fuel permit trading system.

In the case of emissions trading, participants would be allowed to buy and sell permits that specify an amount of greenhouse gas emissions. If Kyoto is approved, the national emissions limitations represent each nation's constraint without permits. The overall cap for the Kyoto system is the 5.2% reduction in 1990 greenhouse gas emissions amongst the Annex 1 nations. However, because the constraints are based on 1990 emissions, some nations, such as the former USSR, are far below their constraints. These nations would have the incentive to sell their permits to those nations, such as the US, which are well above their limitations.

There are multitudes of disadvantages to the Kyoto system; the most obvious of which is the exclusion of non-Annex 1 countries. In order for a permit system to function correctly and lead to environmental improvements, all sources within the polluted region are required to have permits to emit. Since greenhouse gas pollution is a global pollution problem, all nations should theoretically be included. (However, this is a problem with all of the Kyoto-based policies for climate change prevention.)

Another problem with the system, argued by the EU and the developing countries, is that because of the situation in the formerly Communist nations, the richer countries in the Annex 1 could simply 'trade' their way into compliance without making any actual reductions. In fact when comparing 1997 emission rates to the Kyoto requirements, the increases allowed to the Russian Federation and Ukraine alone could cover the entire reduction required of the US

(Najam and Page, 1998). However, the merits or demerits of this situation are perspective-dependent.

Another barrier also threatens the use of emissions trading - practical difficulties. Looking only at carbon dioxide emissions from fossil fuel use, there are literally scores of millions of sources. In addition, precise measurement methods for CO_2 emissions are only practical for large boilers equipped with continuous emission monitors. Because of these difficulties, fossil fuel permits have been suggested as an alternative trading system. Since fossil fuel-related carbon dioxide emissions are essentially perfectly correlated with a fuel's carbon content, emissions could intuitively be measured through the accounting of fuel use. Sources would include interstate pipelines, refineries, mines and processing plants. In this system, the "commodity" traded is the option to emit a unit of carbon, based on carbon content released. Other greenhouse gases could also be included within this system, based on their relative contributions to global warming. (Fischer, Kerr, and Toman, 1998)

Another permit approach is to allow for the trading of atmospheric permits – actual portions of the atmosphere, which is being altered through greenhouse gas emissions. Buyers of these permits would pay for the right to pollute or protect that atmospheric section as they see fit. The amount of pollution allowed within each segment would have to be decided. The largest obstacle to the use of fuel or atmospheric permits is the initial allocation of property rights. The benefit of the emissions trading approach over these is that the emissions rights have already been designated amongst the Annex 1 nations under the Kyoto Protocol. Above all, enforcement and liability measures are also crucial for any permit system to function correctly.

Joint Implementation

Joint implementation, which allows a firm (or country) to receive credit for making emissions reductions in another firm (or country) is another version of emissions trading. The Kyoto Protocol allows for joint implementation (JI) projects between Annex 1 nations, and between Annex 1 and developing nations, which fall under the Clean Development Mechanism (CDM). JI endeavors amongst A1 nations are almost identical to emissions trading, because both parties' emissions are regulated (capped) under the Kyoto Protocol. CDM projects differ, however, in that the developing nations are not regulated and therefore, have no baseline for which to compare their reductions. These reductions are instead measured in comparison to a business-as-usual baseline, which can be extremely difficult and costly to define. (Kerr, 1998)

As with other permit systems, liability assignments within these projects are crucial to success. Within A1 projects, the seller countries are always liable for the sum of net emissions plus permit sales being below their assigned amount. (Kerr, 1998) Suzi Kerr, of Resources for the Future, suggests that in order to distinguish those sellers with good reputations and domestic enforcement, qualifying requirements for Annex 1 countries should be coupled with the after-the-fact sanctions for non-compliance. In this case, the buyer would be aware of the character of the seller with which he is dealing. For CDM projects, buyers (Annex 1 nations) have considerably stronger compliance incentives than sellers, due to international punishments and domestic regulations. (Kerr, 1998)

Implications of Technology

Technologies such as automobiles and power plants are the root causes for the fossil fuel-based, greenhouse gas emissions, which plague our atmosphere and future. However, more efficient, lower emitting technologies will also be a crucial piece of the solution to climate change. Although it is not within the scope of this paper to detail individual technology programs and proposals, high-tech alternatives such as fuel-cell cars and less-complex options such as solar and wind power will most definitely play a role in reducing GHG emissions in megacities of the future.

Technology forcing in the form of increased research and development (R&D) funding by government and the private sector can help to both improve existing technologies and lower their costs and lead to the creation of new ones. In fact, a May 1997 draft report of the Clinton Administration's Interagency Analytic Team (IAT) states that a 40 percent increase in the pace of technical change giving rise to energy efficiency improvements would lead to a 65 percent drop in the cost of GHG abatement in the year 2020. Technical advances are also ultimately the forces, which drive increases in per-capita living standards. It goes without saying though that the costs of devoting economic resources to enhancing abatement technologies reflect the value of economic resources that could have been allocated elsewhere. (Kopp, 1998).

The Costs of Prevention

The costs of climate change prevention will be highly dependent upon national circumstances, national and international policy choices and goals, and technological innovation. Because of the uncertainties associated with global warming, technology development, and

international cooperation, it has been difficult for economists and policy makers to develop and agree upon cost estimates.

Resources for the Future, however, has developed a hybrid system of an emissions target and cost relief mechanism that allows for emissions reductions and still addresses the cost concerns. The proposed carbon trading system would establish a fixed number of tradable permits based on a pre-specified emissions target. Additional permits would be available at a pre-specified trigger price, which they propose to be initially $25/ton of carbon, rising by 7% plus inflation each year. If the cost of emissions remains below the trigger price, the goal will be attained. If costs turn out to be high, the policy protects the interests of businesses and consumers. (Kopp, Morgenstern, Pizer, and Toman, 1999)

CHAPTER 7 MEGACITY IMPLICATIONS

The climate change debate up until now has been specifically focused on national interests. However, urban areas, specifically megacities have much to gain or lose from both climate change and climate change-related policies. Coastal locations, high population concentrations, and existing resource scarcities make many megacities extremely susceptible to the potentially devastating effects of climate change such as sea level rises, increased infectious epidemics and droughts. At the same time, policies aimed at preventing climate change may lead to harsher economic consequences for large urban areas, which tend to be significant fuel consumers. However, if implemented, these same policies could lead to ancillary environmental benefits such as reduced local air pollution within urban areas. If the Kyoto Protocol is implemented, those megacities and urban areas located in Annex 1 countries are likely to experience negative economic consequences and positive environmental consequences, whereas their developing world counterparts will probably experience the opposite.

Connections between Megacities & Climate Change

Oceanic proximity; large, dense populations; and massive amounts of consumption have all worked to define today's megacity. Therefore, when making the connection between megacity and climate change, two questions must be raised about megacities: 1) how have they contributed to climate change, and 2) how will they be affected by climate changes?

It is obvious that extraordinarily large populations are the most significant similarity amongst the world's megacities. Along with populations of 10 million or more, exist immense needs in terms of food, water, shelter, and employment. As cities become wealthier, they are

able to draw upon an increasing supply of the world's resources to satisfy these needs. As these consumption demands are satisfied, vast outputs of gaseous, liquid, and solid wastes are generated both within a city's borders and those of its hinterland, which in some cases spans the entire world. As with the pattern of consumption, as cities become wealthier they are also better equipped to distribute their wastes and polluting byproducts farther away from themselves. Included in this urban input/output cycle is the constant consumption of fossil fuels for transportation, temperature control, and food and energy production, and the associated emissions of greenhouse gases.

As the world's largest consumers of fossil fuels, urban areas may in large part ironically contribute to their own environmental demise. Lagos, New York City, and Bombay, along with Hong Kong, Buenos Aires, and London are all port cities. Much of their growth was stimulated by their geographical location, which continues to sustain their consumption and production forces. However, in the case of sea level rises induced by global warming, a port location may no longer be ideal. Wealthier port cities however, may eventually be able to construct massive coastal barriers for protection.

In the case of climate change though, land flooding from sea level rises will not be the only consequence. Those environmental problems, which already plaque urban areas, specifically those in the developing countries will only be exacerbated. Demand for high quality water supplies already greatly exceeds the natural supply in many urban areas. Temperature increases may only serve to reduce water supplies further, while sea level rises could lead to salinization. Food supplies also risk destruction from climate change through salinization, land loss, and human relocations. High incidences of infectious disease amongst urban poor are already related to environmental factors such as water contamination, overcrowding, and human

waste accumulation without proper disposal. Climate changes could only worsen these situations, specifically in the developing world megacities, which are at times characterized by "a lack of resources and insufficient investment in urban infrastructure and services and a generally uncontrolled and poorly regulated pattern of urban development and expansion" (Burgess, Carmona and Kolstee, 1997).

Effects of Climate Change Policies (specifically Kyoto) on Megacities

Although uncertain and maybe even unlikely, global ratification of the Kyoto Protocol [or any other climate change policy] would presumably have significant implications for all cities. Those cities within the regulated, Annex 1 nations and the industries contained within them are likely to be responsible for the majority of national emissions reductions. Because of this, they are likely to suffer disproportional economic consequences due to their heavy industrialized composition. However, greenhouse gas reductions will eventually lead to cleaner land, air, water, and infrastructures within regulated metropolises. One study of the ancillary benefits of reduced air pollution from greenhouse gas mitigation policies found that they are approximately equal to 30 percent of the cost per ton of carbon reduced. In addition, those areas with greater population densities and higher levels of exposure (such as megacities) are likely to experience larger than average benefits. (Burtraw and Toman, 1997)

The non-Annex 1, developing world megacities are likely to experience something quite different. If the dire economic consequences of climate change policy opponents do come to pass, many Annex 1 industries could potentially relocate to the urban areas of the developing world. This could help to bolster the local economies of these nations, but could have negative local and global environmental consequences. Heavier localized industrial pollution will be

incurred in the areas of relocation. In addition, continued industrial operation within unregulated nations will only work to increase global carbon dioxide emissions. Those emissions will have merely been transferred from one nation's inventory to another's. However, because international relocation is an expensive last resort for many companies, most may choose to cooperate and find other ways to reduce greenhouse gas emissions domestically or internationally. International projects under the clean development mechanism may lead to both economic and environmental benefits for the cities of the developing world. More efficient energy production technologies can also provide services to more urban inhabitants while simultaneously reducing per capita emissions.

The specific structures of enacted climate change policies will determine the magnitude at which economic and environmental consequences are experienced within the urban areas of both the developed and developing worlds. Those policies, which rely resolutely on command and control approaches, will exact heavy economic tolls on regulated urban areas. The associated global and local environmental benefits will come at disproportionate national costs. The scientific uncertainties of global warming make costly CAC policies difficult to swallow. CAC policies may be more successful, environmentally, in unregulated developing world cities, which already suffer from serious localized pollution. These cities could benefit greatly in both the short and long terms by reduced or more efficient fossil fuel use.

Policies based on market mechanisms offer more palatable methods of reducing greenhouse gases in urban areas and globally. Although urban areas would still be responsible for making the majority of GHG emissions reductions under any policy, there are advantages to the market-based policies. By functioning within the economy rather than in opposition to it, policies such as permits and taxes are based on the same economic growth mechanism, which

fuels megacity development. As opposed to command and control policies, market-based policies can provide urban areas with a means of revenue generation, which can later be used towards other government activities such as service provisions, tax neutralization, or technology development.

Future Urban Development & Growth

Although many view cities as "high-rise concrete canyons", urban areas do have many positive qualities – perhaps the reason why they are now becoming our primary habitat. At their best, cities bring enormous benefits both in terms of the environment and in terms of development, of meeting human needs and of providing enjoyable, stimulating and valued places to live (Mitlin and Satterthwaite, 1994). By accommodating large numbers of people in a limited space, cities offer significant economies of scale in the provision of jobs, housing, and services, such as public transportation, education, and garbage collection.

However, it is the same concentration of intense economic activity coupled with high levels of consumption, which place such high demands on natural resources; natural resources, which are ultimately located in the cities outskirts, or hinterland. Cities have always been dependent upon their hinterland areas for essentials such as food, timber, firewood, and water. However, as cities become larger and larger, and more numerous, as does the hinterland needed to supply their consumption habits. Built on only two percent of the world's land surface, urban areas use over three-quarters of the world's resources and discharge similar amounts of waste. (Girardet, 1996)

If cities are going to continue to function as the habitat of choice in the future, they must develop in a more sustainable manner. In other words, cities must find ways to take greater

advantage of the significant economies of scale available to them while simultaneously reducing their ecological footprints. Canadian economist William Rees defined a city's ecological footprint as the land required to feed and supply timber products to the city, and to reabsorb its carbon dioxide emissions. By this definition, London, which accounts for only 12 percent of Britain's population, maintains an ecological footprint of 21 million hectares – the entire productive land of the UK (Girardet, 1996).

Regulation without Representation

Lack of information and political resources has really prevented the involvement of urban interests and governments in the climate change debate. National and business interests have been at the forefront of the negotiations and political proposals to date. Urban interests and existence, however, will be significantly influenced by climate change policy or, in the lack thereof, climate change itself. As extreme representations of human consumption and the homes to the majority of the world's production and services, megacities, their governments, and interests must be represented within the climate change debate and accounted for in proposed policies.

CHAPTER 8 CONCLUSIONS & RECOMMENDATIONS

I have come to several conclusions upon completion of this thesis. Similar to the thesis itself, these conclusions do not provide the solution to climate change or environmentally sound megacity development. Instead, my conclusions seek to delineate the existing relations between megacities, climate change, and climate change policy.

It is apparent from this research that megacities play many significant roles in the climate change arena. As homes to a large percentage of the world's population, they will be proportionally more affected by climate change and climate change policy than other urban and rural areas. As immense, aggregate, consumers and producers, their existence has significantly contributed to climate change. On the same token, policies intended to limit consumption will greatly affect the economies and environments of those megacities, both regulated and unregulated.

If the Kyoto Protocol, or a similar international agreement regulating the actions of the industrialized world, is implemented, developing world megacities may benefit economically and environmentally from developed world capital and investment flight, technology transfers, and joint implementation projects. The regulated nations may also be witness to the ancillary benefit of cleaner urban environments due to greenhouse gas reductions.

However, if the developing nations continue to insist that greenhouse gas reductions are the equivalent of developmental sacrifice and that emissions limitations will stunt their economic growth, the results may be detrimental. Many urban areas in the developing world are already unhealthy and unsustainable due to high levels of localized air, water, and land pollution, insufficient and unaffordable housing supplies, and haphazard development policies. Because of

this, they will suffer the most from continued rampant, uncontrolled greenhouse gas emissions and industrialization, both now and in the future. If they cooperate, however, they may be able to reap the benefits of developed world reparations for historical environmental harm.

Specific policy choices for climate change will greatly affect the magnitude of the economic costs and environmental benefits, which will be witnessed. Because greenhouse gas emissions have been associated with economic growth, policies that work within the market system may be better able to correct for these externalities at the lowest cost possible. Under the scientific uncertainties of climate change, they are also more politically feasible and favorable.

Finally, megacity existence and development needs to be more clearly figured into future climate change negotiations and policy designs. The sustainable development of megacities and other urban areas, taking into account for their hinterland relations may be vital to climate change prevention or adaptation.

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