The implications of population growth and urbanization for climate change

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SUMMARY: The paper considers the implications of population growth and urbanization for climate change in terms of the contribution of urban populations (and centres) to human induced climate change. It emphasizes how it is not the growth in (urban or rural) population but the growth in consumption that drives the growth in greenhouse gas emissions and that a significant proportion of the world's urban (and rural) population have consumption levels that are so low that they contribute little or nothing to such emissions. Reviewing carbon dioxide emission levels for nations and how they changed between 1980 and 2005 (and also between 1950 and 1980), there has been little association between nations with rapid population growth and nations with rapid greenhouse gas emission growth; indeed, it is mostly nations with very low emissions per person (and often only slowly growing emissions) that have had the highest population growth rates. The paper also discusses how in the much-needed planning for global emissions reduction, provisions must be made to allow low-income low-consumption households with greenhouse gas emissions below the 'fair-share' level to increase their consumption. A nation where average per capita greenhouse gas emissions are projected to increase from 0.1 to 0.5 tonnes of CO_2 equivalent per person should not be treated the same as a nation whose average per capita emissions are projected to increase from 5.1 to 5.5 tonnes.

INTRODUCTION

Urbanization can be viewed as one of the most serious 'problems' causing climate change in that in general, the more urbanized a nation, the higher the greenhouse gas emissions per person (although with very considerable differences in GHGs per person for nations with comparable levels of urbanization). But it can also be viewed as a key part of the 'solution' as it provides the basis for delinking high standards of living/quality of life from high greenhouse gas emissions per person. For the limited range of cities for which greenhouse gas emission inventories have been undertaken, there are very large differences in per capita emissions between cities with high living standards. For instance, Barcelona, widely considered as one of the nicest cities in Europe, has a fifth of the GHGs per person of many US cities. New York City has a third to a half of the GHG emissions per person of many other US cities (see Dodman 2009). Many of the most desirable and expensive residential areas in or close to city centres in Europe have residential areas that are or can be made very energy efficient (typically terraces with three to five storeys) and settlement patterns and public transport systems that allow most trips to be made on foot, by bicycle or by public transport. Indeed, one of the drivers of urbanization is the economic advantages that close proximity provides for a great range of enterprises.

Similarly, urban areas can be seen as one of the most serious 'problems' in regard to the impacts of climate change as they concentrate people, assets and infrastructure in ways that increase risk and vulnerability – and many cities and smaller urban centres are in locations that climate change is making (or will make) particularly hazardous (see Bicknell et al 2009). Or urban areas can be seen as having large potential advantages in building resilience to climate change impacts – i.e. in the economies of scale and proximity that they present for key protective infrastructure and services and for risk-reducing governance innovations - for instance through partnerships between government agencies and civil society groups to reduce risk and vulnerability (ibid, Reyos 2009). It is also generally easier in urban areas than in rural areas to organize a rapid response to approaching extreme-weather events that are judged serious enough to need to move many people temporarily from their homes.

GETTING MORE PRECISION IN ALLOCATING RESPONSIBILITIES FOR CLIMATE CHANGE

Cities (or urbanization in general) are often "blamed" for climate change. Sometimes, this is on the basis of estimates that seem to have no supporting evidence. This can be seen in the much cited suggestion that cities account for 80 percent of all greenhouse gas emissions worldwide (actually, only around 35 percent of the world's greenhouse gas emissions are emitted within city boundaries although city populations account for a higher proportion if emissions are allocated to consumers – see Satterthwaite 2008). In other instances, it seems to be based on an assumption that urbanization will bring higher greenhouse gas emissions – see, for instance, Jiang and Hardee 2009 which assumes that per capita emissions in urban areas are higher than those in rural areas because of "big differences in productive and consumptive behaviours between rural and urban populations." But this certainly not always the case. In regard to consumption-levels, in many nations, a high proportion of high-income high-consumption households live in rural areas and are likely to have higher average GHGs per person or per household than urban dwellers with comparable incomes – for instance because of larger less energy-efficient homes and greater use of (or indeed dependence on) private automobiles. This in part explains why New York and London have much lower average GHGs per person than the US or UK national average. This might be considered a phenomenon that is only common in high-income nations – but it is likely that a significant and often growing proportion of the high-income population in low- and middle-income nations now live outside urban boundaries, even if a high proportion have one or more family member who commutes. In addition, when viewing the energy use of low-income urban dwellers in many low-income nations, it is not clear that their consumption patterns generate more greenhouse gas emissions than their rural counterparts (as discussed in more detail later in this paper).

When assessing the contribution of urban centres or urbanization to climate change, this can be done from the production perspective (by assessing what proportion of GHGs emitted by human activities take place within urban boundaries) or the consumption perspective (assessing all the GHGs emitted as a result of the consumption and waste generation of urban and rural populations). Table 1 below lists the most likely sources of growing GHGs for any city or any nation's urban population from a production and a consumption perspective (using the sectors in the IPCC's 2007 Assessment – Metz et al 2008 - except for the addition of 'public sector and governance' within the consumption perspective).

Table 1: Possible drivers of growing GHGs in a city or a nation's urban population

Sector	What drives growing greenhouse gas emissions in urban areas	What can moderate, stop or reduce this
From a production perspective		
Energy supply	Large part of this is from fossil fuel power stations so growth in electricity provision from high GHG emitting sources.	Shifts to less GHG emitting power generation and distribution; incorporation of electricity-saving devices; increase in proportion of electricity generated from renewable energy sources.
Industry	Growing levels of production; growing energy intensity in what is produced	Shifts away from heavy industries and from industry to services; increasing energy efficiency within enterprises; capture of particular GHGs from waste streams
Forestry and agriculture	Many urban centres have considerable agricultural output and/or forested areas but mostly because of extended boundaries encompassing rural areas; from the production perspective, GHGs generated by deforestation and agriculture are assigned to rural areas.	
Transport	Growing use of private automobiles; increase in average fuel consumption of private automobiles; increased travel by air (although this may not be allocated to urban areas)	Increasing number of trips made by walking, bicycling, public transport; decrease in use of private automobiles and/or decrease in their average fuel consumption (including use of automobiles using alternative fuels). Ensuring urban expansion avoids high levels of private automobile dependence
Residential and commercial buildings	Growth in the use of fossil fuels and/or growth in electricity use from fossil fuels for space heating and/or cooling, lighting and domestic appliances	Cutting fossil fuel/electricity use so cut in the GHGs from space heating (usually the largest user of fossil fuels in temperate climates) and lighting. Much of this relatively easy and with rapid paybacks.
Waste and wastewater	Growing volumes of waste and of more energy-intensive waste	Reducing volumes of wastes and waste management that captures GHGs
From a consumption perspective		
Energy supply	GHGs from energy supply now assigned to consumers of energy supplies/electricity. Consumers also get allocated the GHGs used to make and deliver the goods and services they consume.	As above but also greater focus on less consumption among high-consumption households, shift to less GHG intensive consumption
Industry	As above; GHGs from these no longer allocated to the enterprise that produces these but to the consumers of their products	As above but with a new concern added to reduce the GHGs embedded in goods consumed by residents and to discourage consumption with high GHG emission implications
Forestry and agriculture	GHGs from these no longer allocated to rural areas (where they are produced) but to the consumer of their products (many or most in urban areas).	Encouraging less fossil-fuel intensive production and supply chains (remembering how energy-intensive most commercial agriculture has become); address the very substantial non-CO_2 GHG emissions from farming
Transport	As above; GHGs from fuel use by people's travel outside the urban area they live in is allocated to them so this includes air travel	As above but with a stronger focus on reducing air travel
Residential/ commercial buildings	As above with the addition of the CO_2 emissions arising from construction and building maintenance (including the materials used to do so)	As above, with an added interest in reducing the CO_2 emissions embedded in building materials, fixtures and fittings.

Waste and wastewater	GHGs from these allocated to the consumer who generated the waste, not the waste or waste dump	As above but with a new concern to reduce waste flows that arise from consumption in the city but contribute to GHGs outside its boundaries
Public sector and Governance	Conventional focus on attracting new investment and allowing urban sprawl with little concern for promoting energy efficiency and low GHGs	Governance that encourages and supports all the above; also a strong focus on lowering GHGs through better management of government owned buildings, infrastructure and services; includes a concern for reducing the CO_2 emissions generated in the building of infrastructure.

What is noticeable is that all the above drivers of growing GHGs can take place (and have often taken place) in a national urban population or a particular city without population growth. This is particularly so if the consumption perspective is adopted.

From the production perspective, if cities concentrate energy-intensive production, this will push up their average GHG emissions per person (unless the production is served by electricity not generated by fossil fuels). But in many nations, a considerable proportion of energy-intensive production or electricity generation takes place in rural areas or urban areas too small to be considered cities – for instance mines and mineral processing and fossil-fuelled power stations. Certain rural districts with such energy-intensive production can have GHG emissions per person that are much higher than cities – although most city emissions inventories that adopt the "production perspective" use the "consumption perspective" in regard to electricity (as the emissions generated by the electricity used in the city are allocated to the city, not to the location where the electricity was generated). In addition, when comparisons are made between rural and urban areas for GHG emissions where the high contribution of urban areas is stressed, generally no consideration is given to emissions from agriculture and land-use changes in rural areas which the IPCC suggest account for around 30 percent of all human-induced greenhouse gas emissions (Metz et al 2008).

One obvious objection to using the production perspective is that a large proportion of the products of the rural based mines, forests and land-use changes are to serve production or consumption needs in urban areas so it is misleading to allocate these to rural areas (or rural populations). But the real issue here is the inappropriateness of allocating responsibility for GHG emissions to nations (and by implication to all that nation's population) or urban areas in general or particular cities (and by implication to all the urban population or particular cities' population). Human-induced GHG emissions are not caused by 'people' in general but by specific human activities by specific people or groups of people. It is not 'urban populations' in general that account for high private automobile use or high levels of air travel or high-consumption lifestyles but particular individuals or households (including many that live in rural areas).

The dominant underlying cause of global warming is the consumption of goods and services whose draw on resources for their fabrication, distribution, sale and use (and, for goods, disposal) causes the emission of GHGs. Of course, consideration also needs to be given to the (now heavily globalized) production systems that serve this (and that do so much to encourage high consumption). ***Thus for any individual or household to contribute to global warming, they have to consume goods and services that generate greenhouse gas emissions**.*[1]

A significant proportion of the world's urban (and rural) population has very low levels of GHG emissions because their use of fossil fuels and of electricity generated by fossil fuels and the fossil-fuel input into the goods or services they consume is very low and their consumption patterns contribute little or nothing to the generation of other greenhouse gas emissions. In many low-income nations, most rural and urban households do not have electricity – and thus also no electricity-using household appliances.[2] For low-income households in rural and urban areas in most of the lowest-income nations, recent demographic and health surveys show that fuel-use is dominated by charcoal, firewood or organic wastes (e.g. dung). Where access to these is commercialized, as it is in many urban centres, total fuel use among low-income populations will be low because fuel is expensive and difficult to afford. If urban households are so constrained in their income levels that many family members are severely under-nourished and they often have to resort to only one meal a day, it is hardly likely that their consumption patterns are generating much GHGs. In addition, their fuel use may be largely or completely based on renewable resources which means no net contribution to GHGs.[3]

Drawing on data on cooking fuel use and access to electricity for urban populations from the Demographic and Health Surveys; among the 43 nations for which data were available, 20 had more than half of the urban population relying primarily on non-fossil fuel cooking fuels – charcoal, woodfuel, straw and dung. There were also 15 nations where more than half of urban households did not have access to electricity. But even when low-income households do shift to fossil-fuel based energy sources – in low-income nations, typically kerosene – their consumption levels remain low. Low-income households in Delhi that rely on kerosene typically use 25-30 litres per month (Dhingra et al 2008) which implies CO_2 emissions per person per year of around 0.15-0.2 tonnes (very small by global standards). Low-income urban households also use transport modes that have no GHGs (walking, bicycling) or low GHGs (buses and trains mostly used to more than full capacity). To give an illustration of how low consumption levels are, in Kibera, Nairobi's largest informal settlement (with around 600,000 inhabitants), a 1998 survey found that only 18% had electricity, only 7% had a bicycle and only 1.5% had a fridge; 31 percent of all households surveyed had no radio, television or fridge (APHRC 2002). In India, **s**tudies of households' CO_2 emissions from household energy use and transport (covering rural and urban areas) found that average CO_2 emissions ranged from 335 kg per capita per year for the lowest income class (below 3,000 rupees a month) to an average of 1,494 kg per capita per year for the highest income class (above 30,000 rupees a month). Those households earning less than 3,000 rupees a month had less than a fifth of the use of electricity per capita of the 30,000 rupee plus households and one seventh of the CO_2 emissions per capita for transport (Ananthapadmanabhan, Srinivas and Gopal 2007). When low-income urban dwellers get electricity, the few studies available on consumption levels suggest that these are very low – for instance among low-income households in three Indian cities (Kulkarni and Krishnayya 1994), just 32-33 kilowatt hours per month (which would mean these were $1/20^{th}$ to $1/40^{th}$ of the average per person in high-income nations). A very considerable number of (rural and

[1] Consideration is also needed to how particles in the atmosphere from fuel combustion, open field and forest burning can contribute to warming – see Bond, Venkataraman and Masera 2004.
[2] Apart of course from those like radios that can be powered by batteries
[3] The assumption that widespread use of firewood or charcoal among urban populations was driving deforestation was shown to be inaccurate in detailed studies in the late 1980s (Leach and Mearns 1989); in addition, it is clear that firewood use by the rural or urban poor is very rarely the main driver of deforestation (which is more driven by commercial forest enterprises and land clearance for agriculture/cattle raising).

urban) people may have zero or negative GHG emissions per person. These would include many low-income urban dwellers whose livelihoods are based on reclaiming and re-using or recycling waste where the 'GHGs saved' from their work equals or exceeds the GHG emissions that their consumption causes. It may also include tens of millions of small farmers able and willing to engage in sustainable agriculture and in maintaining or increasing forests on their land.

So perhaps up to a fifth of the world's population have incomes and consumption levels that are so low that they are best not included in allocations of responsibility for GHGs. The failure of more than 50 years of development to reduce the number of people living in poverty (which also means the number with very low and inadequate consumption levels)[4] also suggests that a very considerable proportion of the world's population will continue to live in extreme poverty and in effect contribute very little to future GHGs. Of course, how income distribution changes within urban populations has very large implications for future GHGs. For instance, drawing on the figures noted above, a household added to India's urban population with an income of 30,000 plus rupees a month is likely to contribute five or more times the GHGs of a household with less than 3,000 rupees a month. And 30,000 rupees a month is not a high income by global standards – it is around US$625 per month. So adding an urban household to India's urban population with say 90,000 rupees a month may contribute 10 or more times the GHG emissions of those with less than 3,000 rupees per month.

Thus, it is neither fair nor accurate to suggest that population growth or urbanization (growth in the proportion of a national population living in urban areas) necessarily causes increases in GHGs. It depends on the form and levels of consumption among the growing population or among the population that moves to urban areas (the immediate cause of urbanization). Many urban centres in sub-Saharan Africa and low-income nations in Asia (including many with growing populations) are likely to have very low average GHGs per person – whether from a production perspective (they have very little or no industry) or a consumption perspective (with a very low proportion of residents or no residents with high consumption lifestyles). But this is not recognized, in part because of no data available on their emissions. But note should be taken of the many nations whose average carbon dioxide emissions per person are under 0.2 tonnes per person per year (so less than 1/200th that of the USA or Canada). By contrast, as discussed in more detail below, there are nations with slow or no population growth and with very small increases in urbanization levels where both total GHGs and GHGs per person have increased rapidly in recent decades. This would be even more the case if there were statistics of GHG emissions from a consumption perspective.

In addition, it is not fair to equate increases in GHGs per person among low-income populations (say from 0.1 to 0.5 tonnes of CO_2e per person per year) with comparable GHG increases among high-income populations (for instance from 7.1 to 7.5 tonnes per person per year). The reduction of global emissions to avoid dangerous climate change depends on achieving a particular global average for emissions per person – what is sometimes termed the 'fair share' level that is generally set at around 2 tonnes of CO_2e per person. So making provision for increases in GHGs for those people below the 'fair-share' so they can move out of poverty cannot be considered in the same light as increases in emissions from those already above the fair share. It is only the high current

[4] Using the $1 a day poverty line, urban poverty appears to have decreased in many nations – but this poverty line is known to greatly understate the scale and depth of urban poverty because in many urban contexts, especially in successful cities in low and middle income nations, the costs of food and of non-food needs (including rent for housing, payment for water and sanitation, keeping children at school, household energy, transport and health care) is much higher than this – see Satterthwaite 2004, Bapat 2009, Sabry 2009.

and historical contributions of wealthy people's consumption to GHGs in the atmosphere that makes the modest increases sought by low-income groups appear to be a problem.

If what is stated above is accepted, it changes the discussion of the links between population and the causes of climate change (and within this the links between urbanization and the causes of climate change). Perhaps the most fundamental point is that the increase in GHGs per person by people with below the global 'fair-share' figure would be treated differently from increases by people with above it. Most of the nations with the most rapid growth in their national (and urban) populations have GHG emissions per person far below the 'fair-share' level.
It is also worth looking at the associations between population growth and GHG emission growth. Today, many of the nations with the most rapidly growing national and urban populations have very low levels of CO_2 emissions per person and have had slow growth in this; many of the nations with the slowest growing national and urban populations have the highest levels of GHGs per person and have had rapid growth in CO_2 emissions per person.[5] Table 1 illustrates this by contrasting the nations with low population growth and high growth in CO_2 emissions per person between 1980 and 2005 and nations with high population growth and relatively slow CO_2 emissions growth per person during this same period.[6] (Table A1 presents data on this for most of the world's nations).

Looking first at the nations with the highest and lowest CO_2 emissions. Data are available for nations' average CO_2 emissions per person for 185 nations (see Table A1) so these can be divided into five sets of 37 nations. All but four of the 37 nations with the highest CO_2 emissions per person in 2005 were high-income nations (encompassing North America and much of Europe). Three small population high-income Middle-East oil producers had the highest emissions (Qatar, Kuwait, UAR) and very high population growth rates (mostly from immigation?). But generally this group of high-emission nations had very low population growth rates 1980-2005 (more than half had population growth rates of less than 1 percent a year). Of the 37 nations with the lowest CO_2 emissions per person, all were low-income nations and most (30) were in sub-Saharan Africa. 27 had population growth rates of more than 2 percent a year; 11 had population growth rates of more than 3 percent a year,

[5] Some high-income nations only have a slow growth in GHG emissions per person because they have long had very high emissions per person; the data are also only available for the production perspective; if data were available for the consumption perspective, it is likely to show that high-income nations have had much more growth in emissions per capita and many low- and middle-income nations much less growth.

[6] This analysis had to focus only on CO_2 emissions and not to include GHGs from land-use changes as the data on these over time by nation are not available.

Table 1: The nations with high growth rates for CO_2 emissions and low population growth rates and with low growth rates for CO_2 emissions and high population growth rates

Country	Tonnes CO_2 per capita, 2005	Region and per capita income category		Million tonnes of carbon dioxide (mtoc)		Population (thousands)		GHG growth $mtCO_2$ 1980 minus 2005	Popn growth 1980 minus 2005	Compound growth rate 1980 to 2005	
				1980	2005	1980	2005			CO_2 em	Popn
Nations with low population growth (below 1.5% a year) and CO_2 emission growth rates of 3% or more a year, 1980 to 2005											
Thailand	3.7	AS	LM	36.8	233.2	46,809	63,003	196.4	16,194	7.7	1.2
Seychelles	7.0	AF	UM	0.1	0.6	66	86	0.5	19	7.4	1.0
Mauritius	2.7	AF	UM	0.6	3.4	966	1,241	2.8	275	7.2	1.0
Saint Lucia	2.5	LA	UM	0.1	0.4	118	161	0.3	43	5.7	1.3
China	4.2	AS	LM	1,443.2	5,577.3	998,877	1,312,979	4134.1	314,102	5.6	1.1
Korea (South)	9.9	AS	high	129.7	474.5	38,124	47,870	344.8	9,746	5.3	0.9
El Salvador	1.0	LA	LM	1.9	6.6	4,586	6,668	4.7	2,082	5.1	1.5
Trinidad & Tobago	19.6	LA	UM	8.0	26.0	1,082	1,324	18	242	4.8	0.8
Sri Lanka	0.7	AS	LM	4.0	12.9	14,941	19,121	8.9	4,180	4.8	1.0
Chile	3.7	LA	UM	22.0	60.7	11,174	16,295	38.7	5,121	4.1	1.5
Malta	6.5	EUR	high	1.0	2.6	324	403	1.6	78	3.9	0.9
Portugal	6.4	EUR	high	26.9	67.5	9,766	10,528	40.6	762	3.7	0.3
Cyprus	9.4	AS	high	3.2	7.9	611	836	4.7	225	3.7	1.3
New Zealand	8.7	PAC	high	16.8	35.5	3,113	4,097	18.7	984	3.0	1.1
Nations with high population growth (above 2.5% a year) and CO_2 emission growth rates that are significantly slower or negative 1980 to 2005											
Gambia	0.2	AF	Low	0.2	0.3	671	1,617	0.1	946	1.6	3.6
Djibouti	0.5	AF		0.3	0.4	340	804	0.1	464	1.2	3.5
Cote d'Ivoire	0.4	AF	Low	4.0	6.6	8,344	18,585	2.6	10,241	2.0	3.3
Chad	0.0	AF	Low	0.2	0.1	4,611	10,146	-0.1	5,534	-2.7	3.2
Kenya	0.3	AF	Low	6.2	10.9	16,282	35,599	4.7	19,316	2.3	3.2
Malawi	0.1	AF	Low	0.7	1.0	6,215	13,226	0.3	7,011	1.4	3.1
Congo, Dem. Republic	0.0	AF	Low	3.3	2.3	28,071	58,741	-1	30,670	-1.4	3.0
Madagascar	0.2	AF	Low	1.6	2.8	9,059	18,643	1.2	9,583	2.3	2.9
Burkina Faso	0.1	AF	Low	0.4	0.7	6,827	13,933	0.3	7,106	2.3	2.9
Nigeria	0.7	AF	Low	70.5	97.7	71,065	141,356	27.2	70,291	1.3	2.8
Guinea	0.2	AF	Low	0.9	1.4	4,575	9,003	0.5	4,428	1.8	2.7
Brunei	13.9	AS	High	3.3	5.2	193	374	1.9	181	1.8	2.7
Libya	8.2	NA	UM	28.5	48.8	3,063	5,918	20.3	2,855	2.2	2.7
Zambia	0.2	AF	Low	3.4	2.4	5,946	11,478	-1	5,532	-1.4	2.7
Mali	0.1	AF	low	0.4	0.6	6,069	11,611	0.2	5,543	1.6	2.6
Gabon	3.7	AF	UM	4.4	4.8	682	1,291	0.4	609	0.3	2.6
Liberia	0.1	AF	low	2.0	0.5	1,868	3,442	-1.5	1,574	-5.4	2.5
Vanuatu	0.5	PAC	LM	0.1	0.1	117	215	0	98	0.0	2.5

SOURCE: Data on GHG emissions from Climate Analysis Indicators Tool (CAIT) Version 6.0. (Washington, DC: World Resources Institute, drawing on Marland, Boden and Andres (2008)); data on population from UN 2008.

Looking at the nations with the highest and lowest population growth rates, 2000-2005; apart from the three oil-producing high income Middle East nations noted above, almost all nations with the highest population growth rates 2000-2005 were low-income nations with per capita CO_2 emissions per person below 1 ton, half had figures below 0.2 and 12 had figures below 0.1. For the 37 nations with the slowest population growth (including 8 with declining populations), nine were high-income nations (including Japan and most of the wealthiest European nations), 12 were upper middle-income nations (all in Latin America and Europe), 13 were low-income nations (7 in Europe, all part of the former Soviet Union) and only two were low-income (Moldova and Armenia).

When considering how CO_2 emissions per person change in relation to population growth:
When considering the period 1980-2005, many of the nations with among the slowest population growth rates had among the fastest growth rates in CO_2 emissions while many of the nations with among the fastest population growth rates had among the slowest increases in CO_2 emissions. There are some obvious contrasts between the two groups of nations in Table 1. The low-population growth high CO_2 emissions growth nations are mostly high-income nations or upper-middle-income nations, most are in Europe or Asia and all had very considerable economic success in this period; the high population growth low emissions growth nations are mostly low-income nations, most are in sub-Saharan Africa and many had little economic success in this period. Perhaps not surprisingly, China is within the first group. This group also includes Portugal and Malta; Italy, Spain and Greece also enjoyed a very considerable increase in their per capita incomes between 1980 and 2005 and had (by global standards) low population growth rates. This group includes South Korea, one of the few Asian economies whose per capita income grew sufficiently to be reclassified as among the world's high-income nations. ***Clearly, any consideration of changes in nations' CO_2 emissions in the last few decades cannot be separated from a consideration of economic changes that include the extent (or not) of economic growth and the sectors where this growth took place and changes in incomes and how these are distributed within the national population.*** For China, the very rapid growth in production from 1980 to 2005 (much of it for export) is an important underpinning for its rapid growth in CO_2 emissions. This is also likely to have been important for South Korea and perhaps for Thailand. For several of the nations listed, including Portugal, South Korea, Chile and New Zealand, it is likely that the growth in per capita incomes and increases in incomes (and consumption) that benefitted a large part of their national populations is an important underpinning for CO_2 emissions growth – although this is not fully represented in the CO_2 emission figures for nations because these take no account of the CO_2 emissions embedded in imported goods. Perhaps the success of the tourist industry contributed to such emissions growth in some of the southern European nations (and perhaps Thailand) – and if this was tourists from other nations, within the consumption perspective, these would be allocated to the tourists' nation of residence.

For the group of nations with high population growth rates and low CO_2 emission growth rates, almost all are low-income nations and many are among the lowest-income nations in the world and among those that had the least economic growth between 1980 and 2005. Some have had a decline in CO_2 emissions between 1980 and 2005 – for instance Zambia, Congo DR and Chad.

The lack of an association between population growth and CO_2 emissions per person is also shown by a range of nations that had very rapid decreases in per capita emissions 1980-2005 with very slow population growth or no population growth or much slower rates of decrease in population –

for instance Germany, Denmark, the Russian Federation, the Czech Republic, Poland, Sweden, Hungary, Slovakia, Belarus, Estonia, Lithuania, Romania, Moldova and Georgia.

GETTING NEEDED DETAIL IN WHAT PRODUCTION OR CONSUMPTION CHANGES DRIVE CHANGES IN GREENHOUSE GAS EMISSIONS

Perhaps the key issue from the above discussion is that far more attention needs to be given to changes in production and changes in consumption within nations, if we are to identify the main potential contributors to GHG emission growth in the future. The main implications of Table 1 are to caution against any assumption that population growth necessarily causes increases in CO_2 emissions. What is needed for any consideration of climate change and population is a consideration for each nation of changes in production, changes in income and its distribution and changes in consumption. Of course, this is linked to urbanization because urbanization is driven by the increasing proportion of GDP generated by industry and services (most of which is located in urban areas) while the form that urbanization takes is much influenced by the social and spatial distribution of the incomes arising from these economic changes. It also cautions against any generalization related to climate change and population applied to 'developing countries' or even to particular regions ('sub-Saharan Africa') because there will be such diversity between nations in almost all the factors that influence production and consumption patterns. Also in what possibilities a nation has in delinking CO_2 emissions from growing production and consumption (as in, for instance, nations that can draw on hydro-electricity for a significant proportion of demand for electricity).

Considering the 184 nations for which there are data on CO_2 emissions in 1980 and 2005. To look at which nations contributed most to the increase in CO_2 emissions between 1980 and 2005. Eritrea, Namibia and Palau had to be excluded because of no data on their 1980 CO_2 emissions. So the rest were ordered by the total increase in CO_2 (in millions of tonnes of CO_2) and then divided into five sets, four of 36 nations and the last set with 37 nations – see Table 2.

Table 2:

Set of nations	Share in global increase in CO_2 1980-2005	Share in global population growth 1980-2005
36 nations with largest increases in CO_2 emissions	113.9	72.0
Next 36 nations	5.4	12.2
Next 36 nations	0.8	8.3
Next 36 nations	0.06	2.3
37 nations with the smallest increases in CO_2 (including those with declines)	- 20.2	5.0

The first set of 36 nations accounted for 114 percent of the global increase in CO_2 emissions 1980-2005 because the global figure is lower than the figure for these nations, since many nations had large falls in CO_2 emissions between 1980 and 2005.

Looking at the period 1950 to 1980, for the nations for which there are data on growth rates for CO_2 emissions per person, many nations with the most rapid increase had slow population growth rates while a few nations with the most rapid increase in population had slow increases in emissions.

What are today the world's wealthiest nations accounted for 45% of the increase in CO_2 emissions between 1950 and 1980 but only 11% of the population growth. The USA alone accounted for 17.5% of the growth with Japan (6.4%), Germany (4.4%), Italy (2.7%), Canada (2.2%) and France (2.2%). The Russian Federation accounted for 13%, China for 10.7%. Again, if data were available for allocating emissions from the consumption perspective, this would lead to an even larger lack of association between growth in CO_2 emissions and growth in population.

HOW MUCH DOES ECONOMIC PERFORMANCE COINCIDE WITH GROWTH IN PER CAPITA EMISSIONS

Table 3 compares the different regions in regard to their share of world population growth and CO_2 emission growth between 1980 and 2005 and between 1950 and 1980. This highlights how sub-Saharan Africa accounted for very little of the growth in CO_2 emissions for both these periods (less than 3%) but for 18.5% of population growth between 1980 and 2005 and 10.7% of population growth between 1950 and 1980. Meanwhile, Northern America accounted for around 4% of population growth for both periods but for 20% of the growth in CO_2 emissions 1950 to 1980 and 14% of the growth in emissions, 1980-2005. This is despite the fact that in 1950, CO_2 emissions per person in Northern America were already very high (much higher than most high-income nations today). Table 3 also includes figures for the five nations with the largest increases in CO_2 emissions. Note how China accounted for a much larger share of the increase in CO_2 emissions than India, but with a smaller contribution to increases in population. USA, Japan and South Korea contributed far more to increases in CO_2 emissions than they contributed to increases in population. Note too that China and sub-Saharan Africa accounted for similar proportions of the increase in the world's population 1980-2005 (15.3 and 18.5 percent) but China's contribution to increased CO_2 emissions was nearly 20 times that of sub-Saharan Africa. At a risk of unnecessary repetition, it is the number of consumers (and their consumption) that drives GHG emissions, not the number of people (while from a production perspective, it is also the nature and location of production). Europe's share in CO_2 emissions growth is negative because many European nations had lower emissions in 2005 than in 1980, especially the Russian Federation, Ukraine, Poland and Germany. But if data were available for a 'consumption perspective' analysis, this might well change this – with much higher emissions attributed to wealthy European nations.

Table 3: Share of the world's population growth and CO_2 emissions 1980-2005

	1980-2005		1950-1980	
Region	Population growth	CO_2 emissions	Population growth	CO_2 emissions
Africa, North	3.0	2.5	2.5	1.0
Africa, sub-Saharan	18.5	2.4	10.7	2.2
Asia	63.1	84.9	64.1	30.6
Europe	1.8	-12.9	7.6	39.7
Latin America and Caribbean	9.4	6.7	10.2	5.3
Northern America	4.0	14.2	4.4	19.9
Oceania	0.4	2.1	0.4	1.3
Nations with largest increase in population and in CO_2 Emissions 1980-2005; share of global growth				
China	15.3%	45.7%		
USA	3.4%	12.9%		

India	21.7%	10.1%		
Korea, Rep of	0.5%	3.8%		
Japan	0.5%	3.7%		

SOURCE: Data on GHG emissions from Climate Analysis Indicators Tool (CAIT) Version 6.0. (Washington, DC: World Resources Institute, drawing on Marland, Boden and Andres (2008)); data on population from UN 2008.

To return to the qualitative difference between nations with increasing emissions per person above and below the global 'fair-share.' If it was possible to take out the increase in CO_2 emissions 1980-2005 that was in nations with below the 'fair-share' per person in 2005, then the growth in emissions would be even more strongly tied to high-income nations or regions with slow population growth rates in Tables 2 and 3. 63% of the world's growth in population from 1980 to 2005 took place in countries with average CO_2 emissions per person below 2.0 tonnes in 2005.

Table 4 shows the different contributions of nations to population growth and to CO_2 emissions, 1980 to 2005, when they are classified by their per capita income levels. Nations classified as 'low-income' in 2005 contributed far more to global population growth between 1950 and 2005 than they did to CO_2 emissions. Nations classified as 'high-income' in 2005 accounted for far more CO_2 emission growth than for population growth. Again, if we shifted to a consumption focused analysis, the contrasts between the nations contributing most to population growth and the nations contributing most to CO_2 emissions would be even more dramatic.

Table 4: The contribution to the world's population growth and CO_2 emissions 1980-2005 from low, lower-middle, upper-middle and high-income nations

	1980-2005		1950-1980	
	Popn growth	CO_2 emissions	Popn growth	CO_2 emissions
Low-income nations	52.1%	12.8%	36.0%	5.6%
Lower middle income nations	35.7%	53.2%	47.0%	39.8%
Upper middle-income nations	5.0%	5.0%	5.7%	9.6%
High-income nations	7.2%	29.1%	11.2%	44.9%

SOURCE: Data on GHG emissions from Climate Analysis Indicators Tool (CAIT) Version 6.0. (Washington, DC: World Resources Institute, drawing on Marland, Boden and Andres (2008)); data on population from UN 2008.

So population growth can only be a significant contributor to GHG emissions if the people that make up this population growth enjoy levels of consumption that cause significant levels of GHGs per person (or from the production perspective live in nations with a rapid increase in GHG generating production). Of course, this has relevance not only today but also to the future in the life-time contribution of people born now to GHGs***. If most of the growth in the world's population is among low-income households in low-income nations who never 'get out of poverty', then there is and will be little connection between population growth and GHG emission growth..***

But even if a significant proportion of the future increase in GHGs is from certain nations with rapid population growth, if this is in nations with below the 'fair-share' in average per capita emissions, it cannot be judged as comparable to those in nations with above 'fair-share' per capita emissions. More to the point, a growth in GHGs per capita among those individuals or households with below 'fair-share' emission levels (whatever the wealth of that nation) should be considered as qualitatively different from any growth in GHGs per capita among individuals or households with above 'fair share' levels. Of course, this is very difficult to act on, in part because of limited data, in part because it is difficult to allow and support needed consumption increases among low-income groups while bringing down GHG emissions per person among groups with above fair share levels.

URBANIZATION AND CLIMATE CHANGE

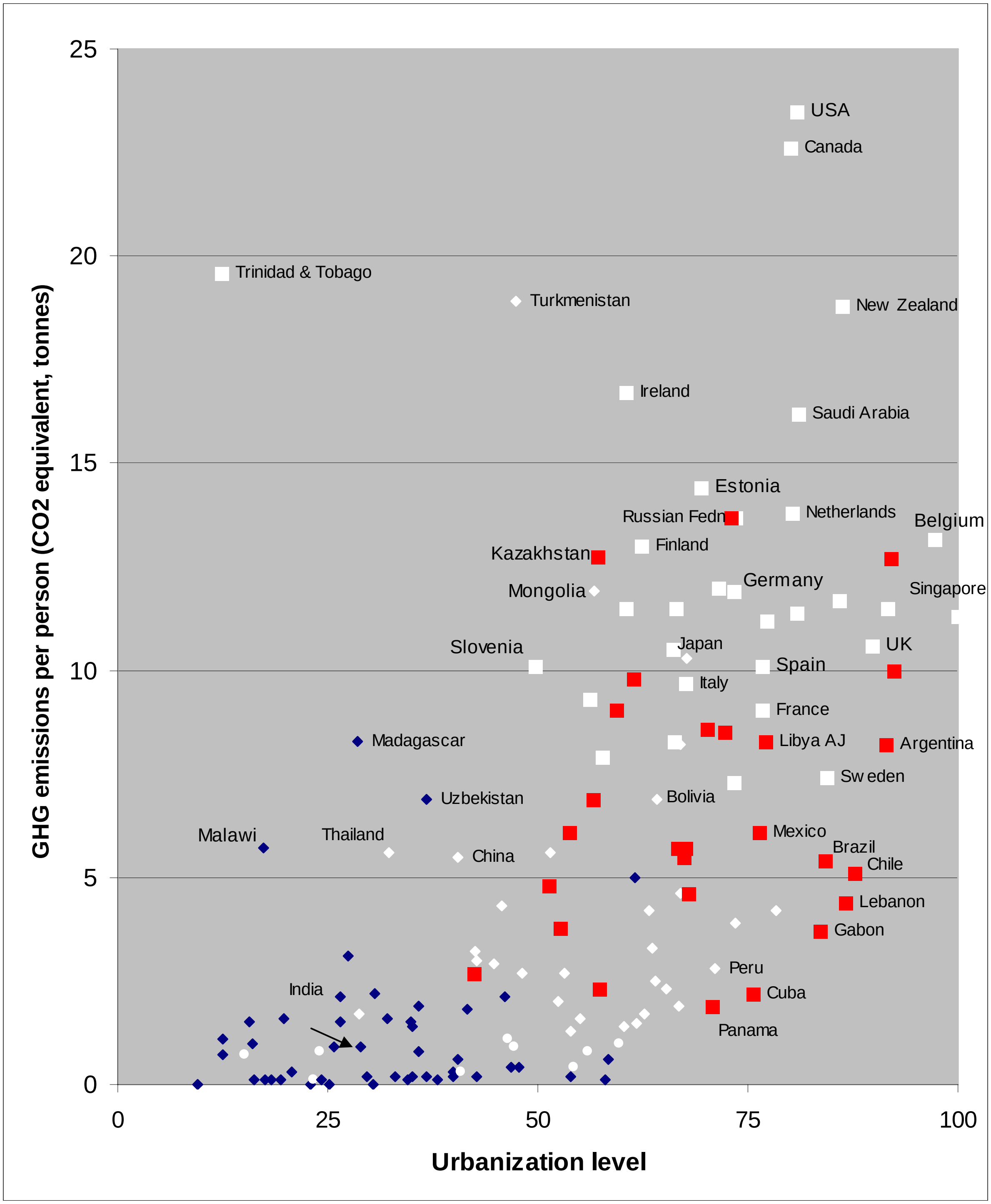
Since most of the world's growth in population in the next few decades is likely to be in urban areas in low- and middle-income nations (UN 2008), the link between population growth and GHG emissions is much influenced by the GHG emission implications of urbanization.

Figure 1 shows nations' level of urbanization plotted against GHGs per capita for 2005 (in CO_2e). Of course, the GHG emissions per person figures are based on the production perspective. The small dark triangles are low-income nations, the small white triangles are lower-middle income nations, the large dark squares are upper-middle income nations and the large white squares are high-income nations. The figure shows few surprises. In general, the more urbanized the nation the higher the GHG emissions per person although with considerable variation in regard to emissions levels per person for nations with comparable urbanization levels. Also, the wealthier the nation, the higher the GHGs per capita although with very considerable variations in GHGs per capita for nations with comparable levels of urbanization and very considerable variations in levels of urbanization for nations with comparable GHGs per capita.

Most low-income nations have less than half their population in urban areas; many have GHGs per capita below 0.2 tonnes a year and very few have above 2.5 tonnes. Most lower-middle income nations have more than 40 percent of their population in urban areas and most have GHG emissions per person per year in the 0.5 to 5 tonnes range. Most upper middle-income nations have more than 60 percent of their population in urban areas and their GHG emissions per person per year are mostly within the 3-10 tonnes range. Most high-income nations have more than 60 percent of their population in urban areas and most have their GHG emissions per person per year within the 7-15 tonnes range. Of course, part of the large variation in GHGs per capita between nations with comparable levels of urbanization may be explained by the different criteria used to define urban populations or urban places. For instance, Trinidad and Tobago appears very unurbanized in relation to its high GHGs per person but this is because the official figure for its level of urbanization bears no relation to the proportion of its population in urban areas.

So is urbanization a driver of climate change? It is generally assumed that it is. But urbanization cannot be the "driver" in that it is driven mainly by economic and political change. In almost all low- and middle-income nations, urbanization in the last few decades has been driven by the investment patterns that have increased the proportion of production in industry and services (mostly located in urban areas) and that then underpinned the increase in the proportion of the economically active population working in industry and services. So increasing levels of urbanization track increasing proportions of GDP generated by industry and services and increasing proportions of the workforce working in industry and services (see Figure 2). This strong association between growing levels of urbanization and changing investment/production patterns was less evident in most nations in Asia and Africa in earlier decades, around the achievement of political independence, especially in nations where the rights of the population to live and/or work in urban areas had been controlled; thus much urbanization just pre or post Independence was the movement of individuals or households to cities that previously had controls on their right to live or work there and the building of the institutional infrastructure that is part of a nation-state so here political change was a major influence on increasing urbanization levels.[7]

Figure 1: GHG emissions per person for nations against level of urbanization, 2005



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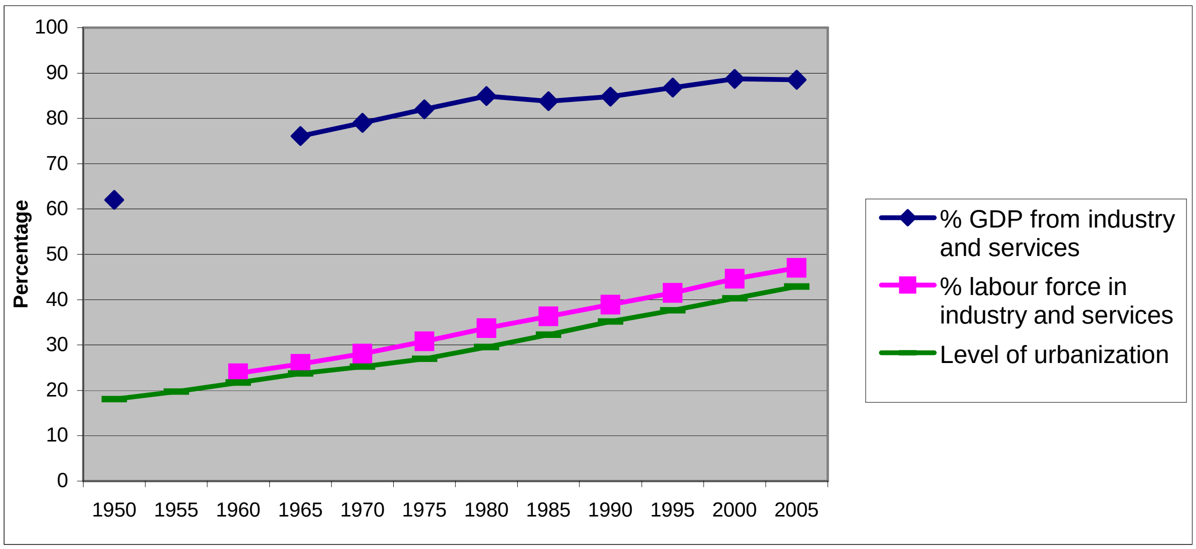
7 The influences of economic and political change on urbanization and how they and their relative importance have changed in low- and middle-income nations is discussed in more depth and detail in Satterthwaite 2007.

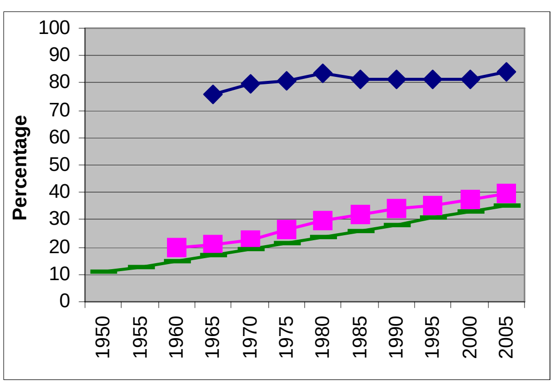
From a production perspective, what drives greenhouse gas emissions in low-income and most lower-middle income nations is increasing use of fossil fuels in industries and services (and usually electricity generation) and this is related to urbanization in the extent to which this production is within urban boundaries. It is likely that the rapid growth in greenhouse gas emissions in cities such as Beijing and Shanghai are driven in large part by the very large expansion in manufacturing there.

Figure 2: Changes in the proportion of GDP from industry and services, of the labour force working in industry and services and of the population in urban areas, 1950–2005

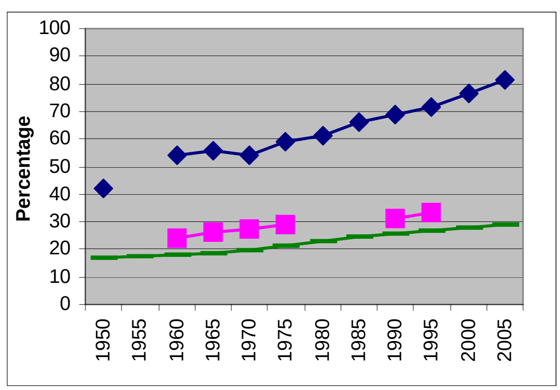
a) All low- and middle-income nations



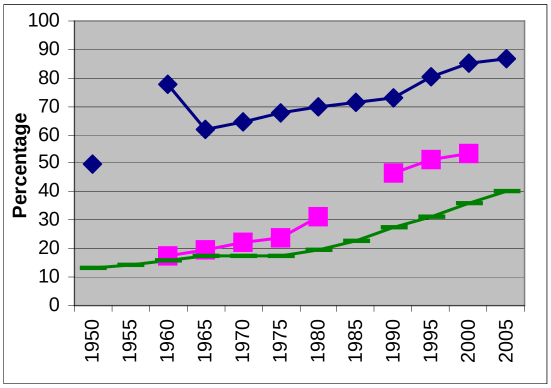
b) Sub-Saharan Africa



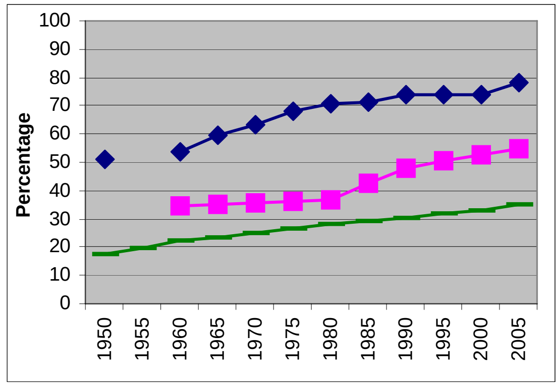
c) India



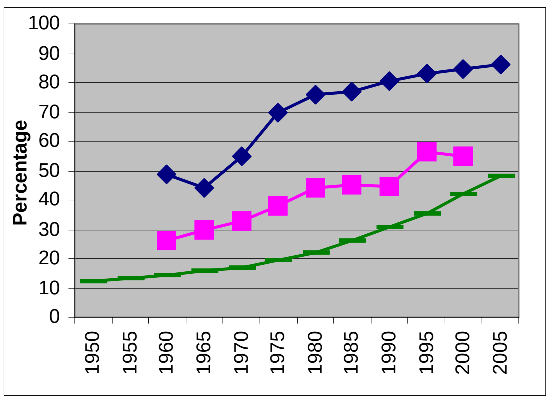
d) China



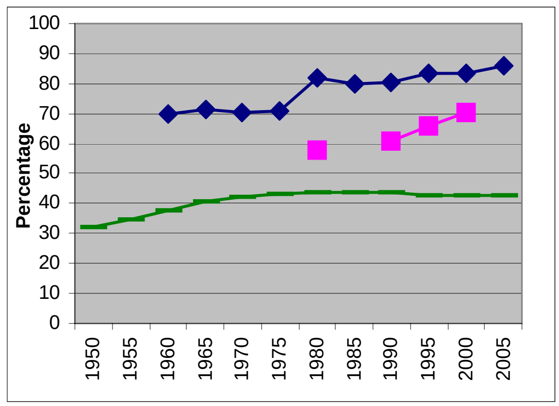
e) Pakistan



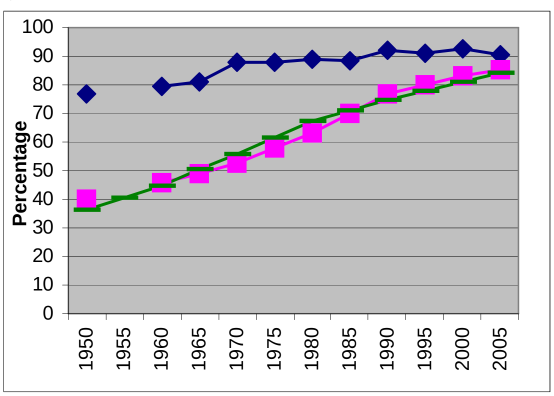
f) Indonesia



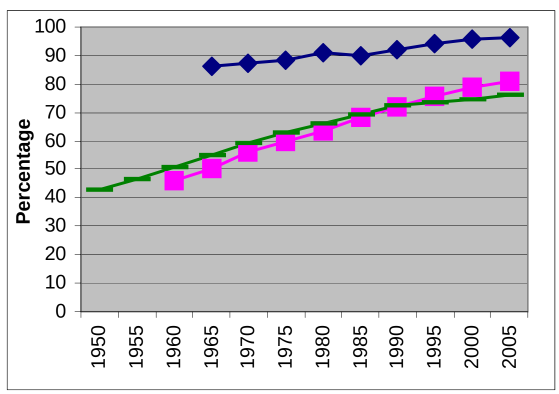
g) Egypt



h) Brazil



i) Mexico



SOURCES: Drawn from Satterthwaite 2007. Percentage GDP in industry and services from World Bank, *World Development Indicators Online*, The World Bank, Washington DC; percentage of workforce in industry and services from *World Development Indicators Online*, op. cit., FAO (2006), *FAOSTAT Online Statistical Service*, FAO, Rome and World Resource Institute, *Earthtrends (* http://earthtrends.wri.org/searchable_db); level of urbanization from United Nations (2006), *World Urbanization Prospects: the 2005 Revision*, United Nations Population Division, Department of Economic and Social Affairs, CD-ROM Edition – Data in digital form (POP/DB/WUP/Rev.2005), United Nations, New York. Some historic data for percentage GDP in industry and services for India and China from Gordon, Jim and Poonam Gupta (2003), *Understanding India's Services Revolution*, Paper prepared for the IMF-NCAER Conference, A Tale of Two Giants: India's and China's Experience with Reform, November 14-16, New Delhi, 34 pages.

But as low- and middle-income nations get wealthier (which also means becoming more urbanized), so the location of consumers and their consumption behaviour becomes an increasingly important contributor to GHGs. What increasingly drives GHG emissions in wealthy cities or cities rapidly becoming wealthier is the consumption behaviour of those that live there. For instance, one would guess that within India's urban population, it is generally urban areas with heavy industry that have the highest GHGs per person but in particular successful cities such as Delhi, Mumbai, Pune and Bangalore, GHG emissions per person may be increasingly driven by the consumption patterns of their higher income groups.

But as noted already, in successful nations or successful cities, it is common for a growing proportion of middle and upper income households to live outside city boundaries. In many high-income nations, there are also many manufacturing and service enterprises that locate in rural areas. But here, the division between rural and urban in terms of employment structures and access to infrastructure and services has disappeared; in effect, virtually all rural areas are 'urban' in that almost all of the population do not work in primary activities and almost all enjoy levels of provision for infrastructure and services that were previously only associated with urban locations. So in high-income nations, there can be a large increase in per capita emissions and very little or no increase in urbanization levels,

If the real driver of climate change is rising consumption, how do we arrive at a more accurate understanding of the links between urbanization and climate change? We know that allocating responsibilities for GHGs through average per capita emission figures for nations is misleading for at least two reasons. The first is that these are based on where GHGs are emitted, not on what caused them to be emitted. If GHGs were allocated to the homeplace of the consumers whose consumption was the root cause of these GHGs, it would considerably increase the GHGs per person in most high-income nations (and cities) and considerably decrease the GHGs per person in nations (and cities) who were successful exporters of consumer goods (especially those with high GHG emissions in their manufacture and transport to markets). The second is that it is very misleading to discuss responsibilities for GHGs per person using national averages because of the very large differences in GHGs per person within each nation. There are large differentials in GHGs per person in each nation between the highest-income and lowest-income population. Perhaps a hundred-fold or even a thousand-fold or more difference between GHGs per person in many low and middle-income nations if we could compare the wealthiest 1 percent and the poorest 1 percent?

So to return to the real driver of GHG emission growth – high consumption and rapid growth in consumption, not population (or rapid population growth). The discussion of responsibilities for GHGs is always obscured by only using national averages as if all citizens in a nation had equal responsibilities for emitting GHGs. And by not allocating GHGs to consumers. If it was possible to assess the GHG emission implications of household's consumption and lifestyle, it is likely that the very rich would have GHGs per person that were millions of times those of large sections of the poorest groups. If this was mapped on the whole globe's population irrespective of which nation they live in, it would produce a figure similar to the 'champagne glass' figure used by the UNDP Human Development Report in 1992 to highlight global inequality in incomes (see Figure 3)

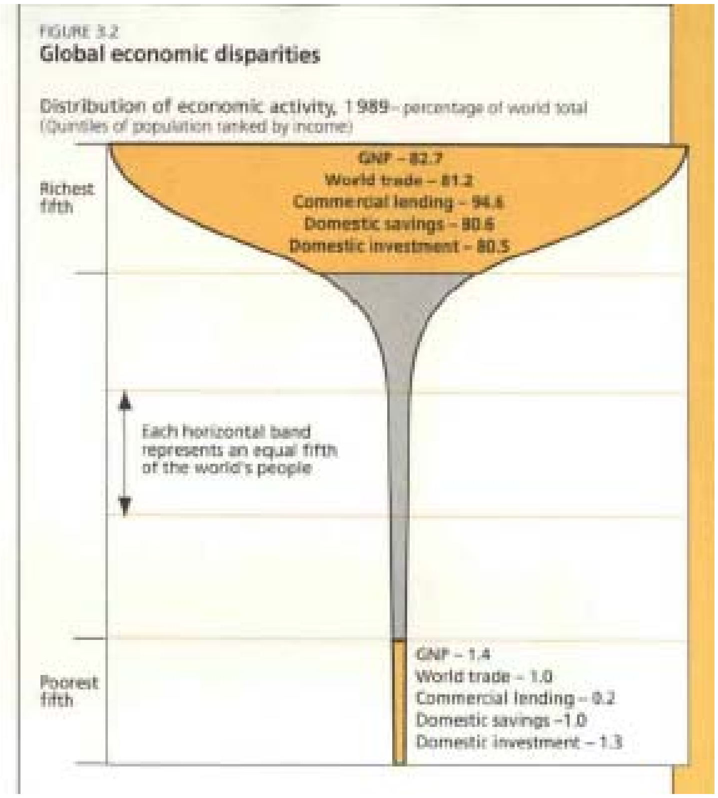
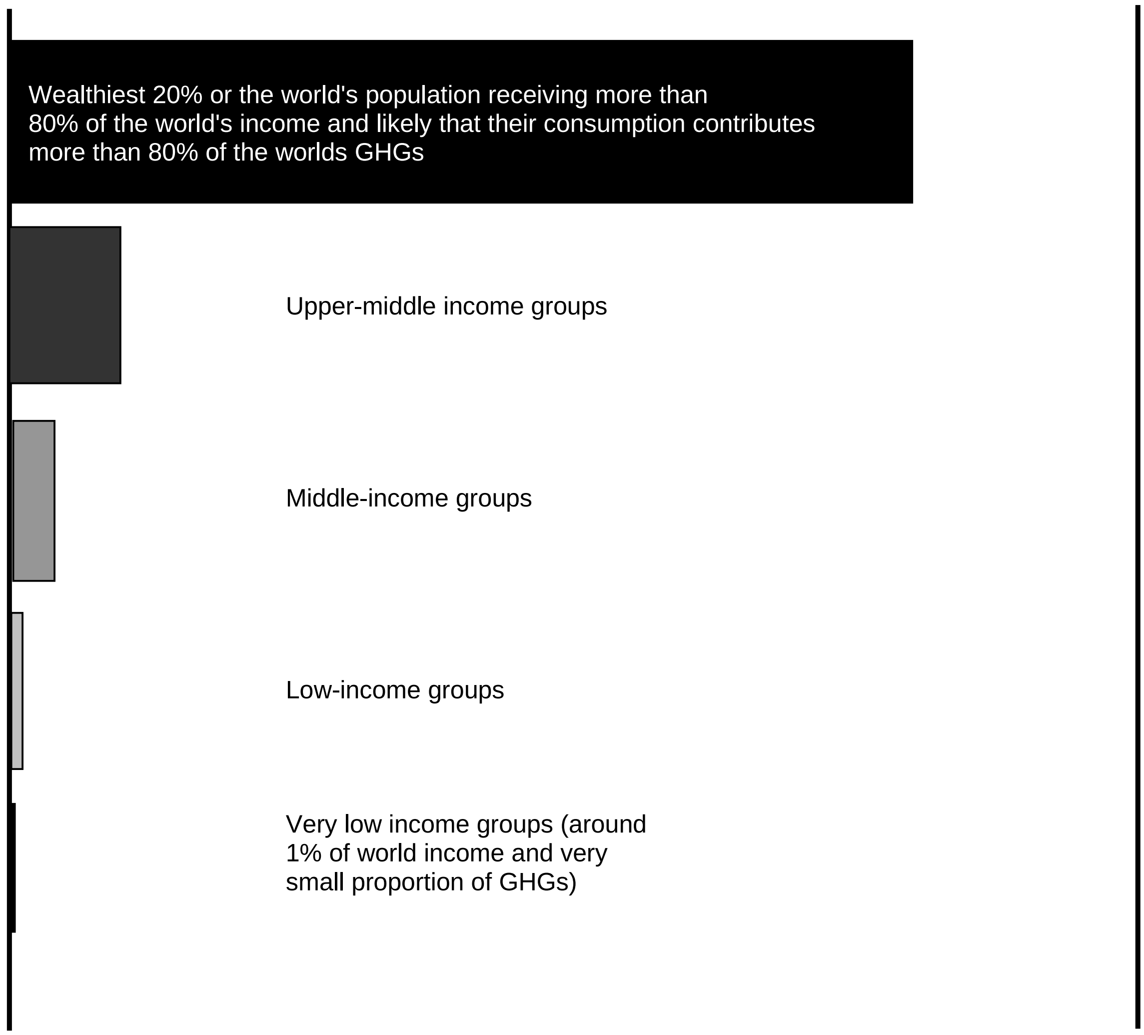


Figure 3: Global economic disparities (taken from the 1992 Human Development Report).

If GHGs were allocated to people (not nations) on the basis of the contribution of their consumption to GHGs, it is likely that the wealthiest fifth of the world's population would account for more than 80 percent of all GHGs (they have more than 80 percent of the world's income) and for an even higher proportion of historical contributions to GHGs. The consumption of the fifth of the world's population with the lowest income levels may account for only around 1 percent of all GHGs.

Figure 4: Current contributions to human induced GHGs by income group (globally)



Thus, it is very simplistic and misleading to apply the 'IPAT formula' (Impact = Population X Affluence X Technology) to GHG emissions when a large part of the world's population generate such a tiny proportion of total GHGs. It is also misleading to compare growth in emissions per person without separating those people with below and above the 'fair share' level. But it serves a range of interests to do so, especially those individuals with high consumption lifestyles. In international discussions, it also serves the governments of those nations with high current and historical contributions to human induced GHGs in the atmosphere. And it serves those nations that keep down the greenhouse gas emissions ascribed to them by importing most of the goods whose fabrication has high GHG emissions.

So in conclusion:

It is high consumption levels, not population numbers, that drive human-induced GHG emissions. It is growth in consumption that underpins growth in such emissions. So in theory, (leaving aside the difficulties in measurement), responsibility for GHG emissions should be to individuals and households, based on their consumption. Globally, the 20 percent of the population with the highest consumption levels may account for 90% or more of all human induced GHGs? And perhaps an even higher proportion of historical contributions? Then in considering how to reduce emissions globally, far more attention should be directed to this group. And as responsibilities for managing this are allocated to governments, consider how this 20 percent of the world's population is distributed between nations (obviously most but certainly not all in high-income nations).

It is the demographic changes associated with affluence or of increasingly affluent individuals, households and societies that are the most important demographic causes of GHGs already in the atmosphere and the most important drivers of their growth. From the consumption perspective, this is associated with urbanization only where an increasing proportion of consumption takes place in urban areas – which is only partly the case in high-income nations. And it is mostly in urban areas that it is possible to delink a high quality of life and high GHGs per person. Of course, from an adaptation perspective, the critical issue in low- and middle-income nations is to reduce risks from climate-change, especially for vulnerable populations – but this has very strong complementarities with a successful development agenda (for a discussion of this for urban areas see Bicknell et al 2009). Of course, this includes a high priority to ensuring that all households have good quality sexual and reproductive health services, within a larger commitment to ensuring other health care services, good environmental health, adequate incomes and other services. But this would not necessarily reduce GHGs.

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Table A1: Data for nations on population and population growth and CO_2 emissions and emissions growth, 1980 to 2005 (not including land-use changes; sorted by growth rate for CO_2 emissions, 1980-2005)

Country	Tonnes CO_2 per capita, 2005	Region and per capita income category		Million tonnes of carbon dioxide (mtoc)		Population (thousands)		GHG growth mtco2 1980 minus 2005	Popn growth 1980 minus 2005	Compound growth rate 1980 to 2005	
				1980	2005	1980	2005			CO_2 em	Popn
Equatorial Guinea	6.6	AF	low	0.1	3.2	213	484	3.1	271	14.9	3.3
Oman	12.0	AS	UM	2.2	30.0	1,187	2,507	27.8	1,320	11.0	3.0
Cambodia	0.3	AS	low	0.3	3.7	6,748	13,956	3.4	7,208	10.6	2.9
Angola	1.3	AF	low	2.9	20.4	7,834	16,095	17.5	8,261	8.1	2.9
Laos	0.2	AS	low	0.2	1.4	3,103	5,664	1.2	2,561	8.1	2.4
Congo	1.4	AF	low	0.8	5.2	1,802	3,610	4.4	1,807	7.8	2.8
Vietnam	1.1	AS	low	14.8	95.4	53,005	85,029	80.6	32,024	7.7	1.9
Nepal	0.1	AS	low	0.5	3.2	15,159	27,094	2.7	11,935	7.7	2.4
Thailand	3.7	AS	LM	36.8	233.2	46,809	63,003	196.4	16,194	7.7	1.2
Seychelles	7.0	AF	UM	0.1	0.6	66	86	0.5	19	7.4	1.0
Malaysia	5.7	AS	UM	24.5	146.9	13,763	25,653	122.4	11,890	7.4	2.5
Mauritius	2.7	AF	UM	0.6	3.4	966	1,241	2.8	275	7.2	1.0
Yemen	0.9	AS	low	3.5	19.5	8,381	21,096	16	12,714	7.1	3.8
Bangladesh	0.3	AS	low	7.4	38.9	88,855	153,281	31.5	64,426	6.9	2.2
Benin	0.3	AF	low	0.5	2.6	3,709	8,490	2.1	4,781	6.8	3.4
Pakistan	0.8	AS	low	28.0	127.4	79,222	158,081	99.4	78,859	6.2	2.8
Indonesia	1.6	AS	LM	84.7	367.4	151,108	226,063	282.7	74,955	6.0	1.6
Qatar	55.5	AS	high	10.2	44.2	229	796	34	567	6.0	5.1
Botswana	2.3	AF	UM	1.0	4.3	996	1,836	3.3	840	6.0	2.5
Jordan	3.6	AS	LM	4.7	19.9	2,225	5,544	15.2	3,319	5.9	3.7
India	1.1	AS	low	304.8	1,221.6	688,575	1,134,403	916.8	445,828	5.7	2.0
Ethiopia	0.1	AF	low	1.4	5.6	37,138	78,986	4.2	41,848	5.7	3.1
Antigua & Barbuda	4.8	LA	UM	0.1	0.4	72	83	0.3	11	5.7	0.6
Belize	2.9	LA	UM	0.2	0.8	144	276	0.6	132	5.7	2.6
Saint Lucia	2.5	LA	UM	0.1	0.4	118	161	0.3	43	5.7	1.3
Iran	6.4	AS	LM	113.7	447.0	39,330	69,421	333.3	30,091	5.6	2.3
Honduras	1.1	LA	LM	1.9	7.4	3,633	6,834	5.5	3,201	5.6	2.6
China	4.2	AS	LM	1,443.2	5,577.3	998,877	1,312,979	4134.1	314,102	5.6	1.1
Uganda	0.1	AF	low	0.6	2.3	12,661	28,947	1.7	16,286	5.5	3.4
Egypt	2.2	NA	LM	43.8	163.5	43,674	72,850	119.7	29,176	5.4	2.1
Korea (South)	9.9	AS	high	129.7	474.5	38,124	47,870	344.8	9,746	5.3	0.9
Cameroon	0.4	AF	low	1.9	6.8	9,078	17,795	4.9	8,717	5.2	2.7
El Salvador	1.0	LA	LM	1.9	6.6	4,586	6,668	4.7	2,082	5.1	1.5
United Arab Emirates	28.3	AS	high	33.4	116.0	1,015	4,104	82.6	3,089	5.1	5.7
Taiwan*		AS	high	79.1	271.2			192.1	0	5.1	
Ghana	0.4	AF	low	2.4	8.0	11,390	22,535	5.6	11,145	4.9	2.8
Trinidad & Tobago	19.6	LA	UM	8.0	26.0	1,082	1,324	18	242	4.8	0.8
Sri Lanka	0.7	AS	LM	4.0	12.9	14,941	19,121	8.9	4,180	4.8	1.0
Singapore	10.0	AS	high	13.6	43.1	2,415	4,327	29.5	1,913	4.7	2.4
Syria	2.7	AS	LM	16.1	50.6	8,971	18,894	34.5	9,923	4.7	3.0
Turkey	3.3	AS	LM	78.0	240.3	46,316	72,970	162.3	26,654	4.6	1.8
Israel	9.3	AS	high	20.5	62.2	3,764	6,692	41.7	2,928	4.5	2.3
Central African Republic	0.1	AF	low	0.1	0.3	2,329	4,191	0.2	1,863	4.5	2.4
Guinea-Bissau	0.2	AF	low	0.1	0.3	793	1,597	0.2	804	4.5	2.8
Cape Verde	0.6	AF	LM	0.1	0.3	289	507	0.2	218	4.5	2.3
Morocco	1.5	NA	LM	15.7	46.8	19,567	30,495	31.1	10,928	4.5	1.8
Tanzania	0.1	AF	low	1.7	4.8	18,681	38,478	3.1	19,796	4.2	2.9

Togo	0.2	AF	low	0.5	1.4	2,784	6,239	0.9	3,454	4.2	3.3
Chile	3.7	LA	UM	22.0	60.7	11,174	16,295	38.7	5,121	4.1	1.5
Sudan	0.3	AF	low	3.8	10.4	19,641	36,900	6.6	17,258	4.1	2.6
Dominican Republic	1.9	LA	LM	6.7	18.2	5,934	9,470	11.5	3,536	4.1	1.9
Paraguay	0.6	LA	LM	1.4	3.8	3,198	5,904	2.4	2,707	4.1	2.5
Bolivia	1.4	LA	LM	4.8	12.9	5,355	9,182	8.1	3,827	4.0	2.2
Mauritania	0.5	AF	low	0.6	1.6	1,503	2,963	1	1,460	4.0	2.8
Tunisia	2.3	NA	LM	8.7	23.2	6,458	10,105	14.5	3,647	4.0	1.8
Malta	6.5	EUR	high	1.0	2.6	324	403	1.6	78	3.9	0.9
Haiti	0.2	LA	low	0.7	1.8	5,691	9,296	1.1	3,606	3.9	2.0
Costa Rica	1.5	LA	UM	2.5	6.4	2,347	4,327	3.9	1,980	3.8	2.5
Guatemala	0.9	LA	LM	4.5	11.4	7,013	12,710	6.9	5,696	3.8	2.4
Portugal	6.4	EUR	high	26.9	67.5	9,766	10,528	40.6	762	3.7	0.3
Senegal	0.5	AF	low	2.2	5.5	5,871	11,770	3.3	5,900	3.7	2.8
Bahrain	25.4	AS	high	7.4	18.4	347	725	11	378	3.7	3.0
Cyprus	9.4	AS	high	3.2	7.9	611	836	4.7	225	3.7	1.3
Papua New Guinea	0.7	AS	low	1.8	4.4	3,199	6,070	2.6	2,871	3.6	2.6
Philippines	1.0	AS	LM	34.5	83.2	48,088	84,566	48.7	36,478	3.6	2.3
Lebanon	4.4	AS	UM	7.3	17.5	2,785	4,011	10.2	1,226	3.6	1.5
Nicaragua	0.8	LA	low	1.9	4.4	3,257	5,463	2.5	2,206	3.4	2.1
Kuwait	28.8	AS	high	34.0	77.8	1,375	2,700	43.8	1,325	3.4	2.7
Ecuador	2.0	LA	LM	12.1	26.7	7,961	13,061	14.6	5,100	3.2	2.0
Myanmar	0.2	AS	low	5.3	11.6	33,294	47,967	6.3	14,673	3.2	1.5
New Zealand	8.7	PAC	high	16.8	35.5	3,113	4,097	18.7	984	3.0	1.1
Burundi	0.0	AF	low	0.1	0.2	4,130	7,859	0.1	3,729	2.8	2.6
Lesotho	0.1	AF	low	0.1	0.2	1,296	1,981	0.1	685	2.8	1.7
Rwanda	0.1	AF	low	0.3	0.6	5,197	9,234	0.3	4,037	2.8	2.3
Solomon Islands	0.4	PAC	low	0.1	0.2	229	472	0.1	243	2.8	2.9
Fiji	1.9	PAC	LM	0.8	1.6	634	828	0.8	194	2.8	1.1
Samoa	1.1	PAC	LM	0.1	0.2	155	184	0.1	29	2.8	0.7
Swaziland	0.9	AF	LM	0.5	1.0	615	1,125	0.5	509	2.8	2.4
Greece	9.3	EUR	high	52.0	103.1	9,643	11,100	51.1	1,457	2.8	0.6
Saudi Arabia	14.1	AS	UM	171.5	333.0	9,604	23,612	161.5	14,008	2.7	3.7
Iraq*	3.6	AS	LM	52.5	100.5	14,093	27,996	48	13,903	2.6	2.8
Panama	1.9	LA	UM	3.2	6.1	1,949	3,232	2.9	1,282	2.6	2.0
Barbados	4.5	LA	UM	0.7	1.3	249	292	0.6	43	2.5	0.6
Algeria	2.9	NA	LM	51.9	95.6	18,811	32,854	43.7	14,043	2.5	2.3
Brazil	1.9	LA	LM	191.6	352.0	121,615	186,831	160.4	65,216	2.5	1.7
Niger	0.1	AF	low	0.6	1.1	5,784	13,264	0.5	7,480	2.5	3.4
Australia	18.8	PAC	high	210.3	381.6	14,638	20,310	171.3	5,672	2.4	1.3
Spain	8.5	EUR	high	203.4	366.8	37,527	43,397	163.4	5,871	2.4	0.6
Mexico	3.9	LA	UM	229.0	410.6	69,325	104,266	181.6	34,941	2.4	1.6
Kenya	0.3	AF	low	6.2	10.9	16,282	35,599	4.7	19,316	2.3	3.2
Burkina Faso	0.1	AF	low	0.4	0.7	6,827	13,933	0.3	7,106	2.3	2.9
Madagascar	0.2	AF	low	1.6	2.8	9,059	18,643	1.2	9,583	2.3	2.9
Colombia	1.5	LA	LM	37.6	65.7	28,356	44,946	28.1	16,590	2.3	1.9
Libya	8.2	NA	UM	28.5	48.8	3,063	5,918	20.3	2,855	2.2	2.7
Ireland	11.1	EUR	high	27.0	45.8	3,401	4,143	18.8	742	2.1	0.8
Cote d'Ivoire	0.4	AF	low	4.0	6.6	8,344	18,585	2.6	10,241	2.0	3.3
Slovenia	8.1	EUR	high	10.1	16.1	1,832	1,999	6	168	1.9	0.4
Brunei*	13.9	AS	high	3.3	5.2	193	374	1.9	181	1.8	2.7
Guinea	0.2	AF	low	0.9	1.4	4,575	9,003	0.5	4,428	1.8	2.7
Venezuela	5.8	LA	UM	99.5	154.7	15,091	26,726	55.2	11,634	1.8	2.3
South Africa	7.0	AF	LM	218.1	337.1	29,074	47,939	119	18,864	1.8	2.0
Jamaica	3.8	LA	LM	6.6	10.1	2,133	2,682	3.5	549	1.7	0.9
Gambia	0.2	AF	low	0.2	0.3	671	1,617	0.1	946	1.6	3.6
Mali	0.1	AF	low	0.4	0.6	6,069	11,611	0.2	5,543	1.6	2.6
Sierra Leone	0.2	AF	low	0.6	0.9	3,236	5,586	0.3	2,351	1.6	2.2
Argentina	3.8	LA	UM	99.5	146.0	28,094	38,747	46.5	10,654	1.5	1.3
Peru	1.1	LA	LM	21.6	31.1	17,325	27,274	9.5	9,950	1.5	1.8

Malawi	0.1	AF	low	0.7	1.0	6,215	13,226	0.3	7,011	1.4	3.1
Mongolia	3.8	AS	low	6.8	9.7	1,663	2,581	2.9	918	1.4	1.8
Nigeria	0.7	AF	low	70.5	97.7	71,065	141,356	27.2	70,291	1.3	2.8
Japan	9.8	AS	high	912.8	1,248.9	116,807	127,897	336.1	11,089	1.3	0.4
Austria	9.6	EUR	high	58.7	79.5	7,549	8,292	20.8	743	1.2	0.4
Croatia	4.9	EUR	UM	16.8	22.5	4,377	4,551	5.7	175	1.2	0.2
Djibouti	0.5	AF		0.3	0.4	340	804	0.1	464	1.2	3.5
Norway	8.4	EUR	high	29.4	38.9	4,086	4,639	9.5	553	1.1	0.5
Canada	17.3	NAM	high	436.2	559.1	24,516	32,271	122.9	7,754	1.0	1.1
Zimbabwe	0.8	AF	low	8.2	10.5	7,285	13,120	2.3	5,835	1.0	2.4
Iceland	7.8	EUR	high	1.8	2.3	228	296	0.5	68	1.0	1.0
United States of America	19.6	NAM	high	4,721.5	5,891.6	230,917	299,846	1170.1	68,929	0.9	1.1
Italy	8.1	EUR	high	383.3	477.1	56,434	58,646	93.8	2,212	0.9	0.2
Serbia & Montenegro	5.2	EUR	LM	43.0	51.5	8,946	9,863	8.5	917	0.7	0.4
Netherlands	11.3	EUR	high	155.6	184.1	14,150	16,328	28.5	2,178	0.7	0.6
Bosnia & Herzegovina	4.2	EUR	LM	14.6	16.4	3,914	3,915	1.8	2	0.5	0.0
Switzerland	6.3	EUR	high	41.9	47.0	6,319	7,424	5.1	1,105	0.5	0.6
Gabon	3.7	AF	UM	4.4	4.8	682	1,291	0.4	609	0.3	2.6
Turkmenistan	8.6	AS	LM	38.6	41.7	2,861	4,833	3.1	1,972	0.3	2.1
Macedonia, FYR	4.3	EUR	LM	8.2	8.7	1,795	2,034	0.5	239	0.2	0.5
Suriname	5.3	LA	LM	2.4	2.4	356	452	0	96	0.0	1.0
Vanuatu	0.5	PAC	LM	0.1	0.1	117	215	0	98	0.0	2.5
Nauru	9.9	PAC		0.1	0.1	7	10	0	3	0.0	1.2
Finland	10.7	EUR	high	56.4	56.1	4,780	5,246	-0.3	466	0.0	0.4
Luxembourg	25.6	EUR	high	12.1	11.7	364	457	-0.4	92	-0.1	0.9
Uruguay	1.7	LA	UM	6.0	5.8	2,914	3,326	-0.2	412	-0.1	0.5
United Kingdom	8.9	EUR	high	580.2	538.6	56,314	60,245	-41.6	3,931	-0.3	0.3
Belgium	11.1	EUR	high	130.3	115.2	9,828	10,398	-15.1	570	-0.5	0.2
Uzbekistan	4.2	AS	low	128.0	112.6	15,952	26,593	-15.4	10,641	-0.5	2.1
Guyana	2.0	LA	LM	1.8	1.5	761	739	-0.3	-21	-0.7	-0.1
France	6.5	EUR	high	479.3	399.0	53,880	60,991	-80.3	7,111	-0.7	0.5
Cuba	2.2	LA	LM	29.9	24.6	9,823	11,260	-5.3	1,437	-0.8	0.5
Germany	10.0	EUR	high	1,060.6	828.8	78,289	82,652	-231.8	4,364	-1.0	0.2
Denmark	9.0	EUR	high	63.9	49.0	5,123	5,417	-14.9	294	-1.1	0.2
Russian Federation	10.9	EUR	LM	2,067.1	1,568.0	138,655	143,953	-499.1	5,298	-1.1	0.2
Czech Republic	11.8	EUR	UM	168.8	120.1	10,284	10,192	-48.7	-92	-1.4	0.0
Mozambique	0.1	AF	low	2.4	1.7	12,137	20,533	-0.7	8,396	-1.4	2.1
Zambia	0.2	AF	low	3.4	2.4	5,946	11,478	-1	5,532	-1.4	2.7
Poland	7.9	EUR	UM	428.5	302.1	35,574	38,196	-126.4	2,621	-1.4	0.3
Korea (North)	3.2	AS	low	109.3	76.2	17,239	23,616	-33.1	6,376	-1.4	1.3
Congo, Dem. Republic	0.0	AF	low	3.3	2.3	28,071	58,741	-1	30,670	-1.4	3.0
Sweden	5.8	EUR	high	75.5	52.2	8,310	9,038	-23.3	728	-1.5	0.3
Hungary	5.9	EUR	UM	88.0	59.5	10,707	10,086	-28.5	-621	-1.6	-0.2
Slovakia	7.4	EUR	UM	60.1	40.0	4,976	5,387	-20.1	411	-1.6	0.3
Kazakhstan	10.3	AS	LM	239.1	156.7	14,919	15,211	-82.4	292	-1.7	0.1
Belarus	6.4	EUR	LM	98.3	62.3	9,659	9,795	-36	137	-1.8	0.1
Albania	1.6	EUR	LM	8.1	4.9	2,671	3,154	-3.2	482	-2.0	0.7
Azerbaijan	3.8	AS	low	52.9	32.0	6,161	8,352	-20.9	2,192	-2.0	1.2
Tajikistan	0.9	AS	low	9.7	5.8	3,953	6,550	-3.9	2,598	-2.0	2.0
Estonia	12.1	EUR	UM	27.4	16.3	1,473	1,344	-11.1	-129	-2.1	-0.4
Bulgaria	6.1	EUR	LM	86.8	47.2	8,862	7,745	-39.6	-1,117	-2.4	-0.5
Lithuania	4.0	EUR	UM	26.1	13.8	3,413	3,425	-12.3	12	-2.5	0.0
Ukraine	6.5	EUR	LM	580.4	302.9	50,044	46,918	-277.5	-3,126	-2.6	-0.3
Romania	4.4	EUR	LM	184.3	94.5	22,201	21,628	-89.8	-574	-2.6	-0.1
Chad	0.0	AF	low	0.2	0.1	4,611	10,146	-0.1	5,534	-2.7	3.2

Afghanistan	0.0	AS	low	1.4	0.7	13,946	25,067	-0.7	11,122	-2.7	2.4
Latvia	3.3	EUR	UM	15.2	7.5	2,512	2,302	-7.7	-210	-2.8	-0.3
Moldova	2.1	EUR	low	22.1	8.2	4,010	3,877	-13.9	-133	-3.9	-0.1
Kyrgyzstan	1.1	AS	low	16.0	5.9	3,627	5,204	-10.1	1,576	-3.9	1.5
Armenia	1.5	AS	low	13.1	4.4	3,096	3,018	-8.7	-79	-4.3	-0.1
Bahamas	6.5	NAM	high	8.0	2.1	210	323	-5.9	113	-5.2	1.7
Liberia	0.1	AF	low	2.0	0.5	1,868	3,442	-1.5	1,574	-5.4	2.5
Georgia	0.9	AS	LM	20.3	4.0	5,073	4,473	-16.3	-600	-6.3	-0.5

Nations with no data on the growth in CO_2 emissions, 1980-2005

Bhutan	0.63	AS	low	0.0	0.4	423	637	0.4	214		1.7
Comoros	0.13	AF	low	0.0	0.1	387	798	0.1	411		2.9
Eritrea	0.13	AF	low	--	0.6	2,469	4,527		2,058		2.5
Sao Tome & Principe	0.66	AF	low	0.0	0.1	95	153	0.1	58		1.9
Kiribati	—	PAC	LM	0.0	0.0	55	92	0	37		2.1
Maldives	2.37	AS	LM	0.0	0.7	158	295	0.7	137		2.5
Namibia	1.39	AF	LM	--	2.8	993	2,020		1,027		2.9
Tonga	1.01	PAC	LM	0.0	0.1	97	99	0.1	2		0.1
Dominica	1.47	LA	UM	0.0	0.1	73	68	0.1	-5		-0.3
Grenada	1.90	LA	UM	0.0	0.2	89	105	0.2	16		0.7
Palau	4.97	PAC	UM	--	0.1	12	20		8		2.0
Saint Kitts & Nevis	2.04	LA	UM	0.0	0.1	43	49	0.1	6		0.5
Saint Vincent & Grenadines	1.68	LA	UM	0.0	0.2	100	119	0.2	19		0.7
Niue	—	PAC		0.0	0.0	3	2	0	-2		-2.9