WORLD RESOURCES INSTITUTE

CLIMATE NOTES

CLIMATE ENERGY & POLLUTION PROGRAM

WHAT MIGHT A DEVELOPING COUNTRY CLIMATE COMMITMENT LOOK LIKE?

BY KEVIN A. BAUMERT, RUCHI BHANDARI, AND NANCY KETE

International climate change negotiations have stalemated over the timing and nature of developing country commitments. This is both unfortunate and unnecessary. The Climate Convention itself makes clear that developing and industrialized countries have "common but differentiated" responsibilities to meet the Convention's goals. While the North has focused on common responsibilities, the South has focused on differentiated responsibilities. The purpose of this Climate Note *is to examine voluntary participation by developing countries under an approach that reintegrates the two facets of the common but differentiated principle.*[1]

Most developing countries argue that making commitments now to reduce or limit greenhouse gas (GHG) emissions is incompatible with existing national priorities, such as economic development or improving living standards. Many believe that industrialized countries (Annex I) should make and keep the first round of commitments under the Framework Convention on Climate Change (FCCC) and the Kyoto Protocol before asking developing countries (non-Annex I) to do more. Industrialized countries must act first, they argue, because they are more responsible for the historical buildup of GHGs in the atmosphere and have per capita emissions many times higher than those of developing countries.[2] Furthermore, contrary to popular perceptions, even without formal commitments, developing countries are already taking significant steps to rein in GHG emissions.[3] The policies and measures behind these largely unrecognized improvements have required leadership and entailed political cost for which these countries deserve recognition.

In pressing for voluntary commitments from developing countries, the United States and other industrialized countries frequently invoke the fact that Annex I countries alone cannot achieve the ultimate objective of the climate convention—preventing dangerous interference with the cli-

KEY FINDINGS

- Modeling developing country climate commitments after industrialized country commitments poses environmental dangers, given the uncertainty of future emission levels and the international emissions trading provisions in the Kyoto Protocol.
- If a developing country is contemplating a voluntary commitment under the climate treaty, other measures such as greenhouse gas *intensity* could provide a better standard.
- A *greenhouse gas intensity indicator* is a measure of sustainable development that addresses the real climate challenge in developing countries—decoupling economic growth and emissions growth. The Clean Development Mechanism can also help address this challenge.
- The lack of accurate and comprehensive data on greenhouse gas emissions (including emissions from land-use change) impairs any discussion of developing country commitments.

mate system. Indeed, effectively addressing a global problem like climate change does require a global solution. However, neither the United States, nor any other country, has yet offered a policy approach for treaty participation that effectively accommodates the development priorities of non-Annex I countries.

The stalemate stems, at least in part, from a default assumption evident in the current political debate that a developing country commitment would take the same basic form as an Annex I commitment—a limitation on the *absolute level* of GHG emissions. Of course, one key difference is assumed—a developing country commitment would likely be expressed as a growth cap set at some level *above* the country's current emission level, while Annex I commitments collectively cap emissions at 5.2 percent *below* historical levels, with some variations among countries. This is problematic for several reasons.

For a developing country that is not yet ready to implement the set of measurement, reporting, and verification requirements of industrialized countries, a quantitative binding commitment is not likely to be appropriate or desirable. In fact, for a developing country experiencing high or volatile rates of economic growth, binding growth caps may be highly inappropriate. Yet, developing countries are being urged to make voluntary commitments expressed as growth caps so that they can participate in international emissions trading under the Kyoto Protocol. Given the inherent uncertainty of estimating future emissions, growth caps for developing countries raise serious environmental concerns over how many emissions might be added to the collective Annex I cap, and whether significant GHG reductions will ever actually take place in industrialized countries.

> The challenge for most developing countries is not to reduce absolute emission levels but to lower the greenhouse gas intensity of their economies.

Fortunately, developing country participation under the Protocol or Convention can take a different approach. Because most developing countries are not currently in a position to make *absolute* emission reductions, the most immediate and realistic challenge is lowering the *greenhouse gas intensity* of their economies. Thus, rather than measuring the absolute amount of a country's emissions, the GHG intensity indicator provides a more realistic and practical framework for participation by expressing the emissions that an economy generates *per unit of output.* This can be expressed as:

$$\textit{GHG intensity indicator} = \frac{\textit{GHG emissions}}{\textit{gross domestic product}}$$

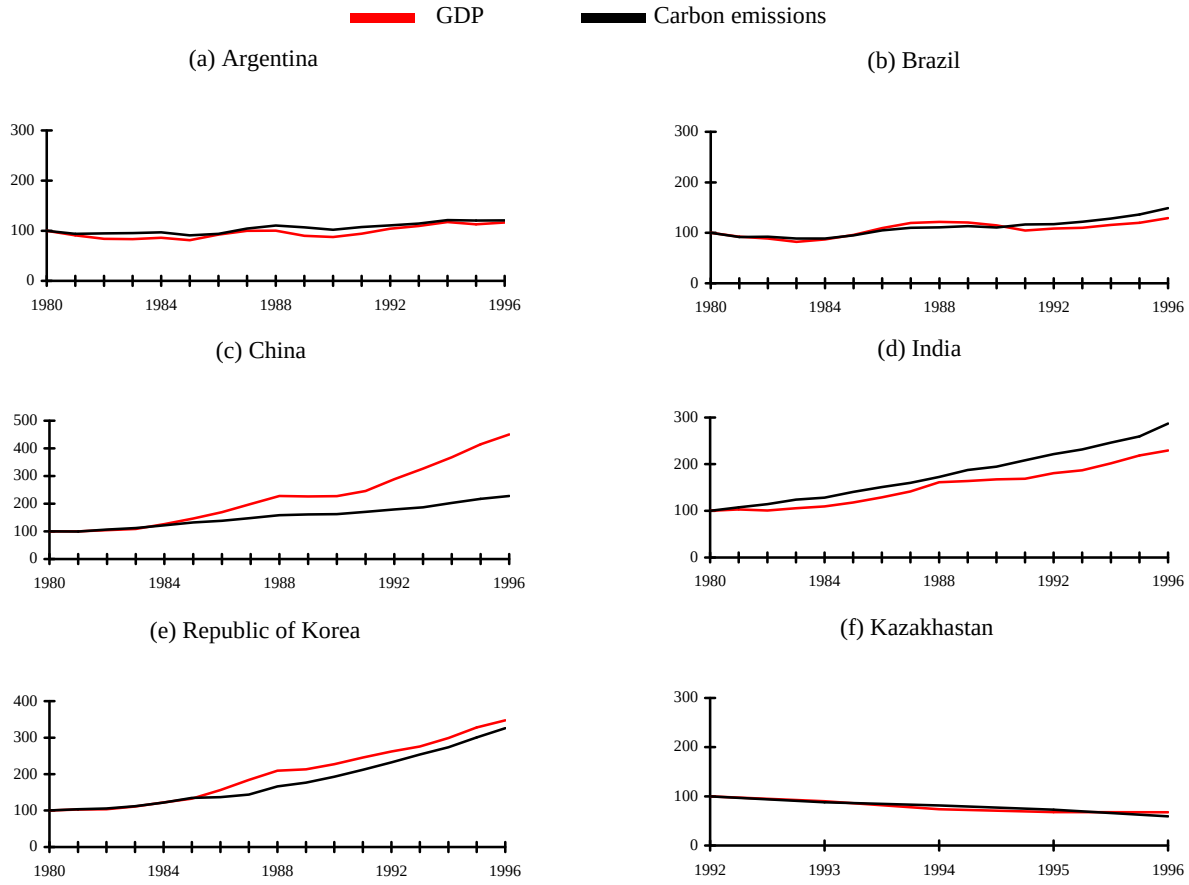
Given the *voluntary* character of new commitments, developing countries could choose the form of commitment that is most environmentally sound and compatible with domestic priorities. For countries that wish to make "soft," nonbinding commitments, a GHG intensity indicator is an effective way to benchmark national progress on climate change. This measure might even help shape their priorities for the Clean Development Mechanism. For countries that wish to make binding commitments—already agreed to in principle by Argentina and Kazakhstan—commitments could still take the form of an intensity-based measure, such as a carbon intensity indicator, without losing the ability to engage in emissions trading. This would entail voluntarily accepting a set of binding obligations, including some limit on the future GHG intensity of the economy. In either case—binding or nonbinding—a GHG intensity indicator may be a useful approach for many developing countries in furthering both sustainable development and Climate Convention objectives.

LESSONS FROM THE KYOTO PROTOCOL: WHAT DO WE ALREADY KNOW?

Country experiences, in relation to formulations already agreed to under the Kyoto Protocol, can help shape our preliminary thoughts on whether An-

Absolute Carbon Emissions Are Closely Correlated with Economic Growth

FIGURE 1 Gross Domestic Product and Carbon Emissions, Selected Developing Countries (index: 1980 = 100)



Sources: The World Bank and the Carbon Dioxide Information Analysis Center.
Note: Gross domestic product (GDP) is measured in millions of international dollars using purchasing power parity. Carbon emissions are from fossil fuel burning, gas flaring, and cement manufacturing only.

nex I-style commitments are applicable to developing countries, or alternatively, whether an intensity-based or other measure might be more appropriate. First, by exploring several cases, we know that total emission levels may not effectively gauge a country's "climate performance." Second, we also know that there are great uncertainties associated with forecasting GHG emission levels in developing countries since emission projections depend on shaky economic growth assumptions. Finally, there are potential environmental dangers in mixing an approach that measures new developing country commitments in terms of absolute emission levels with the international emissions trading system envisioned in the Kyoto Protocol. GHG intensity indicators may help mitigate some of these difficulties.

This is *not* to suggest that Annex I commitments for 2008–2012 should be reconsidered in light of an intensity indicator. But when addressing future developing country commitments and even new commitments for some Annex I countries in subsequent compliance periods, negotiators should learn from country experiences with respect to provisions already put forth in the Climate Convention and Kyoto Protocol. In practice, this means shaping commitments using a measure that is most appropriate to the countries under consideration and most conducive to advancing the goals of the Climate

Convention. The experiences of Annex I economies in transition and rapidly growing developing countries are particularly useful in assessing the potential problems that may arise from capping developing country emissions.

Measuring Climate Performance

Because carbon emission levels in most countries are closely correlated with economic growth, a country's *absolute* emission level may not always be a good indicator of "climate performance." Figure 1 shows the typically tight relationship between these two variables.[4]

In some cases, rapidly growing GHG emission levels are not necessarily indicative of poor climate performance. For example, even though China's annual GHG emissions grew by nearly 500 million tons of carbon (MtC) between 1980 and 1997, energy efficiency gains achieved during this period resulted in avoided emissions of 432 MtC.[5] Although not done to protect the climate, without the price reforms and other measures that improved energy efficiency, China's carbon emissions in 1997 would have been more than 50 percent higher than its actual emissions. This decoupling of economic development and emissions growth is evident in terms of China's carbon intensity, which has declined by about 45 percent since 1980. (*See Figure 2*.) Unfortunately, China's rapidly declining carbon intensity is the exception rather than the rule for most countries.

In the Ukraine, carbon emissions from 1990 to 1995 dropped by more than 40 percent.[6] (*See Figure 3*.) However, this decrease is due primarily to economic decline, rather than energy efficiency, fuel saving, or any other climate- or energy-related policy.[7] In fact, the Ukraine's carbon intensity actually worsened during this period, increasing 20 percent from 994 to 1,194 tons of carbon per million dollars of gross domestic product (GDP) (measured in purchasing power parity). Similarly, absolute carbon emissions in the Russian Federation fell by more than 169 MtC between 1990 and 1995 (26 percent) while the economy became *more* carbon intensive, increasing in carbon intensity from 807 to 950.[8] Thus, although overall levels of carbon emissions have decreased, neither Russia nor the Ukraine has become more sustainable this decade.

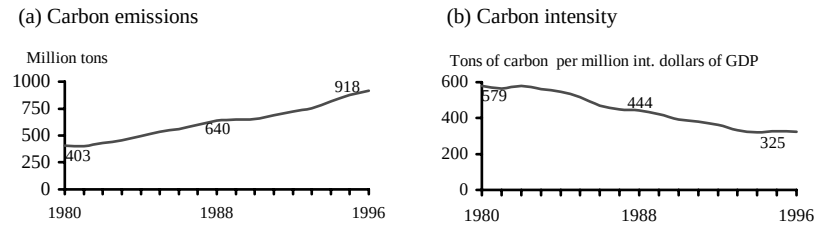
> A carbon intensity indicator measures tons of carbon emissions per million dollars of GDP.

Climate performance can be better expressed through emissions *per unit of GDP*. This measure illustrates how well countries are decoupling the typically high correlation between carbon emissions and GDP shown in Figure 1. Indeed one could argue that the path toward achieving the Climate Convention's objective will necessarily require decoupling economic output and GHG emissions, much in the way conventional air pollution has been delinked from GDP in many industrialized countries.

We have a long way to go in terms of GHG emissions, however, because economic decline or expansion typically shapes a country's GHG emissions profile more profoundly than climate-related policies and measures.

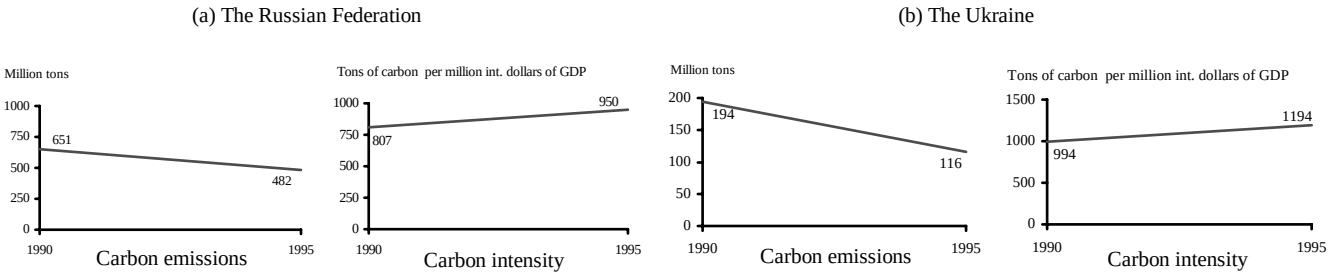
Despite Huge Increases in Absolute Emissions, China's Carbon Intensity Has Declined by 45 Percent Since 1980

FIGURE 2 Absolute Carbon Emissions versus Carbon Intensity in China, 1980–1996



Carbon Emissions Have Decreased in Russia and the Ukraine Since 1990, but Neither Country Has Become More Sustainable

FIGURE 3 Absolute Carbon Emissions versus Carbon Intensity, Russia and the Ukraine



The Emissions Guessing Game: Projecting Future Levels

It is widely accepted (and already framed in the Climate Convention) that developing country GHG emissions will grow in the coming decades to meet development needs. (*See Box 1.*) So if an Annex I-style commitment—in the form of a growth cap—is applied to a developing country, the debate will likely begin with the question of *how high* emissions are expected to grow under a business-as-usual scenario (often referred to as a baseline, or reference case scenario). Table 1 shows emission growth estimates for selected developing countries. In some cases, emissions are projected to grow by more than 200 percent above 1990 levels by 2010. By comparison, under the Kyoto Protocol, Annex I countries will collectively *reduce* emissions by 5.2 percent in 2008–2012 compared with 1990 levels.

The problem is that all projections are based primarily on economic growth assumptions or on energy demand scenarios that result from economic assumptions. These assumptions are highly uncertain, making carbon projections equally uncertain. In China, where multiple projections have been made, estimates vary widely, by as much as 519 MtC in 2010—an amount exceeding the 1990 carbon emissions of Brazil, India, Indonesia, Korea, and

Box 1

Principles for Developing Country Participation in the Climate Convention

Several principles already agreed to under the Climate Convention may guide the debate over what constitutes the fairest, most environmentally effective, and politically palatable commitments for developing countries. The Climate Convention affirms that:

- Parties should protect the climate system in accordance with their common but differentiated responsibilities and respective capabilities.
- Parties have the right to, and should, promote sustainable development. Climate-related policies and measures should be integrated with national development programs.
- The share of global emissions originating from developing countries will grow to meet their social and development needs.
- Climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response.
- Industrialized countries shall provide new and additional financial resources to developing countries for complying with their inventory and reporting obligations as well as the transfer of technology for implementing climate measures.

Source: United Nations Framework Convention on Climate Change, Preamble and Articles 3 and 4. 1992.

Table 1 **Projected Growth in Carbon Emissions, Selected Developing Countries**

Country	Million Tons of Carbon[a] 1990 Level	Million Tons of Carbon[a] 2010 Projections	Percentage Above 1990 Level	Sources
BRAZIL	57	102–144	79–153	U.S. Energy Information Administration[b]
CHINA	620	1,067–1,586	72–156	U.S. Energy Information Administration[b]
	653	1,381	113	International Energy Agency[c]
	587	1,441	145	ZhongXiang Zhang[d]
INDIA	153	326–455	113–198	U.S. Energy Information Administration[b]
INDONESIA	45	142	213	Republic of Indonesia (FCCC)[e]
REP. OF KOREA	65	217	233	Republic of Korea (FCCC)[f]
	61	141–201	131–230	U.S. Energy Information Administration[b]
MEXICO	78	116–139	49–78	U.S. Energy Information Administration[b]
	84	151	80	International Energy Agency[c]

Notes: a. Where necessary, data are converted from tons of carbon dioxide (CO_2) to tons of carbon. b. Energy Information Administration. December 1998. *International Energy Outlook 1999 With Projections to 2020.* U.S. Department of Energy. c. International Energy Agency projections are from "Energy/CO_2 Forecasts." No. 6, Autumn 1997. *Energy Environment Update.* International Energy Agency. d. ZhongXiang Zhang. "Is China Taking Actions to Limit its Greenhouse Gas Emissions? Past Evidence and Future Prospects." In Reid and Goldemberg (eds.). April 1999. *Promoting Development While Limiting Greenhouse Gas Emissions: Trends and Baselines.* United Nations Development Programme and World Resources Institute. e. Indonesia's projection is for 2011 (*not* 2010) and is included in its *Initial National Communication under the UNFCCC,* October 1998. State Ministry of Environment, Republic of Indonesia. f. Korea's projection is from the *National Communication of the Republic of Korea.* 1998. Submission of the Republic of Korea to the United Nations Framework Convention on Climate Change.

Mexico combined. Adding to the difficulty of projecting emissions is the incentive for countries to inflate the business-as-usual scenario to secure future targets that are easier to meet and more conservative in terms of avoiding any future constraints on economic growth.

The case of Korea and others illustrates why binding emission targets for developing countries—expressed in tons per year—is risky environmental policy. Korea's national communication to the Climate Convention projects a 5.2 percent annual growth in emissions from 1996 to 2010 (217 MtC by 2010)—a scenario based on a 5.3 percent annual growth in GDP.[9] The report states that the next communication will need to revise emission projections because "the Korean economy is now facing financial turmoil that had not been expected." Once emission commitments are established under the Convention or Protocol, however, there will likely be no opportunity to revise them in the event of economic turmoil or expansion that was not factored into the GHG projections. So, if Korea had agreed to a voluntary cap in Kyoto, as the United States and other Annex I countries had wanted, and if the current Asian economic downturn were to linger, the Annex I cap would be diluted. In other words, the collective target would be less stringent than what was expected at the time of negotiations. Thus, progress under the climate treaty would be slower than expected. In climate treaty parlance, negotiators would have created more of what is often referred to as "hot air."

Article 17 Implications: Trading Away the Atmosphere?

The international emissions trading system envisioned in Article 17 of the Kyoto Protocol multiplies the stakes of

being wrong about future emissions. A developing country would be extremely wary of committing to an emissions cap based on lower-than-desired GDP growth. However, it is likely, if not inevitable, that excess emissions would be welcomed by some participants in a global trading system because it would make compliance less expensive for industrialized countries.

These risks—to growth (or compliance) on the one hand, and to the environment on the other—exist even if everyone involved in making the projections and negotiating the commitments were acting fully in good faith with genuine concern for climate protection. The risks are exacerbated if one allows for the possibility of intentionally inflating future emission levels.

By dynamically lowering the cost of meeting more stringent emission targets, emissions trading offers great promise as a policy tool in the context of the Kyoto Protocol. However, what ensures the environmental efficacy of this tool is a meaningful cap (i.e., an overall limitation) on the total allowable emission level.[10] Negotiators must be mindful that if the cap becomes too high—too lenient to achieve meaningful emission reductions that will mitigate climate change—the environmental integrity and usefulness of international emissions trading, and more generally, the effectiveness of the entire Kyoto Protocol, will be undermined.

The case of Annex I economies in transition, in relation to the overall Annex I cap, illustrates the risks posed by the interaction of new commitments and trading. The collective Annex I reduction goal set in the 1997 Kyoto Protocol is 5.2 percent below 1990 levels. Many observers believe that the Kyoto Protocol also embodied a significant amount of hot air—allowances for emissions above expected levels for some of the countries in Central and Eastern Europe and the former Soviet Union. However, it is safe to conclude that the United States would not have agreed to lower its emissions 7 percent below 1990 levels without the expectation of low-cost emission reductions available from the eastern half of Annex I. The so-called hot air and the overall stringency of the cap for Annex I, as well as the individual caps for countries such as the United States, have to be considered as a package. In other words, the 5.2 percent Annex I target includes the relatively lenient targets in the half of Annex I countries undergoing economic transition balanced by relatively stringent targets for the West.

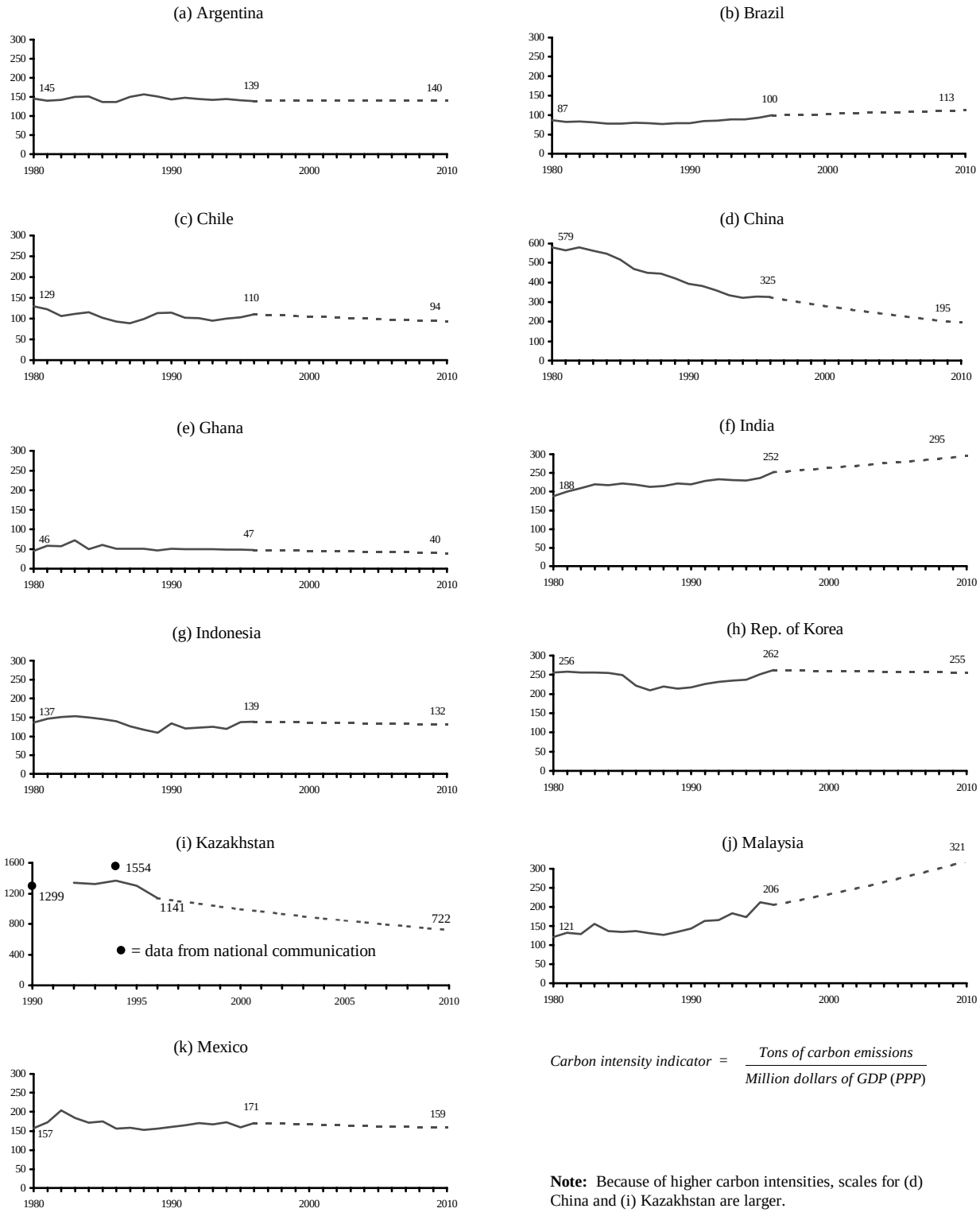
> Using a carbon intensity indicator can lower the incidence of "hot air."

This dynamic no longer exists—the subject of existing Annex I commitments during the 2008–2012 period is unlikely to be revisited. So voluntary commitments, in the form of generous developing country growth caps during the same commitment period, cannot be balanced by simultaneously strengthening other Annex I party targets. Thus, it is entirely likely that by combining these two factors—emissions trading and new voluntary commitments based on uncertain growth caps—global GHG emissions could be higher than if the Kyoto Protocol were implemented as currently formulated.

Because intensity indicators do not lock in an absolute emission target for countries, using this measure to express a country's commitment would reduce the incidence of hot air, while still allowing for emissions trading and ensuring that the integrity of existing Annex I targets is maintained. If adopted as a commitment measure, a country's allowable amount of GHG emissions would be a function of both the carbon intensity target and economic output. This form of commitment embodies no expectations or constraints on economic growth—high economic growth would mean more emissions would be allowed, while low growth, or economic decline, would require a country to emit less. For countries that have highly uncertain economic futures, or countries that are vulnerable to the vagaries of international financial markets, this would prevent gross overestimations or underestimations of future emission levels. The subsequent sections illustrate how a country with a commitment ex-

Carbon Intensity Indicators Are Not Driven by Economic Growth

FIGURE 4 Carbon Intensity Indicator, Selected Developing Countries

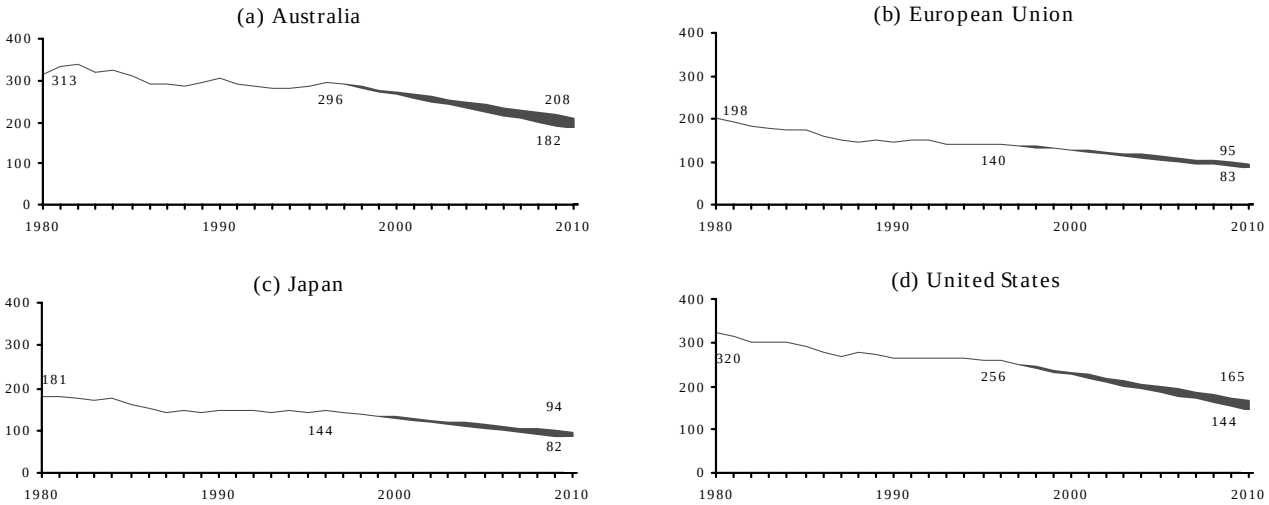


Carbon intensity indicator = $\frac{\textit{Tons of carbon emissions}}{\textit{Million dollars of GDP (PPP)}}$

Note: Because of higher carbon intensities, scales for (d) China and (i) Kazakhstan are larger.

Because GDP Usually Outpaces Energy Consumption in Industrialized Countries, Carbon Intensity Typically Drops over Time

FIGURE 5 Carbon Intensity Indicator, Selected Industrialized Countries



$$\textit{Carbon intensity indicator} = \frac{\textit{Tons of carbon emissions}}{\textit{Million dollars of GDP (PPP)}}$$

Note: Projections represent the range of carbon intensity reductions implied by the Kyoto Protocol commitments, using a projected GDP growth rate of 2 to 3 percent.

pressed in terms of an improved carbon intensity indicator could still participate in international emissions trading.

EXPLORING THE CARBON INTENSITY INDICATOR

Indicators show how two important quantities relate to one another. They are commonly used as measures for a variety of things such as fuel efficiency (miles per gallon) and development (income per person).[11] The relationship between the two components of the carbon intensity indicator (*see Figure 1*) is intuitive—most economic activity typically results in GHG emissions. Figure 4 shows carbon intensity indicators for 10 developing countries and one country in economic transition, Kazakhstan. Figure 5 shows similar indicators for the United States, the European Union, Japan, and Australia.

The key determinants of a national-level indicator are a country's economic structure, geography, fuel mix, and the energy efficiency of its production processes. Argentina and Brazil (*Figures 4a and 4b*), for example, have low intensities partly due to the widespread use of carbon-free hydroelectric power. China and India (*Figures 4d and 4f*) have high intensities (although their trend lines differ) due partially to exploitation of domestic coal resources.

More important, however, the main *drivers of change* in developing country carbon intensities are policies and measures (or external shocks) that affect a country's economic structure, energy efficiency, and fuel choices. For example, China's successful decoupling of economic growth and carbon emissions (demonstrated by the steep decline in the carbon intensity indicator) is due largely to energy price reforms. Coal subsidies in China fell from 61 percent in 1984 to 29 percent in 1995, and petroleum subsidies dropped from 55 percent in 1990 to 2 percent in 1995.[12] Shifts in economic activity to lower or higher carbon sectors as well as technological progress also contribute to variations in intensity trends. Disaggregating the carbon intensity indicators by sector and subsector would help reveal where fossil fuel

use is most efficient and inefficient, shedding light on which sectors and industries drive the country-level indicators.[13] (*See Box 2*.)

Finally, carbon intensity indicators differ from other measures, such as total carbon emissions or emissions per capita, in that they are not driven primarily by economic growth. Typically, during economic decline, both GDP and energy-related carbon emissions fall (while the opposite is true for economic growth). Which figure falls faster, and how a country's carbon intensity changes, is less clear. In some cases, such as economic decline in the Russian Federation and the Ukraine, GDP fell faster than carbon, signaling an increase in carbon intensity. In other cases, such as Bulgaria, Poland, Hungary, and other Eastern European countries, carbon intensity levels fell when economies declined (i.e., carbon emissions fell faster than GDP). This is often the result of deliberate energy policy reforms, including price liberalization and energy restructuring.[14]

How Are Countries Performing?

Analyzing changes in a country's carbon intensity indicator over time can tell us whether a country is getting less or more carbon intensive. In terms of trends from 1980 to 1996, developing countries vary widely in performance. Of the countries examined here, only India and Malaysia (*Figures 4f and 4j*) have carbon emissions that increase faster than GDP (hence the rising intensities). Most countries—Argentina, Brazil, Chile, Ghana, Indonesia, Korea, and Mexico—have fairly flat trajectories, maintaining a slightly increasing or slightly decreasing carbon intensity over time. The few points calculated for Kazakhstan (1990–1996 only) (*Figure 4i*) also show a fairly steep decline in carbon intensity. China (*Figure 4d*) has decoupled its economic and emission growth to the greatest degree, with emissions growing at roughly half the rate of economic growth.

Figures 4 and 5 also show that some countries have much higher intensities than others. The overall level of intensity may be an important factor in determining the ability of countries to alter historical trends. For example, improving from a high intensity level may require less effort and cost than improving from a low carbon intensity. This and other factors such as differences in resource endowments, geography, and economic structures should also be taken into account when trying to make meaningful cross-country comparisons.[15] What is most important, however, is not international comparisons but assessing a country's performance *relative to itself*, taking into account both absolute intensity levels and changes over time. This can be done by observing the trends across the 1980 to 1996 period for each country.

Box 2 Indicators Big and Small

Carbon intensity indicators presented in this *Climate Note* are aggregate, *national-level* figures. Other such measures may also be useful to judge national-level progress on climate or energy intensity. For example, the carbon intensity of the energy supply, *C/E*, reflects changes in the commercial fuel mix of a country.

While useful in tracking countrywide change, national-level indicators (such as *C/GDP* and *C/E*) do not tell us which sectors, subsectors, processes, or fuels are driving overall national carbon intensity. Analysis by the International Energy Agency (IEA) shows how disaggregated indicators can provide an understanding of the way in which various sectors, subsectors, and processes drive a country's emission level and shape future emission profiles. This analysis can help determine where policies and measures can be most effective in lowering the carbon intensity indicator. For example, through the use of sectoral, subsectoral, and process-level data for activity, efficiency and fuel use, carbon emissions per unit of GDP have been decomposed into residential, manufacturing, services, automobile travel, freight, and other components (for IEA countries). This level of disaggregation would enable countries to make more informed decisions regarding which activities to target with policies and measures aimed at reducing emissions.

Sources: Lee Schipper, Fridtjof Unander, and Celine Marie. November 1998. "The IEA Energy Indicators Effort: Extension to Carbon Emissions as a Tool of the Conference of the Parties and Lee Schipper and Reinhard Haas. "The Political Relevance of Energy and CO_2 Indicators—An Introduction." In *Energy Policy*, Vol. 25, Nos. 7-9, 1997.

The Connections Between Carbon Intensity and Stages of Development

Among developing countries, there is no discernible relationship between carbon intensity and level of development. For example, China and India have similar per capita income levels, yet China's intensity is falling rapidly while India's is rising. (*See Figures 4d and 4f.*) Similarly, Chile and Malaysia have commensurate incomes but opposing trends in carbon intensity. (*See Figures 4c and 4j*.)

However, for mature, industrialized economies such as the United States, the European Union, and Japan, carbon intensity decreases consistently over time because GDP growth typically outpaces energy consumption. (*See Figure 5*.) In these economies, GDP (and energy demand) growth rates are modest and predictable, and often driven by a relatively less carbon-intensive service sector.

For most Annex I countries, however, an intensity indicator is *not* an appropriate basis for determining commitments. The larger historical contribution to the stock of GHGs in the atmosphere as well as the greater technical and financial capacity confer a special responsibility upon Annex I countries to begin *absolute* reductions in total emissions and gradual convergence with developing countries. This situation is qualitatively different from that of most developing countries, which are expected to increase their emissions to meet human development needs at least in the next few decades.

What Might a Developing Country Commitment Look Like?

A carbon intensity indicator, or another more comprehensive intensity-based measure, could also be used as a measure for a country commitment under the Climate Convention or Kyoto Protocol. Such a commitment might represent an agreement to *improve* intensity levels relative to past performance. In other words, the commitment might take the form of lowering the country's carbon or GHG intensity indicator. Determining compliance would be simple and straightforward in this case—a country would be in compliance if its actual intensity indicator was less than or equal to a target intensity indicator (i.e., the commitment) during the compliance period.

However, a country making a binding commitment might want to engage in international emissions trading. In this case, the intensity indicator could be translated into an absolute level of emissions during the compliance period. (*See the equation below.*)

Allowable GHG emissions =
(GDP) (GHG emissions/GDP)

where *GHG emissions / GDP* is the target intensity indicator and *GDP* is the total economic output during the compliance period. (*See Boxes 3 and 4*.) For the purposes of an individual country commitment, GDP would likely be measured in *local currency* rather than PPP or market exchange rates. This could eliminate possible controversy over exchange rate variations or PPP conversion factors.

A Benchmark for Countries without Commitments

Carbon intensity indicators can also provide an analytic basis for discussing developing country participation *outside the context of formal commitments*. In some cases, a binding emissions commitment using any measure (absolute levels or intensity) may be unsuitable for developing countries. Substantial technical and administrative capacity is needed to measure and report emissions accurately, as well as to implement GHG abatement measures. These constraints may make binding commitments for many developing countries impractical or unachievable. Still, in the context of the Climate Convention, and through the World Bank and other multilateral institutions, countries could benchmark their carbon intensity indicators against historic trends or another performance standard. Some may be willing to aim for soft goals—not legally binding, but declared intentions nonetheless. These nonbinding commitments, of course, would not enable countries to participate in an international emissions trading system.[16]

Another application of the carbon intensity indicator, outside the context of

Box 3

Applying a GHG Intensity Indicator: A Thought Exercise

STEP 1. Formulating the Target

IF: ***Country A, a rapidly growing developing country, agrees to lower its greenhouse gas (GHG) intensity by 40 percent below 1996 levels between the 2013–2017 period, and 1996 data are:***

Greenhouse gas emissions	=	1,000 tons of carbon equivalent
Gross domestic product	=	$2 million
GHG intensity	=	500 tons of greenhouse gas per million dollars of GDP

THEN: ***The target GHG intensity for 2013–2017 = 300 (40 percent below the 1996 level of 500).***

STEP 2. Determining Allowable Emissions

IF: ***During 2013–2017, Country A actually has:***

Gross domestic product	=	$30 million (average of $6 million per year for 5 years — three times higher than 1996 levels)

THEN: ***Country A's allowable greenhouse gas emissions = 9,000 metric tons of carbon equivalent over the 5-year period (30 x 300) (i.e.,GDP times the target GHG intensity indicator).***

Despite this reduction in intensity, absolute levels of GHG emissions are still allowed to increase by 80 percent (from 1,000 tons of carbon equivalent in 1996 to 1,800 tons of carbon equivalent yearly during the 2013–2017 period).

STEP 3. How Much to Trade?

Outcome 1: If GHG emissions equal 8,000 tons of carbon equivalent during the 2013–2017 period, Country A may *sell* 1,000 tons of allowances through international emissions trading (i.e., the allowable amount exceeds actual emissions by 1,000 tons).

Outcome 2: If GHG emissions equal 10,000 tons of carbon equivalent, Country A must *buy* 1,000 allowances through emissions trading (actual emissions exceed the allowable amount by 1,000 tons).

formal commitments, is through the Clean Development Mechanism (CDM)—an instrument for North-South cooperation already created under the Kyoto Protocol. In addition to attracting investment and building capacity, CDM projects should help to lower a country's carbon intensity. A carbon intensity indicator can measure the national effects of CDM projects, ensuring that these investments do indeed lead to a less carbon-intensive economy.

Bringing an Intensity Indicator into Practice

While a carbon intensity indicator may mitigate some of the problems inherent in basing commitments on absolute emission levels (*see page 2*), it does not remedy all the issues associated with discussing developing country commitments. Some issues, such as determining an acceptable target level and gathering comprehensive data, cut across any method used to measure a commitment. Intensity indicators also raise some new issues that would need to be addressed or discussed before such a commitment measure could be functionally implemented. In particular, international emissions trading, long-term environmental considerations, and treaty compliance would need to be reconceptualized in the context of intensity indicators.

Data Coverage of the Intensity Indicator

Ideally, a voluntary commitment would factor in all gases and sinks included in the Kyoto Protocol. However, this may not be possible for some countries that may wish to make a commitment in the foreseeable future. Because of a lack of data availability in developing countries, the analysis here includes only carbon emissions from fossil fuel burning, cement manufacture, and gas flaring. Other GHGs and carbon emissions from land-use change (including biomass burning) that are *not* factored into Figure 4 and Figure 5 may, in many cases, be significant. (*See Box 5*.)

While comprehensive coverage of sources and sinks is desirable, data accuracy and consistency are crucial both for determining the magnitude of an initial commitment and ensuring its compliance—a fact true regardless of how commitments are measured. The current data limitations seriously constrain any focused discussion of voluntary commitments. In fact, the lack of

technical capacity to measure and report emissions may be an important signal that a developing country is not ready to assume binding commitments. Remedying this data deficiency should be an objective of developing country governments, relevant multilateral bodies, *and* Annex I countries, which are required to provide "financial resources to meet the agreed full costs incurred by developing country Parties" in complying with their reporting obligations under the Climate Convention.[17] Although there are bilateral and multilateral initiatives to address this issue, only a handful of non-Annex I countries have submitted national communications to date that contain emission inventories. Additional capacity-building initiatives are needed.

In addition to the importance of GHG emissions data, using intensity indicators raises the added issue of scrutiny over reported GDP levels. In at least one recent case, officials have raised doubts about the validity of reported economic growth rates.[18] Currently, the World Bank relies on countries to supply GDP data in their own local currencies. A common understanding of methodologies and full transparency would be required to ensure that GDP figures are not purposefully inflated in order to lower the reported intensity level.

Agreeing on a Commitment Level

Another issue inherent in any discussion of developing country commitments is agreeing on an acceptable target level. As noted above, a carbon intensity indicator removes the need to engage in an emissions "guessing game." However, negotiators will still need to consider what constitutes good performance and the intensity level from which to judge progress.

For many countries, progress could be benchmarked against a base year intensity indicator. Because the carbon intensity indicator internalizes fluctuations in economic growth, it is signifi-

Box 4

What Would Have Happened If Economies in Transition Had Made Commitments Based on Carbon Intensity?

To show the effect of using an intensity-based measure, the Kyoto Protocol emission reduction commitments of eight Central and Eastern European (CEE) countries can be applied to countries' carbon intensity indicators, rather than their base-year emission levels. For illustrative purposes only, 1995 (rather than the 2008–2012 compliance period) can be used as the "compliance year" for the countries in this example. If this were the case, the 1995 allowable carbon emissions for these countries would drop by about 45.1 million tons of carbon (MtC)—17 percent of the total allowable amount. In other words, these countries would be required to emit less if the commitment took the form of a carbon intensity indicator. For countries that have made emission reductions partially due to economic decline (such as CEE countries), this means that the amount of hot air is reduced—emission reductions that are marketable through international emissions trading are lowered from 60.2 to 15.1 MtC (a difference of 45.1 MtC). Using a carbon intensity indicator would still enable these countries to sell excess emission reductions, but it would help ensure that emission reductions that are sold are generated from legitimate climate- or energy-related activities, rather than from economic changes.

If the Kyoto commitments for Russia and the Ukraine (i.e., 100 percent of 1990 emissions, or, no change in emissions) had been expressed using a carbon intensity indicator, neither country would be able to sell *any* emission "reductions" through an international emissions trading system. Both countries had carbon intensities in 1995 that exceeded 1990 levels, despite the fact that absolute emission levels were far below the base year.

Notes: The eight countries include Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania, and Slovakia. Base years are 1990 for all countries except Bulgaria (1988), Poland (1988), and Romania (1989). The total allowable amount, using the carbon intensity indicator, is obtained by summing the allowable amounts for each country, which are each calculated by multiplying a country's percentage reduction inscribed in Annex B of the Kyoto Protocol by the country's base year carbon intensity indicator. The resulting total allowable amount, 223.7 MtC (using the carbon intensity indicator), is about 17 percent below the allowable amount using the method described in Article 3 of the Kyoto Protocol (268.8 MtC)—multiplying the Annex B percentage by total tons of emissions in the base year. Carbon emissions are derived from national communications to the UNFCCC for all countries except Latvia: *How to Mitigate Climate Change: Study on the Assessment of Policy and Technology Options in Energy and Forestry Sectors in Latvia*. Summary. 1998. Riga. Ministry of Environmental Protection and Regional Development of the Republic of Latvia. Due to constraints in data availability in the national communications, 1995 indicator calculations were not possible for Poland (where 1994 was used), Latvia (also 1994), Romania (1993), and Bulgaria (1992).

Box 5

A Complete Indicator

In addition to emissions from fossil fuel burning, cement manufacture, and gas flaring, a complete intensity indicator would include carbon emissions from land-use change and forestry as well as the five other GHGs included in the Kyoto Protocol. Including carbon emissions and absorptions from land-use change and forestry is particularly important for developing countries. Roughly 30 percent of the total carbon that accumulated in the atmosphere from 1850 to 1990 is attributable to land-use change, the majority of which occurred in developing countries. [1]

For the few countries and years for which data are available, the incorporation of emissions from land-use change and forestry can profoundly change a developing country's carbon intensity indicator. However, country estimates of these emissions are uncertain and use different estimation methodologies. In addition, the Kyoto Protocol specifies that only "direct, human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990…" shall be used to meet national commitments. Parties have not yet agreed on these definitions and it is not clear which land-use change and forestry emissions and absorptions will be included in national inventories.[2]

Notes:
1. See Duncan Austin, José Goldemberg, and Gwen Parker. October 1998. "Contributions to Climate Change: Are Conventional Metrics Misleading the Debate?" *Climate Note.* World Resources Institute.
2. See The Kyoto Protocol to the UNFCCC. Article 3. See also, UNFCCC. 1 September 1998. "Matters Related to Decision 1/CP.3, Paragraph 5. Land-Use Change and Forestry." Submissions by Parties. FCCC/CP/MISC.1.

cantly less variable over time. The carbon intensity levels of Argentina, Brazil, Ghana, Indonesia, Korea, and Mexico have changed less than 10 percent over a 17-year period from 1980 to 1996. (*See Table 2.*) The Republic of Korea, for example, increased its absolute level of emissions by more than 225 percent during the 1980–1996 period. Over the same period, however, the carbon intensity indicator changed a mere 1.1 percent. For countries that experience more noticeable increases or declines in carbon intensity, projections may be needed.

The projections shown in Figure 4 embody a continuation of the past performance of an economy's changing "carbon structure"—not a prediction of either GDP or annual carbon emission levels. These trajectories may be a starting point for identifying a country's business-as-usual path, although factors unique to individual countries should color the detailed discussions on refining projection figures.

For example, carbon-reduction measures already taken and any future planned initiatives may help refine predictions and help shape a more plausible business-as-usual path from which to gauge progress.[19] Carbon intensity indicators *disaggregated by sector* could also help forecast intensities by revealing where opportunities for reducing emissions exist and how existing policies and measures may alter future intensity levels.[20]

Alternatively, future intensity indicator estimates could be derived from separate emissions and GDP model projections. The results for the few countries for which such projections are available are similar to the extrapolations in Figure 4. [21]

Long-Term Considerations

Fulfilling the objective of the Climate Convention will require stabilizing atmospheric concentrations of GHGs at an agreed-upon level. This, in turn, could eventually require all country commitments to be fixed in terms of absolute GHG emission levels (regardless of economic performance), consistent with the approach already taken by Annex I countries under the Kyoto Protocol. However, for reasons outlined above, until a country is prepared to make an absolute emission reduction, an intensity-based commitment should be considered as an alternative to growth caps. A carbon intensity indicator is a possible next step, but not the last step, that will help address the real climate challenge in developing countries, namely decoupling economic development and GHG emissions growth. A set of conditions—such as level of economic de-

velopment, degree of economic stability, reporting capacity, and cumulative contribution to the atmospheric stock of GHGs—could be explored that might trigger whether a commitment takes the form of an absolute reduction versus an intensity reduction.

Compliance and Emissions Trading

Although there are environmental advantages to intensity indicators, countries will be uncertain of their exact allowable emission levels until the *end* of the compliance period (unlike an Annex I-style commitment, where a country's allowable amount is calculated on the basis of the 1990 emission level). The time lag is necessary because GDP levels are needed to calculate allowable emissions. Thus, until emissions and GDP data are compiled at the end of the compliance period, a country will be unsure of both actual and allowable emissions. This added uncertainty has implications for compliance and emissions trading.

Table 2 Changes in Carbon Intensity and Carbon Emissions from 1980 to 1996

Country	Percent Change In	
	Carbon Intensity	Total Carbon Emissions
ARGENTINA	–5.8	20.8
BRAZIL	6.4	49.0
CHILE	–18.5	74.6
CHINA	–47.2	127.8
GHANA	5.5	66.8
INDIA	29.1	187.2
INDONESIA	–4.9	159.0
REP. OF KOREA	–1.1	226.1
MALAYSIA	57.6	325.6
MEXICO	1.8	38.4
AUSTRALIA	–5.4	51.2
EUROPEAN UNION	–29.2	–2.5
JAPAN	–20.4	26.9
UNITED STATES	–20.3	15.9

Annual assessments during the multi-year compliance period are one means of gauging country progress. However, an interim period at the conclusion of the compliance period would be needed during which countries could purchase allowances to come into compliance if necessary. Such a grace period is already envisioned by some as a desirable, or necessary, feature of an Annex I compliance system.[22]

Emissions trading might also be inhibited by the absence of specific targets expressed in tons per year. However, options and futures markets could in-

Table 3 Design Features of Existing Commitments under the Kyoto Protocol

Link to Major Obligations	Links to Rights	Legal Character	Baselines	Target
• Demonstrable progress by 2005 (3.2) • Subsequent commitments (3.9) • National inventories (5) • National reporting (7) • In-depth review (8)	• Emissions trading (3.10; 3.11; and 17) • Joint Fulfillment (4) • Joint Implementation (3.10; 3.11; and 6) • Clean Development Mechanism (3.12; 12)	Binding	• Historical; single year (1988, 1989, or 1990) or average (1985–87) • Measurement: tons of carbon equivalent	–8 to +10 percent by 2008–2012

Source: Kyoto Protocol.
Note: Numbers in parentheses refer to the relevant Article of the Protocol.

NEXT STEPS

Key next steps that can help operationalize the use of intensity indicators include:

- Enhance the long-term institutional and technical capacities in developing countries for measuring, gathering and reporting greenhouse gas emissions data. Annex I governments and international organizations have special roles to play in capacity-building programs. These efforts should include attention to carbon emissions and absorption from land-use change and forestry.
- Disaggregate greenhouse gas intensity indicators to enable more effective use by national decision-makers. Decomposing national-level indicators will help countries:
  - more accurately forecast future intensity levels,
  - determine which policies and measures will help reduce GHG intensity, and
  - decide whether a voluntary commitment, either binding or nonbinding, is possible or desirable.
- Include national, sectoral, and subsectoral intensity indicators (where possible) in the National Communications submitted by countries under Article 12 of the Climate Convention.

crease market efficiency and enable market transactions before or during the compliance period, with the final trades for compliance purposes occurring during the grace period. More significantly, again, multiyear compliance periods allow for *annual* assessments that would help countries gauge the amount of allowances needed to purchase or available to sell. After the first year of the compliance period, for example, a country could compare its actual emissions with the year's "allowable amount."

Thus, emissions trading could be far more dynamic than the simplistic example in Box 3 suggests. The possible shortcomings of emissions trading under an intensity indicator should be weighed against the dangers of operating a trading system that would combine existing Annex I targets with large emission growth commitments from non-Annex I countries.

Is There a Third Way?

In addition to being often divisive and counterproductive, the debate on voluntary commitments has also been narrowly focused. Discussions have converged entirely around the question of quantitative commitments to the neglect of additional issues that arise if any developing country assumes a new legal status under the Climate Convention or Kyoto Protocol. Table 3 shows the basic set of rights and obligations that form the core design features of the existing Annex B commitments under the Kyoto Protocol.

These design features, as well as those of the Climate Convention, raise inevitable questions about the status of a developing country that has made a voluntary commitment. For example, does such a commitment necessarily imply accession to Annex B (of the Protocol) and/or Annex I (of the Convention)? If so, would this unfairly subject developing countries to the other legal requirements—such as technology transfer or financial assistance—that Annex I/B countries are bound to in the Convention and Protocol? At a minimum, however, granting the right to engage in emissions trading must be balanced by the existing inventory and reporting obligations of Annex I countries.[23] Legally and procedurally, how might these issues be dealt with to ensure the fair treatment of countries and the environmental integrity of the treaty? We have explored the inapplicability of Annex I-style commitments for developing countries, but certainly other issues suggest a third way—an entirely different path that may be appropriate for developing countries under the Kyoto Protocol.

CONCLUSION

To the neglect of other important climate issues, upcoming negotiations will continue to grapple with the con-

tentious issue of developing country participation. But rather than follow the default path established by Annex I countries, government officials and negotiators must begin to reconceptualize developing country participation and learn from what we already know—that absolute levels of GHG emissions are a poor indicator of national climate performance and impossible to forecast accurately. These constraints, coupled with an international emissions trading system, could undermine the environmental integrity of the Kyoto Protocol if countries push for emissions caps in developing countries. Alternatively, negotiators and officials could focus on a mechanism that has already been agreed to for promoting developing country participation under the Kyoto Protocol. The Clean Development Mechanism could bring substantial development benefits while at the same time lowering carbon intensity.

A differentiated policy approach for developing countries can better achieve the common objectives of the Convention. One aspect of such an approach could be assessing developing country progress in terms of a carbon intensity indicator or a more comprehensive intensity-based measure. This method rectifies many of the shortcomings inherent in the current method and better addresses the key climate challenge in developing countries: reducing carbon intensity to advance sustainable development. Perhaps most significantly, carbon intensity indicators promote the integration of two objectives—increasing economic growth and limiting emissions—which have traditionally been regarded as antithetical.

About the Authors

Kevin Baumert *and* **Ruchi Bhandari** *are research analysts and* **Dr. Nancy Kete** *is the director of the Climate, Energy and Pollution Program at the World Resources Institute.*

Acknowledgments

The authors wish to thank Harald Dovland, Christiana Figueres, José Goldemberg, Michael Grubb, Lynn Price, Lee Schipper, Fernando Tudela Abad, Jacob Werksman, and ZhongXiang Zhang for reviewing this Climate Note. *We are also indebted to Eric Rodenburg and Allen Hammond for their help in thinking through the methodological aspects of this effort. The authors are grateful for the advice and contributions of many WRI staff, including Duncan Austin, Theresa Bradley, Elizabeth Cook, Michelle Corrigan, Navroz Dubash, Tony Janetos, Tony La Viña, Gwen Parker and Changhua Wu. We also thank Hyacinth Billings, Deborah Farmer, and Benjamin Hart for their editorial and production work. The Spanish edition of this publication was supported by the Wallace Global Fund and benefited from translation by the Center for Sustainable Development in the Americas and Patricia Ardilla, as well as production by Hyacinth Billings and Benjamin Hart. The World Resources Institute greatly appreciates the financial support provided by the Wallace Global Fund, the United States Agency for International Development, and the John D. and Catherine T. MacArthur Foundation.*

Notes

1. Several recent works have addressed the issue of participation under the Climate Convention. See Eileen Claussen and Lisa McNeilly. October 1998. *The Complex Elements of Global Fairness*. Pew Center on Global Climate Change and Cédric Philibert. Revised draft, March 1999. "How Could Emissions Trading Benefit Developing Countries?" Presented to the 4th OECD Forum on Climate Change, Paris, 9 – 10 March 1999. Recent works that also apply carbon per unit of GDP analysis are "Growth Baselines: Reducing Emissions and Increasing Investment in Developing Countries." January 1998. Center for Clean Air Policy; and Walter V. Reid and José Goldemberg (eds.). April 1999. *Promoting Development While Limiting Greenhouse Gas Emissions: Trends and Baselines*. United Nations Development Programme and World Resources Institute. For an early discussion of the political difficulties of agreeing on emissions caps and different approaches to targets, see Michael Grubb. 1989. *The Greenhouse Effect: Negotiating Targets*. Royal Institute of International Affairs.

2. For a discussion of stock contributions to atmospheric carbon dioxide concentrations, see Duncan Austin, José Goldemberg, and Gwen Parker. October 1998. "Contributions to Climate Change: Are Conventional Metrics Misleading the Debate?" *Climate Note*. World Resources Institute. Per capita emission levels of carbon dioxide, by country, are available in World Resources Institute, UNEP, UNDP, and the World Bank. 1998. *World Resources 1998-99*. Data Table 16.1. Annex I countries also include countries with economies in transition.

3. Walter V. Reid and José Goldemberg. July 1997. "Are Developing Countries Already Doing as Much as Industrialized Countries to Slow Climate Change?" *Climate Note*. World Resources Institute. See also Reid and Goldemberg (eds.). April 1999.

4. Using linear regression analysis, the *R*-squared measure shows the strength of the linear relationship between the dependent variable (carbon) and the independent variable (GDP). *R*-squared indicates the amount of variation in carbon that can be explained by an estimated linear relationship with GDP. An *R*-squared value of 1.00 would mean that 100 percent of the variation in carbon is explained by changes in GDP. *R*-squared values (1980–1996) include: Argentina (0.834), Brazil (0.711), China (0.977), India (0.982), Kazakhstan (0.833, from 1992–1996), and Korea (0.971).

5. This savings of 432 MtC amounts to more than 50 percent of China's 1997 emissions. ZhongXiang Zhang. "Is China Taking Actions to Limit its Greenhouse Gas Emissions? Past Evidence and Future Prospects," in Reid and Goldemberg (eds.), April 1999.

6. *Draft Ukrainian National Action Plan on Climate Change*. 1998. Final Report. Agency for Rational Energy Use and Ecology and U.S. Country Studies Program.

7. "Country Study on Climate Change in Ukraine." December 1995. United States Country Studies Program.

8. *Report on the In-depth Review of the National Communication of the Russian Federation*. February 1997. UNFCCC. FCCC/IDR.1/RUS.

9. *National Communication of the Republic of Korea*. 1998. See p. xliii.

10. An exception to this statement is "credit trading," similar to the method envisioned under the Clean Development Mechanism, elaborated in Article 12 of the Kyoto Protocol. For an explanation of the two types of trading systems ("cap and trade" vs. credit trading), see Fiona Mullins and Richard Baron. March 1997. "International GHG Emissions Trading." Annex I Expert Group on the UNFCCC.

11. See Lee Schipper, Fridtjof Unander, and Celine Marie. November 1998. "The IEA Energy Indicators Effort: Extension to Carbon Emissions as a Tool of the Conference of the Parties."

12. ZhongXiang Zhang. "Is China Taking Actions to Limit its Greenhouse Gas Emissions? Past Evidence and Future Prospects." In Reid and Goldemberg (eds.), April 1999.

13. See Schipper et al., 1998; Lee Schipper and Reinhard Haas. "The Political Relevance of Energy and CO_2 Indicators—An Introduction." In *Energy Policy*, Vol. 25, Nos. 7-9; International Energy Agency. 1997. *Indicators of Energy Use and Efficiency*, IEA; E. Worrell, N. Martin and L. Price. Forthcoming 1999. "Energy Efficiency and Carbon Emissions Reduction Opportunities in the U.S. Iron and Steel Industry." Lawrence Berkeley National Laboratory (LBNL-41724); G.J.M Phylipsen, K. Blok, and E. Worrell. *Handbook on International Comparisons of Energy Efficiency in the Manufacturing Industry*. 1998. Department of Science, Technology and Society, Utrecht University; and E. Worrell, N. Martin, and L. Price. 1999. "Energy Efficiency and Carbon Emissions Reduction Opportunities in the U.S. Iron and Steel Industry." Lawrence Berkeley National Laboratory (LBNL-41724).

14. Central and Eastern European countries are not pictured in Figure 4**.** Examples of declining carbon intensities during the 1990s in this region include Hungary, Poland, Romania, the Czech Republic, Lithuania, Slovakia, Estonia.

15. To facilitate comparisons, GDP is expressed in purchasing power parity (PPP), rather than market exchange rates. However, the other factors mentioned in the text should also be considered. See the "mine-yours" approach to comparisons in Schipper et al., 1998.

16. An exception would be emissions trading under the "emissions budget" concept envisioned in Philibert, 1999.

17. UNFCCC. Article 4.3 and 12.

18. "China Reports Solid GDP, but Rate Questioned." *The Washington Post*. 30 December 1998. Reported figures are from World Bank staff reports. China reported a 7.8 percent GDP growth rate for 1998.

19. Kazakhstan, for example, has already adopted a Law on Energy Savings that identifies priority measures such as improving energy efficiency in thermal power plant and district heating improvements. See Kazakhstan's *Initial National Communication to the Framework Convention on Climate Change*. 1998.

20. See Schipper et al., 1997 and 1998.

21. This is the case for Mexico (IEA, 1997), China (IEA, 1997), and Korea (National Communication, 1998). GDP *and* carbon projections are not available for other countries.

22. See Jan Corfee Morlot. October 1998. "Monitoring, Reporting and Review of National Performance under the Kyoto Protocol." OECD Information Paper; Jacob Werksman. October 1998. "Responding to Non-Compliance under the Climate Change Regime." OECD Information paper. OECD; and Environmental Defense Fund (EDF). "Cooperative Mechanisms Under the Kyoto Protocol." June 1998. EDF.

23. See Jacob Werksman. Draft, March 1999. "Procedural and Institutional Aspects of the Emerging Climate Regime: Do Improvised Procedures Lead to Impoverished Rules?" paper presented at Concluding Workshop for the Project to Enhance Capacity under the Framework Convention on Climate Change and the Kyoto Protocol, London, 17-18 March 1999.

TECHNICAL APPENDIX

DATA SOURCES

Carbon emissions for all countries, except where noted, are from the Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory, Tennessee: G. Marland, T. Boden and A. Brenkert. January 1999. *National CO_2 Emissions from Fossil Fuel Burning and Cement Manufacture, and Gas Flaring: 1751–1996*. Preliminary Data. CDIAC, Oak Ridge National Laboratory. For select Central and Eastern European countries and Newly Independent States, some carbon emissions data are derived from the respective national communications to the United Nations Framework Convention on Climate Change Secretariat. Where necessary, data are converted from tons of carbon dioxide (CO_2) to tons of carbon.

Annual country data represent the sum of carbon dioxide emissions produced during the consumption of solid, liquid, and gaseous fuels, and from gas flaring and cement manufacturing. These data do not include emissions from bunker fuels and from oxidation of nonfuel hydrocarbon products (e.g., asphalt, lubricants, petroleum waxes, etc.). CDIAC calculates emissions from data on the net apparent consumption of fossil fuels (based on the World Energy Data Set maintained by the United Nations Statistical Division) and from data on world cement manufacturing (based on the Cement Manufacturing Data Set maintained by the U.S. Geological Survey). Emissions are calculated using global average fuel chemistry and usage.

Data for gross domestic product (GDP) were taken from *1998 World Development Indicators* on CD-ROM, International Bank for Reconstruction and Development/The World Bank. Except where noted, GDP is expressed as constant (adjusted for inflation) 1987 international dollars using purchasing power parity (PPP) conversion factors. Relative to market exchange rates expressed in U.S. dollars, GDP expressed in PPP may enable more meaningful cross-country comparisons of carbon intensity. PPP uses an "international dollar" designed to equalize the purchasing powers of different currencies. PPP conversion factors tend to increase GDP figures for developing countries relative to industrialized countries.

METHODOLOGY

A country's carbon intensity indicator for a given year is the ratio of a country's total tons of carbon emitted to the gross domestic product, expressed in millions of 1987 international dollars (PPP). To smooth the annual fluctuations in the GDP data, 5-year moving averages of each country's GDP were calculated (except 1995 and 1996 figures, which are 4-year and 3-year averages, respectively). Carbon intensity indicators were calculated for each country from 1980–1996. (Five-year averages were *not* used in Figure 1 calculations.) For projections (1997–2010), the geometric mean was calculated for the past 15 years (1982–1996) of each country's indicator calculations. This value was multiplied by the previous year's carbon intensity to calculate the next year's intensity figure. For example, to project the carbon intensity for 1997, the 1996 intensity was multiplied by the 15-year geometric mean number. Similarly, for 1998, we multiplied the 15-year geometric mean number by the 1997 intensity figure.

LIMITATIONS

The methodology used in this *Climate Note* for calculating carbon intensity has several limitations. First, intensity calculations include only carbon emissions from the combustion of fossil fuels, natural gas flaring and cement manufacturing. Although carbon dioxide typically constitutes a major share of a country's GHG emissions, five other greenhouse gases are included in Annex A of the Kyoto Protocol. Lack of data availability prevented the inclusion of more gases in indicator calculations. Calculations and projections also exclude carbon emissions and removals by sinks from land-use change. Roughly 30 percent of the total carbon dioxide that accumulated in the atmosphere from 1850 to 1990 is from land-use change, the majority of which came from developing countries.

Second, GDP figures used for calculating carbon intensity are expressed using purchasing power parity, in constant 1987 international dollars. The choice of the currency base year (1987, rather than a more recent year) and the PPP conversion factors may prevent GDP figures from reflecting the actual value of a country's output. In addition, the lack of GDP data for Germany from 1980–1996 prevented the European Union (EU) calculations from including all 15 EU member states. The EU calculations *exclude* Germany, the EU's largest economy.

Third, at the time of printing, the latest available carbon emissions and GDP data were for 1996. Considerable lag times in national fossil fuel data compilation and subsequent carbon emission estimations prevent more timely data sets. Thus, rather than using actual data, *projections* have been made for 1997 and 1998 carbon intensities.

Fourth, because of differences in inventory calculation methodologies, the CDIAC's carbon emissions data often vary significantly from country estimates reported in U.S. Country Studies Reports, National Communications to the UNFCCC, and other national studies. This variance can be seen in Figure 4 for Kazakhstan's 1994 indicator, where both CDIAC- and National Communications-based calculations are shown. Based on uncertainty analyses, CDIAC's global emission estimates are accurate to within ±10 percent. National estimates for those countries with the best systems for data collection and management may have uncertainties less than 2 or 3 percent.

The World Resources Institute (WRI) is an independent center for policy research and technical assistance on global environmental and development issues. WRI's mission is to move human society to live in ways that protect Earth's environment and its capacity to provide for the needs and aspirations of current and future generations.

Because people are inspired by ideas, empowered by knowledge, and moved to change by greater understanding, the Institute provides—and helps other institutions provide—objective information and practical proposals for policy and institutional change that will foster environmentally sound, socially equitable development. WRI's particular concerns are with globally significant environmental problems and their interaction with economic development and social equity at all levels.

The Institute's current areas of work include economics, forests, biodiversity, climate change, energy, sustainable agriculture, resource and environmental information, trade, technology, national strategies for environmental and resource management, business liaison, and human health.

In all of its policy research and work with institutions, WRI tries to build bridges between ideas and action, meshing the insights of scientific research, economic and institutional analyses, and practical experience with the need for open and participatory decision-making.

WORLD RESOURCES INSTITUTE

10 G Street, NE
Washington, D.C. 20002 USA
http://www.wri.org/wri

ISBN: 1-56973-407-0