sustainability indicators. Economic instruments are used to direct environmental policy. The economic approach may be simply stated in a set of propositions. Environmental degradation has an economic cost viz., natural capital stock, natural forest, GNP, aesthetic damage. Population growth, insecure resource rights, bad central planning, the failure of markets to price resources and outputs also reflects social costs.

Conclusion

The developing countries should formulate appropriate environmental policy, which is crucial for the management of resources. Majority of global environmental damages represent the cumulative and contemporary impact of Western industrialization. Developing countries have the potential for environmental degradation but ultimately lead to the balance against human survival. The developed world was successful with economic growth but the heavily populated developing countries could bring negative environmental externalities to the world and then the rich and poor would suffer alike. The adjustment programs of IMF and World Bank stabilization policies ensured that the continued poverty of the nations in the South is a necessity for maintaining the attained prosperity of the nations in the North. The environmental interdependence is allowed to developing countries to get financial assistance to pursue environmentally sustainable development objectives.☆

Reference # 22J-2006-02-01-01

References

1. David W Pearce and Jeremy J Warford (1993), *World without End: Economics, Environment, and Sustainable Development—A Summary*, Washington D.C., World Bank.
2. Government of India (2001), *Central Statistical Organization*, Compendium of Environment Statistics, New Delhi.
3. Government of India (2004), Ministry of Environment and Forest, "India's Initial National Communication to the United Nations Framework Convention on Climate Change", New Delhi.
4. Jose, I, Dos R, Furtado and Tanara Belt, Ramachandra Jammi (2000), World Bank Indicators, Economic Development and Environmental Sustainability Policies and Principles for a Durable Equilibrium, Washington D.C., USA.
5. Michael P Todaro, Stephen C Smith (2004), "Economic Development", Pearson Education, Delhi.
6. Sous La Director De Denizhon Eroccal (1991), *Environment Management in Developing Countries*, OECD, France.
7. World Development Indicators (2004), World Bank, Washington D.C.
8. World Development Report (2001), World Bank, Washington D.C.
9. World Resource Institute (1998), *World Resources: A Guide to the Global Environment*, Oxford University Press, New York.

The Climate Change and Development Nexus

Matthew Clarke*

The rapid economic success achieved by the developing countries in general, and India and China in particular, has brought the issue of climate change, which is a spin-off of development, to the fore. Economic growth is essential for the eradication of poverty and generation of wealth. However, it drives energy consumption and demand for energy which, in turn, produces toxic gases like carbon dioxide (CO_2). Thus, the price of economic growth is climate change. The paradox lies in the fact that when economic growth is the only solution to poverty, the resultant climate change (characterized by emission of greenhouse gases) also affects the poor greatly. In this context, it is observed that while traditionally the developed countries were charged with polluting the environment globally, now the developing countries have overtaken their counterparts as polluters. The developing countries have emerged, over the years, as the agents responsible for growing pollution in the world, though they are also the victims, as most of the poor people belong to the developing countries. The author explores the nexus between climate change and development in the context of the economic growth of the developing countries and its impact on them.

1. Introduction

Climate change has, at different times, been discussed either as a scientific (IPCC 2001, 2002; Pittock 1998), economic (Nordhaus 1994; Islam *et al.* 1998; World Bank 2000), or ethical (Broome 1992; Mueller 2002; Strauss 2003) issue. As the developing countries, especially China and India, continue to achieve high levels of economic growth, climate change must now be considered as a development issue. Securing improvements in the standard of living of the world's poor requires increased economic growth. But herein lies the paradox of this climate change–development nexus. Economic growth drives energy demand and consumption. Overwhelmingly, this energy is derived from the burning of fossil fuels for both electricity generation

* Lecturer, International Development Program, School of Social Science and Planning, RMIT University, Melbourne, Victoria, Australia. E-mail: matthew.clarke@rmit.edu.au

and transport, resulting in high levels of greenhouse gas emissions. Economic growth therefore increases greenhouse gas emissions. Increased economic growth is good for the poor. Increased greenhouse gas emissions are bad for the global community, especially the poor. Thus, achieving development will come at the cost of climate change.

Whilst developed countries have been historically responsible for greenhouse gas emissions, developing countries are becoming increasingly responsible for current emissions (IPCC 2002; IEA 2004; CDIAC 2004). This is largely a factor of large populations, low-level technology, and ongoing industrialization. This is particularly the case with China and India. China is the second largest greenhouse gas emitting economy in the world—second only to the United States. India is the world's fifth largest emitter—emitting more greenhouse gases than Germany, the United Kingdom and Canada.

This paper is structured as follows: Section 2 notes issues with data for greenhouse gas emissions in developing countries. The climate change—development nexus is illustrated by focusing on the energy consumption trends of China in Section 3 and India in Section 4. Certain policy implications are briefly discussed in Section 5, before the paper concludes in Section 6.

2. Greenhouse Gas Emission Data for Developing Countries

Despite the importance of developing countries to global emissions, data is limited. The international body charged with the responsibility of coordinating an international response to climate change is the United Nations Framework Convention on Climate Change (UNFCCC). Under the UNFCCC, developed (Annex 1) countries are required to submit yearly inventories of greenhouse gas emissions in a 'common reporting format' in order to assess the progress of abatement policies against the Kyoto Protocol commitments (UNFCC 2003). A comparison of the data is reasonable and accurate as the methodology is standard across all estimates. However, such data does not exist for developing countries, as these countries are not required to undertake national greenhouse gas emission inventories in line with UNFCCC regulations.

Third parties have estimated emissions data for developing countries. Two organizations have comprehensive CO_2 emissions estimates for most countries. The first is the CO_2 Informational Analysis Center (CDIAC) located within the US Department of Energy, and the second is the International Energy Agency (IEA) located within the OCED. However, methodologies for estimating CO_2 emissions differ between the two organizations. It should also be noted that while the estimates of both organizations are comprehensive in terms of countries included, estimates are not for the full suite of greenhouse gases (only CO_2) nor do they consider emissions from sources other than the consumption and flaring of fossil fuels. This is significantly less data than is available for developed (Annex 1) countries reporting in the "common reporting format".

However, as CO_2 emissions from the consumption and flaring of fossil fuels accounts for the largest portion of total greenhouse gas emissions, this data is valid for analysis. Finally, the International Energy Agency (IEA) data is available for the period 1980 to 2002, while the Carbon Dioxide Information Analysis Center (CDIAC) data starts at various times (often as far back as the mid 1800s), but is currently limited to 2000. While the total estimates between CDIAC and IEA data are roughly comparable, no consistent pattern of over or under-estimation exists of carbon dioxide (CO_2) emissions from the consumption and flaring of fossil-fuels of either dataset.

Table 1: CDIAC Rankings

Ranking	Total Fossil Fuel CO_2 Emissions		Per Capita Fossil Fuel CO_2 Emissions	
	Nation	Emission (Thousand Metric Tonnes Carbon Equivalent)	Nation	Emission (Metric Tonnes Carbon Equivalent)
1	USA	1528796	US Virgin Islands	29.91
2	**China**	761586	Qatar	19.65
3	Russian Federation	391664	The Netherland Antilles	12.61
4	Japan	323281	Bahrain	7.70
5	**India**	292265	Guam	7.17
6	Germany	214386	UAE	6.17
7	UK	154979	Kuwait	5.97
8	Canada	118957	Trinidad and Tobago	5.58
9	Italy	116859	USA	5.40
10	Republic of Korea	116543	Luxembourg	5.31
11	Mexico	115713	Falkland Islands	5.24
12	Saudi Arabia	102168	Aruba	5.20
13	France	98917	Brunei	5.08
14	Australia	94094	Wake Island	4.91
15	Ukraine	93551	Australia	4.77
16	South Africa	89323	Saudi Arabia	3.90
17	Iran	84689	Singapore	3.87
18	Brazil	83930	Canada	3.84
19	Poland	82245	Faeroe Islands	3.84
20	Spain	77220	Palau	3.48
			China	0.60
			India	0.29

Source: CDIAC 2004.

3. China's Energy Demand and Energy Consumption

Since the economic liberalization in 1979, China's Gross Domestic Product (GDP) has increased nearly seven-fold. Yet, despite this enormous increase, China is still a developing country with GDP per capita of only 15% of the Organization for Economic Co-operation and Development (OECD) average. China is aiming to quadruple its GDP over the next two decades and increase the urbanization rate from 35% to 65% (a more conservative estimate of 50% would still result in 700 million people living in urban centres with greater energy consumption than their rural counterparts). If these targets are achieved, China will reach GDP per capita levels of a middle-income country in only a few decades. Such economic development will place great stress on the environment, particularly through the emissions of greenhouse gases, rising between 70% to 130% (Dadi and Levine, 2003).

China is the world's second largest emitter of CO_2. China's heavy energy needs are driven by its population growth and its economic development. It presently emits nearly 14% of the world's total CO_2 emissions up from 80% in 1980 (IEA, 2002a). Given the current demand for energy, propelled by economic growth, it is likely that this share will increase sharply in the future. China's total CO_2 emissions have grown in line with its energy consumption over the past two decades. Since 1971, CO_2 emissions in China have increased three-fold, predominantly due to its reliance on dirty coal and other fossil fuel combustion to produce enough energy to meet spiraling demand. China's reported CO_2 emissions peaked in 1996 but have remained stable since then.

Table 2: CDIAC and IEA Estimates of CO_2 Emissions
(In thousands of carbon equivalent metric tonnes—except per capita)

Year	CDIAC Estimates of Total Fossil Fuel CO_2 Emissions	CDIAC Per Capita CO_2 Emissions Rates	IEA Estimates of Total Fossil Fuel CO_2 Emissions	IEA Per Capita CO_2 Emissions Rates
1990	654710	0.57	616891	0.53
1991	687542	0.59	645779	0.55
1992	721323	0.61	667897	0.56
1993	760462	0.64	711856	0.60
1994	807334	0.67	768007	0.64
1995	872721	0.72	787716	0.65
1996	912318	0.74	803146	0.65
1997	898820	0.72	824279	0.66
1998	850695	0.68	805182	0.64
1999	771022	0.61	794548	0.63
2000	761586	0.60	822848	0.65
2001	–	–	866114	0.67
2002	–	–	906110	0.70

Source: CDIAC 2004; IEA 2004.

According to the CDIAC (2004) estimates, CO_2 emissions from fossil fuels fell 16.2%, from 912 million metric tonnes of carbon to 762 million metric tonnes between 1996 and 2000. Despite this recent decline, China's emissions have increased steadily since 1950. Between 1970-1996, emissions grew at 5.6% per annum. Due to China's large population (approaching 1.3 billion people), per capita emission rates (0.60 metric tonnes of carbon in 2000) are well below the global average. The estimates of CO_2 emissions by the IEA (2004) are higher than CDIAC estimates. According to this data, China increased its CO_2 emissions by 32% between 1990-2002, from 616,891 to 906,110 thousand metric tonnes carbon equivalent. Over three-quarters of these emissions resulted from coal consumption. Within the IEA dataset, China's per capita emission rate was 0.70 metric tonnes of carbon equivalent, an increase of nearly 24% between 1990-2002.

3.1 Explaining China's Energy Production and Consumption

China's industrial sector accounts for 75% of all energy-related CO_2 emissions. The commercial sector accounts for 11%, the transport sector 9% and the residential sector 5%. It is expected that the transport sector will increasingly contribute to greenhouse emissions as China continues to develop. Mobility has increased as a result of car affordability improving for large sections of the population in conjunction with an easing of internal travel restrictions. Therefore, CO_2 emissions from the road transport sector increased 125% and other transport increased 46% between 1990-2000 (CDIAC 2004).

In terms of global primary energy consumption, China accounted for nearly 70% of the global increase between 2001 and 2002 (see Table 3). China's primary energy production increased 19.7% between 2001 and 2002 compared to an increase of 0.6% in OECD countries and 2.6% for the entire world (BP 2003).

China became self-sufficient in oil during the mid-1960s and an oil exporter in the mid-1980s. By 1993, China's domestic energy demand resulted in evolving it as a net importer. Just seven years later, China was the world's sixth largest importer, behind the US, Japan, Germany, France and Italy. China is now the world's second largest oil consumer. The increase in world oil consumption was only 0.1% between 2001-2002, yet China's oil consumption increased by 5.8% (BP 2003). It is forecast that by 2030, China will import 600 million tonnes of oil (a figure comparable with the US today).

China also accounts for one quarter of the total world consumption of coal. China's coal consumption increased by 27.9% between 2001-2002, compared to the rest of the world (excluding China) of 6.9%. In 2003, domestic coal production rose by 100 million tonnes. In 1998, coal accounted for 62% of primary energy use, increasing to 70% in 2002. Even the most optimistic and sustainable-focused scenario still, coal will be responsible for at least 55% of energy production in 2020 (Dadi and Levine 2003). The coal used is dirty and a primary source of China's CO_2 emissions. Officially, coal use for energy reached the peak in 1996 but declined by nearly 25% by 1999. From 1996,

Table 3: Energy Data for China, OECD and World

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	% Change from 2001-2002
Oil Consumption (millions of tonnes)												
China	129.0	140.5	149.5	160.7	174.4	185.6	190.3	207.2	230.1	232.2	245.7	5.8
OECD	1979.0	1956.7	2041.0	2053.0	2112.4	2144.6	2150.5	2187.5	2198.4	2194.5	2181.9	-0.6
World	3170.4	3140.1	3199.5	3245.0	3321.3	3395.2	3411.7	3480.4	3517.5	3517.1	3522.5	0.1
Oil Consumption by Product Group – China (thousands of barrels daily)												
Gasoline	711	804	848	904	986	1111	1098	1164	1313	1252	1387	10.8
Middle Distillates	790	898	878	997	1080	1202	1277	1455	1633	1709	1786	4.5
Fuel oil	674	725	665	669	719	750	725	694	725	728	631	-13.3
Others	488	486	755	819	888	871	946	1103	1314	1342	1558	16.1
Coal Consumption (million tonnes of oil equivalent)												
China	549.5	570.3	606.4	671.9	681.6	681.7	608.3	492.3	454.7	518.7	663.4	27.9
OECD	1042.9	1035.6	1037.3	1044.5	1077.3	1082.4	1082.9	1070.8	1118.1	1105.8	1116.3	0.9
World	2202.8	2201.4	2218.8	2290.3	2340.7	2350.6	2268.8	2136.7	2174.3	2243.1	2397.9	6.9
Primary Energy Consumption (million tonnes of oil equivalent)												
China	722.2	758.4	811.8	893.6	917.4	930.4	864.3	766.2	765.7	833.6	997.8	19.7
OECD	4673.0	4740.2	4821.3	4931.2	5103.1	5147.7	5170.6	5243.6	5355.1	5314.0	5346.1	0.6
World	8197.1	8242.2	8339.0	8568.3	8816.6	8899.0	8884.9	8896.4	9092.2	9165.3	9405.0	2.6

Source: BP Statistical Review of World Energy, 2002.

inefficient small coal pits were closed by government order and over 57,000 mines were officially closed down by 2001 reducing coal production by 350 million tonnes (Stinton and Fridley, 2002).

3.2 Things Could be Worse

Reductions in population growth have reduced China's potential emission output by 150 million tonnes per year (Pew 2002). By developing various population policies, it is estimated that 300 million less births occurred over the past three decades. Forest cover in China has increased from 13% to 17% since 1986. The importance of forest cover is that it acts as a carbon sink. It is estimated that more than 123 million tonnes of carbon dioxide (CO_2) have been absorbed by afforestation over the last 50 years (Pew 2002). Another 100 million tonnes of emissions have been reduced through reduced energy intensity. Energy intensity fell by 2.9% per annum over the last four decades, well ahead of that experienced in developed countries (Xue and Sheehan, 2003). This reduction is particularly significant as most countries at China's stage of development have steady or rising energy intensities. China's energy efficiency is largely a result of the liberalization program implemented in 1979, including, structural adjustment, tax reform, fewer subsidies for state-owned enterprises and price deregulation.

3.3 Things Could be Much Worse—Inaccurate Data

Emission data estimates by both IEA and CDIAC are based on data prepared by national governments. Official Chinese figures show that coal consumption actually fell by one-third between 1997 and 2000 and rose 46% between 2000 and 2002 (BP 2003—see Table 3). Such fluctuations cast serious doubts over the accuracy of these statistics. Indeed, claims that China has dramatically reduced coal consumption and greenhouse gas emissions are beginning to be questioned (Zittel and Treber, 2003; Stinton 2001; Stinton and Fridley 2002, 2003). It would be of great importance if these official figures had been systematically understated and misreported for some time. If these government figures are understated, then so too are the estimated CO_2 emissions. This raises doubts that emission growth has reduced over the past three

Table 4: Comparisons of China's Intensity Changes

	Emissions Intensity (tons of Co_2/\$m GDP) 1999	Change in Intensity (% per annum) 1960-80	1980-99	Change in Rate of Change (% per annum) 1960-80 and 1980-99
Hong Kong	67.7	-1.0	-0.2	0.8
UK	114.3	-2.2	-2.8	-0.6
USA	171.0	-1.6	-2.2	-0.6
Australia	195.4	0.1	-0.6	-0.8
China (Mainland)	180.6	-1.0	-3.9	-2.9

Source: Xue and Sheehan (2003).

decades by an estimated 250 million tonnes of carbon per year, about one-third of China's current emissions.

If under-reporting of coal consumption did occur, it is possible to adjust coal consumption figures from 1997 in order to estimate what the real consumption figures may be and then re-estimate CO_2 emissions (CSES 2005). Three sets of adjustments are made: 1) Low; 2) Mid-range; and 3) High range. The *low* estimate is based on an average increase of around 5% per annum. This roughly reflects the increase reported between 1992 and 1996. The *mid-range* estimate is based on average increases of 7.8% per annum. This figure reflects recent growth in GDP, which is a primary driver of energy demand. The *high-range* figure is based on average increases of 14% per annum. This figure is half of the increase in official coal consumption reported between 2001-2002. Given the large fluctuations in reported coal consumption, it is likely that the true figure lies between the mid and high-range estimates.

The difference between the reported coal consumption and the projected estimates is quite significant (see Table 5 and Figure 1). At the most extreme, the estimated high-range in 2002 is 2.25 times greater than the reported figure.

An important figure in relation to climate change is the cumulative consumption of coal over this period. Between 1992-2002, 6499 million tonnes of oil equivalent (mtoe) were consumed officially. This compares to 7983 mtoe, 8843 mtoe and 9712 mtoe, respectively for the low, mid and high range estimates. In terms of total coal consumed for this 11-year period, the estimates range up to 50%. This difference will have a significant impact on climate change analysis.

Table 5: Coal Consumption Estimates

	Coal Consumption (toe*)			
	BP 2003	Low (5% p.a.)	Mid (7.8% p.a.)	High (14% p.a.)
1992	549.5	549.5	549.5	549.5
1993	570.3	570.3	570.3	570.3
1994	606.4	606.4	606.4	606.4
1995	681.7	681.7	681.7	681.7
1996	681.6	681.6	681.6	681.6
1997	681.7	*725.7*	*734.8*	*777.0*
1998	608.3	*762.3*	*792.1*	*885.8*
1999	492.3	*798.8*	*853.9*	*1009.8*
2000	454.7	*835.4*	*920.5*	*1151.2*
2001	518.7	*872.0*	*992.3*	*1312.4*
2002	663.4	*908.6*	*1069.7*	*1496.1*
Cumulative Total	6498.8	*7982.5*	*8443.0*	*9712.0*

* toe = tonnes of oil equivalent.

Figure 1: Trajectories of Coal Consumption Estimates

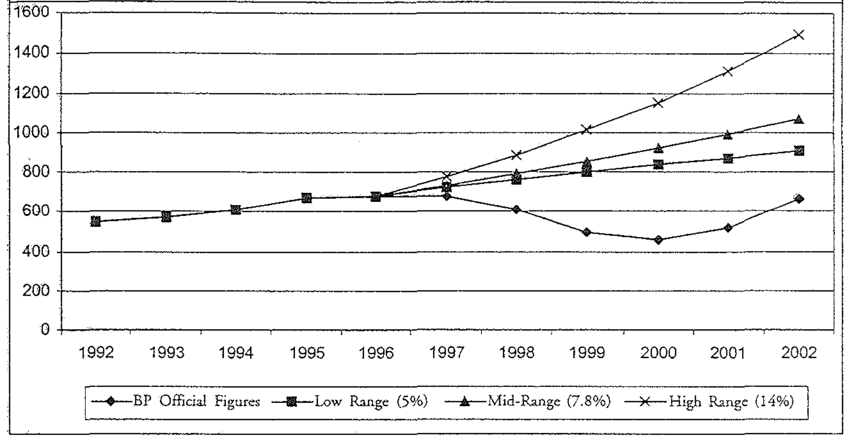

Table 6: CO_2 Emission Estimates

	Coal Consumption (toe*)			
	BP 2003	Low (5% pa)	Mid (7.8% pa)	High (14% pa)
1992	2103.5	2103.5	2103.5	2103.5
1993	2183.1	2183.1	2183.1	2183.1
1994	2321.3	2321.3	2321.3	2321.3
1995	2572.0	2572.0	2572.0	2572.0
1996	2609.2	2609.2	2609.2	2609.2
1997	2328.6	*2777.9*	*2812.7*	*2974.4*
1998	2328.6	*2917.9*	*3032.1*	*3390.9*
1999	1884.5	*3058.0*	*3268.6*	*3865.6*
2000	1740.6	*3198.0*	*3523.5*	*4406.8*
2001	1985.6	*3338.0*	*3798.4*	*5023.7*
2002	2539.5	*3478.0*	*4094.6*	*5727.1*
Cumulative Total	24877.4	*30556.9*	*32319.0*	*37177.6*

* toe = tonnes of oil equivalent.

It is possible to estimate CO_2 emissions from developing countries by applying emissions factors to the consumption of oil, gas and coal. The estimation is based on converting coal consumed from mtoe to MWh using a conversion factor of 11.6 and then estimating CO_2 emissions by using an emission factor suggested by the IPCC (2002) of 330 g CO_2/kWh. Whilst a rough estimate, this LBST method is reasonably accurate (Zittel and Treber, 2003).

The different estimates present a large difference in the likely emissions emitted through coal consumption for this period. The estimates range from 24877 (Mt) of CO_2 emissions to 37177 (Mt). This difference will impact on climate change.

4. India's Energy Development and Energy Consumption

Two estimates of India's greenhouse gas emissions using the UNFCCC common format have been undertaken. The first was for the base year 1990 and was estimated by the National Physical Laboratory as part of the Asia Least-Cost Greenhouse Gas Emission Program. The second was undertaken by the Ministry of Energy and Forests for the year 1994. While broad comparisons between these two inventories are possible, analysis is limited due to there being only two estimates (which are now quite dated). Therefore, the data that is estimated by IEA and CDIAC is preferred for this analysis.

In 2000, India was the world's fifth highest CO_2 emitting country (CDIAC 2004). However, India's large population (now over 1 billion people) has resulted in CO_2 per capita emissions rate being well below the global average at only 0.29 metric tonnes. Average annual growth in fossil fuels CO_2 emissions since 1950 has been just under 6%, with total emissions rising by nearly 60% since 1990. India is the world's third largest producer of coal and coal consumption is the major source of CO_2 emissions. In 2000, nearly three-quarters of fossil fuel emissions came from coal consumption (down from 87% in 1950). Oil consumption accounts for nearly 20% of CO_2 emissions.

Table 7: CDIAC and IEA Estimates of CO_2 Emissions
(in thousands of carbon equivalent metric tonnes—except per capita)

Year	CDIAC Estimates of Total Fossil Fuel CO_2 Emissions	CDIAC Per Capita CO_2 Emissions Rates	IEA Estimates of Total Fossil Fuel CO_2 Emissions	IEA Per Capita CO_2 Emissions Rates
1990	184296	0.22	161801	0.19
1991	197516	0.23	169778	0.20
1992	211336	0.24	180201	0.20
1993	220346	0.25	189593	0.21
1994	234778	0.26	200172	0.22
1995	247689	0.27	236477	0.25
1996	273682	0.29	226329	0.24
1997	279873	0.29	238219	0.25
1998	289269	0.30	245034	0.25
1999	293938	0.30	254717	0.25
2000	292265	0.29	271665	0.27
2001	–	–	275491	0.27
2002	–	–	279871	0.27

Source: CDIAC 2004; IEA 2004.

According to the CDIAC (2004) estimates, CO_2 emissions from fossil fuels increased nearly 60% from 184 million metric tonnes of carbon to 292 million metric tonnes between 1990-2000. Due to India's large population, per capita emissions rates (0.29 metric tonnes of carbon in 2000) are amongst the lowest in the world. The estimates of CO_2 emissions by the IEA (2004) are lower than CDIAC estimates. According to this data, India increased its CO_2 emissions by 73% between 1990 to 2002, from 161 million metric tonnes to 279 million metric tonnes of carbon equivalent. Nearly, 70% of these emissions resulted from coal consumption. Within the IEA dataset, India's CO_2 emissions per capita rate in 2002 was 0.27 metric tonnes carbon equivalent.

4.1 Explaining India's Energy Production and Consumption

India is the world's second most populous country and despite having a large portion of its population (around one-third) living below the poverty line, it is the world's fourth largest economy.

During the 1990s, India's economy grew on average, just over 6.5% per annum, almost doubling in size within this period. However, energy use grew slightly faster at 7% per annum and demand for electricity grew at 8% per annum. Despite this growth, India's per capita electricity use is one-half of China's and one-sixth of the world's average. This is primarily a factor of over 400 million people lacking access to electricity (IEA, 2002). India's carbon emissions have increased by 63% since 1990. "This emissions growth results primarily from energy use associated with economic development and heavy dependence on coal" (Pew 2002, p. 22).

India's industrial development has been fueled by energy derived from coal. Thus, India's growth has come at a high price—domestically this equates to worsening air pollution, and globally this equates to increased greenhouse gas emissions. Another significant greenhouse gas in India is Methane from rice paddies and ruminating cows.

Coal accounts for 55% of primary energy use, oil accounts for 3%, gas accounts for 8%, hydro for 5% and nuclear for 1%. The industrial sector produces around two-thirds of all energy-related CO_2 emissions. The transport sector produces 16%, the residential sector produces 14% and the commercial sector 3% (Pew 2002).

Between 1992-2002, India's oil consumption increased from 62.1 million tonnes to 97.7 million tonnes. This increase of 58% is far greater than the increase in world consumption for the same time, which was only 11%. Coal consumption in India increased by 40% from 123.3 mtoe to 180.8 mtoe, compared to the worldwide increase of only 8% for the same period. Primary energy consumption increased 50% from 216.4 mtoe to 325.1 mtoe compared to the increase in world consumption levels of 15% (see Table 8).

A business-as-usual scenario, which assumed sustained economic growth and continued dependence on domestic coal resources for energy production, resulted in energy-related carbons of 668 million tonnes in 2030 (Pew, 2002). This is three times the current level.

4.2 Things Could be Worse

Over the last decade, India's growth in energy-related CO_2 emissions has been reduced through economic restructuring, enforcement of existing clean air laws, and renewable energy programs (Pew, 2002).

The adoption of new and efficient technologies and the expansion of non-energy intensive industries have resulted in the gradual decline of industrial energy intensity over the past decade. However, the Indian industry is still highly energy intensive when compared to the rest of the world.

Biomass accounts for nearly one-third of the total energy use. This should not be surprising, as over 440 million people in India do not have access to electricity. Biomass is used for cooking energy needs for nearly all rural households and nearly half of urban households (Shuckle, 1996).

India's fuel quality, technology standards, infrastructure and operating practices was improved over the past decade through market reform driven by domestic policy and international dynamics (Pew 2002). Power and liquid fuel pricing now occurs within the market place rather than being centrally planned as in the past. Some subsidies still exist, for example, LPG for household cooking, but nearly two-thirds of current prices cover the actual cost of supplying energy.

The coal sector is being successfully restructured through a combination of privatization, price reform and technological improvements. The Indian coal price is now near world price as the subsidies have been removed. Therefore, there is not a false demand leading to higher carbon emissions. Technology has improved stoves, reduced gas flaring in fossil-fuel production, improved both demand and supply-side efficiencies and introduced modern renewable energy systems. These technology advances equate to 18 million less tonnes of carbon emissions each year (Pew, 2002).

India's motor vehicle stock has also changed considerably over the past decade. There has been a rapid penetration of foreign brands and European emissions standards have now been adopted in the major cities of India. Such standards have improved local air quality but also resulted in more energy efficient cars. This has led to reduced greenhouse gas emissions (Mashekler *et al.* 2002).

"The Indian electricity sector has long been carbon intensive and the largest source of CO_2 emissions. In 2000, the sector emitted 115 million tonnes of carbon, about 42% of India's carbon emissions. Natural gas has penetrated this market in recent years and helped to reduce the carbon intensity of electric power generation. Improvement in the combustion efficiency of conventional coal technologies along with strong promotion of renewable technologies has made measurable contributions to mitigation. Improved combustion in coal-fired power plants slowed the growth of carbon emissions by 2.5 million tonnes between 1990 and 2000. The Indian government has set a goal of using renewables for 10% of new power generating capacity by 2010" (Pew, 2002, p. 24).

Over the past 20 years, India has developed a large renewable energy program. Over 3 million small biomass gasification systems have been built to fuel cooking for a large percentage of rural households. The efficiency of wood stoves has been improved in 34 million homes directly leading to reduced levels of deforestation. Government subsidies have made some solar power technologies available and similar subsidies support the installation of wind, small hydro, biomass and industrial waste-based electricity generation technologies (Pew, 2002). Given the huge domestic market in India, the small and successful introduction of these renewable technologies bodes well for future use.

Deforestation rates in India are amongst the lowest in the developing world. "Forest conservation measures include prohibiting the use of forest land for non-forestry purposes, encouraging agroforestry and private plantations to meet industrial wood needs, and expanding areas under protection" (Pew, 2002, p. 26). Since 1990, over 14 million hectares of forest were protected by such programs.

5. Policy Implications of the Climate Change—Development Nexus

The international community must now consider development and climate change as a single issue to determine a new approach. Climate change is a function of greenhouse gas emission concentrations. The IPCC (2002) have estimated that increases in CO_2 concentrations from pre-industrial level based on various scenarios of future energy use may lead to an increase in global temperatures of between 1.4°C and 5.8°C. It is also possible to estimate the level of greenhouse gas emissions that will result in these various increases in CO_2 concentrations. Capping emissions with these limits in mind must now also be considered an urgent policy initiative in post-Kyoto negotiations. So whilst it is immoral to suggest that economic growth in developing countries be slowed to reduce greenhouse gas emissions, CO_2 emissions increased 80% in the Asia and Oceania region between 1980 and 2002 (IEA, 2004). This compares to an increase for the same period of just 3% for Western Europe. Future projections suggest these trend will continue (CSES, 2005). Therefore, a focus on curbing emissions in some manner in developing countries is required.

Countries must act both individually and in coalition with the international community to address climate change. Many developing countries, including China and India, have begun domestic actions to reduce greenhouse gas emissions, but have been largely excluded from international efforts (such as the Kyoto Protocol) to reduce greenhouse gas emissions.

The growing influence of developing countries on global emissions is well known. Both Australia and the United States used the omission of developing countries from the Kyoto Protocol as a major reason for not ratifying it. More recently, on July 26, 2005 a new multilateral climate change compact was announced. This new compact is an alternative to the Kyoto Protocol. It includes the United States, Australia, South Korea, Japan, China and India. These countries account for around half of the

References

1. British Petroleum (BP) (2003), *BP 2003: Statistical Review of World Energy*, BP, London.

2. Broome, J (1992), *Counting the Cost of Global Warming*, White House Press, Cambridge.

3. Centre for Strategic Economic Studies (CSES) (2005), *New Technologies, Industry Developments and Emission Trends in Advanced Countries*, Victoria University, Melbourne.

4. CDIAC (2004), *World CO_2 Emissions*, CDIAC, Washington D.C.

5. Dadi, Z and Levine, M (2003), *China's Sustainable Energy Future*, ERI, Beijing.

6. International Energy Agency (IEA) (2004), *World Energy Outlook, 2004*, OECD and IEA, Paris.

7. International Energy Agency (IEA) (2002), *World Energy Outlook, 2002*, OECD and IEA, Paris.

8. International Energy Agency (IEA) (2002), *CO_2 Emissions from Fuel Combustion*, IEA, Paris.

9. International Panel on Climate Change (IPCC) (2001), *Climate Change 2001: The Scientific Basis*, IPCC, Geneva.

10. International Panel on Climate Change (IPCC) (2002), *Emission Scenarios*, Cambridge University Press, Cambridge.

11. Islam S, Gigas, J and Sheehan, P (1998), "Cost-Benefit Analysis of Climate Change: Towards an Operational Decision Making Rule for Climate Change Policy", *Indian Journal of Applied Economics*, Vol. 7(3), pp. 217-226.

12. Mashelker, R *et al.*, (2002), *Report of the Expert Committee on Auto Fuel Policy*, Ministry of Petroleum and Natural Gas, Government of India, New Delhi.

13. Muller, B (2002), *Equity in Climate Change: The Great Divide*, Oxford Institute for Energy Studies, Oxford.

14. Nordhaus, W (1994), *Managing the Global Commons: The Economics of Climate Change*, MIT Press, London.

15. Pew Center on Global Climate Change (Pew) (2002), *Climate Change Mitigation in Developing Countries*, Pew Center on Global Climate Change, Arlington.

16. Pittock, B, (ed.) (2003), *Climate Change: An Australian Guide to the Science and Potential Impact*, Australian Greenhouse Office, Canberra.

17. Shuckle, R (1996), *Wood Energy and Global Climate Change*, World Energy News, FAO, Bangkok.

18. Stinton, J (2001), "Accuracy and Reliability of China's Energy Statistics", *China Economic Review*, Vol. 12, 347-354.

19. Stinton, J and Fridley, D (2002), "A Guide to China's Energy Statistics", *The Journal of Energy Literature*, Vol. 8(1).

20. Stinton, J and Fridley, D (2003), "Comments on Recent Energy Statistics from China", *Sinosphere*, Vol. 6(2), 6-11.

21. Strauss, A (2003), "The Legal Option: Suing the United States in International Forums for Global Warming Emissions", *Environmental Law Reporter*, Vol. 33, pp. 10185-10191.

22. United Nations Framework Convention on Climate Change (UNFCCC) (2003), Compilation and Synthesis of Third National Communications, UNFCCC, Geneva.

23. World Bank (2000), *Cities, Seas and Storms—Managing Change in Pacific Island Economies*, World Bank, Washington D.C.

24. Xue, L and Sheehan, P (2002), "China's Development Strategy", in B Grewal *et al.* (eds.), *China's Future in the Knowledge Economy: Engaging the New World*, Centre for Strategic Economic Studies, Victoria University, Melbourne and Tsinghua University Press, Beijing.

25. Zittel, W and Treber, M (2003), *Analysis of BP Statistical Review of World Energy with Respect to CO_2 Emissions*, Joint Working Paper Germanwatch and LBS, Bonn.