

Climate Change and India: Implications and Policy Options

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Very Preliminary Draft

Comments Welcome

Not for Quotation

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Table of Contents

1	Introduction.....	1
2	Climate Change in India During the Past Century.....	4
2.1	Temperatures.....	6
2.2	Rainfall.....	7
2.3	Glacier Melting.....	7
2.4	Sea Level.....	8
2.5	Extreme Weather Events.....	9
3	Predicted Changes, Vulnerabilities and Adaptation	10
3.1	Temperatures and Rainfall.....	11
3.2	Water Supply	13
3.3	Agriculture	15
3.4	Health.....	17
3.5	Migration.....	18
3.6	Poverty	19
4	Mitigation: Efficiency.....	22
5	Mitigation: The Distributional Issue.....	33
5.1	Compensation for the Past stock of Emissions.....	33
5.2	Flow Emissions.....	37
5.3	Flow Emissions: Numerical Applications	40
6	Policy Action: The Current State of the Play.....	43
6.1	Action at the International Level	43

6.2	Action at the National Level.....	48
7	India's Options.....	52
8	Concluding Remarks.....	57

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“Action on Climate Change must enhance, not diminish the prospects for development. It must not sharpen the division of the world between an affluent North and an impoverished South, and justify this with a green label. What we require is a collaborative spirit which acknowledges the pervasive threat of Climate Change to humanity and seeks to find answers that enhance, not diminish the prospects of development, particularly of developing countries. All members of our common global family should have equal entitlement to the fruits of prosperity.”

Government of India, *The Road to Copenhagen*, February 27, 2009.

1 Introduction

While the fact of global warming is no longer in dispute, significant uncertainty remains with respect to its precise nature and the changes it implies with respect to rains, floods, droughts and storms. At the broadest level, there is uncertainty with respect to the magnitude of the change in the average temperature that would accompany different levels of greenhouse gas (GHG) emissions during the course of the 21st century. Predictions based on the experience to-date are uncertain because the association between GHG emissions and temperature change, which have been highly variable over time, may not repeat themselves in the future.¹ Even ignoring this problem, the temperature change is going to vary across regions, over different parts of the year and during different parts of any given day. The average temperature is a highly aggregative measure consistent

¹ For example, surface air temperatures have recently risen in two phases: 1910 to 1945 and 1976 to-date. The period from 1945 to 1975 exhibited no trend change in the average annual temperatures around the globe.

with a variety of distributions. A given increase in the mean temperature in any given year in any specific location may result from a uniform increase in the temperature at all points in time in the year; increase in the number of very hot days; decrease in the number of very cold days; increase in the temperature during the summer or during the winter; increase in the maximum or minimum temperature; and so on.²

Similar uncertainties exist with respect to how the temperature change impacts other natural phenomena. Rainfall may increase or decrease on the average with differential impact across seasons and across regions. A rise in rainfall on the average may represent an increased intensity of rains, increased frequency, expanded rainy season or the emergence of new rainy days outside the rainy season. One further uncertainty relates to the presence of factors other than GHG emissions contributing to warming.³ If such factors are present and significant, changes in them may reinforce or counteract the effects of GHG emissions.

Economic analysis is further complicated by the fact that even absent any actions towards mitigation of GHG emissions, the impact of climate change is not predicted to be significant until at least 2030. But once we get past 2030, our ability to predict the changes in economic activity even approximately plummets. The experience of China in

² Surprisingly, in the case of India, we encounter disagreement on even the *actual* change in the average temperature. While the Intergovernmental Panel on Climate Change (IPCC 2007) states that the average temperature in India has been increasing at the rate of 0.68°C per century, in its draft report on climate change in South Asia, the World Bank (2009, p. 162) states, “There have been no significant increases in temperatures observed over the country.”

³ IPCC leaves the door open to this possibility when it states in its Fourth Assessment, “Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.” [Italics in the original.] In principle, natural phenomena such as El Niño and La Niña can explain some of the extreme weather events associated with global warming.

recent years illustrates the point: no one in the mid 1980s predicted that China would turn into the world's largest GHG emitter by mid to late 2000s. Likewise, few in the 1980s predicted the 8 percent average annual growth India has cloaked in the last six years and its ascent as CO₂ emitter to the fourth position (after China, United States and Russia) in the world. Equally difficult are predictions regarding the emergence of clean technologies and alternative sources of energy.

This discussion suggests that any analysis of climate change must carry a significant speculative element in it. This is particularly true of quantitative estimates of costs and benefits of mitigation. Therefore, references to any quantitative estimates in the paper must be taken with a heavy dose of skepticism. Indeed, where possible, I will try to rely on qualitative and conceptual analysis turning to numbers only when they are useful for clarifying a point.

In Section 2, I discuss the climate change in India during the last century and its implications for the physical phenomena such as drought, cyclones, sea levels and melting of glaciers. In Section 3, I consider the predictions of temperature and rainfall changes in the 21st century, how they would impact agriculture, health, migration patterns and poverty and the measures India would need to take to adapt. The main conclusion here is that while climate change will likely add to the intensity of weather related extreme events and the associated problems, rapid growth in the next two decades will also better prepare the country to adapt to them. In section 4, I turn to the basic economics of policy action to regulate GHG emissions. This section is devoted principally to the efficiency issue and focuses on the optimal solution and appropriate choice of instruments to regulate global GHG emissions. An important conclusion here

is that assuming risk-neutral behavior, even if the costs of GHG emissions in the form of droughts, floods and economic damage are uncertain, emission tax and tradable permits are perfect substitutes as policy instruments. What distinguishes them is the difference in the rent-seeking behavior they are likely to engender. In Sections 5, I turn to the distributional issue: who should pay for the costs of mitigation? A critical issue here is the treatment of costs imposed by past emissions. In this section, I also report the results of numerical simulations by Jacoby et al. (2008) to bring out the source of conflict between developed and populous developing countries with respect to the costs of mitigation. In Section 6, I discuss the current state of play in mitigation at both international and national levels. I pay particular attention to the cap and trade legislation currently under consideration in the United States Congress and its implications for India. I argue here that the WTO compatibility of actions subjecting the imports from countries such as India that do not have mitigation program to the U.S. domestic environmental regulation is less than clear-cut and a successful challenge to them is far from ruled out. In Section 7, I offer a more frontal discussion of India's options going forward. I argue that India has a strong case for resisting any mitigation actions for the next two to three decades. But it needs to better articulate that case through careful detailed research. In Section 8, I conclude the paper.

2 Climate Change in India During the Past Century

India is a peninsular country with a coastline of approximately 6,000 kilometers along the mainland and an additional 1,500 kilometers around the islands of Lakshadweep and Andaman and Nicobars. The tropic of cancer divides the country into two halves with the northern half being temperate and southern half tropical. Variations

in temperatures in the peninsular region are smaller and rains heavier than in the inner continent. In the inner continent, temperatures range from near-freezing levels in the winter to 40°C or more during the summer. The Himalayan states in the northernmost part of the country experience sub-freezing temperatures during the winter with elevated regions in those states receiving sustained snow.

In *India's Initial National Communication to the United Nations Framework Convention on Climate Change*, The Government of India (2004) identifies four seasons during a year: winter from December to February; pre-monsoon season from March to May; southwest or summer monsoon from June to September; and post monsoon from October to November.⁴ The precise timing of these seasons exhibits some variation across regions. A major variation relates to the northeast monsoon that occurs in October and November. The states of Tamil Nadu, Karnataka, and Kerala receive most of their rainfall from the northeast monsoon during November and December. The Himalayan states experience two additional seasons: autumn and spring.

The primary points of impact of climate change are air temperature and rainfall.⁵ These changes in turn impact the rates at which glaciers melt and the sea level. They also influence the occurrences of extreme weather events such as the frequency and intensity of droughts, cyclones and floods. In the following, I briefly discuss the changes in the temperatures and rainfall; melting of glaciers and sea levels; and extreme weather events in India in the last century.

⁴ The ancient Hindu calendar divides a year into six seasons with each season lasting approximately two months. The six seasons are: spring (*vasanta* in Snaskrit), summer (*grīśma*), monsoon (*varsā*), early autumn (*śarada*), late autumn (*hemanta*), and winter (*śiśira*).

⁵ Air temperature, also termed surface temperature in meteorology, refers to the ambient temperature indicated by a thermometer exposed to the air but sheltered from direct solar radiation and kept 1.5 to two meters above ground.

2.1 *Temperatures*

Three different figures for the increase in the mean temperature in India during the 20th century have been reported. The World Bank (2009, p. 162) reports no change, The Government of India (2004) a 0.4 percent increase and the IPCC Fourth Assessment a 0.68 percent increase.⁶ The Government of India (2004, p. 62) further notes, “On a seasonal scale, the warming in the annual mean temperatures is mainly contributed by the post-monsoon and winter seasons. Also, data analyzed in terms of daytime and nighttime temperatures indicate that the warming was predominantly due to an increase in the maximum temperatures, while the minimum temperatures remained practically constant during the past century. The seasonal/annual mean temperatures during 1901-2000 are based on data from 31 stations, while the annual mean maximum and minimum temperature during 1901-1990 are based on data from 121 stations. Spatially, a significant warming trend has been observed along the west coast, in central India, the interior peninsula and over north-east India, while a cooling trend has been observed in north-west India and a pocket in southern India.”⁷

Figure 1 in Lal (2003) shows that temperatures in India have recently increased in two phases: the first half of the 20th century and the period since the mid 1970s. The average annual temperature during approximately quarter century between 1950 and 1975 exhibited no trend. The warming in India is concentrated in the post-monsoon and winter seasons and in the maximum daytime temperatures rather than nighttime

⁶ These changes are in contrast to 2 to 3°C increases in North Asia, the region subject to most global warming within Asia.

⁷ IPCC evidently relies on Lal (2003, p. 8) who states that “an analysis of seasonal and annual surface air temperatures, using data from 1880 to 2000 for 25 or more stations, showed a significant annual mean warming of 0.68°C per 100 years.”

minimum temperatures. In the monsoon season, temperatures exhibit a *declining* trend in northwest India and no trend in the rest of the country. Increases in surface air temperatures relative to climatologically normal temperatures have been observed at most of the locations in India.

2.2 *Rainfall*

With respect to rainfall, The Government of India (2004, 61) notes, “Although the monsoon rainfall at the all-India level does not show any trend and seems mainly random in nature over a long period of time, the presence of pockets of significant long-term changes in rainfall have been recorded. Areas of increasing trend in the monsoon seasonal rainfall are found along the west coast, north Andhra Pradesh and north-west India (+10 to +12 per cent of normal/100 years) and those of decreasing trend over east Madhya Pradesh and adjoining areas, north-east India and parts of Gujarat and Kerala (-6 to -8 per cent of normal/100 years).” This assessment is consistent with that in Lal (2003, Figure 2), which reports no change in the trend on either the annual or seasonal basis during 1871-2000 in all-India rainfall.

2.3 *Glacier Melting*

According to NASA, although certain types of glaciers—for example, surge glaciers and tidewater glaciers—have been expanding, the vast majority are shrinking. The Glacier National Park in North America had 147 glaciers 150 years ago. Today, only 37 remain.⁸ In India, glaciers in the Himalayas are in decline. According to Naithani et al. (2001), at 30.2 kilometers long and between 0.5 to 2.5 kilometers wide, Gangotri Glacier

⁸ See <http://earthobservatory.nasa.gov/IOTD/view.php?id=4594>.

in the Uttarkashi District of Garhwal Himalaya is one of the largest Himalayan glaciers. It has been receding since scientists began to keep its measurement in 1780. Data between 1936 and 1996 show that 1,147 meters of the glacier melted away during the 61 years. This works out to a rate of 19 meters per year. Data for 1975 to 1999 show the glacier has receded 850 meters during these 25 years. At 34 meters per year, the rate at which the glacier is melting has accelerated over that observed in the prior years.⁹

Over one percent of water in the Ganges and Indus Basins is currently due to runoff from wasting of permanent ice from glaciers. This water flow will first rise and then decline as the Glacier becomes smaller and smaller. In assessing the cost of the glacier retreat, we must take into account two benefits as well: it is currently helping ameliorate the rate at which water availability per person is declining due to rising population and as glacier recedes, land underneath becomes available for use.

2.4 Sea Level

The average of the sea level along India's coastline is reported to be rising at 1mm per year on the average. According to The Government of India (2004), at 0.4 to 2.0 mm per year, the rise is the highest along the Gulf of Kutchh in Gujarat and the coast of West Bengal. Along the Karnataka coast, there is a relative decrease in the sea level. Much of the rise in the sea levels has been due warming of seawater that increases its volume.

⁹ This account is at odds with that presented in The Government of India (2004, Box 3.5, p. 79), which states, 'The rate of retreat of the snout of Gangotri glacier demonstrated a sharp rise in the first half of the 20th century. This trend continued up to around the 1970s, and subsequently there has been a gradual decline in its rate of retreat.'

2.5 *Extreme Weather Events*

Although numerous accounts of increased risk of extreme weather events can be found, the available historical data on the incidence of extreme weather events—heat waves, droughts, floods, cyclones and tidal waves—are equivocal.¹⁰ De, Dubey and Rao (2005) compile data spanning over approximately the entire 20th century from various sources. Assuming the data are comparable, the incidence of heat waves declined in Uttar Pradesh, Madhya Pradesh, and Gujarat during 1978-99 relative to 1911-67 but rose in Rajasthan, West Bengal and Maharashtra between the two time periods. Major cyclones over the North Indian Ocean numbered four in the 1940s, 1960s and 1990s and three in the 1970s. Frequency of rainfall of 30 inches or more in one day also does not show a clear pattern.

The bottom line with respect to droughts and floods offered by The Government of India (2004, p. 63) is consistent with these observations: “Instrumental records over the past 130 years do not indicate any marked long-term trend in the frequencies of large-scale droughts or floods in the summer monsoon season. The only slow change discernible is the alternating sequence of multi-decadal periods of more frequent droughts, followed by periods of less frequent droughts. This feature is part of the well-known epochal behavior of the summer monsoon.”

The report points to nuances not reflected in the data in De, Dubey and Rao (2005). It notes (p. 63), “In the northern Indian Ocean, about 16 cyclonic disturbances occur each

¹⁰ For example, Lal (2003, p. 8) states, “The frequency of extreme weather events in India—for example, heat waves, droughts and floods—has increased over the past two decades.” While Lal provides examples of droughts and floods from Orissa, Maharashtra and other states during the 1990s and early 2000s, he does not compare their frequency to what has been observed in the past. IPCC Fourth Assessment echoes Lal without additional data.

year, of which about six develop into cyclonic storms. The annual number of severe cyclonic storms with hurricane force winds averages to about 1.3 over the period 1891-1990. During the recent period 1965-1990, the number was 2.3. No clear variability pattern appears to be associated with the occurrence of tropical cyclones. While the total frequency of cyclonic storms that form over the Bay of Bengal has remained almost constant over the period 1887-1997, an increase in the frequency of severe cyclonic storms appears to have taken place in recent decades (Figure 3.7). Whether this is real, or a product of recently enhanced monitoring technology is, however, not clear.”

3 Predicted Changes, Vulnerabilities and Adaptation

Given the difficulties in accurately measuring even the past shifts in temperatures and rainfall, it should be no surprise that predicting the future shifts in them is bound to be subject to extremely large errors. This in turn makes the measurement of the vulnerabilities resulting from future climate changes even more difficult. For example, consider food security. Climate change is associated with increased CO₂ (carbon dioxide) emissions, rising temperatures, increased or decreased rainfall, increased or reduced moisture, rising or declining sea levels and more rapidly melting of glaciers. Not only is the magnitude of productivity change in agriculture implied by these changes taken together is uncertain but also the direction of change is unpredictable. To make matters worse, climate change related changes are spread over a whole century during which new products and production processes are bound to emerge. In principle, these changes may overwhelm the effects of any climate related changes. Needless to say, the discussion below must be taken with lots of grains of salt.

3.1 Temperatures and Rainfall

In Table 1, I reproduce the predictions of average temperature and rainfall changes during the 21st century in South Asia and North Asia reported in the chapter on Asia by Working Group II of the IPCC Fourth Assessment. The predictions are derived from Atmosphere-Ocean General Circulation Models (AOGCM). The table reports the results of simulations based on two sets of assumptions with respect to GHG emissions: scenario A1FI assumes the highest future emission trajectory and B1 the lowest emission trajectory. Therefore, the two scenarios give the upper and lower limits of predicted changes. The changes are recorded relative to the baseline period of 1961 to 1990.

Two points follow from Table 1. First, the variation in predictions across regions is large. In North Asia, the region with the greatest climate change impact within Asia, the predicted temperature increase in the winter months (December, January and February) ranges from 6 to 10.5°C during 2070-99. That is to say, even if strong measures to contain emissions around the globe are taken, the temperature rise in North Asia would be as much as 6°C during the winter months by the end of the 21st century. The temperature change in South Asia in the winter months during 2070-99 is predicted to be between 3 and 5.5°C in South Asia. The rainfall is predicted to rise between 29 and 59 percent in North Asia and to fall between 6 and 16 percent in South Asia. The changes in temperatures and rainfall also vary according to seasons: broadly speaking, they are larger during the winter months and become smaller as we move away from those months. Indeed, in so far as rainfall in South Asia is concerned, it even changes sign between winter and non-winter months. It is predicted to fall in winter months but substantially rise in the remaining nine months during 2070-99.

Second, the predicted changes in nearer term are smaller than those in the longer term but still larger than those observed during the last entire century. For example, the temperature increases in South Asia during 2010-39 are predicted to range between 1.1 and 1.2°C during the winter months and 0.78 to 0.83°C in the post-monsoon months. Rainfall increase is predicted to range between –3 and 4 percent in the winter months and 1 to 3 percent in the summer months. Interestingly thus the rainfall is mostly predicted to marginally rise in the near term but fall in the longer term in South Asia.

The Government of India (2004) reports the results from a set of General Circulation Models with regional details under the assumption that GHG forcing is increased at the compound rate of 1 percent per year during 1990-2099. Like the IPCC Fourth Assessment, these simulations predict marked increase in temperatures and rainfall by the end of the 21st century. The increase in the average temperature ranges from 3 to 6°C and that in rainfall from 15 to 40 percent over the 1961-90 baseline. The models predict increased precipitation during the monsoon season especially in the northwestern part of the country. State-wise projected increases show wide variation across models, however. The Government of India (2004) cautions that projections based on the models are subject to very substantial uncertainty: “Regionally, there are large differences among different GCMs [General Circulation Models], especially in precipitation-change patterns over the Indian subcontinent. Most GCM models project enhanced precipitation during the monsoon season, particularly over the northwestern parts of India. However, the magnitudes of projected change differ considerably from one model to the other. Uncertainties exist in the projections of climate models specifically concerning their

spatial resolutions. The GCMs are robust in projecting temperature changes rather than rainfall changes.”

3.2 *Water Supply*

India has 16 percent of the world’s population but only 4 percent of its water. Rising population has been continuously lowering the availability of water per capita. The current availability of utilizable surface and ground water stands at 1,122 billion cubic meters (The Government of India 2001, p. 72). Given India’s current population of 1.15 billion, this works out to approximately 1000 cubic meters per capita. Conventionally, utilizable water below 1700 cubic meters per capita per year is associated with “stress” in water availability and that below 1,000 cubic meters per capita per year with chronic water “scarcity.” The Government of India (2004, Table 3.1) estimates actual total water consumption in 2010 to be 200 billion cubic meters. With the expected population of 1.2 billion in 2010, this works out to approximately 165 cubic meters per capita per year. This consumption is comparable to that in some of the developed countries though considerably below many others.¹¹ Irrigation accounts for more than 80 percent of water consumption in India.¹²

Looking ahead, per capita water availability is expected to decline due to rising population. According to some estimates, population is expected to stabilize around 1.6 billion in 2050. Assuming no change in water availability, this would place per capita

¹¹ This availability level is distinct from actual consumption level. Interestingly, the consumption levels vary vastly across countries. Based on 2002 (or latest available) data, annual per-capita water consumption in the OECD countries ranged from 130 cubic meters in Denmark to 1,730 cubic meters in the United States. All OECD countries except Portugal, Australia, Canada and the United States have water consumption below 1,000 cubic meters.

¹² In the United States, industrial, agricultural and domestic consumption account for approximately 65, 27 and 8 percent of the total consumption.

water availability at approximately 700 cubic meters per year. In the light of the current consumption levels, this may seem adequate but such a conclusion is unwarranted. Surface water accounts for only 60 percent of the available supply and 40 percent of it is concentrated in the Ganges-Brahmaputra-Meghna system. This has meant that water usage in the majority of the river basins is already between 50 to 95 percent of the available supply. In addition, variation in the availability across seasons can also add to scarcity in certain parts of the year.

Climate change can impact water availability through several channels. Increased rains by themselves would add to the availability of surface water. More rapid melting of glaciers will also add to the availability of utilizable water initially though this channel will dry up as glaciers disappear. Increased temperatures that lead to increased evaporation and transpiration cause the availability of utilizable surface water to shrink. Estimates reported in The Government of India (2004, Table 3.2) show the net effect to be positive for some rivers and negative for others.

Climate change can further impact water availability through its influence on droughts and floods. Water shortages in specific regions can occur if drought conditions become more severe, prolonged and frequent. According to The Government of India (2004, p. 78), areas served by river Luni, which occupies about one-fourths of the area of Gujarat and three-fifths of the area of Rajasthan, are likely to experience acute physical water scarcity conditions. Increased frequency and severity of floods can also temporarily create a shortage of utilizable water.

From the policy perspective, climate induced changes require more intense pursuit of measures to conserve and develop water resources that India must undertake even absent

climate change. These include more prudent utilization of surface and ground water through proper pricing as well as training, harvesting of rainwater, building of dams, development of distribution networks, and re-forestation to help replenish ground water. The government can also exercise the option to import of food grains to conserve water utilization in agriculture.

3.3 *Agriculture*

From an economic standpoint, climate change is likely to have its most pronounced effects in the area of agriculture. Approximately 70 percent of India's population lives in rural areas and 55 to 60 percent of its workforce is engaged in agriculture. On the other hand, the share of agriculture (including forestry and fishing) in the GDP has declined from 29.3 percent in 1990-91 to only 17.8 percent in 2007-08. Already, three-fifths of the workforce lives on less than one-fifth of the GDP.

Very low productivity growth in Indian agriculture is a well-recognized problem. Future prospects also look bleak. The sector is likely to face progressive scarcity of water. Ground water level has been progressively declining and the supply of river water may also shrink over time. Progressive division of land holdings over last several generations has led to extremely low size of land holdings: In 2002-03, 70 percent of land holdings were less than one hectare (2.47 acres) and the average land holding was 1.06 hectares. Land leasing laws in various states result in vast volumes of land being left uncultivated in some states while leading to highly inefficient methods of farming in virtually all states.

Against this background, how do we assess the impact of climate change? There are several possible channels. Increased droughts and floods can lead to partial

destruction of crops with greater frequency. Compression of the monsoon season and increased intensity of rains may also impact agricultural productivity. Increased sea levels can reduce the availability of arable land. Rising maximum temperatures in drought prone areas lead to reduced productivity while those in cooler areas raise productivity. Increased carbon dioxide levels in the air lead to increased productivity in certain crops. According to the World Bank (2009, Box on p. 76), C3 crops, which include rice, wheat, soybeans, fine grains, legumes, and most trees, benefit significantly from such a change; C4 crops including maize, millet, sorghum, and sugarcane, benefit less.

A number of studies try to estimate the effects of rising temperatures, increased or reduced rain, increased carbon dioxide levels and other climate related changes on yields in different crops and regions. Table 7.3 in World Bank (2009) summarizes the results of many studies. The effects vary widely according to crops, specific climate changes assumed and region. For example, Aggarwal and Mall (2002) simulate various IPCC climate change scenarios for parts of northern, eastern, southern, and western India and predict gains in rice yields ranging from 1.3 percent by 2010 to 25.7 percent by 2070. On the other hand, assuming increases of 2°C in maximum and 4°C in minimum temperature, 5 percent reduction in the rainy days, 10 percent reduction in monsoon rains and an increase in carbon dioxide levels to 550 ppm (parts per million) from 430 ppm, World Bank (2006) predicts 9 percent reduction in rice yields and 2, 3, 10 and 3 percent increases in yields of groundnut, jowar, sunflower and maize, respectively. There are very large errors associated with these predictions so that it is not altogether clear how

seriously one should take them. My personal view is that they are just about as reliable as astrological predictions!

3.4 Health

In general, the relationship between climate change and health outcomes is complex. Therefore, as in other areas, we can only speak in terms of possible outcomes. If temperatures rise in warmer parts of the country and on the maximum end of the spectrum, heat waves may become more intense and longer lived. That would result in increased incidence of heat stroke and related diseases. Heatstroke related deaths might rise as well. Warmer climate also makes air pollution more harmful and contributes to airborne diseases with greater potency. Increased dampness and water pollution accompanying floods are likely to increase the risk of spread of diseases such as Malaria. Water contamination that may accompany floods and draughts may also lead to increased incidence of intestinal diseases such as diarrhea. On the other hand, warming in colder regions, during winter season and in minimum temperatures may reduce health risks associated with cold waves. Increased rains in currently dry regions may also reduce the risk of heat waves.

To the extent that the climate change is expected to be associated with increased health problems, the change represents an intensification of some of the existing public health problems in India. My detailed analysis of health sector (Panagariya 2008, chapter 19) shows that the government is already behind the curve in addressing these problems. The possibilities outlined above call for renewed vigor in implementing major policy reforms in the sector. India needs to accelerate medical education at all levels to ensure access to trained medical personnel. It also needs to improve access to medicines. And,

of course, it needs to take a variety of public health measures to combat the spread of infectious diseases by ensuring proper drainage and supply of clean drinking water.

3.5 *Migration*

Intensification of urban-rural and inter-state migration may be another area of impact of climate change. To begin with, given diverse rates of growth across states and between urban and rural areas, migration is likely to accelerate. Demographic changes are likely to reinforce this phenomenon: whereas all four southern states (Andhra Pradesh, Kerala, Tamil Nadu and Karnataka) have reached the replacement levels of fertility rates, many of the poorer states in the north such as Bihar, Uttar Pradesh, Madhya Pradesh and Rajasthan have high population growth rates. This would likely lead to increased migration from the latter set of states to the former.

Climate change can further add to complications in migration patterns. For example, rising sea levels may displace a part of the population currently living in the coastal zones.¹³ More frequent cyclones, droughts and floods may also lead to increased migration. Finally, it is commonly suggested that climate related events may lead to massive migration from Bangladesh into India. These sources of migration are bound to interact with other sources and, very importantly, the ongoing process of urbanization. Other than noting these possibilities, it is not clear what precise policy prescriptions can be offered in anticipation of what are at this stage guesses with high degree of uncertainty. While migration may generate some social stress, in so far as it involves the

¹³ According to the Government of India (2004, p. 114), a rise of one meter in sea level is projected to displace 7.1 million people. Predicted levels of sea rise, based on temperature increases of 1.5 to 2°C by the middle and 2.5 to 3.5°C by the end of the century would raise the sea level by 15 to 38 centimeter by the middle and 46 to 59 centimeter by the end of century, respectively.

movement of people from low-income to high-income areas and leads to urbanization and modernization, it is to be welcome.

3.6 Poverty

Climate change may impact poverty at two levels: it may increase the number of poor by impoverishing those with incomes just above the poverty line and the burden of some of the climate related extreme events may fall disproportionately on the poor.

The proportion of the poor living below the poverty line may rise due to reduced incomes of farmers many of whom may be living just above the poverty line. But it must be acknowledged that this effect may also go the other way if the net effect of climate change is to increase rather than reduce agricultural productivity. An increase in poverty may also result from reduced opportunities for the bottom deciles elsewhere in the economy and reduced revenues available to the government to carry out anti-poverty programs. Whether or not the effect would be large depends how large climate related changes in temperatures, floods, cyclones and droughts are and how close the connections between these changes and reduced farm incomes, shrunken opportunities elsewhere in the economy and decline in government revenues are.

Turning to climate-change-related extreme events such as floods, cyclones and droughts, a prima-facie case can be made that they would asymmetrically hurt the poor. The poor are more exposed to floods. Disproportionately large number of them being landless workers or marginal farmers, they also bear the greatest burden of droughts. Natural calamities are also likely to adversely impact indigenous populations that are less able to shelter themselves. Floods and heavy rains are also likely to asymmetrically

damage the urban poor who live in dwellings that readily collapse under heavy downpour.

One way to pose the poverty question in the context of climate change is where we expect poverty levels to be in 2030 absent any climate related effects and where it will be taking the latter into account. We may then ask how the strategy to combat poverty ought to be different. The same may be said of necessary protection against the vagaries of droughts and floods. These are ongoing phenomena that are predicted to become more frequent and more intense. The question then is how best to modify flood and drought relief policies in anticipation of climate related changes.

Here we must not shy away from raising the issue of priorities: Given that the government has limited resources and, indeed, very limited capacity to deliver services, how much importance should it give to combating the adverse effects of climate change relative to other priorities such as the provision of education and health, helping sustain a high rate of growth and attending to localized environmental concerns ranging from pollution of river waters to indoor air pollution associated with cooking with solid fuels such as dung, wood, crop waste or coal.

An argument can be made that rapid growth currently under way will better prepare the population to cope with vagaries of future climate changes. If the current near-double-digit growth were sustained for two decades—an entirely feasible proposition—the country would almost entirely be free of extreme poverty. With proper shelters and substantially improved purchasing power, people will themselves be better prepared to

adapt to climate change effects in two decades.¹⁴ This line of reasoning argues for minimizing the commitments for mitigation GHG emissions in the next two decades that might compromise growth. This is not a recommendation for irresponsible behavior but simply for negotiating an agreement whereby India's mitigation commitments are back-loaded.

In concluding this section, let me note that my assessment of the prospects for India's ability to adapt to climate related changes that will occur even after actions for mitigation are taken are less apocalyptic than some others who describe them as potentially "calamitous." For instance, on the authority of Nordhaus and Boyer [2000], Mendelsohn *et al.* [2006] and IMF [2008], Joshi and Patel (2009, p. 4) express the urgency for India to negotiate an agreement in these terms:

"India is more vulnerable to climate change than the US, China, Russia and indeed most other parts of the world (apart from Africa). The losses would be particularly severe, possibly calamitous, if contingencies such as drying up of North Indian rivers and disruption of Monsoon rains came to pass. Consequently, India has a strong national interest in helping to secure a climate deal."

Quite apart from the large uncertainty associated with the predictions, it is difficult to reconcile this assessment with any of the existing predictions of the impact of global warming on rains, evaporation and transpiration for India. Rains are uniformly predicted to rise and the impact of temperature increase on evaporation and transpiration is not

¹⁴ My assessment in this regard is consistent with India's National Action Plan on Climate Change released on June 30, 2008. The plan rightly emphasizes the overriding priority of maintaining high economic growth rates to raise living standards and focuses on identifying "measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively."

expected to be large enough to significantly change the net availability of surface water significantly.

4 Mitigation: Efficiency

The contentious policy issue we currently confront is how best to address the regulation of GHG emissions. Because the issue is global and thus involves multiple countries, the problem has two aspects: efficiency and the distribution of costs of mitigation across countries. Discussions on mitigation often lump these two aspects but they can be separated both in principle and practice. In this section, I focus on the efficiency issue.

Efficiency itself has many aspects: optimal level of GHG emissions by country, their time phasing and the choice of instruments. To pose the problem most simply initially, ignore the multi-country as well as inter-temporal aspect of it. Assume a one-country, one-good world. Denoting the output of the aggregate good by X , capital by K , labor by L and GHG emission by Z , the production function of X can be represented by a conventional constant-returns-to-scale production function $F(\cdot)$.

$$(1) \quad X = F(K, L, Z)$$

The social welfare function to be maximized is written

$$(2) \quad W = U(X, Z)$$

$U(\cdot)$ is rising in X and declining in Z and satisfies the usual properties of a utility function. We take K and L as given. Therefore, the optimization problem is to choose Z (and therefore X as well) to maximize utility. Using a subscript to denote a partial derivative, the solution is given by:

$$(3) \quad F_Z(\cdot) = -U_Z(\cdot)/U_X(\cdot)$$

The left hand side of this equation represents the extra X attributable to the last unit of GHG emission and may be viewed as the marginal benefit of Z. The right-hand side represents the absolute value of social cost imposed the last unit of GHG emitted, where the cost is measured in terms of units of X. The right-hand side thus represents the marginal social cost of Z.

In Figure 1, I measure Z on the horizontal axis and its marginal benefit, marginal cost and “price” in terms of X on the vertical axis. Remembering $F_{ZZ} < 0$ by concavity of the production function, the left-hand side of (3) can be represented by the downward-sloped curve labeled MBZ. Likewise, we can represent the right-hand side by the curve labeled MCZ. A sufficient but not necessary condition for MCZ to be upward sloped is that the marginal utility of X decline with a rise in Z ($U_{XZ} < 0$). In words, the latter condition says that an extra unit of consumption of X gives less pleasure in a more polluted environment. In the rest of the paper, I assume that the conditions necessary for the MCZ curve to be upward sloped are satisfied.

MC, MB, P

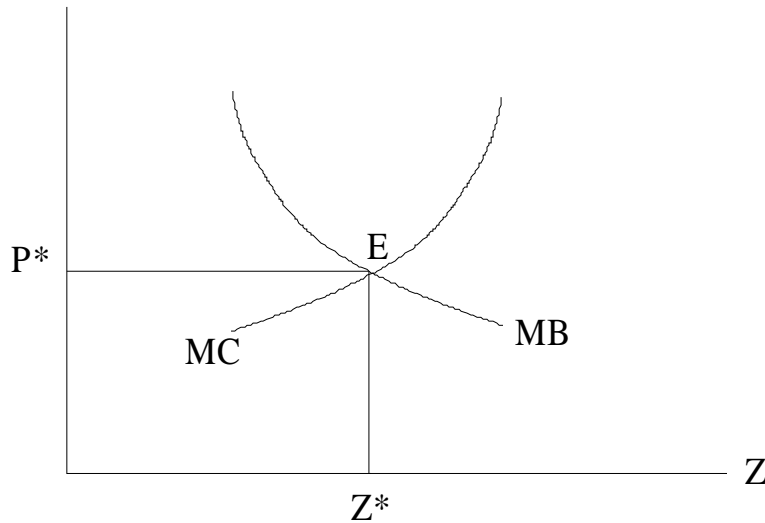


Figure 1: Optimal Choice of Emissions

The optimal solution in Figure 1 is given by point E. One way to achieve this solution is to fix the price of Z at P^* . This is equivalent to the imposition of a pollution tax at rate P^* per unit of pollution. Given P^* as the price, firms will use up Z up to the point where the marginal product of Z equals P^* or $F_Z = P^*$. Recalling that the MBZ curve represents nothing but F_Z , we immediately obtain Z^* as the equilibrium value of Z.

Alternatively, we could fix the quantity of Z at Z^* . The instrument to ensure this would be tradable pollution permits. The government could issue pollution permits for Z^* units and auction them competitively. The firms will keep bidding for the permits until the marginal product of Z exceeds the price of the permit. Therefore, if the auction is perfectly competitive, the price of the permits will settle at P^* . If the price is any lower, there will be firms with higher marginal product and an excess demand for permits would exist. If it is any higher, some permits will go unsold pushing the auction price down. Therefore, the price (tax) and quantity (pollution permits) solutions are exactly identical.

A key point to observe is that in both price and quantity solutions, we raise revenue in the amount of P^*Z^* . A key question is who should receive this revenue. If the problem we have outlined relates to a nation, the answer may be less complex. In either case, revenues could be treated as a part of general revenues. But in the present case, we are dealing with multiple governments.

One solution would be to pass on the revenue generated by the purchase of Z by a firm to the government with jurisdiction over that firm. But this solution is complicated by the fact that in the past countries have been able to emit without a charge. Developed countries that currently enjoy high standard of living have acquired their wealth by partially using up a common resource at no price. The cost imposed by their past emissions is going to be borne by all nations. Indeed, if the resulting calamities concentrate more in the poor countries, costs would have fallen disproportionately on them. That is to say, the benefits of past pollution would have gone to the rich countries and costs would have fallen on the poor countries. Additionally, high demand for Z at high incomes reflected through high demand for X makes Z more expensive everywhere. Firms located in India and China must pay a high future price of Z because, among other things, the United States and Europe consume very high levels of Z, an outcome not related to the free availability of Z in the past.

I will return to these issues in the next section. Presently, let me briefly extend the model depicted in Figure 1 to explicitly allow for a two-country world consisting of a rich northern country and a poor southern country. I use upper-case letters to denote variables associated with the northern country and lower-case letters those associated with the southern country. The simple model above is now replaced by

$$(4) \quad X = F(K, L, Z), \quad x = f(k, l, z)$$

$$(5) \quad W = U(X, \zeta), \quad w = u(x, \zeta)$$

$$(6) \quad \zeta = \zeta_0 + Z + z$$

I now introduce parameter ζ_0 , which measures the stock of past pollution. This modification makes explicit the proposition that the social cost of emissions depends on not just current but past emissions as well. The optimal levels of z and Z are now given by

$$(7) \quad (U_\zeta + u_\zeta)/u_x = (U_\zeta + u_\zeta)/U_X = F_Z = f_z$$

This is the usual solution to the public good (“public bad” in the present case) problem: global welfare is maximized by equating the sum of the costs imposed on the two countries by the last unit of emission to the benefit produced by it in either country.

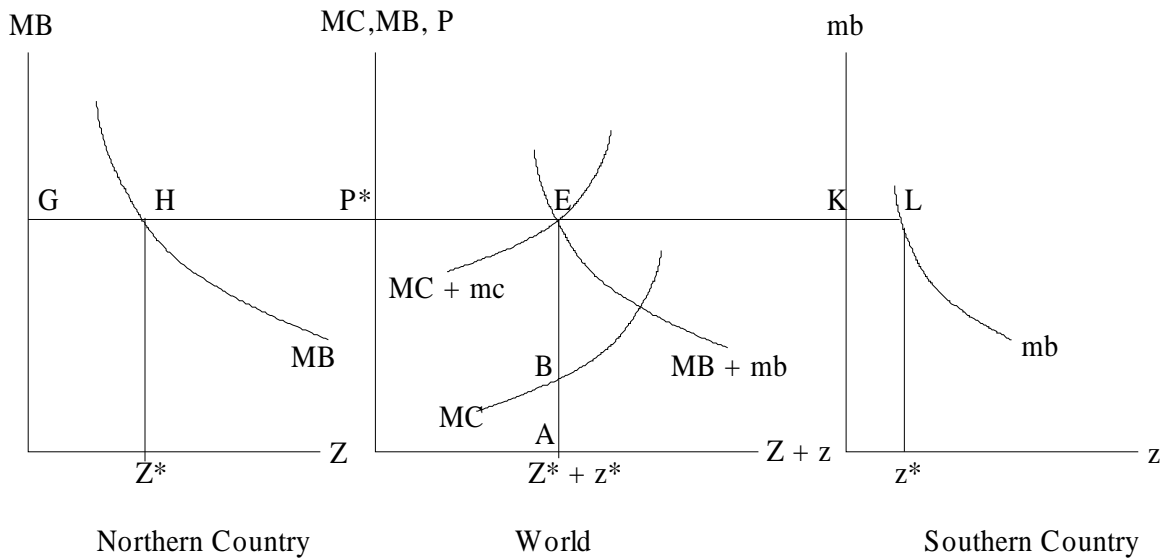


Figure 2: Optimal Emission in a Two-country Model

Figure 2 depicts this solution graphically. The marginal products of GHG emissions in the northern and southern countries are depicted by curves labeled MB and mb in the first and last panels, respectively. In the middle panel, MB + mb is derived by

horizontally summing the MB and mb curves. Curve labeled MC in the middle panel depicts the marginal cost of worldwide GHG emissions (inclusive of the past emissions) in the northern country. Stacking the marginal cost in the southern country for each value of the worldwide GHG emissions vertically above MC, we obtain MC + mc curve showing the global marginal costs of worldwide emissions.

Point E where the global marginal benefit and cost curves intersect yields the optimal level of global GHG emissions, $Z^* + z^*$. Setting the price of (tax on) emissions at P^* , the northern country firms chooses Z^* and the southern country firms z^* . Alternatively, if globally tradable permits in the amount $Z^* + z^*$ are issued and competitively auctioned, permits will be priced at P^* , with the northern country firms buying Z^* and southern country firms z^* worth of permits. The globally efficient solution will be reached.

As drawn, Figure 2 shows that the southern country pollutes much less than the northern country. This feature derives from its smaller economic size mainly captured by smaller resource base and perhaps lower productivity. Given these features, emission levels of the southern country turn out to be small in relation to the northern country. Figure 2 also shows that in equilibrium, the southern country bears the bulk of the cost of emissions: the marginal cost absorbed by the southern country, EB, is significantly bigger than that absorbed by the northern country, AB. As drawn, the total costs measured by the area under the MC and above the horizontal axis up to emission level $Z^* + z^*$ for the northern country and by the area below mc curve and above MC curve up to the same emission level also show higher costs to the southern than northern country. This feature is intended to represent the greater vulnerability of the southern countries to climate

change that many analysts, especially from developed countries, emphasize. I must acknowledge, however, that given the uncertainties previously noted, it is difficult to judge the truth of this claim.

Assuming for now that Figure 2 realistically represents the current situation between rich and poor countries, the distributional conflict between northern and southern countries is evident: the latter can claim with some justification to be the innocent victims of emissions by the former.

This problem gets much worse when we consider the past emissions. Recall that these are represented by parameter ζ_0 introduced in equation (6). These emissions have two important implications. First, while developing countries suffer the damage caused by those emissions, they did not benefit from them in any way. Second, those emissions have raised the shadow price of current and future emissions. In Figure 2, a lower value of ζ_0 shifts the MC and MC + mc curves down and thus lowers the optimal price of current and future emissions. While the first of these implications has been previously recognized, the second has not received its deserved share of attention.

How does the presence of uncertainty with respect to the cost of GHG emissions impact this analysis? Surprisingly, at least under risk-neutral behavior, the equivalence of price and quantity instruments is entirely preserved. The point is readily made using the simpler, one-country model of Figure 1. I reproduce this model in Figure 3 with the modification that the location of the MC curve is known only probabilistically. Specifically, marginal costs may turn out to be high or low each with a probability of 0.5. These are respectively represented by MC' and MC'' in Figure 3. For simplicity, I make all curves linear. MC represents the expected (or mean) value of the marginal cost for

various levels of Z . The objective now is to maximize the expected net benefit from Z . This is achieved at point E with $Z = Z^*$. Given MC shows the mean value of the marginal cost, the shaded triangles are equal in area. If the cost curve ends up being MC' , Z is overshoot with a deadweight loss of the upper shaded triangle relative to the ex post optimum E' . If the cost curve turns out to be MC'' , Z undershoots with the lower shaded triangle representing unexploited benefits relative to the ex post optimum E'' . Any other value of Z will lead to lower expected net benefits.

MC, MB, P

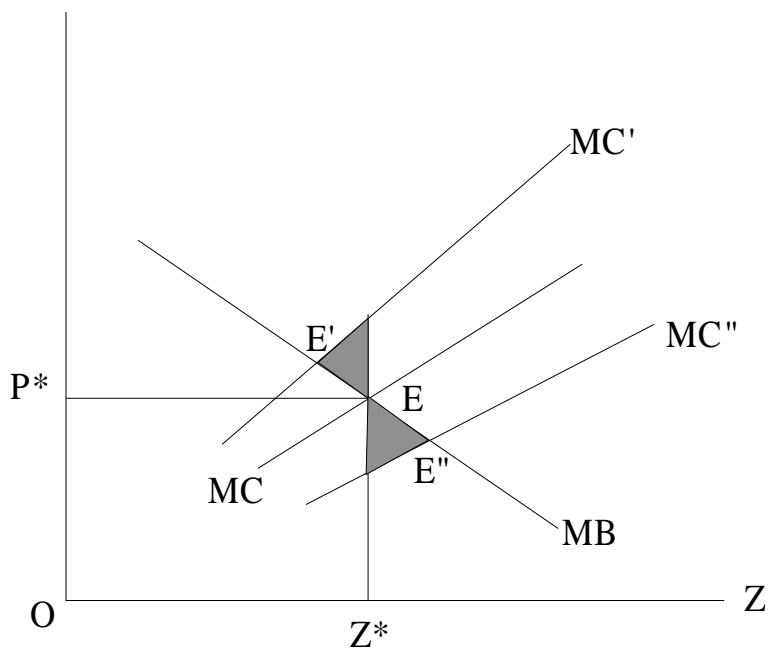


Figure 3: Uncertainty and the Optimal Instrument

In view of the fact that the marginal benefits are not uncertain, outcome E can be reached by either setting the price of Z at P^* or issuing pollution permits for Z^* quantity and auctioning them competitively. In the former case, firms will buy Z until $P^* = F_Z$, which leads to Z^* as the solution and $P^* \cdot Z^*$ as revenue. If permits are auctioned

competitively, firms are willing to pay a price equal to the marginal benefit, which equals P^* . Once again, the same solution obtains with revenues equaling P^*Z^* .

I may note without actual demonstration that if the marginal benefits of Z happen to be uncertain instead of marginal cost, pollution permits turn out to be the preferred instrument. The asymmetry arises because firms operate along the marginal benefit curve. When the price instrument is used, firms choose Z at the given price along the realized marginal benefit curve, which causes the pollution level to deviate from ex ante optimum solution. The quantity instrument (pollution permits) does not allow this deviation: the burden of adjustment ex post falls on the permit price.

Given the large part of the uncertainty is associated with costs rather than benefits of emissions, in practice, the bigger difference between the price (tax) and quantity (permits) instruments is likely to result from the political economy accompanying them. A tax will work more transparently with the government readily collecting revenue. But a decision to go with permits is likely to result in demands for their free distribution to firms better able to lobby the government. This is aptly illustrated by the recent U.S. experience with the “cap and trade” legislation aimed at regulating domestic emissions by U.S. firms in specific sectors. The U.S. Congress opted for permits, which immediately led firms to begin lobbying for their free distribution. The outcome has been a decision to distribute 85 percent of the permits freely. To justify this action, the U.S. Congress now plans to hold down the price charged by electricity suppliers, the largest beneficiaries of the give away. This clearly violates the efficiency principle. On the political economy and transparency counts, a tax on GHG emissions is clearly superior.

I have analyzed the problem of optimal choice in a static framework. Evidently, there is a time dimension to the problem. We must derive the optimal target levels of emissions based on expected costs and benefits for each period, which may be defined as one year or longer. In general the optimal tax or number of permits would vary across periods depending on the how the expected costs and benefits are phased. An important point to remember is that since emissions cumulate, they progressively push the marginal cost curves up over time. This fact pushes for more stringent regulation in the early years.

Finally, it is important to address and clarify three issues related to mitigation. First, it has been argued that any solution can be successfully implemented only if it includes all major countries. One reason offered in support of this view is that countries would simply not agree to commit to mitigation unless all other major countries do as well. Another reason, emphasized by Cooper (2008), is that the grant of an exception to large countries such as China and India would lead to leakages (through relocation of production to these countries) that would offset the actions taken by countries undertaking mitigation. Both arguments have their limitations. As I discuss later, the original United Nations Framework Convention on Climate Change (UNFCCC), within which the international negotiations have been taking place, explicitly exempts the developing countries from mitigation commitments. Consistent with the UNFCCC, the Kyoto Protocol, the first major agreement setting targets for mitigation, includes only developed countries. As for leakages, two qualifications may be noted: the vast majority of emissions take place in non-traded sectors that cannot migrate; and environmental regulation being only one of the many factors determining the location of industries,

leakage are capped even in traded goods sectors. For example, the EPA estimates U.S. emissions leakage rates under Lieberman-Warner of approximately 11 percent in 2030 and 8 percent in 2050.¹⁵

Second, implementation of the efficient solution requires monitoring. Cooper (2008) argues that this is not a problem since the International Monetary Fund (IMF) is well equipped to fulfill this function. But given the current governance structure of the IMF, acceptability of the IMF to countries such as India and China, if these countries were to undertake mitigation obligations, is far from obvious. These countries are unlikely to accept surveillance by an institution heavily dominated by many tiny European countries that would themselves make limited contribution to the alleviation of global warming.

Finally, the agreement will have to rule out any implicit subsidies that counteract the emission tax in case the chosen instrument for mitigation is a tax. For instance, if an increase in carbon tax on gasoline is accompanied by an equivalent reduction in an existing sales tax on it, the end result will be the same level of consumption of gasoline. Likewise, if petroleum subsidies are present as in India and the carbon tax is accompanied by an increase in these subsidies, the desired reduction in petrol consumption will not obtain. This is a familiar problem in the World Trade Organization, which forbids the imposition of para-tariffs. A similar problem is less serious when mitigation is achieved through a quantity-based instrument. In this case, permits are available only up to the desired global limit on emissions. A government wishing to subsidize its firms has to buy permits and distribute to the chosen firms for less than the

¹⁵ EPA Analysis of the Lieberman-Warner Climate Security Act of 2008 *S. 2191 in 110th Congress* March 14, 2008

full price. But even in this situation, though the global emissions remain capped at the desired level, efficiency is compromised.

5 Mitigation: The Distributional Issue

The issue of how the costs of mitigation should be divided among various countries is the most contentious one and, indeed, a key factor behind the difficulties in reaching an agreement to limit the GHG emissions. Several issues must be addressed.

5.1 Compensation for the Past stock of Emissions

Carbon emissions accumulate over time. Therefore, the damage to the environment is due as much to the past emissions as from the future ones. As Bhagwati (2006) has argued, if future emitters are to be held responsible for their acts, so must be past emitters. He refers to future emissions as the “flow” problem and the past ones as the “stock” problem. While countries such as China and India are becoming substantial contributors (India less so than China) to the flow problem, they have contributed very little to the stock problem.

According to the Pew Center on Global Climate Change, the United States contributed 30 percent of the cumulative CO₂ emissions between 1850 to 2000; EU-25 together 27 percent (Germany 7 percent, U.K. 6 percent, France 3 percent, and each of Poland and Italy 2 percent); Russia 8 percent; China 7 percent; Japan 4 percent; and Ukraine, Canada, and India 2 percent each.¹⁶ In other words, approximately 71 percent of the emissions from 1850 to 2000 were accounted for by the United States, EU, Russia,

¹⁶ These data are taken from website <http://www.pewclimate.org/facts-and-figures/international/cumulative>.

Japan and Canada alone. With 4 percent of the global CO₂ emissions, India is now the third largest contributor to the flow problem coming behind the United States and China each of which contributes 16 percent of the world's CO₂ emissions.¹⁷ Quite apart from the fact that the gap between the current top two emitters and India is very large, the latter's contribution to the stock problem at 2 percent is tiny. Under any reasonable equity principle, it cannot be expected to become a part of an agreement that addresses only the flow problem, letting the nations responsible for stock emissions entirely off the hook.

Coming from the opposite viewpoint, Cooper (2008) categorically rejects the case for compensation by rich countries for the past emissions. He reasons thus (Cooper 2008, p. 19-20),

“Increased CO₂ concentration in the atmosphere is due in considerable measure to emissions by today's rich countries during the course of their development over the past two centuries. Therefore, some observers argue, today's rich countries should bear the burden of reducing CO₂ emissions and, eventually, atmospheric concentration. This concept of equity is highly dubious. When Englishmen launched the coal-based industrial revolution, they had no idea that climate change three centuries later would be a consequence. Why should their descendants be held responsible? When Americans in the mid-19th century created the petroleum industry with the invention of kerosene (a substitute for increasingly scarce whale oil), they did not know its full long-term implications (including, probably, saving several species of whales from extinction). Moreover, on one estimate the rich

¹⁷ See the Government of India (2009).

countries are not overwhelmingly responsible for the increased concentration of greenhouse gases in the atmosphere. If changes in land use are taken into account, the rich countries account for only 55 percent of the increase since 1890, the poor countries for 45 percent (Mueller et al, 2007). A debate over past culpability will not help solve a global problem. Economists teach that optimal decisions generally require by-gones to be ignored: in this as in many areas we should look forward rather than backward, and provide adequate incentives for desired behavior. To focus on alleged retrospective wrongs of the remote past is to assure inaction.”

In this paragraph, Cooper makes four arguments against compensation by rich countries for past emissions: past polluters were ignorant that they were doing any harm and long gone; optimal decisions require forgetting the past; focusing on the past wrongdoing will lead to inaction; and, according to one calculation, rich countries are responsible for only 55 percent of the past damage. There are problems with all four arguments.

Regarding the first argument, Bhagwati responds that compensation by a future generation for a harmful act that its ancestors committed without knowing that it was harmful is not unusual. Americans who practiced slavery in the 19th century acted according to the prevailing social norms; they did not know their actions would cause harm to the future generations of African Americans. Yet, once it came to be recognized that those acts had inflicted harm, the affirmative action program was put in place. In India, those responsible for cruelty against the dalits two centuries ago did not know that they were harming future dalit generations. But once this was recognized, the Indian Constitution provided for a strong affirmative action program for them.

As for Cooper's second argument, there is nothing in economics that says that optimization requires forgetting events that have already occurred. A blanket adoption of such a rule is bound to encourage irresponsible behavior whenever individuals are assured that they would not be caught for a long time. An important reason behind punishment for a crime is to deter future crimes. Indeed, there is an important precedent from within the environmental area in the United States for compensation against past damage. The United States Comprehensive Environmental Response, Compensation and Liability Act of 1980, commonly called the Superfund, allows the Environmental protection Agency (EPA) to compel parties responsible for dumping toxic waste in the 1970s in rivers, canals and other sites to perform cleanups or reimburse the government for cleanups. The U.S. law also permits individuals adversely impacted by toxic waste sites to sue the offending companies for damages.

Cooper's third argument that focusing on the past will delay action cannot be taken seriously. Surely, the past offenders could speed up action by offering compensation just as much as the recipient countries can speed it up by agreeing to forego it. Every negotiator worth his salt tells the other party that it is wasting valuable time by refusing to accept the deal on the table.

Finally, Cooper's claim that rich countries account for only slightly more than half of the past damage is based on applying a specific correction. If such corrections are to be made, we should also correct for population size. Moreover, future emissions should be corrected for land use as well. But as the bottom line, even if we accept Cooper's numbers, the conclusion would be that both rich and poor countries that contributed to

past emissions must pay for their use of a scarce resource. It is not an argument that absolves the offenders of their responsibility.

If it is agreed that polluter pay principle must be applied to past emissions, how is it be implemented? Bhagwati (2006) suggests creating a substantial global warming superfund to which developed countries contribute for no less than 25 years. Unlike in the case of the Superfund, there is no toxic waste to be cleaned up in this case. Therefore, the funds could be made available to the developing countries such as India and China to promote clean technologies including wind and solar energy. Given developed country companies are likely to develop a significant part of these technologies, the fund would also benefit the developed countries.

5.2 *Flow Emissions*

Equity issue arises not just with respect to the past stock of damages but future, flow emissions as well. Joshi and Patel (2009) argue that developed countries should bear substantially all burden of mitigation on ethical and moral grounds. Their argument is reinforced by the fact that developing countries are predicted to disproportionately suffer from the damage from climate change effects of emissions.

Any redistribution in the context of future mitigation will have to be achieved through a redistribution of revenues collected through the emission tax or, equivalently, auctioning of pollution permits. In the following, I cast the discussion in terms of permits though the case of taxes is identical. Given pollution permits would be tradable worldwide, a single price for them will obtain. Therefore, a country's share in revenues would be exactly equal to the proportion of the pollution permits it receives. For example, awarding a country 10 percent of the permits would give it a 10 percent share in

the revenue. Of course, this share need not coincide with the country's share in actual emissions: it can emit more by buying additional permits from other countries or it can emit less and sell the extra permits for cash to other countries. Recalling the direct relationship between the initial allocation of permits and revenue received, we can describe various redistribution schemes in terms of the allocation of permits. Several illustrative possibilities may be mentioned, each assuming a known global cap on emissions.

- Each country is given permits in proportion to the emissions in an initial base year. This scheme would give the developed countries, which account for the bulk of the current emissions, the lion's share of the revenues and is unlikely to be acceptable to the developing countries, especially absent any compensation for the past emissions.
- Each country is allocated permits equal to its actual emissions in the globally efficient equilibrium. In this case, a central body would auction permits to firms around the world, collect the revenue and then return it to the countries in proportion to the purchases by firms within their respective jurisdictions. The scheme is equivalent to a pollution tax at a pre-specified rate with each country collecting and keeping the tax revenue collected from firms within its jurisdiction. Cooper (2008) favors such a tax and reports that assuming the CO₂ emissions equal those predicted by the U.S. Department of Energy and the emission tax is set at \$15 per ton, carbon revenue in 2015 would be 0.4 percent of the GDP in the United States, 1.3 percent in China, 1.1 percent in India and 0.7 percent for the world as a whole. Like the previous scheme, absent action on the stock problem,

this is unlikely to be acceptable to large developing countries such as India and China since they would be compromising their growth prospects by undertaking substantial obligations.

- Permits are distributed in proportion to each country's population. This scheme awards equal permits per-capita across the globe. This is justified on the ground that the environment is a common resource with each individual having an equal claim to it. This is the allocation favored by India in its representations but the developed countries oppose it. It may be noted that if the objective is equity, this allocation still falls short of full egalitarian distribution for two reasons: the stock problem still remains since the rights to past emissions were not equally distributed and the damage from emissions will still be unevenly distributed across individuals and countries.
- A related scheme would be to distribute permits in inverse proportion to each country's per-capita income.¹⁸ Given the bulk of the population is concentrated in the low-income countries, this criterion would closely track the previous one with the qualification that within developing countries it would result in smaller allocations for China and within developed countries for the United States. This scheme would also lack support in the developed countries.
- In the first twenty years, developing countries are allocated permits equal to their predicted emissions absent any restriction on pollution. Their allocations are then gradually reduced, dropping to the level consistent with global efficiency (i.e., a

¹⁸ Letting y_i denote per-capita income of country i , the share of country r according to this criterion would be $(1/y_r)/\sum_i (1/y_i)$.

uniform emission tax) within a pre-specified time period. This will allow the countries full flexibility to pursue their development goals in the first twenty years. Developed countries will be allocated fewer permits in the first twenty years than dictated by efficiency considerations.

5.3 Flow Emissions: Numerical Applications

Many authors have simulated the implications of different allocation schemes for the costs and benefits to various countries. Joshi and Patel (2009) report the results of three such studies. In this section, I discuss the results of report on one of those three studies—Jacoby et al. (2008)—which in my view provides a nice illustration of how the developed and developing country interests clash under different permit allocation schemes. The basic strategy of the simulations is straightforward. Rather than explicitly model the costs of emission represented by the marginal cost curves in Figures 1-3 above, they take the global emission targets as exogenously given. Permits for the targeted level are then allocated among countries according to a pre-specified such as those considered in the previous section. Because permits are tradable, actual emissions are determined endogenously. Free tradability of permits establishes a single price of emission per unit and thus equalizes the marginal benefits of emissions across countries along the lines of Figure 2 and ensures efficiency. Any output losses relative to the scenario in which no restrictions on emissions are imposed, commonly called Business as Usual (BAU), determines the economic cost of mitigation. Permit trading generates financial flows from countries that have less permits than their firms use to those that have more of them than their own firms emit. In all scenarios, emissions are brought down to 50 percent of

their observed levels in the year 2000. The scenarios are thus mainly distinguished according to the rules governing the allocation of emission permits across countries.

In the simple model I considered above and illustrated in Figures 1-3, I packed all production activity into a single aggregate good. The simulations in Jacoby et al. (2008) replace this aggregate good by a full-blown multi-good, multi-factor and multi-country general-equilibrium model with all major GHG emissions endogenously chosen and free international trade in goods permitted. The model has 7 developed and 8 developing countries and the rest of the world as an aggregate. Emissions caps are applied to all GHG emission and are defined relative to 2000 emission levels. All simulations bring the global emissions down by 50 percent relative to their 2000 levels in 2050, linearly falling beginning in 2015. The authors consider seven different scenarios of which four suffice to bring out the source of conflict between developed and developing countries:

1. Developed countries are at 30% and developing countries at 70% of 2000 emissions in 2050.
2. Allocations follow 2000 population shares. That is to say, permits are allocated equally on a per-capita basis according to 2000 populations of countries.
3. Allocations are based on inverse share of per-capita GDP in year 2000.
4. Developing countries are fully compensated for the costs of mitigation with developed country allocations of the remaining permits determined according to their year 2000 emissions

Table 2 reports the allocations of emission permits, the welfare changes and financial flows implied by the purchase or sale of permits in years 2020 and 2050 for the United States and India. Because the results on the other countries are not central to the present

paper, I suppress them. In the first case, the allocation of permits declines to 80 percent of 2000 emission levels for the United States and 98 percent for India as shown in the top rows. By 2050, these fall to 30 and 70 percent, respectively. On the surface, this may seem a good deal for India but the catch is that India's emissions in 2000 are very low relative to where they would be in 2050 absent mitigation. Therefore, India's growth suffers on account of mitigation. This is reflected in the welfare cost shown in the middle rows: by 2050, India suffers a welfare loss of 11.4 percent relative to the level it would achieve absent mitigation. This occurs due to rather high price of permits with India choosing to sell a part of its allocation of permits. This last fact can be gleaned from the last set of numbers that show a positive financial flow into India. In comparison, the United States does well in this scenario: in 2050, it experiences a welfare gain of 2.6 percent despite having to buy permits worth \$179.6 billion.

Scenarios 2 and 3 turn out to be good for India as expected. In these cases, India ends up receiving permits several times its emissions in 2000. For instance, under equal per-capita distribution rule, it receives 2.7 times and 1.5 times its 2000 allocations in 2020 and 2050, respectively. This naturally proves a good deal for India: its welfare gain over business as usual scenario turns out to be 21 percent higher in both 2020 and 2050. The United States takes a major hit: its welfare falls 5.5 percent in 2050. The contrast is even starker in the third case when allocations are done according to inverse per-capita income.

In the last case, permit allocations are determined by fixing the welfare of the developing countries at business as usual welfare level. Therefore, by definition, the welfare of India is unchanged in this case. What is interesting in this case, however, is

that by 2050, the United States does not only get no permit allocation but must effectively purchase permits worth 8.3 percent of its 2000 emissions in the market and give them away to the developing countries. The result is a whopping 7.4 percent decline in its welfare.

While precise numbers generated by these examples are not to be taken seriously, their relative magnitudes across various cases illustrate why the negotiations for mitigation are so complex and difficult. The uncertainty associated with the implications of warming for individual countries absent action, different levels of development and growth trajectories and different perceptions of equity depending on where one stands greatly add to this complexity. Unsurprisingly, substantive action to-date has been difficult, as we will see below from a brief discussion of the efforts to-date.

6 Policy Action: The Current State of the Play

Action is currently under way at both international and national levels. Internationally, the United Nations Framework Convention on Climate Change (UNFCCC) provides the overarching institutional framework though initiatives outside of the UNFCCC framework have also been taken. At the national level, the United States is considering “cap and trade” legislation that has potential implications for India. I consider below each of them.

6.1 Action at the International Level

The United Nations Conference on Trade and Environment (UNCED) held in Rio de Janeiro in June 1992 and popularly called the Earth Summit produced the international treaty UNFCCC. The aim of the treaty is to stabilize GHG concentrations to avoid

"dangerous anthropogenic interference" with the climate system. In its original form, the treaty contains no enforceable limits on GHG emissions but provides for updates called "protocols" setting such limits. The Kyoto Protocol (see below) is such an update.

The UNFCCC entered into force on March 21, 1994 and has been signed by as many as 192 countries to-date. The members are divided into three categories: Annex I countries, Annex II countries and Non-Annex or developing countries. Annex I countries consist of all industrialized countries. Annex II countries are a subset of Annex I countries and include all OECD countries that were not "transition economies" in 1992.

Annex I countries are expected to reduce their GHG emissions to levels to be negotiated within the UNFCCC framework. They may do this by allocating the agreed upon emission targets among the major operators within their borders. The operators must then buy offsets to exceed their limits. Under UNFCCC, developing countries are not expected to limit their GHG emissions unless Annex II developed countries supply enough funding and technology. The signatories have agreed under "common but differentiated responsibilities" that the largest share of historical and current GHG emissions originated in the developed countries; per-capita emissions in the developing countries are still low; and the share of developing countries in the global GHG emissions will grow to meet social and development needs.

The signatories to the UNFCCC have been meeting once a year in the Conference of the Parties (COP) beginning 1995. To-date, fifteen COPs have taken place and the sixteenth is scheduled to take place in Copenhagen from December 7 to December 18, 2009. Two of the most visible COP meetings were those in Kyoto in 1997 and Bali in 2007.

The Kyoto conference set out to establish a legally binding international agreement on GHG emissions. The result was the Kyoto Protocol, under which developed (Annex I) countries agreed to bring down GHG emissions 5.2 percent below their 1990 levels with varying limits across countries. For example, the EU15 committed to lowering its emissions by 8 percent of the 1990 levels (with varying targets for different EU members), the United States to 7 percent (though it eventually chose not to ratify the protocol), Japan to 6 percent and Russia to 0 percent. The protocol permitted Australia and Iceland, both Annex I countries, to increase their GHG emissions by 8 and 10 percent of 1990 levels, respectively.

The Kyoto Protocol required that it could only come into force after 55 countries covering 55 percent of the 1990 emissions ratified it. Accordingly, it came into force on February 16, 2005. As of January 2009, 183 countries had ratified the protocol. Neither the Clinton nor Bush administration sent the protocol for ratification to the Congress. George W. Bush explicitly rejected it in 2001.

The signatory countries are to undertake emission reductions between 2008 and 2012. The protocol provides three mechanisms to facilitate implementation: (i) Emission trading, (ii) Clean development mechanism (CDM) and (iii) Joint implementation (JI). Under emission trading, countries that manage to lower their emissions below the assigned target can sell their leftover rights (permits) to other countries that fail to lower theirs to down to the assigned target. Under CDM, countries subject to reductions can meet their targets partially by undertaking emission-reduction projects in developing countries. The project earns the country a saleable certified emission reduction (CER) credit, each equivalent to one tonne of CO₂. Under JI, a country with an emission

reduction commitment under the Kyoto Protocol (Annex B Party) can earn emission reduction units (ERU) from an emission-reduction project in another Annex B Party, each equivalent to one tonne of CO₂. The ERU can be counted towards meeting its Kyoto target.

The current status of intentions of countries on the implementation of targeted emission reductions is variable. Canada has stated that it will not be able to meet its obligations. Within the EU, Greece was excluded from the Kyoto Protocol on 22 April 2008 due to unfulfilled commitment of creating the adequate mechanisms of monitoring and reporting emissions though it was reinstated seven months later. Bigger European countries such as France and Germany will meet their targets. EU15 had achieved a reduction of 2.7 percent and EU27 of 7.7 percent by 2006. The Economist Intelligence Unit (EIU) (2009) estimates that if the EU15 implement all planned measures, they would reduce emissions by 11 percent by 2010.

After generally sluggish progress for nearly a decade, the thirteenth UNFCCC COP held in Bali in December 2007 tried to bring the negotiating process back on track. After spending an extra day over what had been planned, it concluded with the “Bali Action Plan,” which together with a number of important decisions formed the Bali Roadmap. The Bali roadmap sets out the timing, main elements and steps of the negotiations leading to a successor climate regime to the Kyoto Protocol. An ad hoc working group was appointed at Bali to complete the work by the fifteenth COP to be held in Copenhagen. The group was entrusted with the responsibility to discuss “mitigation commitments or actions” by all developed countries and “mitigation actions” by developing countries.

The negotiations at Copenhagen are to be held on the four building blocks of the UNFCCC process: mitigation, adaptation, technology and financing.

The success of Bali COP was limited, however. Specifically, it failed to produce an agreement on future level of ambition on mitigation and ended up vaguely calling for “deep cuts in global emissions.” Greater success in setting up the ambition level with respect to mitigation was achieved in the parallel but separate negotiations under the Kyoto Protocol mainly because the United States was not a party to them. The EU, which has been a strong supporter of mitigation, largely drove the process in these negotiations. The Parties under the Kyoto Protocol noted in their final statement the need for emissions to peak within 10 to 15 years and for the emissions to be brought well below half of the 2000 level. They also recognize that Annex I Parties needed to reduce their emissions in the range of 25 to 40 percent to reach the lowest stabilization scenarios assessed by the IPCC in its fourth Assessment Report.

Three additional processes outside the UNFCCC have been at work to promote action on climate change: Gleneagles Dialogue kicked off by the 2005 G8 plus five meeting; Asia Pacific Partnership (AP6) consisting of Australia, China, India, Japan, South Korea and the United States; and the United States Major Economies Meeting (MES). Of these, the first one has had the most substantive impact on progress.¹⁹ The 2005 G8 meeting brought five major developing countries—Brazil, China, India, Mexico and South Africa—to participate and issued the Gleneagles Communiqué and Plan of Action on Climate Change, Clean Energy and Sustainable Development. It initiated the Gleneagles Dialogue that came to consist of 20 countries. This dialogue concluded at the

¹⁹ For details on the other two processes, see European Parliament (2008). This publication offers an excellent overview of the Bali conference.

2008 G8 Summit in Toyako, Japan, with the G8 leaders expressing strong need to consider and adopt a global Long-Term Goal of a reduction in emissions of at least 50% by 2050 in their final statement.²⁰ The G8 leaders also signalled their intention to agree to a global international climate change framework when the fifteenth UNFCCC COP meets in Copenhagen in 2009.

Under President Bush, the United States had been opposed to participation in an international treaty for mitigation such as the Kyoto Protocol. The U.S. position under President Obama has undergone a drastic change. He has already created the position of a “global warming czar” under the title “White House coordinator of energy and climate policy” and appointed the former EPA Administrator Carol Browner to it. But the conversion of the U.S. President to the cause is only a necessary step towards a comprehensive agreement. The United States Congress remains steadfastly opposed to an agreement that does not require China and India to undertake binding mitigation commitments. For their part, China and India have stated in no uncertain terms that consistent with the UNFCCC, as developing countries, they have no intention of compromising their development and poverty alleviation programs by undertaking emission reduction obligations. Therefore, the negotiations at Copenhagen are bound to be highly contentious.

6.2 Action at the National Level

There are several programs under way at the national level in many countries to address global warming. The EU 20:20:20 initiative whereby it plans to reduce GHG

²⁰ I am unable to ascertain whether this 50 percent reduction is relative to emission levels prevailing in 1990, 2000 or another year.

emissions by 20 percent, increase the share of renewable energy by 20 percent and curb energy consumption by 20 percent by 2020 is one such program. The United States and China have similarly introduced a number of programs aimed at curbing energy consumption. India has also announced its National Action Plan on Climate Change (Government of India 2008) though it substantially lacks specific measures aimed at cutting energy use or emissions.

While the reader can find summaries of the initiatives taken at the national level by a number of countries in the EIU (2009), it is useful to briefly discuss the implications the “cap and trade” legislation under discussion in the U.S. Congress has for India. The leading legislative proposal is H.R. 2454, the American Clean Energy and Security Act of 2009 (ACES Act), popularly known as the Waxman-Markey bill. It proposes to cut the CO₂ emissions to 97% of 2005 levels by 2012, 80% by 2020, 58% by 2030, and 17% by 2050. Firms would be required to hold pollution permits for their CO₂ emissions. The current proposal is to distribute 85 percent of the permits for allowable emissions to the firms free of charge and auction 15 percent of them competitively. Once in private hands, permits will be freely tradable in the market.

A threat facing India (and other countries lacking similar cap and trade or equivalent programs) is that the United States may subject its goods entering into the United States to similar requirements. Importers of a product from India may be required to buy pollution permits to cover its carbon content or pay a tax equal to the allowance price. The issue then would be whether the World Trade Organization (WTO) dispute settlement body would uphold such a measure under its rules.

In a carefully argued paper, Bordoff (2008) takes the view that though we will know the truth of WTO compatibility of such a measure only when it is challenged in the dispute

settlement body and the latter gives its ruling, the case for an affirmative ruling is rather weak. Rather than reproduce various legal arguments made by Bordoff in detail, it suffices to report his broad points here. The United States will have to justify the imposition of a domestic environmental regulation or tax on imports under either the “national treatment” provision of Article III of the General Agreement on Tariffs and Trade (GATT) or the environmental exception allowed under Article XX of the latter. There are problems with both justifications.

GATT Article III requires that once a product has crossed the border, it should be accorded the same national treatment as domestically produced “like” products. In defining like products, the process and production method (PPM) cannot be considered as product characteristics. This would rule out distinguishing products based on GHG content. An additional problem will arise with respect to the Most Favored Nation (MFN) treatment required under Article I of GATT. In so far as many European countries do have cap and trade programs in place, imports from them will have to be exempted from any GHG related charges. This would introduce discrimination based on the origin of imports. A final complication would be that under the current proposals, the United States proposes to hand out 85 percent of the permits free of charge.

In all likelihood, the United States will have to justify any effective carbon taxes on imports under the environmental exception permitted in Article XX of the GATT. Under Article XX, discrimination is permitted but the United States will need to persuasively argue that the measure is required to reduce the overall leakage. This is a tough sell given leakage is itself a small proportion of the emissions and subjecting imports to

permit requirements would do little to plug that leakage.²¹ Based on the Appellate Body report in the shrimp-turtle case, Bordoff (2008) further argues that the WTO may also consider the differences in the conditions of the United States and developing countries in reaching a decision. To quote him, “Fourth, the U.S. program must take into consideration ‘different conditions which may occur’ in different countries. Failure to do so may constitute ‘arbitrary discrimination,’ according to the Appellate Body. In that regard, the WTO might consider the relevance of developed countries’ greater historical responsibility for cumulative carbon emissions and higher current emissions per capita. In that case, there is a possibility the WTO would find that even a border adjustment [through the requirement of permit purchase] applied equally to domestic and imported goods is noncompliant.”

In taking action against India, politically, the United States also runs a different risk. Other developed countries, notably in Europe, have emission reduction programs that possibly go farther than that of the United States. Therefore, any action by the United States will make it vulnerable to similar actions by other developed countries with tougher mitigation programs.

In sum, while India cannot rule out the possibility that the WTO might approve of the United States effort to “level the playing field” through an effective pollution tax equivalent to that borne by the U.S. firms under the proposed cap and trade system, it is by no means a foregone conclusion.

²¹ It is easy to envision countries reshuffling their trade to avoid the charge associated with the permits. For example, the U.S. might import more from Europe, which will not be subject to buying the U.S. permits, and less from India and other developing countries, which will export more to Europe.

7 India's Options

In looking at India's options, we must address three questions: what will best serve the interests of India; is there justification for the position India would need to take in the climate change negotiations to pursue these interests; and can India mobilize the political support for its position?

A common advice heaped on India by western analysts in answer to these questions is that it is among the countries most vulnerable to climate change and therefore stands to gain the most from facilitating a climate change treaty; ergo it should not only actively seek such a treaty but be willing undertake significant mitigation obligations if that is what it will take to make the treaty happen. There is also a view among most western observers that unless India immediately undertakes significant obligations towards mitigation, an international treaty is infeasible. I disagree with this diagnosis and advice.

Before this stance is mistaken for the opposition to any mitigation by India, let me hasten to add that the country must do all it can to reduce its CO₂ emissions when this can be done at negligible or no cost or when it may even generate some additional positive benefits. For example, the use of the so-called "green" bulbs is said to not only reduce CO₂ emissions but also save on energy costs. Therefore, encouraging the use of such bulbs is a win-win strategy. Likewise, there can be no opposition to the encouragement of the use and development of green technologies whenever developed countries are willing to pay for them under the clean development mechanism of the Kyoto protocol or other similar programs.

Where I am parting company with the advice given to India by many western experts is when they tell India to undertake binding commitments for reductions in its GHG

emissions, no matter how minimal, as a part of the post-Kyoto mitigation regime. With nearly 300 million people still below a poverty line that is barely adequate for subsistence, India remains an extremely poor country. Its only hope out of poverty and transition into a decent living standard is sustained growth at the current high rates. It is inconceivable that India could cap emissions anywhere near its current levels and hope to pull its remaining 300 million citizens out of abject poverty.

The enormity of the problem India faces can be seen from Table 3, which reports the total and per-capita CO₂ emission levels of the highest 20 emitter countries in 2006, the latest year for which the U.S. Department of Energy provides such data. Although India ranks fourth according to total CO₂ emissions due to its sheer size, it is at the absolute bottom of the list in terms of per-capita emissions. Indeed, based on 2006 per-capita emissions for all countries, India ranks astonishingly low in the 137th position worldwide and ties with the average for Africa. The analysts interested to pressure India into accepting mitigation obligation often like to bracket it with China but its CO₂ emissions are one fourth of the latter in per-capita and one fifth in absolute terms.²²

The low per-capita CO₂ emissions are a reflection of the vast sections of the country lacking any access whatsoever to electricity, relatively limited industrialization and the dependence of more than half of the population on agriculture which generates only 15 percent of the national income. Therefore, capping emissions around the current levels would essentially deprive India of any hope of eradicating poverty. Given the country's

²² The situation relative to the OECD countries is even starker. Thus, for example, Parikh and Parikh (2002) caustically note, "Through delays, rich OECD countries are occupying global environmental space. During 1990 to 2020 (during which period they were supposed to act, haven't acted and are not likely to act) OECD countries would have emitted more than India would emit in the next 30 years, assuming a 5% increase in India's GHG emission every year."

population is predicted to continue to rise until at least 2050, a cap on emissions at the current level would imply a declining availability of per-capita energy unless clean sources of energy become massively available.

What about the argument that India is highly vulnerable to climate change effects? Here two points must be made. First, with India accounting for just 4.4 percent of the global emissions, stabilizing its emissions at or near current levels will have virtually no impact on the global emissions. To underline this point, I reproduce below the argument Harvard economist Martin Feldstein (2009) made in an op-ed in the *Washington Post* against the Waxman-Markey ACES Act currently under active consideration by the U.S. Congress:

“The Congressional Budget Office recently estimated that the resulting increases in consumer prices needed to achieve a 15 percent CO₂ reduction -- slightly less than the Waxman-Markey target -- would raise the cost of living of a typical household by \$1,600 a year. Some expert studies estimate that the cost to households could be substantially higher. The future cost to the typical household would rise significantly as the government reduces the total allowable amount of CO₂.

“Americans should ask themselves whether this annual tax of \$1,600-plus per family is justified by the very small resulting decline in global CO₂. Since the U.S. share of global CO₂ production is now less than 25 percent (and is projected to decline as China and other developing nations grow), a 15 percent fall in U.S. CO₂ output would lower global CO₂ output by less than 4 percent. *Its impact on global warming would be virtually unnoticeable.*” [Emphasis added.]

Taking the last statement literally, we would conclude that even if India were to entirely eliminate its CO₂ emissions from fossil fuels, the effect on global warming would be unnoticeable.

The second point to note in assessing any actions on emissions by India in relation to its vulnerability to climate change is that the cost of mitigation in terms of adaptation forgone would be extremely high. Growth rates of 10 percent or more for the next two to three decades would substantially improve the ability of the population to withstand the vagaries of extreme weather conditions. Access to modern concrete houses, good drainage system, well functioning infrastructure and the availability of resources to shift people out of vulnerable areas can better prepare the population to withstand extreme weather conditions.

The upshot of this discussion is that if one thinks from purely selfish viewpoint of India, capping its GHG emissions for the next two to three decades in any form does not make sense. The issue then is whether inaction by India while developed countries undertake mitigation is justified. I think India is on a strong wicket here as well. Several arguments supporting this position may be made.

First, there is some merit in India's position that each individual on the planet should have equal right to using up clean air. One may argue that since we do not insist on equal rights to other natural resources—land, oil and minerals—why should clean air be any different? But these resources are fundamentally different from clean air. How a farmer in the United States cultivates his land has no impact on the productivity of land in India. Likewise, how copper Chile takes out of its mines has no impact on copper in the Zambian mines. But how much the U.S. firms pollute does impact the temperatures and

rains in India and the rest of the world and vice versa. Clean air is truly a global resource.

Second, to some degree, the exemption to the developing countries from mitigation commitments unless they choose to voluntarily undertake such commitments is enshrined in the UNFCCC and a forced deviation from it is in effect a violation of an existing agreement. In its preamble, the UNFCCC explicitly recognizes that ‘the largest share of historical and current global emissions of greenhouse gases has originated in developed countries, that per capita emissions in developing countries are still relatively low and that the share of global emissions originating in developing countries will grow to meet their social and development needs.’ Based on this recognition, the UNFCCC divides the signatory countries into Annex I and non-Annex countries with the developed countries placed in the former and developing in the latter. The Convention calls upon only Annex I countries to undertake mitigation commitments. It states in Article 4(2a), “Each of these [developed country] Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs.” Consistent with this provision, the Kyoto Protocol obligates only the developed countries to mitigation commitments. Indeed, it even allows two developed countries—Australia and Iceland—to increase their emissions in the first round of commitments.

Third, it bears pointing out that while virtually all analysts club China and India together in climate change discussions, their emission profiles and magnitudes are vastly different. India is simply not in the “big league” emitters. Figures 2 and 3, which show the evolution of the total and per-capita CO_2 emissions since 1980, respectively,

demonstrate this point. No matter how one measures, emissions by India are neither high nor rising at a sharp rate. In fact, for the amount of poverty reduction India has achieved in the last 25 years, India has been an extremely efficient user of energy.

Finally, even if we do not insist on equal per-capita emissions, almost any social justice criterion would come out against developing countries being denied room to grow sufficiently that they can eradicate abject poverty in order to allow developed countries to more or less maintain their ultra-high living standards. In this regard, any equation between China and India is also absurd: emission levels of China are four times those of India in per-capita terms and five times in aggregate terms. Therefore, the position taken by the Government of India (2009) in the quotation at the beginning of this paper has strong basis in moral philosophy.

The final remaining issue is whether India can mobilize enough political support at Copenhagen to stem the pressure for binding commitments on it. This is indeed possible but only if India does its homework. It must build the case that in two to three decades, it can eradicate poverty and that latest by 2040, it can begin to undertake mitigation commitments. Through appropriate research studies, it must also convincingly argue that in the meantime, developed countries must bear the burden of mitigation and that this can be done without much fear of leakage to countries such as India. And, of course, the existing agreement in the UNFCCC to exempt developing countries from mitigation commitments and its underlying rationale go in India's favor.

8 Concluding Remarks

In this paper, I began by noting that that estimates of how much climate change has impacted India in the last century and predictions of how much it will impact the country

in the current century are subject to vast amounts of errors. This uncertainty calls for sufficient preparation for adaptation to possible extreme weather change effects. This makes sustaining high rates of growth and poverty alleviation even more urgent.

Using simple models, I have shown that the efficient solution to mitigation can be achieved through either a carbon tax or internationally tradable emission permits. While uncertainty associated with the cost of emission (e.g., increased and more severe extreme weather events) does not impact the equivalence of the tax and permit instruments, uncertainty associated with benefits of emission (i.e., production activity) makes permits a superior instrument. I argue, however, that in practice the former uncertainty is more important so that a choice between the two on the basis of uncertainty cannot be made. A choice in favor of the tax can be made, however, on grounds of transparency and minimal bureaucratic abuse. Permits are likely to encourage lobbying activity with inefficient firms successfully acquiring some of them.

While we can resolve the issue of efficiency in relatively straightforward manner, that of distribution turns out to be much rather complex. I discuss it at length diving it into stock and flow counterparts, following Bhagwati (2006). I argue that there is a strong case for the developed countries, which bear the bulk of the responsibility for the past emissions, to compensate the developing countries. Regarding the flow problem, I argue that India has a strong case going forward for exemption from mitigation commitments for two to three decades.

Finally, I have provided a detailed discussion in the paper of the current state of play of mitigation policy at both national and international levels. At the international level, the negotiations for mitigation commitments at the fifteenth UNFCCC COP at

Copenhagen are likely to be contentious as the developed countries try to get reluctant Indian and China to accept binding commitments. At the national level, the United States is poised to introducing a major cap and trade program, which may pose some challenge to imports from countries such as India that do not have similar programs. If the United States eventually decides to subject the imports from the countries without cap and trade programs to its domestic permit requirements, a battle at the WTO on the legality of such extension is almost guaranteed.

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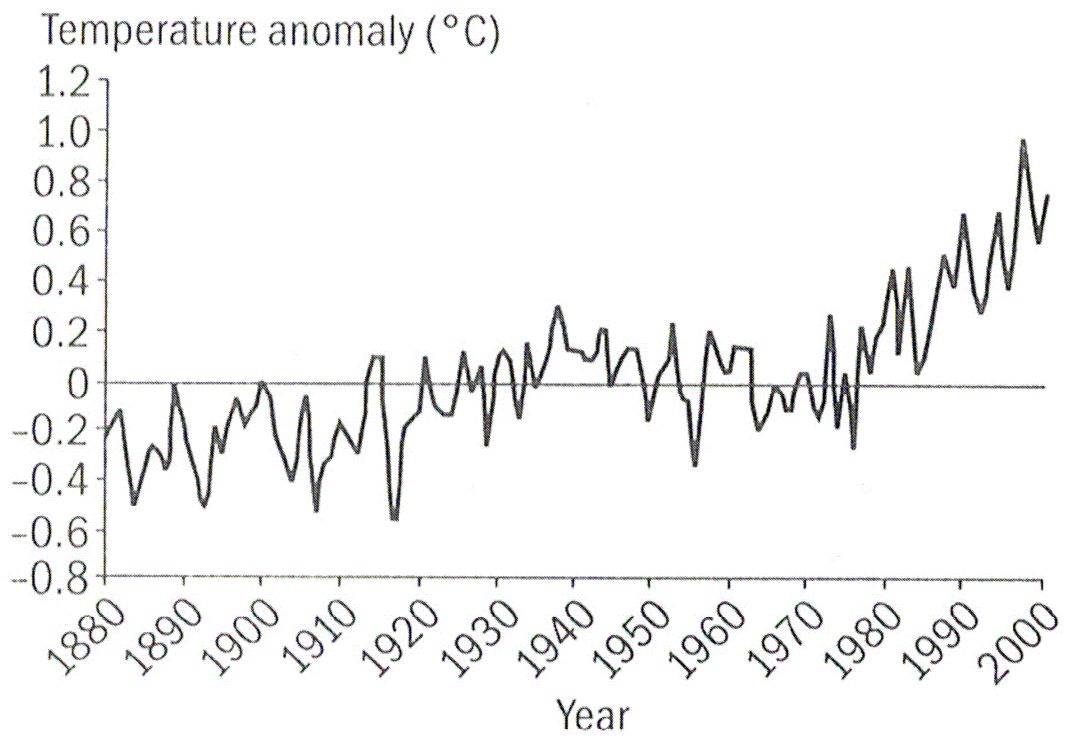


Figure 1: Average temperatures in India: 1880-2000.

Sources: Lal (2003).

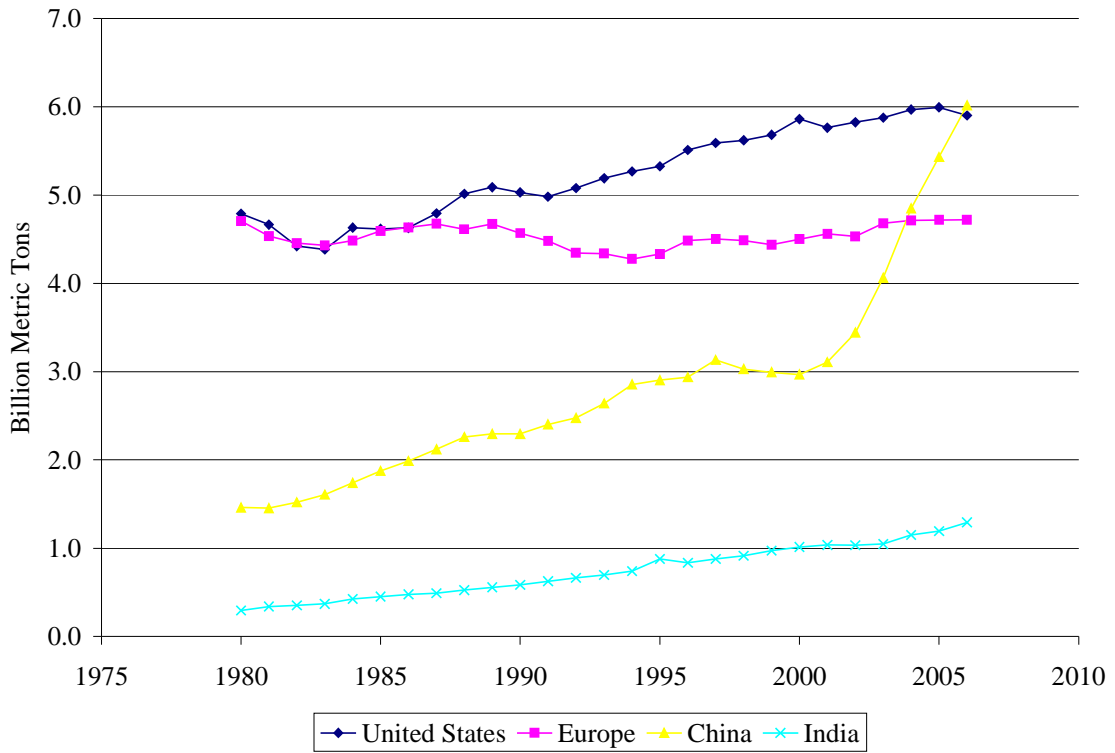


Figure 2: Total CO₂ Emissions from the Consumption and Flaring of Fossil Fuels, 1980-2006

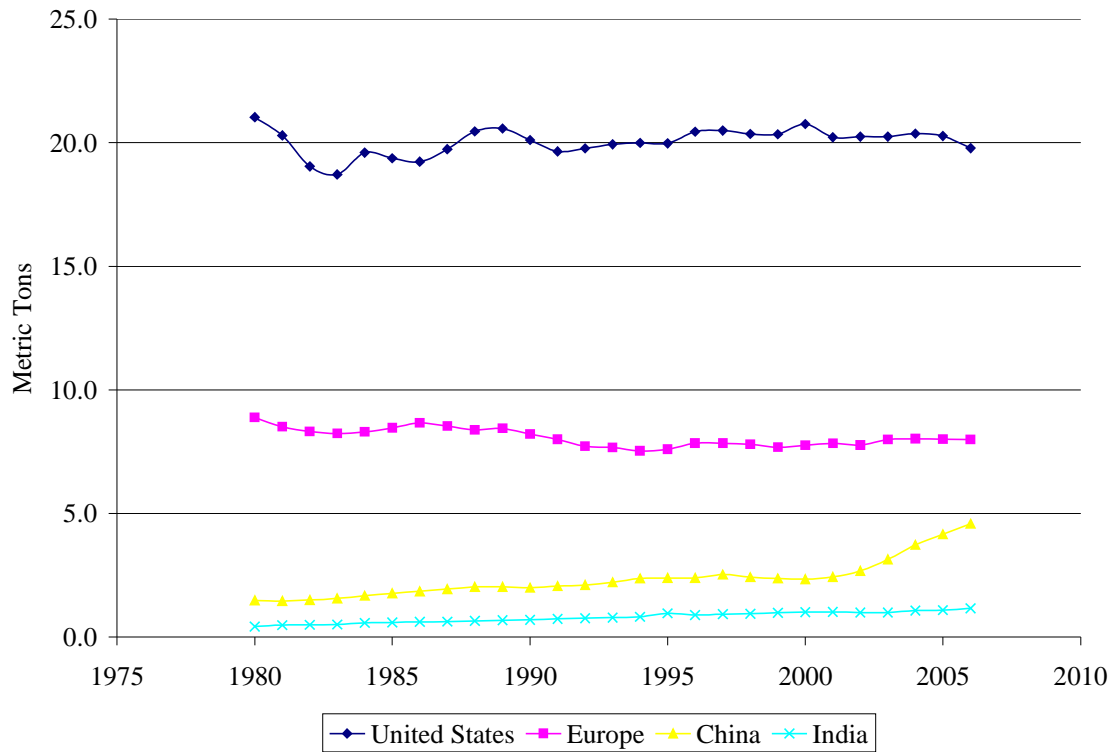


Figure 3: Per-capita Emissions of CO₂ from the Consumption and Flaring of Fossil Fuels for Selected Countries, 1980-2006

Table 1: Predicted Changes in Temperatures and Precipitation (Baseline: 1961-90)

Months	Temperature		Precipitation		Temperature		Precipitation	
	°C		%		°C		%	
	A1FI	B1	A1FI	B1	A1FI	B1	A1FI	B1
South Asia				North Asia				
2010 to 2039								
DJF	1.17	1.11	-3	4	2.94	2.69	16	14
MAM	1.18	1.07	7	8	1.69	2.02	10	10
JJA	0.54	0.55	5	7	1.69	1.88	4	6
SON	0.78	0.83	1	3	2.24	2.15	7	7
2040 to 2069								
DJF	3.16	1.97	0	0	6.65	4.25	35	22
MAM	2.97	1.81	26	24	4.96	3.54	25	19
JJA	1.71	0.88	13	11	4.2	3.13	9	8
SON	2.41	1.49	8	6	5.3	3.68	14	11
2070 to 2099								
DJF	5.44	2.93	-16	-6	10.45	5.99	59	29
MAM	5.22	2.71	31	20	8.32	4.69	43	25
JJA	3.14	1.56	26	15	6.94	4	15	10
SON	4.19	2.17	26	10	8.29	4.98	25	15

Note: Months “DJF” stand for December, January and February. Other symbols for the months are similarly defined. Scenario A1FI refers to the highest future GHG emission trajectory considered in the simulations by the IPCC Fourth Assessment Report and B1 to the lowest emission trajectory.

Source: IPCC Fourth Assessment Report, Working Group II, Chapter 10.

Table 2: Simulated Implications of Alternative Permit Allocation Schemes

	Declining		Allocations in				Full compensation	
	Proportion of 2000		Equal Per-capita		Inverse Proportion		to Developing	
	Emissions		Allocations		of Per-capita GDP		Countries	
	2020	2050	2020	2050	2020	2050	2020	2050
Allocations as % of 2000 Emissions								
USA	80	30	20.5	11.4	1.7	0.9	49.3	-8.3
India	98	70	265.4	147.1	405.2	224.6	127.6	93.3
Welfare (% change from reference level)								
USA	-0.1	2.6	-2.8	-5.5	-3.7	-7.2	-1.3	-7.4
India	-4.9	-11.4	20.9	21	39	48.9	0	0
Net Financial Transfers (2000 US\$ Billion)								
USA	-30.3	-179.6	-368.7	-668.8	-483.5	-1024	-196.7	-1239.4
India	10.1	14.7	232.7	513.9	439.7	1056.3	51.8	176.4

Source: Constructed from simulation results in Jacoby et al. (2008).

Table 3: CO₂ Emissions from the Consumption and Flaring of Fossil Fuels, 2006

Serial Number	Country	Total Emissions		Per-capita Emissions (Tons/capita)
		(Million metric tons of CO ₂)	Percent of World	
1	China	6017.69	20.6	4.58
2	United States	5902.75	20.2	19.78
3	Russia	1704.36	5.8	12
4	India	1293.17	4.4	1.16
5	Japan	1246.76	4.3	9.78
6	Germany	857.6	2.9	10.4
7	Canada	614.33	2.1	18.81
8	United Kingdom	585.71	2.0	9.66
9	South Korea	514.53	1.8	10.53
10	Iran	471.48	1.6	7.25
11	Italy	468.19	1.6	8.05
12	South Africa	443.58	1.5	10.04
13	Mexico	435.6	1.5	4.05
14	Saudi Arabia	424.08	1.5	15.7
15	France	417.75	1.4	6.6
16	Australia	417.06	1.4	20.58
17	Brazil	377.24	1.3	2.01
18	Spain	372.61	1.3	9.22
19	Ukraine	328.72	1.1	7.05
20	Poland	303.42	1.0	7.87
21	World	29,195.42	100	4.48

Source: Energy Information Agency, United States Department of Energy

Filename: IPF Panagariya Climate Change July 14-15 2009
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Last Saved On: 7/2/2009 5:37 PM
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Last Printed On: 7/2/2009 5:40 PM
As of Last Complete Printing
Number of Pages: 71
Number of Words: 15,685 (approx.)
Number of Characters: 89,410 (approx.)