CLIMATE DATA: INSIGHTS AND OBSERVATIONS

Prepared for the
Pew Center on Global Climate Change

by

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Table of Contents

EXPLANATORY NOTES

The following conventions and caveats apply to the data and analysis presented in this paper:

- Treatment of different gases and sources. When examining GHG emissions, the default approach taken is to include six greenhouse gases: CO_2 from fossil fuels and cement, methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). In some cases, there is significant uncertainty with respect to emission figures.[1] CO_2 estimates from land-use change and forestry are typically not included in emission figures, due to extremely high uncertainty levels. However, to illustrate possible implications of including this source, it is selectively shown in several sections.

- The European Union. In addition to individual member states, the European Union (EU) is in most cases treated as a "country". This is because the European Community has acceded to the UN Framework Convention on Climate Change (UNFCCC) as a regional economic integration organization, with "Party" status. Furthermore, the EU is typically considered as a 25-member state body, rather than the 15-member state body that existed when the EU ratified the Kyoto Protocol. To avoid double counting when national data are summed, data are included for the EU but not for individual member states.

- Ranks. The tables and text refer frequently to the "ranks" of particular countries. Unless otherwise noted, ranks indicate a country's position among the 186 countries included in the CAIT database. It is important to note that, in some instances, rank figures may be deceptive because there may be large cross-country differences for a particular indicator, but small differences in rank. Indonesia's population size, for example, ranks fifth in the world while India's ranks second; yet India's population is almost five times larger than Indonesia's. In other cases, the difference in rank may be large, but the absolute difference may be rather small. For example, Japan ranks 28th in education levels; but the difference between the top ranked country and Japan is not especially large.

- "Developed" and "Developing" Countries. References in tables and text to "developed" (or "industrialized") countries and "developing" countries correspond to the distinction under the UN Framework Convention on Climate Change between "Annex I" and "non-Annex I" countries (with non-Parties placed accordingly). As more commonly understood, the distinction between "developed" and "developing" that holds today may have little applicability in future decades. Even by 2010 or 2020, some countries now considered "developing" may no longer fit that classification. Also, Annex I includes several economies in transition that in other contexts might not be considered "developed" countries.

- Sources. Most information presented in this paper is drawn from CAIT. Where noted, data are drawn from other sources or studies.

- Measuring GDP. In this paper (and in CAIT), gross domestic product is measured in units of purchasing power parity. These units, while the subject of some recent controversy, are considered more appropriate than market exchange rates for undertaking international comparisons, especially across north-south lines.

[1] For more details, see Baumert and Markoff 2003 and original data sources.

INTRODUCTION

One important foundation for good policymaking is relevant and reliable data. In considering next steps in the international effort against climate change, policymakers and stakeholders are confronted by a wealth of data on everything from century-old emission trends to likely GDP growth decades in the future. Turning these data into useful input for decision-making is an enormous challenge.

This paper offers a set of policy-relevant insights and observations drawn from the Climate Analysis Indicators Tool (CAIT), a comprehensive database of climate-related indicators developed by the World Resources Institute (WRI). CAIT, which is publicly available from WRI, includes global and national-level data on a wide range of emissions, energy, economic, and socio-economic measures (see **Appendix 2** for a fuller description).

While these data can lend important insight into the international climate challenge, they must be treated with some caution. As will be seen, some of the data are more solid than others. In some cases, the aura of precision projected by a table of figures masks considerable uncertainty in the underlying data. As with any complex issue, a given trend or relationship can be viewed through any number of statistical lenses. Even if the data themselves are wholly reliable, the manner in which they are selected, analyzed, and presented can significantly color perceptions of the realities they represent. For instance, the data presented here are country-based; a sectoral analysis across countries might lend different insights. Finally, even perfect data objectively presented are at best a basis, not a substitute, for informed decision-making.

With these caveats in mind, this paper tries as best as possible to allow the data to speak for themselves. The following sections examine greenhouse gas (GHG) emissions past, present, projected, and per capita; the influence of population, GDP, and carbon intensity on emission trends; the relative contribution of fossil fuels, land use, and other GHG sources; countries' vulnerability to climate impacts; and their capacity to address the causes and consequences of climate change.

Among the key insights and observations:

- A relatively small number of countries produce a large majority of global GHG emissions. Most also rank among the most populous countries and those with the largest economies. The major emitters include almost an equal number of developed and developing countries, as well as economies in transition.

- Carbon dioxide (CO_2) from fossil fuel combustion comprises the majority of GHG emissions. However, CO_2 from land-use change and several other GHG gases together contribute more than 40 percent of global emissions, and a higher proportion of developing country emissions. Still, the top tier of emitters varies little regardless of which gases are counted.

- Carbon intensity – the level of CO_2 emissions per unit of economic output –varies widely across countries, reflecting differences in economic structure, energy efficiency, and fuel mix. Declining carbon intensity in many developed and developing countries may suggest a preliminary or gradual "decoupling" of emissions and economic growth.

- Only a handful of the countries with the largest total emissions also rank among those with the highest per capita emissions. Although generally per capita emissions are higher in wealthier countries, there are notable exceptions. For some countries, per capita emissions vary significantly when CO_2 from land use and non-CO_2 gases are taken into account.

- Most of the largest current emitters also rank among the largest historic emitters, with developed countries generally contributing a larger share, and developing countries a smaller share, of cumulative emissions. A country's historic contribution may differ substantially depending on the time period assessed and whether or not CO_2 from land-use change is included.

- While projections of future emissions are highly uncertain, most models project substantial growth in global emissions, with the fastest growth occurring in developing countries. When historic and future emissions are considered together, the cumulative contributions of developed and developing countries are projected to reach parity sometime between 2030 and 2065.

- Although indices to measure climate vulnerability are not well developed, it appears that countries most vulnerable to climate impacts are among those that have contributed least to climate change. Among the major emitters, vulnerability is generally highest among the developing countries and lowest among the industrialized countries.

- Per capita income, one measure of a country's capacity to address climate change, varies tremendously among the top GHG emitters. Although in percentage terms, per capita income is growing faster in developing countries than in industrialized countries, in absolute terms, the income gap is widening.

Sections I through VIII elaborate on these broad observations and provide specific illustrations. Some of the underlying data are presented within the sections (**Figures 1 through 14**); the remainder can be found in **Appendix 1 (Tables A1.1 through A1.10**).

I. Emissions, Population, and GDP[2]

A relatively small number of countries produce a large majority of global greenhouse gas (GHG) emissions. Not surprisingly, these countries tend also to have large economies or large populations, or both. Indeed, most of the largest GHG emitters also rank among the most populous countries and those with the highest gross domestic product (GDP). An analysis of emissions change over time underscores the importance of population and GDP as drivers of emissions growth. There is significant diversity among the major emitters – the group includes almost an equal number of developed and developing countries, as well as economies in transition.

Together, the 25 countries with the largest GHG emissions account for approximately 83 percent of global emissions (**Figure 1**)[3]. They range from the United States, with 20.6 percent of global emissions, to Pakistan, with 0.8 percent. If the European Union (EU) is counted as a single entity, it and the four other largest emitters – the United States, China, Russia, and India – contribute approximately 61 percent of global emissions.

All but eight of the largest emitters are also among the 25 most populous nations, with China the largest and Australia the smallest (52nd globally). Collectively, the major emitters represent 71 percent of the global population (**Table A1.1**).

All but three of the largest emitters are also among the 25 countries with the highest GDP, ranging from the United States and the EU (each with 21.9 percent of global GDP) to Ukraine (0.4 percent of global GDP). Together, the 25 top emitters generate 86 percent of global GDP. Some countries rank among the largest economies by virtue of their very large populations (China and India together represent 38 percent of global population, but only 17 percent of global GDP); others by virtue of affluence (the United States and the EU together represent only 12.2 percent of global population, but nearly 45 percent of global GDP).

The five largest emitters (again, counting the EU as a single entity) together represent 52 percent of the global population and 63 percent of the global economy. There is significant diversity among the 25 major emitters. As a whole, the group transcends the conventional groupings of developed countries, developing countries, and economies in transition. It includes:

- 13 Annex I (industrialized) countries, 10 of which are OECD members;
- 11 non-Annex I (developing) countries;
- 3 OECD countries not in Annex I (South Korea, Mexico, Turkey);
- 3 economies in transition (Poland, Russia, and Ukraine);
- 3 OPEC members (Indonesia, Iran, and Saudi Arabia); and
- 6 EU-25 members.

The strong correspondence among emission, population, and GDP rankings reflect the importance of population and economic growth as emissions drivers. This is borne out as well in an

[2] GDP is measured in units of purchasing power parity (see Explanatory Notes).
[3] As noted above, these figures include CO_2 from fossil fuel and the five non- CO_2 gases, but not CO_2 from land use.

Figure 1. Top 25 Greenhouse Gas Emitters, 2000

(√ indicates top 25 in GDP or population)

	% of World GHGs	GDP	Population
United States	20.6%	√	√
China	14.8	√	√
EU (25)	14.0	√	√
Russia	5.7	√	√
India	5.5	√	√
Japan	4.0	√	√
Germany	2.9	√	√
Brazil	2.5	√	√
Canada	2.1	√	
United Kingdom	2.0	√	√
Italy	1.6	√	√
Korea (South)	1.6	√	
Ukraine	1.6		√
Mexico	1.5	√	√
France	1.5	√	√
Indonesia	1.5	√	√
Australia	1.4	√	
Iran	1.3	√	√
South Africa	1.2	√	
Spain	1.1	√	
Poland	1.1	√	
Turkey	1.1	√	√
Saudi Arabia	1.0		
Argentina	0.9	√	
Pakistan	0.8		√
Rest of World	**17**		
Developed	**52**		
Developing	**48**		

Note: Emissions include CO_2 from fossil fuels and cement (not land-use related emissions) and five non-CO_2 gases. To avoid double counting when national data are summed, data are included for the EU but not for individual member states. GHG data are aggregated by WRI based on CDIAC and IEA data for CO_2, EDGAR and EPA data for CH_4 and N_2O, and EPA for HFC, PFC and SF_6. Population and GDP data from World Bank.

examination of emission changes over time. Through a factor analysis (for methodology, see **Appendix 3**), it is possible to estimate the relative contribution of several factors to changes in a country's emissions level. The results for the 25 top emitters, for the period 1990-2000, are presented in **Table A1.2**. In most cases, changes in population and GDP (expressed as GDP per capita) appear to be predominant influences. In countries as diverse as the United States, India, Indonesia, Australia, and Iran, population and economic growth both contributed significantly to emissions growth. In other countries, such as Japan and the European nations, population was relatively stagnant and thus had little influence on emissions patterns, while in South Africa, population growth was by far the largest contributor to emissions growth. In others, notably Russia and Ukraine, economic contraction led to a decline in emissions.

In many cases, the analysis also reveals the strong influence of factors other than population and GDP. These factors, which include energy intensity, fuel mix, and the contribution of gases other than carbon dioxide (CO_2), will be explored further in subsequent sections.

II. Land Use Change and Non-CO_2 Gases

While CO_2 from fossil fuel combustion comprises the majority of GHG emissions, CO_2 from land-use change and several other GHG gases together contribute more than 40 percent of overall emissions. The contribution of land-use change and the non-CO_2 gases is significantly higher in developing countries than in industrialized countries. Although emission profiles vary considerably from country to country, the top tier of emitters varies little whether taking into account fossil fuel emissions only, or the additional contributions of land-use change and non-CO_2 gases.

Analyses of GHG emission trends often focus solely on CO_2 from fossil fuel combustion because it is the largest source, and because the data record is the longest, most comprehensive, and most precise. A fuller accounting of anthropogenic GHG emissions, however, would also factor in CO_2 originating from land-use change and several non-CO_2 gases arising from a wide range of activities.

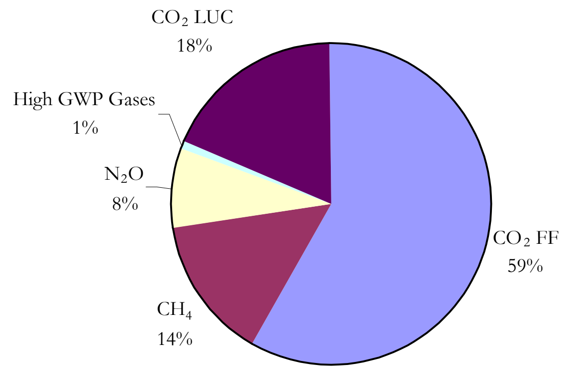

Figure 2. Global Emissions Profile by Gas, 2000

Land Use Change – On a global scale, CO_2 from land-use change represents an estimated 18 percent of total annual emissions (**Figure 2**). This reflects estimates of carbon flux resulting from timber harvest, land clearing for croplands and pasturelands, forest re-growth, and shifting cultivation. (There is substantial uncertainty associated with these estimates, particularly for tropical countries where deforestation is significant.[4]) CO_2 from land-use change constitutes one-third of total emissions from developing countries and more than 60 percent of emissions from the least developed countries (**Figure 3**). In most industrialized countries, on the other hand, land-use change is believed to result in a net absorption of CO_2.

Non-CO_2 GHGs – Among the non-CO_2 gases, the most significant are methane (14 percent of global GHG emissions) and nitrous oxide (8 percent).[5] These arise from a variety of energy, industrial, agricultural, and waste practices (see **Figure 4** for the main sources of non-CO_2 gases). As with CO_2 from land-use change, these gases represent a larger share of total emissions in developing countries than in industrialized countries. In agrarian economies with little heavy industry or energy production, methane is often the largest single GHG. Other non-CO_2 gases include three high global warming potential (high-GWP) gases, which together represent 2 percent

[4] For those countries estimated to have large carbon fluxes, the uncertainty is on the order of plus or minus *150 percent*, while figures for countries estimated to have fluxes near zero might contain higher percentage errors. A full description of the methods and results of the study that produced these estimates (Houghton, 2003) is available at: http://cait.wri.org. See "Data Note: Emissions (and Sinks) of Carbon from Land-Use Change" .

[5] There are uncertainties in estimates of these gases also, in particular nitrous oxide. Uncertainties are expected to be greater in developing countries, due in some cases to weak underlying activity data and emission factors. For more details, see Baumert and Markoff (2003) and underlying data sources.

of global emissions. They are sulfur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). These are emitted almost exclusively by highly industrialized countries.

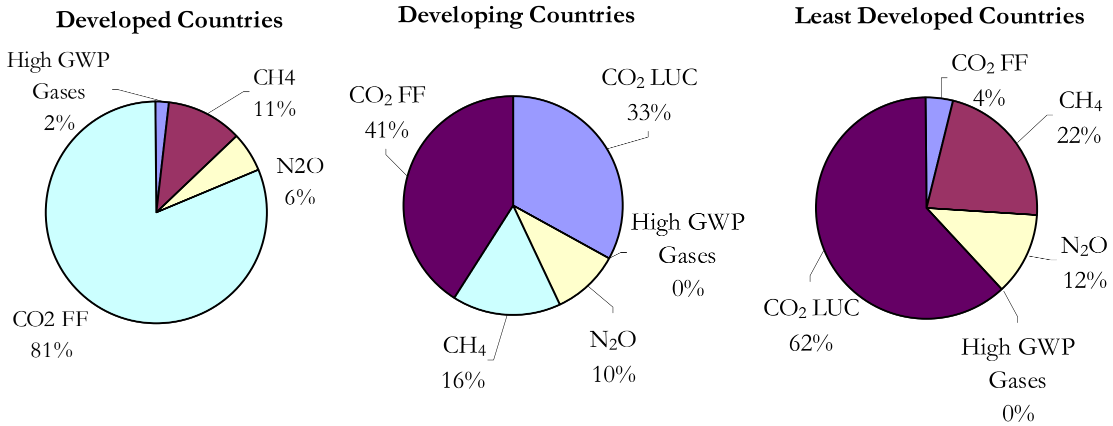

Figure 3. Emissions Profiles by Gas at Different Levels of Development, 2000

A country's ranking in a global emissions inventory may vary considerably depending on which gases are counted (**Table A1.3**). For instance, Indonesia, which ranks 25th in total emissions when only CO_2 from fossil fuel is considered, ranks 4th when land use and non-CO_2 gases are added. Similarly, Brazil rises from 17th to 5th. Together, these two countries account for approximately 50 percent of estimated annual global CO_2 emissions from land-use change. Conversely, for many high-income industrialized countries with high per capita energy use and relatively small agricultural sectors, the share of global emissions declines as non-fossil fuel emissions are added. The United States' share, for instance, drops from 24 percent for fossil fuel-only to 16 percent for all gases (although the United States nevertheless ranks first in all three forms of accounting).

For most countries, rankings are fairly consistent across categories. Consequently, the overall grouping of major emitters is quite similar regardless of which gases are considered. The top 25 emitters of fossil fuel-CO_2 also rank among the top 27 with non-CO_2 gases added, and among the top 30 with CO_2 from land use counted as well.

Figure 4. Selected Sources of non-CO_2 Greenhouse Gases

Methane (CH_4)	**Nitrous Oxide (N_2O)**	**High GWP Gases (HFCs, PFCs, SF_6)**
Biomass Combustion Coal Mining	Agricultural Soils Industrial Processes	Substitutes for Ozone-Depleting Substances (HFCs, PFCs)
Natural Gas and Oil Systems	Fossil Fuel Combustion	Various industrial processes including semiconductor manufacturing, electrical equipment, and the production of aluminum and magnesium
Livestock Wastewater Treatment Rice Cultivation Prescribed Burning of Savannah Fossil Fuel Combustion	Livestock Manure Management Human Sewage	

III. CARBON INTENSITY

Carbon intensity[6] – the level of CO_2 emissions per unit of economic output – is a strong determinant of a country's overall emissions. Carbon intensity varies widely across countries, reflecting differences in economic structure, energy efficiency, and fuel mix. While carbon intensity is rising rapidly in some countries, there is a broader downward trend among both developed and developing countries. Among most of the top 25 emitters, intensity is declining while GDP is rising. These trends may suggest a preliminary or gradual "decoupling" of emissions and economic growth.

Population and GDP[7] were identified in Section I as major determinants of a country's emissions and changes in its emissions over time. Carbon intensity is a collective measure of the other major factors contributing to a country's emissions profile. It is independent of the size of a country's economy or population. A large or wealthy country may have a low carbon intensity, and vice-versa.

Carbon intensity is largely a function of two variables, each of which encompasses a number of factors. The first variable is energy intensity, or the amount of energy consumed per GDP. This reflects both a country's levels of energy efficiency and its economic structure (an economy dominated by heavy industry will have higher energy intensity than one dominated by services, even if the energy efficiencies of these two activities are the same). The second component of carbon intensity is fuel mix, or, more specifically, the proportion of energy derived from carbon-intensive fuels[8]. If two nations are identical in energy intensity, but one relies more heavily on coal and oil, its carbon intensity will be higher.

Among the major emitters, carbon intensity varies nearly four-fold, from 72 tons of carbon/per $1 million GDP in France to 483 tons in Ukraine (**Figure 5**). France – with relatively low energy intensity, and very low carbon intensity, owing to its heavy reliance on nuclear power – generates only 1.5 percent of global CO_2 emissions while producing 3.1 percent of global GDP. Ukraine – with high coal consumption and one of the world's most energy-intensive economies – generates 1.6 percent of global emissions from only 0.4 percent of global GDP.

Carbon intensity rose significantly from 1990 to 2000 in Saudi Arabia, Indonesia, Ukraine, and Brazil[9]. However, for nearly two-thirds of the major emitters, both developed and developing, the intensity trend has been downward. Among the top 25 emitters, carbon intensity dropped an average 12 percent, closely matching a global decline of 13 percent. In several countries, these declines in intensity were accompanied by significant increases in GDP. Five countries

[6] *Greenhouse gas* intensity is the level of all GHG emissions per unit of economic output. *Carbon* intensity reflects only the portion of total GHG emissions arising from fossil fuel combustion. It captures the majority of emissions and can be more accurately calculated. Among the major emitters, average carbon intensity is identical for developed and developing countries, while average greenhouse gas intensity (using the six greenhouse gases listed in CAIT, but not CO_2 from land use change) is 33 percent higher in developing countries (182 tons of C eq./$ mil. GDP-PPP for developed countries vs. 245 tons for developing).
[7] GDP is measured in units of purchasing power parity (see Explanatory Notes).
[8] Commercial energy, used here to evaluate energy intensity, includes domestic production plus imports and stock changes, minus fuel supplied to ships and aircraft. It does not include non-commercially produced energy sources, such as fuel wood, manure or charcoal. The IEA estimates that non-commercial biomass is used by approximately 2.4 billion people worldwide for cooking and heating; accounting for these uses would affect intensity estimates.
[9] In Brazil, the rapid increase reflects at least in part the recent effort to diversify the electricity mix, moving from large hydro-power to natural gas.

simultaneously experienced intensity declines – and GDP increases – of greater than 20 percent. The most striking case is China[10], where intensity fell 47 percent while GDP grew 162 percent. It remains to be seen whether these trends are anomalous one-time shifts reflecting particular circumstances – for instance, the substitution of gas for coal in the UK, or the opening of China's economy to market forces – or whether they suggest the potential for a longer-term decoupling of economic and emissions growth.

Top 25 emitters

	CO_2 Intensity Tons of C / $mil. GDP-PPP	% Change, 1990-2000	
		CO_2 Intensity	GDP
Ukraine	483	28%	-57%
Russia	427	3	-34
Saudi Arabia	260	41	25
Poland	230	-41	43
Iran	223	6	50
China	201	-47	162
South Africa	200	-2	19
Australia	193	-11	42
Korea (South)	185	2	82
Canada	172	-8	32
United States	162	-14	38
Turkey	149	5	42
Indonesia	127	30	51
Mexico	125	-11	41
Pakistan	112	11	47
Germany	111	-28	18
United Kingdom	110	-23	26
EU (25)	107	-21	22
Japan	104	-2	15
Spain	104	4	30
India	99	-4	70
Italy	87	-8	17
Argentina	86	-16	56
Brazil	73	18	30
France	72	-20	20
Developed	**147**	**-20%**	**24%**
Developing	**147**	**-11**	**59**
World	**147**	**-13**	**30**

Note: CO_2 intensity includes CO_2 from fossil fuels and cement only.

The factor analysis introduced in Section I shows the importance of carbon intensity shifts in shaping emission trends over time (**Table A1.2**). In the case of Germany and the United Kingdom, for instance, reductions in both energy intensity and carbon content more than offset the upward pressure of economic growth, resulting in net emission reductions. In China, the upward pressure of tremendous economic growth was heavily counterbalanced by a dramatic reduction in energy intensity resulting from large-scale economic restructuring and energy efficiency improvements.

Table A1.4 highlights the relative contribution of energy intensity and fuel mix to overall carbon intensity shifts. In the EU, declining carbon intensity reflects reductions in both energy intensity and carbon content. In the United States, it stems almost entirely from reduced energy intensity. In some cases, the two factors counterbalance one another. In India, for instance, increased carbon content nearly entirely offset the effect of reduced energy intensity.[11] South Korea's case is virtually the opposite: the switch to lower carbon fuels has nearly offset a sizable increase in energy intensity. Globally, the decline in overall carbon intensity stems more from reduced energy intensity than from changes in fuel mix, which is strongly influenced by energy endowments.

[10] A share of the Chinese energy intensity decline has been attributed to aggressive energy efficiency efforts, a reduction in coal subsidies, and a push toward natural gas. However, according to the EIA, Chinese coal consumption increased in 2001 along with energy intensity.

[11] It should be noted that some of these shifts may be a result of data deficiencies. Namely, in some countries (e.g., India and Nepal) some energy consumption is shifting away from traditional fuel use (e.g., biomass) toward commercial fuel use (e.g., fossil fuels). Energy use increases may be overstated because traditional fuel use tends to *not* get captured in energy data, whereas commercial energy use does.

IV. PER CAPITA EMISSIONS

Among all countries – and among the largest emitting countries – *per capita* GHG emissions vary widely. While as a general rule wealthier countries tend to have higher per capita emissions, there are notable exceptions. The countries with the highest per capita emissions include, for instance, the OPEC Gulf states and several small island nations. Moreover, per capita calculations vary considerably depending on whether they include only fossil fuel-related CO_2, or also non-CO_2 gases or CO_2 from land-use changes.

The "distribution" of emissions among countries looks very different when measured on a per capita basis. Only a handful of the countries with the largest total emissions also rank among those with the highest per capita emissions (see **Figure 6**). Among the 25 major emitters, Australia, the United States and Canada have the highest per capita emissions, ranking 5th, 6th, and 7th globally. Their per capita emissions are more than twice those of the EU (38th globally), six times those of China (97th globally), and 13 times those of India (140th globally).

There is a relatively strong relationship between *emissions* per capita and *income* per capita. Wealthier countries tend to have higher rates of consumption and more energy-intensive lifestyles, generating more emissions per person. By contrast, the four largest developing countries – China, India, Indonesia, and Brazil – account for 44 percent of the global population but only 24 percent of global emissions.

However, factors other than income – such as energy endowments, population density, and climate – can strongly influence a country's per capita emissions. When all countries are ranked on a per capita basis, the upper tiers show considerable diversity (**Table A1.5**):

- The four highest per capita emitters are the gulf states of Qatar, UAE, Kuwait, and Bahrain, largely the result of small populations producing highly GHG intensive commodities for export.

- A number of small island states rank relatively high, including Antigua & Barbuda (11th), Trinidad & Tobago (13th), Nauru (22nd), and Palau (23rd). Most of these countries are highly industrialized, with high population densities – several are also petrochemical and fertilizer producers.

- Several economies in transition with significant fossil fuel resources also rank relatively high, including the Czech Republic (17th), Russia (20th), Estonia (21st), Turkmenistan (28th), and Kazakhstan (34th).

- Some advanced developing economies have per capita emissions commensurate with those of many industrialized countries. Singapore ranks higher than all but one of the EU states. South Korea has the same per capita emissions as the United Kingdom, Taiwan's match the EU average, and South Africa's are just slightly below.

As with total emissions, per capita figures can vary considerably depending on which gases are considered (**Table A1.6**). If, in addition to CO_2 from fossil fuel, the non-CO_2 gases are taken into

Emissions, 2000

Top 25 emitters

	Tons C equiv. per capita
Australia	6.8
United States	6.6
Canada	6.3
	4.3
Russia	3.6
Germany	3.2
United Kingdom	3.1
Korea (South)	3.1
Ukraine	2.9
Japan	2.9
	2.8
Poland	2.7
South Africa	2.6
Spain	2.6
Italy	2.5
France	2.3
Argentina	2.1
	1.9
Turkey	1.5
Mexico	1.4
Brazil	1.3
China	
Indone	0.7
Pakista	0.6
India	0.5
D lo	**3.9**
Develo	**0.9**
World	

Note: The countries shown are the top 25 GHG emitting countries in absolute terms. Includes CO_2 from fossil fuels and cement and non-CO_2 gases.

account, per capita differences between wealthy and less wealthy nations narrow somewhat. For instance, per capita emissions in China, India, and Brazil jump 38, 67, and 160 percent, respectively, while in EU, the United States and Japan, they rise only 22, 20, and 8 percent. The major influences here are methane and nitrous oxide emissions from agriculture, which contributes a larger share of GDP in developing countries.

Adding CO_2 from land-use change further narrows per capita differences, as it represents a third of all emissions from developing countries, while developed countries may be net absorbers. For instance, when all gases including CO_2 from land-use are considered, Indonesia and Brazil have higher per capita emissions than the EU. There are significant uncertainties, however, in country-level estimates of CO_2 from land-use change.

V. CUMULATIVE EMISSIONS

A country's "contribution"[12] to climate change is more a reflection of its cumulative emissions than its emissions at any one time. While most of the largest current emitters also rank among the largest historic emitters, a given country's share of historic global emissions in most cases differs substantially from its share of current global emissions. Generally, developed countries have contributed a much larger share, and developing countries a much smaller share, of historic emissions. Historic contribution differs little whether assessed in terms of cumulative emissions, contribution to atmospheric CO_2 concentrations, or contribution to temperature increase. A country's contribution may differ significantly, however, depending on the time period assessed and whether or not CO_2 from land-use change is included.

The preceding sections focused largely on *current* GHG emissions. However, climate change is caused by the cumulative buildup of greenhouse gases in the atmosphere, not just current emissions. Estimates of CO_2 emissions from fossil fuels, the principal GHG, go back as far as 1850.[13] Based on that record, all but five of the top 25 current emitters also rank among the top 25 historic emitters (**Figure 7**). The United States and the EU rank first and second in both categories. Together, the 25 major emitters today account for 83 percent of current global emissions and 90 percent of cumulative global emissions.

In most cases, a country's historic share of global emissions differs sharply from its current share. For most industrialized countries, the historic share is higher, in many cases significantly so. The EU, with 16 percent of current fossil fuel emissions, accounts for 27 percent of cumulative emissions. For the United Kingdom, an early industrializer, the difference is even more pronounced: its historic share is nearly three times its current share. Conversely, the historic share for most developing countries is sharply below their current share of global emissions. China and India's cumulative shares (7.3 percent and 2.0 percent, respectively) are only half their current shares. Overall, developing countries, which generate 41 percent of current fossil fuel emissions, have contributed only 22 percent of cumulative emissions.

Technically, historic contribution can be assessed in different ways:

- The *cumulative emissions* approach weighs all historic emissions equally, regardless of when they occurred. So, a ton of CO_2 emitted in 1850 has the same "value" as a ton of CO_2 emitted in 2000.
- An alternative approach assesses a country's contribution to increased atmospheric CO_2 *concentrations*. By taking into account the decay of GHGs over time, this approach estimates a country's share of emissions presently in the atmosphere.[14]
- A third approach attempts to measure a country's contribution to the increase in global average *temperature* (approximately 0.6 °C, globally, above pre-industrial levels).

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[12] The term "contribution" is used here in the narrow, physical sense. It refers to a country's cumulative gross emissions and/or their presumed impact on atmospheric GHG concentrations or average global temperature. It does not, for example, reflect trade (i.e. the production of GHG-intensive goods for export).
[13] CO_2 emission estimates for the period prior to 1850 are available, but for only a few countries.
[14] Methodologies for concentrations and temperature indicators follow a simple methodology that had been applied in the original Brazilian Proposal and which was recommended as the preliminary default by the UNFCCC expert group (UNFCCC 2002). For more information see, Baumert and Markoff (2003).

Figure 7. Cumulative CO_2 Emissions,

Includes top 25 emitters

	% of World	(Rank)
United States	29.8%	(1)
EU (25)	27.2	(2)
Russia	8.3	(3)
Germany	7.5	(4)
China	7.3	(5)
United Kingdom	6.5	(6)
	4.1	(7)
France	3.0	(8)
Ukraine	2.3	(9)
Canada	2.1	(10)
Poland	2.1	(11)
India	2.0	(12)
Italy	1.6	(13)
	1.2	(14)
Australia	1.1	(15)
Belgium	1.0	(16)
Mexico	1.0	(17)
Czech Republic	0.9	(18)
Kazakhstan	0.9	(19)
Spain	0.9	(20)
Netherlands	0.8	(21)
Brazil	0.8	(22)
Korea (South)	0.7	(23)
	0.6	(24)
Iran	0.6	(25)
A	0.5	(28)
Indone	0.4	(29)
Turkey	0.4	(31)
S A	0.4	(32)
Pakista	0.2	(47)
Develo	**77**	
D lo	**22**	

Note: Inc
only.

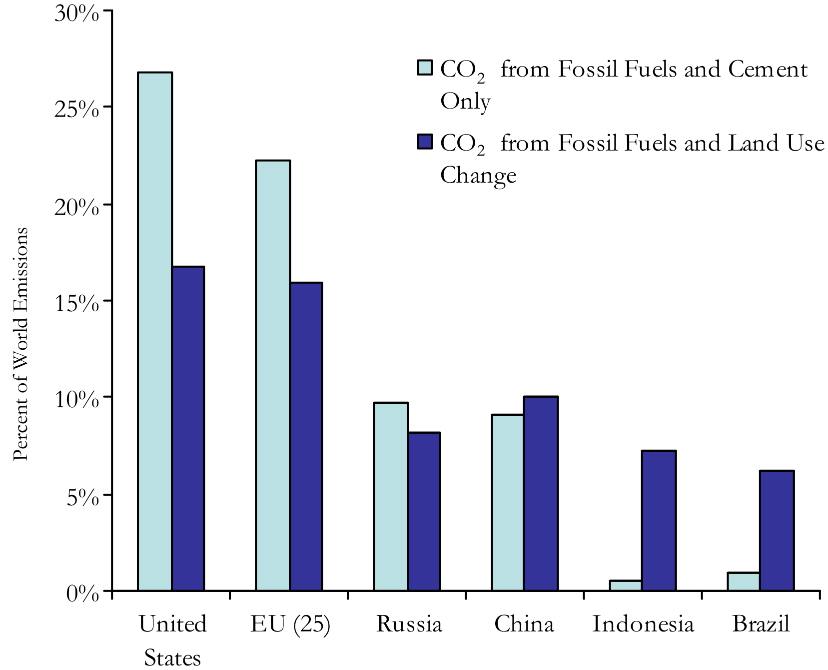
While the scientific certainty underlying these alternative methodologies varies significantly,[15] the results they yield are quite similar for most countries (**Table A1.7**). For several countries, the calculated share of historic contribution is identical in all three approaches.

The assessment of contribution changes markedly, however, when CO_2 from land-use change is also taken into account. Looking at data for all emissions since 1950 (earlier data for land use-related emissions are not available), the historic share for most industrialized (and some developing) countries drops sharply (**Figure 8 and Table A1.8**)[16]. The United States' cumulative contribution, for instance, drops from 26.8 percent to 16.8 percent. The most dramatic increases in historic share are for tropical countries that are major timber producers. Brazil and Indonesia, with 0.9 percent and 0.5 percent of cumulative fossil fuel emissions, respectively, jump to 6.2 percent and 7.2 percent, respectively, with the inclusion of CO_2 from land-use change.[17] Overall, the developing country share of cumulative emissions since 1950 rises from 27 to 47 percent.

A second major factor influencing the calculation of historic contribution is the time period chosen. Data uncertainty increases the further one looks into the past,[18] and historical data may also be geographically biased (e.g., earlier data is more likely to be available for European countries). Going back only to 1990, the baseline year for emission targets in the UNFCCC and the Kyoto Protocol, yields very different results than going back a century-and-a-half (**Figure 9 and Table A1.9**). Collectively, the historic share for developed countries drops from 77 percent to 62 percent, with the share for developing countries rising by a commensurate amount.

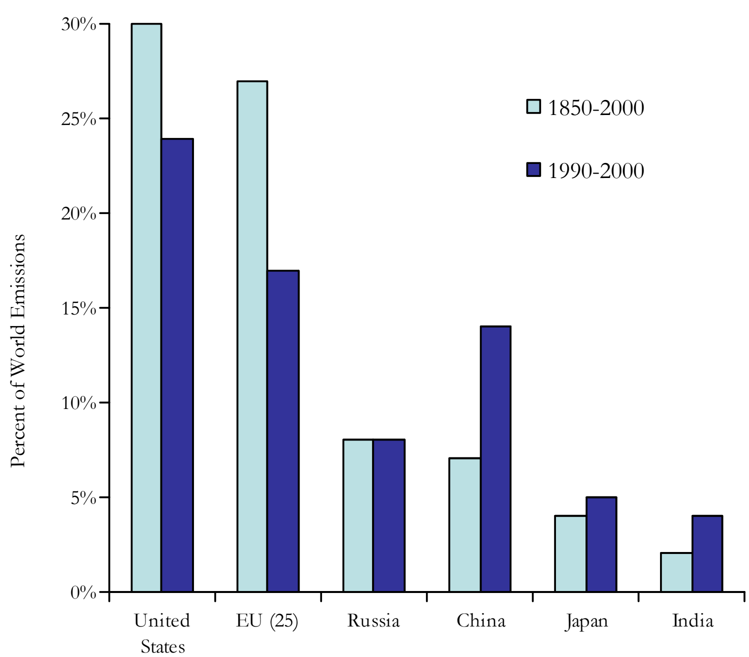
15 Uncertainties are found in precisely attributing temperature increases to change in concentrations, and to attributing concentration changes to changes in cumulative emissions. See Aldy et. al. 2003, UNFCCC 2002 and Baumert and Markoff 2003: 15-21 for details.
16 However, it might be noted that in the case of most industrialized countries, significant deforestation occurred prior to 1950 – and these countries are, in many cases, now receiving the CO_2 benefit from regrowth.
17 Emissions from land-use change are *highly uncertain*, so these figures should be treated with caution.
18 (UNFCCC 2002: 14)

Figure 8. Cumulative CO_2 Emissions, with and without Land Use Change (1950-2000)



Note: See Table 1.6 for sources and other top emitters.

Figure 9. Cumulative CO2 Emissions, 1850-2000 vs. 1990-2000



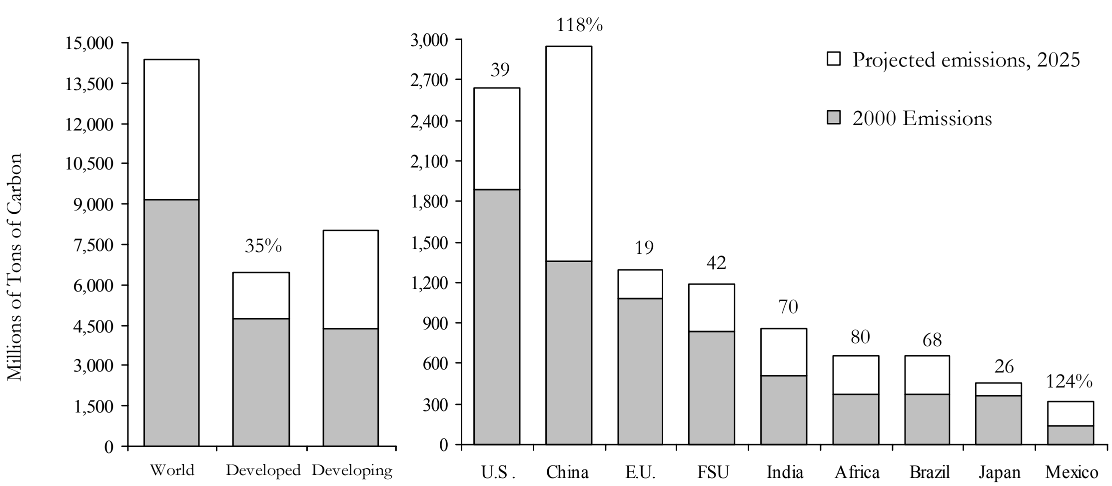
Note: See Table A1.9 for sources and other top emitters. Includes CO_2 from fossil fuels and cement only.

VI. EMISSION PROJECTIONS

While assessments of past and present emission patterns strongly influence the debate over international climate policy, the central challenge is to limit *future* emissions. Projections of future emissions are highly uncertain, particularly for developing countries, and vary widely depending on the assumptions used in modeling key factors such population, economic and technological change. Most models, however, project substantial growth in global emissions, with the fastest growth occurring in developing countries. When historic and future emissions are considered together, the cumulative contributions of developed and developing countries are projected to reach parity sometime between 2030 and 2065.

Projections of long-term emissions growth depend heavily on assumptions about such critical factors as economic and population trends and the rate of technology development and diffusion. The IPCC has developed four "families" of scenarios incorporating different sets of assumptions (**Appendix 4**). Under these scenarios, global GHG emissions are projected to grow 39 to 89 percent by 2025, and 63 to 235 percent by 2050. As in the factor analysis presented earlier, GDP and population are the strongest determinants of emissions trends in most scenarios. The wide range in projections reflects both differing assumptions, for instance with respect to future policy choices, and substantial uncertainties, particularly regarding economic forecasts.

Figure 10. Projected GHG Emissions in 2025



Note: GHGs do not include CO_2 from land use change. Projections are based on EIA Reference Case (CO_2 from fossil fuels) and POLES (non-CO_2 gases).

Among the most widely cited emissions projections are those developed by the Energy Information Administration (EIA) of the U.S. Department of Energy. Under EIA's mid-range or "reference case" scenario for CO_2 from fossil fuels, combined with estimates of future non-CO_2 emissions, global emissions are projected to rise 57 percent by 2025 (**Figure 10**). While growth is projected in all regions, there are significant differences:

- Among industrialized countries, projected increases are relatively modest for the EU (19 percent) and Japan (26 percent), and higher for the United States (39 percent).
- The fastest growth is projected in developing countries, whose emissions rise 84 percent collectively, relative to 35 percent growth for industrialized countries. By 2025, the developing country share of global emissions is projected to be approximately 55 percent (compared to 48 percent in 2000).
- Among developing countries, the largest relative growth is forecast for Mexico (124 percent), and for China (118 percent), which is projected to surpass the United States as the world's largest emitter.

The tremendous uncertainty in national-level projections is reflected in **Figure 11**. For Mexico, for example, one scenario envisions a 68 percent emissions growth by 2025, while another suggests a 215 percent increase. Particularly in large countries, these uncertainties amount to huge quantities of CO_2 emissions. In China, for example, the difference between the low (50 percent increase) and high (181 percent increase) estimates amounts to 1,025 MtC, a quantity that exceeds the *combined* current emissions of India, South Korea, Mexico, South Africa, and Brazil. The differences between low- and high-growth estimates are much smaller for industrialized countries, in part, because economic growth is more stable and can be more accurately forecasted.

Figure 11. Uncertainty in Future Emissions

	Estimated Growth, 2000-2025		
	Low Growth Estimate	**High Growth Estimate**	**% Change**
India	73%	225%	152%
Mexico	68	215	147
China	50	181	131
Brazil	84	165	81
Korea (South)	43	117	74
Former Soviet Union	37	109	72
Japan	4	46	42
European Union (15)	-1	39	40
United States	20	52	32
World	**33%**	**93%**	**60%**

Note: High and low scenarios are from EIA, POLES, and IEA. EU includes Switzerland and Norway. Includes CO_2 from fossil fuels and cement only.

If emissions grow as projected, the type of "contribution" calculations presented in Section V will change dramatically over coming decades. One measure of this shift is the date at which developed and developing countries' contributions (historic plus projected) are projected to achieve parity.[19] This calculation depends heavily on which gases are counted. One modeling exercise projects that parity will be achieved in 2065, if only CO_2 from fossil fuels is considered; in 2055, if CO_2 from land use change is also taken into account; and in 2030, if all GHG gases are counted.[20]

[19] As above, "contribution" refers to cumulative gross emissions and/or their impact on atmospheric GHG concentrations or average global temperature. Large per capita differences between developed and developing countries would remain. Also as noted above, the distinction between "developed" and "developing" that holds today may not hold in future decades.
[20] den Elzen and Schaeffer, 2002.

VII. VULNERABILITY[21]

A country's vulnerability to the impacts of climate change is largely independent of its past, present, or future contribution to climate change. Indeed, it appears the most vulnerable countries are among those that have contributed least to climate change. Among the major emitters, vulnerability varies considerably – it is generally highest among the developing countries and lowest among the industrialized countries.

Most of the indicators presented previously are fairly readily quantified and have been tracked consistently for years. In the case of climate vulnerability, however, there is no consensus as yet even as to what indicators to measure. The IPCC defines vulnerability as *the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change.* [22] Several studies attempt to quantify national-level vulnerability by identifying (1) sectors that are sensitive to climate impacts (such as agriculture, infrastructure and ecosystems); and (2) resources available to cope with those impacts (economic, human, and environmental). [23] The types of indicators used in developing "vulnerability indexes" are presented in **Figure 13**.[24] While providing some indication of a country's climate risk and enabling cross-country comparisons, such indexes are rough approximations at best and fraught with difficulties. A vulnerability index from one study is shown in **Figure 12** (results are shown only for the major emitters and for selected other countries).[25] Among the

Score: *50* = most vulnerable, *10* = least vulnerable
Includes top 25 emitters

Country	Score	Country	Score
Ethiopia	41	*Philippines*	20
Burkina Faso	40	South Africa	19
Pakistan	37	Argentina	18
Haiti	37	Brazil	18
Nepal	35	Korea (South)	18
Bangladesh	32	*Trinidad & Tobago*	16
India	30	Japan	15
China	29	Poland	14
Saudi Arabia	29	*Costa Rica*	14
Indonesia	26	Italy	13
Iran	26	France	12
Guatemala	26	Spain	12
Turkey	23	Canada	11
Russia	22	Germany	11
Ukraine	22	United Kingdom	11
Fiji	22	Australia	10
Mexico	20	United States	10

These vulnerability scores are based on a combination of 11 proxy variables (including sanitation, literacy, maternal mortality, caloric intake, government effectiveness, and life expectancy). For each variable, the full set of countries were divided into quintiles and scored from 1 to 5, based on where the country fell in the range. These individual quintile scores were averaged, and the total multiplied by 10, giving a score of 10 to 50. Not all proxy data were available for all counties.
Source: Adger et al. 2004: 93-95; 120-122.
Note: An aggregate EU value is not shown. *Italicized* countries are those not among the top 25 emitters.

[21] Data in this section are not drawn from CAIT. It should be noted that this area of research is still undeveloped, and indices, metrics, and data are not well established.
[22] See IPCC 2001.
[23] See, e.g., Moss 2001, Adger et al. 2004, Downing 2001.
[24] While "vulnerability indexes" provide some indication of a country's climate risk and enable cross-country comparisons, they are rough approximations at best and fraught with difficulties.
[25] This vulnerability indicator is based on a combination of 11 proxy variables (including sanitation, literacy, maternal mortality, caloric intake, government effectiveness, and life expectancy). For each variable, the full set of countries was divided into quintiles and scored from 1 to 5, based on where the country fell in the range. These individual quintile scores were averaged, and the total multiplied by

major emitters, countries fall into broad bands of vulnerability. The scores range from 10 to 15 for industrialized countries (10 is least vulnerable; 50 is most vulnerable); from 14 to 22 for EITs; and from 18 to 37 for developing countries. The most vulnerable are China and Saudi Arabia (29), India (30), and Pakistan (37).

Globally, the countries rated most vulnerable generally are characterized by weak governance systems, high levels of poverty, poor access to water and sanitation, and, in some cases, recent armed conflict. Countries in this group tend to be those classified as "least developed". Collectively, their contribution to climate change has been negligible.

The pitfalls of attempting to quantify vulnerability across countries are perhaps best illustrated by the case of small island states. These countries are especially vulnerable to sea level rise and extreme weather events affecting a large portion of their populations, and have little capacity to relocate population or economic activity to less exposed areas. Yet, as noted by the authors of the study cited above, they tend to rank lower in vulnerability measures than larger countries where a much smaller portion of the population (though larger numbers of people) face lower-level climate risks.[26]

igure 13. Examples of Vulnerability Indicators

Sensitive Sector / Coping Capacity	Examples of Proxy Indicator(s)
Food Sensitivity	Population employed in agriculture (% of total) Rural population (percent of total)
Ecosystem Sensitivity	Water resources per capita
Settlements / Infra-structure sensitivity	Population in flood prone areas Population without access to clean water / sanitation
Human Health Sensitivity	Fertility Life Expectancy
Economic Capacity	GDP per capita Gini Index (measuring income inequality)
Human Resource Capacity	Dependency Ratio Literacy
Governance Capacity	Political stability Regulatory quality
Environmental Capacity	Population density Land unmanaged, % of total

Sources: Compiled from Adger 2004, Moss et al. 2002, and Downing 2001.

10, giving a score of 10 to 50. Not all proxy data were available for all countries. As noted in the discussion above, these are generic indicators and should only be used to draw general conclusions about the distribution of vulnerability at the global level. See Adger et al, 2004, pp. 93-95.

[26] Adger et al. 2004: 95.

VIII. CAPACITY

One crude but credible measure of a country's capacity to address either the causes or the consequences of climate change is per capita income. There are tremendous income disparities among the top GHG emitters, as the group includes some of the richest and the poorest countries in the world. Other possible measures of capacity, such as education and life expectancy, are similarly skewed. Per capita income is rising in most countries, in some cases dramatically. Although in percentage terms, per capita income is growing faster in developing countries than in industrialized countries, in absolute terms, the gap is widening.

As noted in Section I, the top 25 GHG emitters include highly industrialized countries, middle-income transition economies, advanced developing countries, and lower-income developing countries. Per capita income figures provide a clearer picture of the large disparities in wealth among the major emitters, and some measure of their respective capacities to address climate change (**Figure 14**). In 2000, per capita income ranged from $33,960 in the United States (ranked 2nd globally) to $1,870 in Pakistan (142nd globally).

Three other measures with some bearing on a country's capacity to address climate change or other complex social challenges include healthy life expectancy, educational achievement, and quality of governance (e.g. political stability, level of corruption). As might be expected, the disparities in these measures largely mirror those seen for per capita income, although there are notable exceptions (**Table A1.10**).

Certain patterns and observations are worth noting:

- China and India, the world's largest countries, have per capita incomes that are roughly half and one-third the world average, respectively. Some 550 million people in these two countries (16 percent of China's population and 35 percent of India's) subsist on less than $1 a day.[27]
- Per capita income is lower in the two larger EITs (Russia and Ukraine) than in several advanced developing countries (Argentina, Brazil, South Korea, Mexico, and South Africa). On the governance scale, Russia and Ukraine also rank lower than all but one of the developing countries among the major emitters.
- South Korea stands well above most other developing countries on health, education, and governance measures (and, on education, above some developed countries as well).
- South Africa, while ranking relatively high on governance, is well below all other major emitters in life expectancy, largely as a result of its AIDS crisis.
- Four developing countries among the major emitters – India, Indonesia, Iran, and Pakistan – rank in the lower half globally on life expectancy, education, and governance measures (with one exception: India ranks 71st globally on governance).

Per capita income is on the rise for most countries, in some cases dramatically. For most industrialized countries among the major emitters, per capita income rose from 39 percent to 60

[27] UNDP 2003.

Figure 14. Per Capita Income

		Growth, 1980-2000	
Country	**2000 $PPP rank**	**Average Annual**	**Total**
United States	33,960 (2)	2.1 %	52 %
Canada	26,840 (9)	1.7 %	39 %
Japan	25,280 (11)	2.3 %	58 %
Germany	25,100 (13)	1.7 %	40 %
Australia	24,550 (14)	1.9 %	47 %
	24,280 (15)	1.8 %	43 %
United Kingdom	23,580 (19)	2.3 %	57 %
France	23,490 (20)	1.7 %	41 %
EU (25)	21,518 (22)	1.9 %	46 %
Spain	19,740 (26)	2.4 %	60 %
Korea (South)	14,720 (37)	6.3 %	238 %
Saudi Arabia	13,460 (40)	-2.7 %	-42 %
Argentina	11,880 (43)	0.1 %	2 %
	10,990 (46)	-0.7 %	-13 %
Poland	9,320 (51)	3.5 %	41 %
Mexico	8,570 (58)	0.7 %	16 %
Brazil	7,250 (64)	0.4 %	9 %
Russia	6,760 (69)	-1.2 %	-22 %
Turkey	6,300 (72)	2.2 %	56 %
Iran	5,720 (79)	0.9 %	20 %
Ukraine	3,980 (98)	-7.6 %	-54 %
hin	3,740 (101)	8.3 %	395 %
Indo i	2,970 (113)	3.6 %	102 %
India	(116)	3.6 %	102 %
Pakistan	(142)	2.4 %	62 %
Develop	**21,203**	**2.0 %**	**48 %**
Dev	**3,727**	**2.3 %**	**56 %**
World		**1.3 %**	**29 %**

Notes: Countries shown are top 25 GHG emitters. Growth figures for Ukraine and Poland are from 1990-2000, due to lack of GDP data in 1980..

percent between 1980 and 2000. By far the largest gains among the major emitters were in China and Korea (395 percent and 238 percent, respectively). India and Indonesia experienced gains of roughly 100 percent. For most other middle-income developing countries, however, income was almost stagnant: Argentina, Brazil, and Mexico grew only 2, 9, and 13 percent respectively over the two decades. Per capita income fell in four of the major emitters: 13 percent in South Africa; 22 percent in Russia; 42 percent in Saudi Arabia; and 54 percent in Ukraine.[28]

On the whole, per capita income has grown faster in percentage terms in developing countries (56 percent) than in industrialized countries (48 percent). These figures, however, may be misleading. The *absolute* gains in developing countries were much lower than in industrialized countries. Measured in 1995 U.S. dollars, income in developing countries grew by about $500 (from $878 to $1,372) from 1980 to 2000, while industrialized country income grew by about $8,000 (from $16,693 to $24,680), or 16 times more.

[28] This figure for Ukraine, however, is from 1990 to 2000 due to lack of GDP estimates for earlier periods.

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APPENDIX 1. Tables

Table A1.1. Top 25: Emissions, Population, and GDP 2000

Emissions (6 gases)			Gross Domestic Product			Population		
	MtC Eq.	**% of World**		**GDP-PPP$ (billions)**	**% of World**		**Millions**	**% of World**
United States	1,892	20.6%	EU (25)	9,711	21.9%	China	1,262	20.9%
China	1,356	14.8	United States	9,681	21.9	India	1,016	16.8
EU (25)	1,283	14.0	China	4,724	10.7	EU (25)	451	7.5
Russia	520	5.7	Japan	3,207	7.2	United States	286	4.7
India	506	5.5	India	2,773	6.3	Indonesia	206	3.4
Japan	364	4.0	Germany	2,064	4.7	Brazil	170	2.8
Germany	265	2.9	Italy	1,401	3.2	Russia	146	2.4
Brazil	230	2.5	United Kingdom	1,385	3.1	Pakistan	138	2.3
Canada	195	2.1	France	1,383	3.1	*Bangladesh*	131	2.2
United Kingdom	181	2.0	Brazil	1,234	2.8	*Nigeria*	127	2.1
Italy	146	1.6	Russia	984	2.2	Japan	127	2.1
Korea (South)	143	1.6	Mexico	839	1.9	Mexico	98	1.6
Ukraine	143	1.6	Canada	826	1.9	Germany	82	1.4
Mexico	139	1.5	Spain	799	1.8	*Vietnam*	79	1.3
France	137	1.5	Korea (South)	692	1.6	*Philippines*	77	1.3
Indonesia	135	1.5	Indonesia	613	1.4	Turkey	67	1.1
Australia	130	1.4	Australia	471	1.1	*Ethiopia*	64	1.1
Iran	120	1.3	South Africa	470	1.1	*Egypt*	64	1.1
South Africa	113	1.2	Argentina	440	1.0	Iran	64	1.1
Spain	104	1.1	*Netherlands*	428	1.0	*Thailand*	61	1.0
Poland	102	1.1	Turkey	411	0.9	France	59	1.0
Turkey	99	1.1	*Taiwan*	386	0.9	United Kingdom	59	1.0
Saudi Arabia	90	1.0	*Thailand*	378	0.9	Italy	58	1.0
Argentina	79	0.9	Iran	364	0.8	*Congo, DR*	51	0.8
Pakistan	78	0.8	Poland	360	0.8	Ukraine	50	0.8
Rest of World	**1,562**	**17.0**		**6,084**	**13.7**		**1,320**	**21.8**

Note: MtC is millions of tons of carbon equivalent. Emissions include CO_2 from fossil fuel and cement (not land-use related emissions) as well as 5 non-CO_2 gases. *Italicized* countries are those not among the top 25 emitters. GHG data are aggregated by WRI based on CDIAC and IEA data for CO_2, EDGAR and EPA data for CH_4 and N_2O, and EPA data for HFC, PFC and SF_6. Population and GDP data from World Bank.

Table A1.2. Factors Contributing to CO_2 Emissions Growth, 1990-2000

Top 25 emitters

	CO_2 Change 1990-2000	(MtC)	% Contributions to CO_2 Changes: GDP per capita (GDP/P	Population (Pop)	Energy Intensity (E/GDP)	Fuel Mix (CO_2/E)	Non-CO_2 C
United States	18%	(239)	22%	13%	-16%	-1%	3%
China	39	(267)	102	13	-82	7	23
European Union (25)	-3	-(36)	17	3	-11	-12	-17
Russia	-22	-(199)	-16	-2	-3	-1	-45
India	64	(107)	45	23	-25	20	21
Japan	12	(37)	12	3	4	-7	23
Germany	-15	-(41)	12	3	-20	-11	-36
Brazil	53	(31)	16	17	7	13	10
Canada	22	(26)	20	11	-11	2	36
United Kingdom	-3	-(5)	20	2	-13	-12	-31
Italy	7	(8)	14	2	-3	-6	1
Korea (South)	85	(59)	70	13	19	-17	44
Ukraine	-42	-(77)	-46	-4	15	-8	-26
Mexico	25	(21)	20	18	-14	1	2
France	-4	-(4)	14	4	-5	-16	-15
Indonesia	97	(38)	38	21	5	32	13
Australia	26	(19)	26	13	-14	0	6
Iran	59	(30)	32	20	14	-7	46
South Africa	17	(14)	-2	21	-1	-1	11
Spain	35	(22)	26	5	7	-2	17
Poland	-15	-(15)	32	1	-43	-6	-22
Turkey	49	(20)	21	22	4%	2	9
Saudi Arabia	76	(31)	-7	36	44	2	50
Argentina	31	(9)	36	15	-15	-5	9
Pakistan	63	(11)	18	32	0	13	29

This table reflects the relative contributions of population, energy intensity and fuel mix to changes in national emissions (see Appendix 3 for methodology). These factors account only for changes in energy-related CO_2 emission changes. Changes in non-CO_2 gases are shown in the final column.
Note: Methodology was adapted from Ang, 2001. CO_2 excludes land use change and forestry. For Russia and Ukraine, the time period evaluated is 1992 - 2000, due to lack of energy data in 1990. Data for Germany is created by aggregating information for both East and West Germany prior to 1991. GHG data are aggregated by WRI based on CDIAC and IEA data for CO_2, EDGAR and EPA data for CH_4 and N_2O, and EPA data for HFC, PFC and SF_6. Population and GDP data from World Bank. Energy intensity and fuel mix are from the IEA and the UN.

Table A1.3. Shares of Global Emissions for Different Gas Categories, 2000

Top 25 emitt

CO_2 from Fossil Fuels Only		GHGs		CO_2 from Fossil Fuels and Land-Use Change, plus non-CO_2 GHGs	
	% of World		**% of World**		**% of World**
United St	24.1%	ates		United States	15.8%
EU (25)		China	14.8	China	11.9
China	14.5		14.0	EU (25)	11.4
Russia	6.4		5.7	Indonesia	7.4
Japan	5.1		5.5	Brazil	5.4
India	4.2		4.0	Russia	4.8
Germany	3.5		2.9	India	4.4
United Ki	2.3		2.5	Japan	3.2
Canada	2.2		2.1	Germany	2.4
Korea (So	2.0		2.0	Malaysia	2.1
Italy	1.9		1.6	Canada	1.9
Mexico	1.6		1.6	United Kingdom	1.6
France	1.5		1.6	Mexico	1.5
Ukraine	1.5		1.5	Italy	1.3
South Afr	1.4		1.5	Korea (South)	1.3
Australia	1.4		1.5	Ukraine	1.3
Brazil	1.4		1.4	Myanmar	1.2
Spain	1.3		1.3	France	1.2
Poland	1.3		1.2	Australia	1.2
Iran	1.2		1.1	Iran	1.1
Indonesia	1.2		1.1	South Africa	1.0
Saudi Ara	1.1		1.1	Venezuela	0.9
Taiwan	0.9		1.0	Turkey	0.9
Turkey	0.9		0.9	Poland	0.9
Nether	0.7	Pakistan	0.8	Spain	0.9
Develo	**59.0%**		**51.9%**		**41.7%**
Develo	**41.0**		**47.6**		**57.9**
Least D	**0.4**		**2.8**		**6.0**

Note: GH $_2$O, and
EPA data 6

Table A1.4. Intensity Indicators and Trends

Top 25 emitters

	Carbon Intensity 2000		**Energy Intensity** 2000		**Fuel Mix** 2000	
	Tons of C / $mil. GDP-PPP	% Change, 1990-2000	Tons of Oil / $mil. GDP-PPP	% Change, 1990-2000	Tons of C / Tons of Oil Eq.	% Change, 1990-2000
Argentina	86	-16%	140	-12%	0.62	-4%
Australia	193	-11		-11		0
Brazil	73	18	148	6	0.49	11
Canada		-8	30	-9	0.57	2
na	201	-47	242	-50		6
EU (25)	107	-21	171	-11	0.63	-9
France	72	-20	186	-7	9	-15
Germany	111	-28	165	-20	0.67	-11
India	99	-4	181	-18	0.55	17
Indonesia	127	30	237	4	0.54	25
	223	6	309	12	0.72	-5
Italy	87	-8	122	-3	71	-5
n	104	-2	164	4	.64	-6
Korea (South)	185	2	280	15		-11
Mexico	125	-11	183	-12		1
Pakistan	112	11	248	0	0.45	10
Poland	230	-41	250	-38	0.92	-6
ssia	427	-4	624	-3		-1
Saudi Arabia	260	41	378	37		2
South Africa	200	-2	229	-1	7	-1
Spain	104	4	156	6	0.67	-2
Turkey	149	5	187	3	0.79	2
Ukraine	483	10	709	22		-10
ited Kingdom	110	-23	168	-15	5	-12
United States	162	-14	238	-13	0.68	-1
Developed	**147**	**-20%**	**223**	**-13%**	**0.66**	**-4%**
eveloping	**147**	**-11**	**224**	**-11**	**0.66**	**5**
World	**147**	**-13**	**224**	**-9**	**0.66**	**-2**

Note: For Russia and Ukraine, figures cover the 1992-2000 period, due to lack of energy data in 1990. World, Developed, and Developing changes in energy intensity are also from 1992-2000. Carbon includes CO_2 from fossil fuels and cement only. A ton of oil (or its equivalent) is a unit of energy equal to 44 billion joules, or 1200

Table A1.5. Per Capita GHG Emissions, 2000

Includes top 25 emitters

	Tons of Carbon Eq. (rank)
Qatar	18.5 (1)
United Arab Emirates	10.1 (2)
Kuwait	9.5 (3)
Bahrain	7.0 (4)
Australia	6.8 (5)
United States	6.6 (6)
Canada	6.3 (7)
New Zealand	5.8 (8)
Brunei	5.8 (9)
Luxembourg	5.7 (10)
Antigua & Barbuda	5.4 (11)
Ireland	4.8 (12)
Trinidad & Tobago	4.5 (13)
Singapore	4.4 (14)
Saudi Arabia	4.3 (15)
Belgium	4.0 (16)
Czech Republic	3.8 (17)
Netherlands	3.7 (18)
Finland	3.6 (19)
Russia	3.6 (20)
Estonia	3.5 (21)
Palau	3.5 (22)
Nauru	3.5 (23)
Denmark	3.4 (24)
Israel	3.4 (25)
Oman	3.4 (26)
Germany	3.2 (27)
Turkmenistan	3.2 (28)
Mongolia	3.1 (29)
Norway	3.1 (30)
United Kingdom	3.1 (31)
Korea (South)	3.1 (32)
Greece	3.0 (33)
(Continued)	**Tons of Carbon Eq. (rank)**
Kazakhstan	2.9 (34)
Ukraine	2.9 (35)
Cyprus	2.9 (36)
Japan	2.9 (37)
European Union (25)	2.8 (38)
Taiwan	2.8 (39)
Libya	2.8 (40)
Venezuela	2.7 (43)
Poland	2.7 (44)
South Africa	2.6 (45)
Botswana	2.6 (47)
Spain	2.6 (48)
Italy	2.5 (50)
France	2.3 (54)
Argentina	2.1 (58)
Switzerland	1.9 (63)
Iran	1.9 (64)
Turkey	1.5 (76)
Mexico	1.4 (80)
Jamaica	1.4 (83)
Brazil	1.3 (85)
Bolivia	1.3 (87)
China	1.1 (97)
Indonesia	0.7 (122)
Pakistan	0.6 (131)
India	0.5 (140)
Developed Countries	**3.9**
Developing Countries	**0.9**
World Average	**1.5**

Note: Includes CO_2 from fossil fuels and cement and non-CO_2 gases. Bolded countries are the top 25 emitters.

Table A1.6. Per Capita Emissions, CO_2 Only and with Non-CO_2 GHGs, 2000

	Tons C equiv. per capita			
	C On	**CO_2 Non-C GHG**	**Difference**	**% Change**
States	5	6.6		20.0%
EU (25)	2	2.8	0.5	21.7
	0	1.1		37.5
sia	2	3.6	0.7	24.1
	2	2.9		7.7
	0	0.5		66.7
many	2	3.2	0.4	14.3
	2	3.1	0.5	19.2
	4	6.3	7	37.0
a (South)	2	3.1		11.1
	2	2.5	0.4	19.0
	1	1.4	0.4	36.4
ce	1	2.3	0.6	35.3
ine	1	2.9	1.0	52.6
h Africa	2	2.6	0.4	18.2
stralia	4	6.8	2.1	44.7
	0	1.3	8	160.0
ain	2	2.6	0.5	23.8
and	2	2.7	0.5	23.8
	1	1.9	0.6	46.2
	0	0.7		75.0
Saudi Arabia	3	4.3		22.9
Turkey	0	1.5		66.7
	1	2	1.1	110.0
Pakistan	0	0	0.4	200.0
Developed	**3.1**	**3.9**	**0.7**	**22.6%**
Developing	**0.6**	**0.9**	**0.4**	**66.7%**
World	**1.1**	**1.5**	**0.4**	**36.4%**

Note: The countries shown are the top 25 GHG emitting countries in absolute terms.

Table A1.7. Historical Contribution Indicators, 1850-2000

Top 25 emitters

	Percent of World (Rank)					
	Cumulative Emissions		**Concentration Increase**		**Temperature Increase**	
United State	29.8%	(1)	28.2%	(1)	29.5%	(1)
European U)	27.2	(2)	24.5	(2)	26.7	(2)
Russia	8.3	(3)	8.5	(4)	8.7	(3)
Germany	7.5	(4)	6.6	(5)	7.4	(4)
China	7.3	(5)	8.7	(3)	7.2	(5)
United Kin	6.5	(6)	5.2	(6)	6.1	(6)
Japan	4.1	(7)	4.4	(7)	4.2	(7)
France	3.0	(8)	2.6	(8)	2.9	(8)
Ukraine	2.3	(9)	2.3	(10)	2.4	(9)
Canada	2.1	(10)	2.2	(11)	2.2	(10)
Poland	2.1	(11)	2.0	(12)	2.1	(11)
India	2.0	(12)	2.4	(9)	2.0	(12)
Italy	1.6	(13)	1.7	(13)	1.7	(13)
South Afric	1.2	(14)	1.2	(14)	1.2	(14)
Australia	1.1	(15)	1.1	(15)	1.1	(15)
Mexico	1.0	(17)	1.1	(16)	1.0	(17)
Spain	0.9	(20)	0.9	(17)	0.9	(20)
Brazil	0.8	(22)	0.9	(20)	0.8	(22)
Korea (Sout	0.7	(23)	0.9	(19)	0.7	(24)
Iran	0.6	(25)	0.7	(24)	0.5	(26)
Argentina	0.5	(28)	0.5	(31)	0.5	(28)
Indonesia	0.4	(29)	0.6	(28)	0.4	(30)
Turkey	0.4	(31)	0.5	(30)	0.4	(31)
Saudi Arabi	0.4	(32)	0.5	(29)	0.4	(33)
Pakistan	0.2	(47)	0.2	(45)	0.2	(49)
Developed	**77**		**74**		**77**	
Developing	**22**		**26**		**22**	

This table lists each country's estimated contribution to total world cumulative emissions, to increased atmospheric GHG concentrations, and to the observed increase in average global temperature.
Note: Cumulative emissions include CO_2 from fossil fuels and cement only.

Table A1.8. Cumulative Emissions, With and Without Land Use, 1950-2000

Top 25 emitters

	Percent of World (Rank)				
	CO_2 from Fossil Fuels and Cement		CO_2 from Fossil Fuels, Cement, and Land Use Change		% Change
United States	26.8%	(1)	16.8%	(1)	-37%
EU (25)	22.2	(2)	15.9	(2)	-28
Russia	9.7	(3)	8.2	(4)	-16
China	9.1	(4)	10.0	(3)	10
Germany	5.9	(5)	4.3	(7)	-28
Japan	4.7	(6)	3.8	(8)	-19
United Kingdom	3.8	(7)	2.7	(9)	-29
Ukraine	2.7	(8)	1.9	(12)	-28
France	2.4	(9)	1.7	(13)	-28
India	2.3	(10)	1.5	(14)	-33
Canada	2.2	(11)	2.0	(10)	-7
Poland	2.0	(12)	1.4	(15)	-28
Italy	1.8	(13)	1.3	(16)	-29
South Africa	1.3	(14)	0.9	(21)	-28
Mexico	1.2	(15)	1.2	(17)	5
Australia	1.2	(16)	0.9	(20)	-18
Spain	1.0	(18)	0.7	(26)	-30
Brazil	0.9	(19)	6.2	(6)	567
Korea (South)	0.9	(20)	0.7	(25)	-20
Iran	0.7	(25)	0.6	(33)	-21
Argentina	0.5	(28)	0.6	(28)	12
Indonesia	0.5	(29)	7.2	(5)	1257
Turkey	0.5	(31)	0.5	(36)	-4
Saudi Ar ia	0.5	(32)	0.4	(41)	-28
Pakistan	0.2	(45)	0.3	(48)	22
Developed	**72%**		**52%**		**-28%**
	27		**47**		**74**

Note: Developed and Developing countries may not add up to 100 percent, due to several countries excluded from the database due to lack of data (e.g., Somalia).

Table A1.9. Cumulative CO_2 Emissions, 1850-2000 vs. 1990-2000

Top 25 emitters

	Percent of World (Rank)				
	1850-2000		**1990-2000**		**% Change**
Un	29.8%	(1)	23.5%	(1)	-21%
EU (25)	27.2	(2)	17.3	(2)	-36
Russia	8.3	(3)	7.8	(4)	-5
Ge	7.5	(4)	4.0	(6)	-46
China	7.3	(5)	13.8	(3)	89
United Kingdom	6.5	(6)	2.5	(8)	-61
Japan	4.1	(7)	5.2	(5)	28
Franc	3.0	(8)	1.6	(13)	-45
Ukrai	2.3	(9)	2.1	(9)	-8
Canad	2.1	(10)	2.1	(10)	-3
Polan	2.1	(11)	1.5	(14)	-27
India	2.0	(12)	3.7	(7)	80
Italy	1.6	(13)	1.9	(11)	18
South Africa	1.2	(14)	1.5	(16)	27
Austr	1.1	(15)	1.3	(17)	24
Mexic	1.0	(17)	1.5	(15)	60
Spain	0.9	(20)	1.1	(19)	30
Brazil	0.8	(22)	1.2	(18)	60
Korea	0.7	(23)	1.7	(12)	138
Iran	0.6	(25)	1.1	(20)	93
Argen	0.5	(28)	0.5	(32)	14
Indon	0.4	(29)	1.0	(21)	114
Turke	0.4	(31)	0.8	(25)	89
Saudi	0.4	(32)	0.9	(22)	125
Pakist	0.2	(47)	0.4	(37)	112
Deve	**77%**		**62%**		**-20%**
Deve	**22**		**38**		**73**

Note: In des CO_2 from fossil fue d cement only.

Table A1.10. Health, Education and Governance Indicators, 2000

Top 25 emitters

	Healthy Life Expectancy in years		Education Index 0-100 Scale		Governance Index 0-100 Scale	
Australia	71		100	(1)	94	(9)
United Kingdom	69		100	(1)	94	(10
Canada	70		98	(1	94	(11)
France	71	(6)	96	(13	82	(23)
Spain	71	(8)	96	(17)	86	(18)
Germany	70		96	(18)	90	(16)
Japan	74	(1)	93	(28)	83	(21)
United States	67		98	(10)	90	(17)
EU (25)	69	(23)	96	(16)	84	(19)
Italy	71	)	92	(36)	73	(35)
Korea (South)	67		95	(21)	67	(45)
Poland	64		95	(22)	69	(41)
Argentina	63		94	(27)	59	(58)
Mexico	64		84	(76)	55	(69)
Brazil	56		89	(49)	56	(67)
China	63		75	(106)	48	(84)
Ukraine	58	(94)	92	(35)	34	(123)
Russia	57	(103)	93	(31)	33	(130)
Turkey	60		73	(108)	44	(90)
Saudi Arabia	60		65	(123)	49	(81)
South Africa	43		80	(90)	61	(55)
Iran	57	(104)	67	(120)	41	(99)
India	51		49	(142)	54	(71)
Indonesia	56	(108)	76	(101)	32	(131)
Pakistan	51	(130)	30	(164)	34	(121)
World	**57**		**69**		**51**	

Notes: Countries are ordered according to their collective ratings on all three indicators. The **Education Index** (developed by UNDP) includes literacy and school enrollment data. The **Governance Index** (developed by the World Bank) includes six different components of governance (e.g., corruption). See Kaufmann et al. 2002. Numbers in parenthesis indicate country's global rank.

APPENDIX 2. About the Climate Analysis Indicators Tool

The Climate Analysis Indicators Tool (CAIT) is an information and analysis tool on global climate change developed by the World Resources Institute. CAIT provides a comprehensive and comparable database of greenhouse gas emissions data (including all major sources and sinks) and other climate-relevant indicators. CAIT can be used to analyze a wide range of climate-related data questions and to help support future policy decisions made under the Climate Convention and in other fora. Except where noted, all of the data in this report is derived from CAIT.

Key features of CAIT include:

- All Countries and Regions. CAIT includes data and indicators for all of the Parties to the Climate Convention, plus some non-Parties that are members of the U.N. Several categories of *regions* are also included in CAIT, including major geographic regions (e.g., sub-Saharan Africa), political/economic regions (e.g., OECD, ASEAN), and UNFCCC regions (e.g., Annex I, G-77/China). Users can also create their own "custom regions" with members of their choosing.
- Complete Data. CAIT is the only available source for the "full basket" of all greenhouse gases (i.e., not just CO_2 from fossil fuels) for every country in the world. Thus, CAIT includes data on CO_2 emissions from energy and land-use change as well as non-CO_2 gases such as methane, nitrous oxide, and high-GWP gases.
- Customizable and Interactive Features. Depending on the indicator(s), users can select different (1) timetables for evaluation (e.g., 1850 to 2000), (2) greenhouse gases, and (3) units to display (e.g., aggregate or per capita measures). Likewise, users can apply filters to specify the countries or regions in a table.
- Analysis Features: In addition to viewing indicators, there are several *Analysis* features in CAIT that enable interesting comparisons between countries and across different indicators. Users can also calculate and graph trends in different indicators across different time periods and countries. Likewise, users can create weighted indices that combine two or more indicators into a composite index, according to user-specified weightings. Emission projections from IEA, EIA, POLES, and IPCC (SRES) are also included.
- Supporting Documentation explains emissions sources and methodologies used in CAIT. CAIT data is drawn from a wide variety of sources, including the Carbon Dioxide Information Analysis Center (CDIAC), the Dutch National Institute of Public Health and the Environment (RIVM), EarthTrends (WRI), Richard Houghton, the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), the World Bank, the World Health Organization (WHO), the United Nations Development Programme (UNDP), U.S. Environmental Protection Agency (EPA), and the U.S. Energy Information Administration (EIA).

CAIT is available free of charge from http://cait.wri.org and runs on Microsoft Excel (version 2000 or 2002) on any Windows-based platform.

APPENDIX 3. Factors Driving Energy-Related CO_2 Emissions

One approach to understanding energy-related CO_2 emissions is a simple model utilizing four main factors: activity levels, structure, energy intensity, and fuel mix. Altering any of these factors—alone or in combination—can influence emissions. By way of a simple illustration, the farther one drives a car (*activity*), the more CO_2 emissions will result. However, fewer emissions will result if the car is more energy efficient (*energy intensity*), and emissions might be avoided entirely if the car is operating on a zero-carbon fuel such as hydrogen (*fuel mix*). Alternatively, one might choose to ride the bus instead of driving (changing the *structure* of the activity), which would also alter the CO_2 emissions.

Equation *A* represents these dynamics at the economy-wide level. There are no specific indicators shown for *structure*. Rather, structural changes are part of the energy intensity factor. For example, a structural change away from heavy industry (high energy inputs) toward commercial activities (e.g., financial or insurance, with low energy inputs) will reduce the energy intensity of an economy.

$$CO_2 = \underbrace{\frac{GDP}{\text{per person}} \times \text{Population}}_{\textit{Activity}} \times \underbrace{\frac{\text{Energy}}{GDP}}_{\textit{Energy Intensity}} \times \underbrace{\frac{CO_2}{\text{Energy}}}_{\textit{Fuel Mix}} \qquad \textbf{Equation } \boldsymbol{A}$$

Table A1.2 shows the degree to which the four distinct variables in Equation *A* are driving energy-related CO_2 emissions in the top 25 GHG emitting countries during the 1990-2000 period. This is done through a technique called decomposition analysis.[29] Decomposition analysis identifies and quantifies the contribution of each factor towards changes in the aggregate indicator (CO_2 in this case). Factors can have compounding or offsetting effects on changes in emissions. Relatively small changes in factors can result in a large change in emissions when all the factors change in the same direction. On the other hand, large changes in one factor can be offset by opposing changes in other factors, resulting in only a small change in the emissions. For each country in **Table A1.2**, the sum of the four factor contributions is equal to actual percent change in CO_2. (The percentage contribution to CO_2 changes for each factor is often similar to the actual percent change in that variable over the 10 year period.)

These factors, however, account only for energy-related CO_2 emission changes. In some cases, overall greenhouse gas changes were significantly influenced by increases or decreases in non-CO_2 gases. For that reason, the final column in the table shows changes in non-CO_2 emissions. Finally, *percentage* changes such as those shown in the table can be misleading, and should be evaluated in the context of absolute shifts. For example, although China's emissions grew at more than twice the rate of the United States, the total amount of CO_2 that each added to the atmosphere over the decade was almost the same. This effect can be seen in the second column of **Table A1.2**, which shows the absolute changes alongside the percentage CO_2 changes.

[29] The approach to decomposition analysis employed in this paper follows the methodology of Ang (2001).

APPENDIX 4. IPCC's SRES Scenarios

The IPCC Special Report on Emission Scenarios (SRES)[30] presents a number of scenarios assuming different combinations of demographic change, and social, economic, and technological developments. The scenarios are organized into four "families" – A1, A2, B1, and B2. These are summarized below:

The **A1** storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

The **A2** storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

The **B1** storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

The **B2** storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

[30] IPCC 2000.

APPENDIX 5. Regional Data

This report deals primarily, though not exclusively, with country-level data and indicators. This appendix examines data from various geographic, political, and UNFCCC-related regions, taking a closer look at a few of these regions. **Figure IV.1** outlines a range of indicators and trends across geographic, political, and UNFCCC-related regions.

Asia is notable for its sheer size, containing the largest global shares of population (56 percent), GDP (33 percent), and greenhouse gases (34 percent). It is also the most diverse region, as it includes China and India as well as a range of advanced industrialized countries (Japan), rapidly growing developing countries (South Korea, Singapore), transition economies (Kazakhstan, Uzbekistan), least developed countries (Bhutan, Bangladesh). Asia is also noteworthy for its relatively low income levels ($4,248 per person, measured in purchasing power parity) and per capita emission levels (0.9 tons per capita). China and India, it should be noted, dominate Asia's statistical averages.

Europe is the only geographic region to have reduced its emissions over the 1990s (by 20 percent). The same can be said of the European Union, including its past (15), present (25) and prospective future membership configurations (28). However, as European Union membership increases, its average income levels decline meaningfully, from about $23,700 (15 members) to $18,700 (28 members). The EU's per capita emissions likewise decline (from 2.9 to 2.6 tons per person).

In the **Middle East and North Africa** (MENA), greenhouse gas growth was particularly rapid in the 1990s, at 50 percent growth. However, this region still comprises only 6 percent of global GHG emissions. Among the MENA countries, three countries – Iran, Turkey, and Saudi Arabia – constitute about half the region's emissions. Also, four OPEC Gulf states – Bahrain, Kuwait, Qatar, and United Arab Emirates – are notable for their emissions per capita levels (10.4 tons per person), which are about seven times higher than the world average.

Overall, however, **sub-Saharan Africa** is notable for its low levels of emissions (4 percent of world) and economic activity (3 percent), relative to its population size (11 percent). Sub-Saharan per capita income levels are also the lowest in the world, at $1,800 per person, and economic growth was especially slow in Africa over the 1990-2000 period. This was also the only geographic region where living standards, measured by per capita income, actually declined in the 1990s. However, income growth was relatively strong in a few countries, such as Equatorial Guinea, Uganda, and Botswana. Half of the GHG emissions in sub-Saharan Africa come from three relatively large countries – South Africa, Nigeria, and Sudan.

The **North America** region is composed of two economic giants, Canada and the United States, which together comprise almost a quarter of the world's emissions and economic activity, but only about 5 percent of the population. Accordingly, emissions per capita levels are especially high, at 6.6 tons per person. Not surprisingly, this region also has the highest income levels, at over $33,000 per person. The North American Free Trade Agreement (**NAFTA**) adds Mexico to this region, resulting in appreciable downward shifts in emissions and income per capita levels.

The **Central American & Caribbean** region, composed of 21 countries, constitutes between 2 and 3 percent of global GHGs, GDP, and population. However, this region is statistically dominated by Mexico. Mexico is more than 14 times larger than the second largest economy in the region – the Dominican Republic. Accordingly, the regional averages are not particularly reflective of the Central American countries – such as Costa Rica and Guatemala – or Caribbean countries such as Jamaica and the Bahamas.

South America's shares of global GHGs, GDP, and population are relatively constant, at about 5.5 percent each. The **MERCOSUR** countries (Argentina, Brazil, Paraguay and Uruguay) constitute 70 percent of the region's economy and 65 percent of the emissions. MERCOSUR, and South America generally, are notable in that they have relatively low carbon intensities, primarily due to a fuel mix that includes significant shares of hydroelectric and natural gas (see **Section III**). However, as the table shows, it is also one of the few regions where carbon intensity is increasing, as countries turn to available energy sources with higher carbon content. With respect to per capita emissions and per capita income, this region (like Central America & Caribbean) is remarkably close to world averages.

The last geographic region – **Oceania** – is dominated by Australia and, to a lesser extent, New Zealand. These two countries constitute 96 percent of the region's economy and 76 percent of the population. The remaining 11 countries in the region are primarily small island states, such as Samoa, Fiji, and Vanuatu. Not surprisingly, per capita emissions and income levels are relatively high.

Table A5.1. Regional Indicators

				1990-2000, % Change			Per Capita, 2000	
A.	**GHG**	**GDP**	**Pop'n**	**GHGs**	**Income (GDP pc)**	**CO_2 Intensity**	**GHG tons/capita**	**Income $PPP/capita**
As	34%	33%	56%	29%	15%	3%	0.9	4,248
Europe (38)	23	26	12	-20	17	-30	2.9	15,941
Middle East & N. Africa (21)	6	5	7	50	16	9	1.5	5,437
Su	4	3	11	18	-4	-4	0.6	1,817
No	23	24	5	16	22	-14	6.6	33,269
Ce	2	3	3	19	19	-7	1.2	6,827
So	5	6	6	24	17	3	1.4	7,180
Oc	2	1	0	17	22	-10	5.2	18,672
B.								
AS	4	4	9	51	39	22	0.7	3,593
Co	9	3	5	-36	-36	1	2.9	5,282
Eu 5)	12	20	6	-3	19	-18	2.9	23,670
European Union (25)	14	22	7	-6	19	-21	2.8	21,518
European Union (28)	16	23	9	-7	18	-22	2.6	18,774
G-	40	47	14	-1	17	-18	4.4	24,760
ME	4	4	4	22	19	7	1.5	8,014
NA	24	26	7	16	21	-14	5.4	27,439
OECD (30)	47	59	19	10	18	-11	3.8	23,132
OPEC (11)	6	4	8	48	12	17	1.2	3,768
C. UNFCCC Regions								
Annex I	51	58	19	-3	19	-20	4.0	22,062
non-Annex I	46	39	78	30	34	-11	0.9	3,686
Economies in Transition	12	6	7	-34	-21	-16	2.7	6,327
G-77 / China	42	35	75	34	35	-8	0.9	3,432
AOSIS (Small Island States)	1	1	1	30	49	-7	1.3	5,483
Least Developed Countries	3	2	11	21	9	5	0.4	1,205
Developing Countries	48	40	79	30	34	-11	0.9	3,727
Developed Countries	52	59	20	-3	18	-20	3.9	21,203
World	**..**	**..**	**..**	**11%**	**12%**	**-13%**	**1.5**	**7,316**

Notes: GHGs includes six major gases, but not CO_2 from land-use change. Developed and Developing countries, may not add up to 100 percent, due to several countries excluded from the database due to lack of data (e.g., Somalia).