The implications of population growth and urbanization for climate change

DAVID SATTERTHWAITE

David Satterthwaite is a Senior Fellow with the Human Settlements Group, International Institute for Environment and Development (IIED). He contributed to the Third and Fourth Assessments of the Intergovernmental Panel on Climate Change (IPCC).

Address: IIED, 3 Endsleigh Street, London WC1H 0DD; e-mail: david.satterthwaite@iied.org

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ABSTRACT This paper considers the implications of population growth and urbanization for climate change. It emphasizes that it is not the growth in (urban or rural) populations that drives the growth in greenhouse gas (GHG) emissions but rather, the growth in consumers and in their levels of consumption. A significant proportion of the world's urban (and rural) populations have consumption levels that are so low that they contribute little or nothing to such emissions. If the lifetime contribution to GHG emissions of a person added to the world's population varies by a factor of more than 1,000 depending on the circumstances into which they are born and their life choices, it is misleading to see population growth as the driver of climate change. A review of carbon dioxide (CO_2) emissions levels for nations, and how they changed between 1980 and 2005 (and also between 1950 and 1980), shows little association between nations with rapid population growth and nations with high GHG emissions and rapid GHG emissions 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, provision must be made to allow low-income, low-consumption households with GHG emissions per person below the global "fair share" level to increase their consumption.

KEYWORDS climate change / consumption / greenhouse gas emissions / population growth / urbanization

I. INTRODUCTION

It has long been common for population growth to be blamed for a range of environmental problems, and for the usually far more damaging contributions of high consumption to be downplayed.(1) This misunderstanding is now being applied to climate change. Cities or urbanization in general are also frequently blamed for greenhouse gas (GHG) emissions and hence for climate change. The realities on both fronts are more complex. This paper considers some of these complexities and tries to find more precise ways to allocate responsibility.

II. ACHIEVING MORE PRECISION IN ALLOCATING RESPONSIBILITY FOR CLIMATE CHANGE

Most of the growth in the world's population is taking place in urban areas in low- and middle-income nations and this is likely to continue,(2) so a

1. See Hartmann, Betsy (1998), "Population, environment and security: a new trinity", *Environment and Urbanization* Vol 10, No 2, October, pages 113–127; also Satterthwaite, David (2003), "The links between poverty and the environment in urban areas of Africa, Asia and Latin America", *The Annals of the American*

concern for how the growth in the world's population influences GHG emissions is largely a concern for how the growth in the urban population in low- and middle-income nations influences GHG emissions. An assessment of the contribution of urban centres or urbanization or the growth in urban populations to climate change can be done from the perspective of "where GHGs are produced" (by assessing what proportion of GHGs emitted by human activities comes from within the boundaries of urban centres) or from the consumption perspective (assessing all the GHGs emitted as a result of the consumption and waste generation of urban populations). Table 1 lists the most likely sources of growing GHG emissions for any city or any nation's urban population from these two perspectives (using the sectors in the IPCC's 2007 Assessment,(3) but with the addition of "public sector and governance" within the consumption perspective).(4)

What is noticeable is that all the drivers of growing GHG emissions in Table 1 can take place (and often have taken place) in a national urban population or a particular city without population growth. This is particularly so if the consumption perspective is adopted. For instance, Greater London's population was larger in 1941 than it is today, but the total GHG emissions generated by its population's consumption are likely to have increased many times.

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). This can mean that particular cities in low- and middle-income nations with heavy industry or fossil-fuelled power stations can have very high carbon dioxide (CO_2) emissions per person.(5) But in many nations, a considerable proportion of energy intensive production (for instance, mines and mineral processing) or fossil-fuelled electricity generation takes place in rural areas or urban areas too small to be considered cities. Rural districts with such energy intensive production can have per capita GHG emissions that are much higher than most cities – although most city GHG emissions inventories that use the production perspective(6) use the "consumption perspective" with 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 for GHG emissions are made between rural and urban areas, 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 that the IPCC suggests account for around 31 per cent of all human-induced GHG emissions.(7)

One obvious objection to using the production perspective is that a large proportion of the products of rural-based mines, forests, agriculture 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 that entire 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

Academy of Political and Social Science Vol 590, pages 73–92.

2. The most recent UN Population Division figures suggest that between 2000 and 2010, the growth in urban population accounted for 82 per cent of global growth in population (and more than 90 per cent of this was in low- and middle-income nations); for the period 2010 to 2020, this is anticipated to increase to 94 per cent. Even if this is overstated, as low- and middle-income nations with poor economic performance urbanize less than anticipated, it is still likely that most net global population growth is and will continue to be in urban areas. See United Nations (2008), *World Urbanization Prospects: the 2007 Revision*, CD-ROM Edition, data in digital form (POP/DB/WUP/Rev.2007), United Nations, Department of Economic and Social Affairs, Population Division, New York.

3. IPCC (2008), *Climate Change 2007: Mitigation*, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by B Metz, O R Davidson, P R Bosch, R Dave, L A Meyer, Cambridge University Press, Cambridge.

4. See also Hertwich, Edgar G and Glen P Peters (2009), "Carbon footprint of nations: a global trade-linked analysis", *Environmental Science and Technology*, August, http://pubs.acs.org/doi/abs/10.1021/es803496a.

5. In South Africa, see the very high figures for tonnes of CO_2 emissions per person in 2004 in Saldanha (49 tonnes), Sedibeng (29 tonnes) and uMhlathuze (47 tonnes), but industry and commerce accounted for more than 90 per cent of this. If CO_2 emissions (or GHG emissions) were assessed from the consumption perspective, these three cities would have much lower emissions per person. The figures for South Africa's three largest cities (Cape Town, Johannesburg and eThekwini) were around six tonnes per capita in 2004. See Sustainable Energy Africa (2006), *State of Energy in South*

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 (or provision), 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 also do so much to encourage high consumption). **But for any individual or household to contribute to global warming, they have to consume goods and services that generate GHG emissions**.[8]

A significant proportion of the world's urban (and rural) populations have 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 GHG emissions. In many low-income nations, most rural and urban households do not have electricity – and thus also no household appliances that use electricity.[9] 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 still dominated by charcoal, firewood or organic wastes (e.g. dung). Where access to these is commercialized, as is likely in most 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 undernourished and 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 GHG emissions.[10]

Drawing on data for cooking fuel use and access to electricity for urban populations from recent demographic and health surveys,[11] among the 43 nations for which data were available, 20 had more than half of their urban population relying primarily on non-fossil fuel cooking fuels – charcoal, wood fuel, 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,[12] 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 produce no GHG emissions (walking, bicycling) or low GHG emissions (buses, mini-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 per cent had electricity, only 7 per cent had a bicycle and only 1.5 per cent had a fridge; 31 per cent of all households surveyed had no radio, television or fridge.[13] In India, studies of CO_2 emissions from household energy use and transport (covering rural and urban areas) found that average CO_2 emissions ranged from 335 kilogrammes per capita per year for the lowest income class (less than 3,000 rupees a month) to an average of 1,494 kilogrammes per capita per year for the highest income class (more than 30,000 rupees a

African Cities 2006; Setting a Baseline, Sustainable Energy Africa, Westlake, 164 pages.

6. This is often labelled the "production" perspective, but this implies that it is linked to what is produced when it also includes part of the consumption perspective – for instance, in fossil fuels used for transport and for heating buildings

7. See reference 3.

8. Consideration is also needed of how particles in the atmosphere that result from fuel combustion and open field and forest burning can contribute to warming – see Bond, Tami, Chandra Venkataraman and Omar Masera (2004), "Global atmospheric impacts of residential fuels", *Energy for Sustainable Development* Vol VIII, No 3, pages 20–32.

9. Apart, of course, from those appliances, such as radios, that can be powered by batteries.

10. It might be assumed that the use of firewood and charcoal by urban populations contributes to deforestation and thus to global warming, but detailed studies in the late 1980s showed that this assumption was not true in most instances. See Leach, Gerald and Robin Mearns (1989), *Beyond the Woodfuel Crisis – People, Land and Trees in Africa*, Earthscan Publications, London, 309 pages. In addition, it is unlikely that firewood use by the urban poor is a major driver of deforestation (which is driven more by commercial forest enterprises and land clearance for agriculture and cattle raising).

11. See STATcompiler at http://www.statcompiler.com/ that allows users to draw data from the demographic and health surveys.

12. Dhingra, Chhavi, Shikha Gandhi, Akanksha Chaurey and P K Agarwal (2008), "Access to clean energy services for the urban and peri-urban poor: a case study of Delhi, India", *Household Energy and Health Project* Vol XI, No 2, June 2007 and December 2008.

TABLE 1
Possible drivers of growing greenhouse gas emissions 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 growth?
From the perspective of where the GHGs are produced		
Energy supply	A large part of this is from fossil fuel power stations, hence a growth in electricity provision from high GHG-emitting sources; many large fossil fuel power stations are located outside urban areas but the GHG emissions from the electricity used in urban areas are usually allocated to these urban areas (see below)	A shift to less GHG-emitting power generation and distribution; incorporation of electricity-saving devices; an increase in the proportion of electricity generated from renewable energy sources and its integration into the grid
Industry	Growing levels of production; growing energy intensity in what is produced; importance of industries producing goods whose fabrication entails large GHG emissions – e.g. motor vehicles	A shift 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 that encompass rural areas; from the production perspective, GHGs generated by deforestation and agriculture are assigned to rural areas	
Transport	Growing use of private automobiles; increases in average fuel consumption of private automobiles; increased air travel (although this may not be allocated to urban areas)	Increasing the number of trips made on foot, by bicycle, on public transport; a decrease in the use of private automobiles and/or a decrease in their average fuel consumption (including the use of automobiles using alternative fuels); ensuring that urban expansion avoids high levels of private automobile dependence
Residential/ 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, thus cutting GHG emissions from space heating (usually the largest user of fossil fuels in temperate climates) and lighting; much of this is relatively easy and has rapid paybacks
Waste and wastewater	Growing volumes of solid and liquid wastes 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, so GHG growth is driven by increasing energy use; consumers are also allocated the GHGs from the energy used to make and deliver the goods and services they consume	As in the production perspective, but also a greater focus on less consumption among high consumption households; a shift to less GHG intensive consumption
Industry	GHGs from industries and from producing the material inputs they draw on no longer allocated to the enterprises that produce them, but rather to the final consumers of the products, so again GHG growth driven by increased consumption	As in the production perspective, but with an extra concern to reduce the GHGs embedded in goods consumed by residents and to discourage consumption with high GHG emissions implications
Forestry and agriculture	GHGs from these no longer allocated to rural areas (where they are produced), but rather to the consumers of their products (many or most in urban areas); note how energy intensive most commercial agriculture has become; also the high GHG implications for preferred diets among higher-income groups (including imported goods, high meat consumption…)	Encouraging less fossil fuel intensive production and supply chains for food and forestry products; addressing the very substantial non-CO_2 GHG emissions from farming (including livestock); forestry and land use management practices that contribute to reducing global warming
Transport	As in the production perspective; GHG emissions from fuel use by people travelling outside the urban area they live in are allocated to them, so this includes air travel; also concern for GHG emissions arising from investment in transport infrastructure	As in the production perspective, but with a stronger focus on reducing air travel and a concern for lowering the GHG emissions implications of investments in transport infrastructure
Residential/ commercial buildings	As in the production perspective, but with the addition of GHG emissions arising from construction and building maintenance (including the materials used to do so)	As in the production perspective, but with an added interest in reducing the CO_2 emissions embedded in building materials, fixtures and fittings
Waste and wastewater	Large and often growing volumes of solid and liquid wastes with GHGs; these are allocated to the consumers who generated the waste, not to the waste or waste dump	As in the production perspective, 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 of urban governments on attracting new investment, allowing urban sprawl and heavy investment in roads, with little concern for promoting energy efficiency and low GHG emissions	Governance that encourages and supports all the above; also a strong focus on lowering GHG emissions through better management of government-owned buildings and public infrastructure and services; includes a concern for reducing GHG emissions generated in the building of infrastructure and the delivery of services

month). Those households earning less than 3,000 rupees a month had less than one-fifth the per capita electricity use of the 30,000 rupee plus households, and one-seventh the per capita CO_2 emissions for transport.[14] The differentials in CO_2 emissions per person in India would be much larger if one compared the very low income households (for instance, pavement dwellers in Mumbai) with the high-income households (for instance, those with more than 100,000 rupees a month).

When low-income urban dwellers obtain electricity, the few studies available on consumption levels suggest that these are often very low – for instance, among low-income households in three Indian cities,[15] just 32–33 kilowatt hours per month (1/20th to 1/40th of the average per person in most high-income nations). A very considerable number of (rural and 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 GHG emissions "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 one-sixth of the world's population has incomes and consumption levels that are so low that they are best not included in allocations of responsibility for GHG emissions. The failure of more than 50 years of development to reduce the number of people living in poverty (which also means failing to reduce the number with very low and inadequate consumption levels)[16] 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 GHG emissions. Of course, how income distribution changes within urban (and rural) populations has very large implications for future GHG emissions. 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 GHG emissions of a household with less than 3,000 rupees a month; and 30,000 rupees a month (around US$ 625) is not a high income by global standards. So adding an urban household with say 150,000 rupees a month (around U$ 3,125) to India's urban population might contribute 10 or more times the GHG emissions of those with less than 3,000 rupees per month.

Thus, the much-used formula of I = P*A*T (impact relating to population, affluence and technology) should be I = C*A*T when applied to global warming impacts, with C being the number of consumers, not the number of people. In addition, 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 cause 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 GHG emissions per person – whether from the "production" perspective (they have very little or no industry and most of the population has very low fossil fuel use within households or for transport) or the consumption perspective (with a very low proportion, or no, residents with high consumption lifestyles). This is not recognized, in part because there is no data available

13. APHRC (2002), *Population and Health Dynamics in Nairobi's Informal Settlements*, African Population and Health Research Centre, Nairobi, 256 pages.

14. Ananthapadmanabhan, G, K Srinivas and Vinuta Gopal (2007), "Hiding behind the poor", Greenpeace Report on climate injustice, Greenpeace India Society, Bangalore, 16 pages.

15. Kulkarni, A and J G Krishnayya (1994), "Urbanization in search of energy in three Indian cities", *Energy* Vol 19, pages 549–560.

16. Using the US$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 non-food needs (including rent for housing, payments for water and sanitation, keeping children at school, household energy, transport and health care) are much higher than US$1 a day. See Satterthwaite, David (2004), *The Underestimation of Urban Poverty in Low- and Middle-income Nations*, Human Settlements Poverty Reduction in Urban Areas Series, Working Paper 14, IIED, London, 71 pages; also Sabry, Sarah (2009), *Poverty Lines in Greater Cairo: Underestimating and Misrepresenting Poverty*, Human Settlements Poverty Reduction in Urban Areas Series, Working Paper 21, IIED, London, 48 pages; and Bapat, Meera (2009), *Poverty Lines and Lives of the Poor; Underestimation of Urban Poverty, The Case of India*, Human Settlements Poverty Reduction in Urban Areas Series, Working Paper 20, IIED, London, 53 pages.

on their emissions. But note should be taken of the many nations whose average annual per capita CO_2 emissions are below 0.2 tonnes (i.e. less than 1/200th that of the USA or Canada). In 2005, 13 nations had average CO_2 emissions per person that were less than 0.1 tonnes. 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 GHG emissions and GHG emissions per person have increased rapidly in recent decades. This would be even more the case if there were statistics for GHG emissions from a consumption perspective.

In addition, it is not fair to equate increases in GHG emissions per person among low-income populations (say from 0.1 to 0.5 tonnes of CO_2e per person per year[17]) with comparable GHG increases among high-income populations (for instance, from 7.1 to 7.5 tonnes per person per year). The reduction in 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, which is generally set at around two tonnes of CO_2e per person. Making provision for increases in GHG emissions for those people below the "fair share" level so that they can move out of what might be termed "energy poverty" cannot be considered in the same light as increases in emissions from those already above the "fair share" level.

17. CO_2e (carbon dioxide equivalent emission) is a measure of emissions where other greenhouse gases (such as methane) have been added to carbon dioxide emissions, with adjustments made for the differences in their global warming potential for a given time horizon. See reference 3.

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 increases in GHG emissions per person by people below the global "fair share" level would be treated differently from increases by people above it. Most of the nations with the most rapid growth in their national (and urban) populations have average GHG emissions per person far below the "fair share" level.

III. HOW MUCH DOES POPULATION GROWTH COINCIDE WITH THE GROWTH IN GREENHOUSE GAS EMISSIONS?

It is worth considering the extent of the association between population growth and GHG emissions 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 experienced slow growth in these emissions; many of the nations with the slowest growing national and urban populations have the highest levels of GHG emissions per person and have had rapid growth in CO_2 emissions per person.[18] Table 2 illustrates this by contrasting the nations with low population growth and high growth in CO_2 emissions per person between 1980 and 2005 with nations with high population growth and relatively slow CO_2 emissions growth per person during this same period.[19]

Looking first at the nations with the highest and lowest CO_2 emissions per person, data are available for average CO_2 emissions per person for 185 nations for 1980 and 2005,[20] so these can be divided into five sets of 37 nations. All but ten 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, UAE) and very high population growth rates (mostly from immigration?). But generally,

18. Some high-income nations only have a slow growth in CO_2 emissions per person from 1980, or even from 1950, because they already had very high per capita emissions in 1980 or 1950. In addition, the data are 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 greater growth in emissions per capita, and many low- and middle-income nations much less growth.

19. This analysis had to focus only on CO_2 emissions and not include GHGs from land use changes, as data on these over time by nation are not available.

20. This drew data from CAIT (Climate Analysis Indicators Tool (CAIT) Version 6.0, World Resources Institute, Washington DC, http://cait.wri.org/cait.php.

TABLE 2
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 CO_2 (mtoc)		Population (thousands)		Compound growth rate 1980 to 2005	
				1980	2005	1980	2005	CO_2 emissions	Popu-lation
Nations with low population growth rates (below 1.5% a year) and CO_2 emissions growth rates of 3% or more a year, 1980–2005									
Thailand	3.7	AS	LM	36.8	233.2	46,809	63,003	7.7	1.2
Seychelles	7.0	AF	UM	0.1	0.6	66	86	7.4	1.0
Mauritius	2.7	AF	UM	0.6	3.4	966	1,241	7.2	1.0
Saint Lucia	2.5	LA	UM	0.1	0.4	118	161	5.7	1.3
China	4.2	AS	LM	1,443.2	5,577.3	998,877	1,312,979	5.6	1.1
Korea (South)	9.9	AS	High	129.7	474.5	38,124	47,870	5.3	0.9
El Salvador	1.0	LA	LM	1.9	6.6	4,586	6,668	5.1	1.5
Trinidad & Tobago	19.6	LA	UM	8.0	26.0	1,082	1,324	4.8	0.8
Sri Lanka	0.7	AS	LM	4.0	12.9	14,941	19,121	4.8	1.0
Chile	3.7	LA	UM	22.0	60.7	11,174	16,295	4.1	1.5
Malta	6.5	EUR	High	1.0	2.6	324	403	3.9	0.9
Portugal	6.4	EUR	High	26.9	67.5	9,766	10,528	3.7	0.3
Cyprus	9.4	AS	High	3.2	7.9	611	836	3.7	1.3
New Zealand	8.7	PAC	High	16.8	35.5	3,113	4,097	3.0	1.1

Nations with high population growth rates (above 2.5% a year) and CO_2 emissions growth rates that are significantly slower or negative, 1980–2005

Gambia	0.2	AF	Low	0.2	0.3	671	1,617	2.4	3.6
Djibouti	0.5	AF	LM	0.3	0.4	340	804	0.8	3.5
Côte d'Ivoire	0.4	AF	Low	4.0	6.6	8,344	18,585	2.0	3.3
Chad	0.01	AF	Low	0.2	0.1	4,611	10,146	–1.6	3.2
Kenya	0.3	AF	Low	6.2	10.9	16,282	35,599	2.3	3.2
Malawi	0.1	AF	Low	0.7	1.0	6,215	13,226	1.4	3.1
Congo, Dem. Republic	0.04	AF	Low	3.3	2.3	28,071	58,741	–1.5	3.0
Madagascar	0.2	AF	Low	1.6	2.8	9,059	18,643	2.3	2.9
Burkina Faso	0.1	AF	Low	0.4	0.7	6,827	13,933	2.2	2.9
Nigeria	0.7	AF	Low	70.5	97.7	71,065	141,356	1.3	2.8
Guinea	0.2	AF	Low	0.9	1.4	4,575	9,003	1.8	2.7
Brunei	13.9	AS	High	3.3	5.2	193	374	1.8	2.7
Libya	8.2	NA	UM	28.5	48.8	3,063	5,918	2.2	2.7
Zambia	0.2	AF	Low	3.4	2.4	5,946	11,478	–1.5	2.7
Mali	0.1	AF	Low	0.4	0.6	6,069	11,611	1.5	2.6
Gabon	3.7	AF	UM	4.4	4.8	682	1,291	0.4	2.6
Liberia	0.1	AF	Low	2.0	0.5	1,868	3,442	–5.7	2.5
Vanuatu	0.5	PAC	LM	0.1	0.1	117	215	1.4	2.5

The per capita income categories High, UM (Upper-middle), LM (Lower-middle) and Low were for 2005 and came from the World Bank's *World Development Report 2005*, p. 255.

Regional groupings: AF: sub-Saharan Africa; AS: Asia; EUR: Europe; LA: Latin America and the Caribbean; NA: North Africa; NM: Northern America; PAC: Australasia and the Pacific

SOURCE: Data on GHG emissions from Climate Analysis Indicators Tool (CAIT) Version 6.0, World Resources Institute, Washington DC, drawing on Marland, G, T A Boden and R J Andres (2008), "Global, regional and national fossil fuel CO_2 emissions", in Carbon Dioxide Information Analysis Centre (CDIAC), *Trends: A Compendium of Data on Global Change*, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tennessee, USA. Population data from United Nations (2008), *World Urbanization Prospects: the 2007 Revision*, CD–ROM Edition, data in digital form (POP/DB/WUP/Rev.2007), United Nations, Department of Economic and Social Affairs, Population Division, New York. For some nations, country population figures for 1980 and 2005 from this source were different from those of CAIT, which also means slight differences in figures for per capita CO_2 emissions and for compound growth rates for population and CO_2 emissions, 1980–2005.

this group of high emissions nations had very low population growth rates between 1980 and 2005 (more than half had average population growth rates of less than 1 per cent a year for this period). Of the 37 nations with the lowest CO_2 emissions per person, all were low-income nations and most (29) were in sub-Saharan Africa; 34 had population growth rates of more than 2 per cent a year; nine had population growth rates of more than 3 per cent a year.

Looking at the nations with the highest and lowest population growth rates for 2000–2005, apart from the three oil-producing, high-income Middle East nations noted above, almost all nations with the highest population growth rates for that period were low-income nations with annual per capita CO_2 emissions below one tonne; half had figures below 0.2 tonnes and 12 had figures below 0.1 tonnes. For the 37 nations with the slowest population growth rates (including eight 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), 12 were lower-middle income nations (seven in Europe, all part of the former Soviet Bloc) and only two were low-income nations (Moldova and Armenia).

When considering how CO_2 emissions per person change in relation to population growth, for 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 2. 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 the period 1980–2005; 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 during this period. Perhaps not surprisingly, China is within the first group, which 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 also 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 by 2005. **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 in consumption) that benefitted a large part of their national populations are important underpinnings for CO_2 emissions growth – although this is not fully represented in the CO_2 emissions figures for nations because these take no account of the 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 Thailand) – and if these tourists were from other nations, within the consumption perspective this growth would be allocated to these tourists.

For the group of nations with high population growth rates and low CO_2 emissions 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 are reported to have had a decline in CO_2 emissions between 1980 and 2005 – for instance, Zambia, Congo DR, Liberia and Chad.

The lack of association between population growth and CO_2 emissions per person is also seen in a range of nations that had very rapid decreases in per capita emissions between 1980 and 2005 but no rapid decrease in their populations – for instance, Germany, Denmark, the Russian Federation, the Czech Republic, Poland, Sweden, Hungary, Slovakia, Belarus, Estonia, Lithuania, Romania, Moldova and Georgia.

Table 3 compares the different world regions with regard to their share of world population growth and CO_2 emissions 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 per cent) but for 18.5 per cent of population growth between 1980 and 2005 and 10.7 per cent of population growth between 1950 and 1980. Meanwhile, Northern America accounted for around 4 per cent of population growth for both periods but for 20 per cent of the growth in CO_2 emissions for 1950–1980 and 14 per cent of the growth in emissions for 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 in many 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 (Figure 1). 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 per cent), but China's contribution to increased CO_2 emissions was nearly 20 times that of sub-Saharan Africa. At risk of unnecessary repetition, it is the number of consumers (and their consumption levels) that drives GHG emissions increases, not the number of people (while from a production perspective, it is more the nature and location of production). Europe's share of 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 be different – with much higher proportions of emissions attributed to wealthy European nations (or, more correctly, to their wealthier citizens).

To return to the qualitative difference between nations with increasing emissions per person above and below the global "fair share" level. If it were possible to take out the increase in CO_2 emissions for 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 that had slow population growth rates, as shown in Table 3. Sixty-three per cent of the world's growth in population from

TABLE 3
Share of the world's population growth and CO_2 emissions growth, 1980–2005 and 1950–1980

Region	1980–2005		1950–1980	
	Share of population growth (%)	Share of CO_2 emissions growth (%)	Share of population growth (%)	Share of CO_2 emissions growth (%)
Africa, North	3.0	2.5	2.5	1.0
Africa, sub-Saharan	18.5	2.4	10.7	2.2
Asia	63.1	82.7	64.1	30.6
Europe	1.8	–12.6	7.6	39.7
Latin America and Caribbean	9.4	6.4	10.2	5.3
Northern America	4.0	13.9	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	44.5		
USA	3.4	12.6		
India	21.7	9.9		
Korea, Republic of	0.5	3.7		
Japan	0.5	3.6		

SOURCE: Derived from data from sources listed in Table 2.

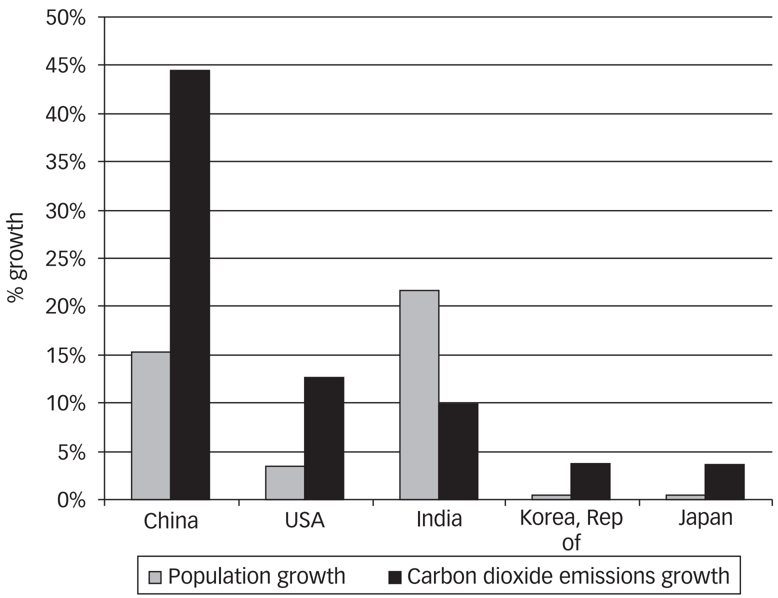

FIGURE 1
Contribution to the growth in world population and CO_2 emissions by the nations with the largest emissions growth, 1980–2005

1980 to 2005 took place in countries with average CO_2 emissions per person below two tonnes in 2005.

Table 4 and Figure 2 show the different contributions of nations to population growth and CO_2 emissions, 1980 to 2005, when they are classified according to their average 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 growth. Nations classified as "high-income" in 2005 accounted for far more CO_2 emissions growth than 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 growth would be even more dramatic.

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 GHG emissions 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 in the future, in the lifetime contribution to GHG emissions of people born now. **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 emissions growth.**

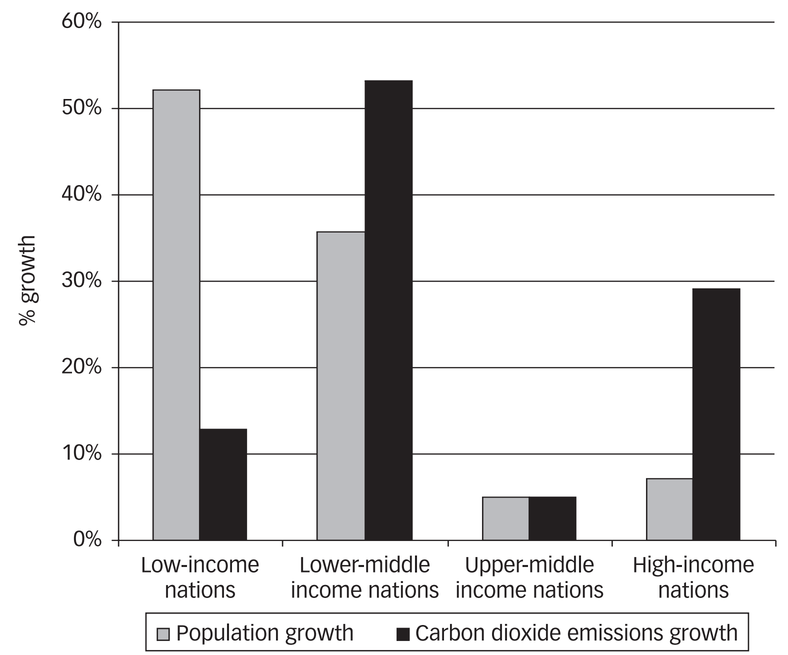

FIGURE 2
Contribution to the growth in world population and CO_2 emissions by groups of nations classified according to their average per capita income levels, 1980–2005

TABLE 4
Low-income, lower-middle income, upper-middle income and high-income nations' contributions to the world's population growth and to CO_2 emissions growth, 1980–2005 and 1950–1980

Income category in 2005	1980–2005		1950–1980	
	Population growth (%)	CO_2 emissions (%)	Population growth (%)	CO_2 emissions (%)
Low-income nations	52.1	12.8	36.0	5.6
Lower-middle income nations	35.7	53.2	47.1	39.7
Upper-middle income nations	5.0	5.0	5.7	9.6
High-income nations	7.2	29.1	11.2	45.1

SOURCE: Derived from data from sources listed in Table 2.

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

Perhaps the key issue from the above discussion is that far more attention needs to be given to changes in production and consumption within nations if we are to identify the main potential contributors to GHG emissions growth in the future. The main implications of Tables 2, 3 and 4 are to caution against any assumption that population growth necessarily causes increases in CO_2 emissions. What is needed for any consideration of GHG emissions and population is a consideration of each nation's changes in production, changes in incomes and their 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),[21] while the form that urbanization takes is much influenced by the spatial distribution of investments in industry and services and the social and spatial distribution of the incomes arising from these economic changes. Demographic changes will be important influences, not only in terms of changes in the number of people but also in terms of changes in age structure and household size (and how these influence consumption).

This implies a need for caution against any generalization relating to climate change and population that is 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, as well as in a nation's possibilities to

21. Satterthwaite, David (2007), *The Transition to a Predominantly Urban World and its Underpinnings*, Human Settlements Discussion Paper Series, Urban Change 4, IIED, London, 86 pages.

delink CO_2 emissions from growing production and consumption (as in, for instance, nations that can draw on hydroelectricity for a significant proportion of demand for electricity).

IV. URBANIZATION AND 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 per cent of all GHG emissions worldwide (actually, only around 35 per cent of the world's GHG emissions are emitted within city boundaries, although city populations account for a higher proportion if emissions are allocated to consumers[22]). In other instances, it seems to be based on an assumption that urbanization will bring higher GHG emissions – see, for instance, the assumption 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*."[23] But this is certainly not always the case. With 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 GHG emissions 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.[24] This explains in part why New York, London and Barcelona have much lower average GHG emissions per person than the US, UK or Spanish national averages.[25] 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 members who commutes. In addition, as discussed already, 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 GHG emissions than their rural counterparts.

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,[26] the link between population growth and GHG emissions is much influenced by the GHG emissions implications of urbanization in these nations. 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 GHG emissions per person (although with very considerable differences in GHG emissions 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 GHG emissions per person. For the limited range of cities for which GHG emissions 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 a city with a high quality of life, has one-fifth of the GHG emissions per person of many US cities. New York City has one-third to one-half of the GHG emissions per person of many other US cities.[27] Many of the most desirable and expensive residential areas in or close

22. Satterthwaite, David (2008), "Cities' contribution to global warming; notes on the allocation of greenhouse gas emissions", *Environment and Urbanization* Vol 20, No 2, October, pages 539–550.

23. Jiang, Leiwen and Karen Hardee (2009), "How do recent population trends matter to climate change?", *Population Action International* Vol 1, Issue 1, page 9.

24. In the USA, average per capita direct fuel consumption from buildings and industry and from transport are much higher in rural counties than in urban counties. See Parshall, Lilly, Stephen Hammer and Kevin Gurney (2009), "Energy consumption and CO_2 emissions in urban counties in the United States, with a case study of the New York Metropolitan Area", Paper presented at the Fifth Urban Research Symposium 2009, "Cities and Climate Change: Responding to an Urgent Agenda", Marseille, 28–30 June, 23 pages.

25. Dodman, David (2009), "Blaming cities for climate change? An analysis of urban greenhouse gas emissions inventories", *Environment and Urbanization* Vol 21, No 1, April, pages 185–202.

26. See reference 2, United Nations (2008).

27. See reference 25.

to city centres in Europe have residential areas that are or can be made very energy efficient (typically terraces with three to six storeys), and settlement patterns and public transport systems that allow most trips to be made on foot, by bicycle or on public transport. Indeed, one of the drivers of urbanization is the economic advantages that close proximity provides for a great range of enterprises. The paper in this issue on the Beddington Zero Energy Development[28] also shows how it is possible to combine high living standards with very low GHG emissions within the home. However, the paper also highlights how GHG emissions per resident are greatly influenced by their choices outside of their homes – for instance, in their use of private automobiles and air travel. It we consider this development from the production perspective, in terms of the GHGs emitted within the housing complex, its performance is very impressive. But if we consider it from the consumption perspective, it would need residents to limit car use and air travel to reduce GHG emissions per person to the "fair share" level. The relatively low GHG emissions per person in cities such as New York and Barcelona may also be in part because these do not include the GHGs embedded in the imported goods their inhabitants consume.

Similarly, urban areas can be seen as one of the most serious "problems" with regard to the impacts of climate change, as they concentrate people and their assets and industries 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.[29] 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.[30] 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.

Figure 3 shows nations' level of urbanization plotted against per capita GHG emissions for 2005 (in CO_2e). Of course, the figures for GHG emissions per person are based on the production perspective. The small black diamonds represent low-income nations, the small white diamonds lower-middle income nations, the black triangles upper-middle income nations and the large black squares 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 variations with regard to emissions levels per person for nations with comparable urbanization levels. Also, the wealthier the nation, the higher the GHG emissions per capita, although also with very considerable variations in GHG emissions per capita for nations with comparable levels of urbanization, and very considerable variations in levels of urbanization for nations with comparable GHG emissions per capita.

Most low-income nations have less than half their population in urban areas, and many have less than a quarter; many have per capita GHG emissions below 0.2 tonnes a year and very few have above 2.5 tonnes a year. Most lower-middle income nations have more than 40 per cent of their population in urban areas and most have GHG emissions per person per year in the 0.5–5 tonnes range. Most upper-middle income

28. Chance, Tom (2009), "Towards sustainable residential communities; the Beddington Zero Energy Development (BedZED) and beyond", in this issue of *Environment and Urbanization*.

29. See papers in *Environment and Urbanization* Vol 19, No 1, April 2007; also Bicknell, Jane, David Dodman and David Satterthwaite (editors) (2009), *Adapting Cities to Climate Change: Understanding and Addressing the Development Challenges*, Earthscan Publications, London, 397 pages.

30. See reference 29, Bicknell et al. (2009); also Co, Jason Christopher Reyos (2009), "Community-driven disaster intervention: experiences of the Homeless People's Federation in the Philippines", HPFP, PACSII and IIED, Manila and London, 70 pages.

nations have more than 60 per cent 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 per cent of their population in urban areas and most have their GHG emissions per

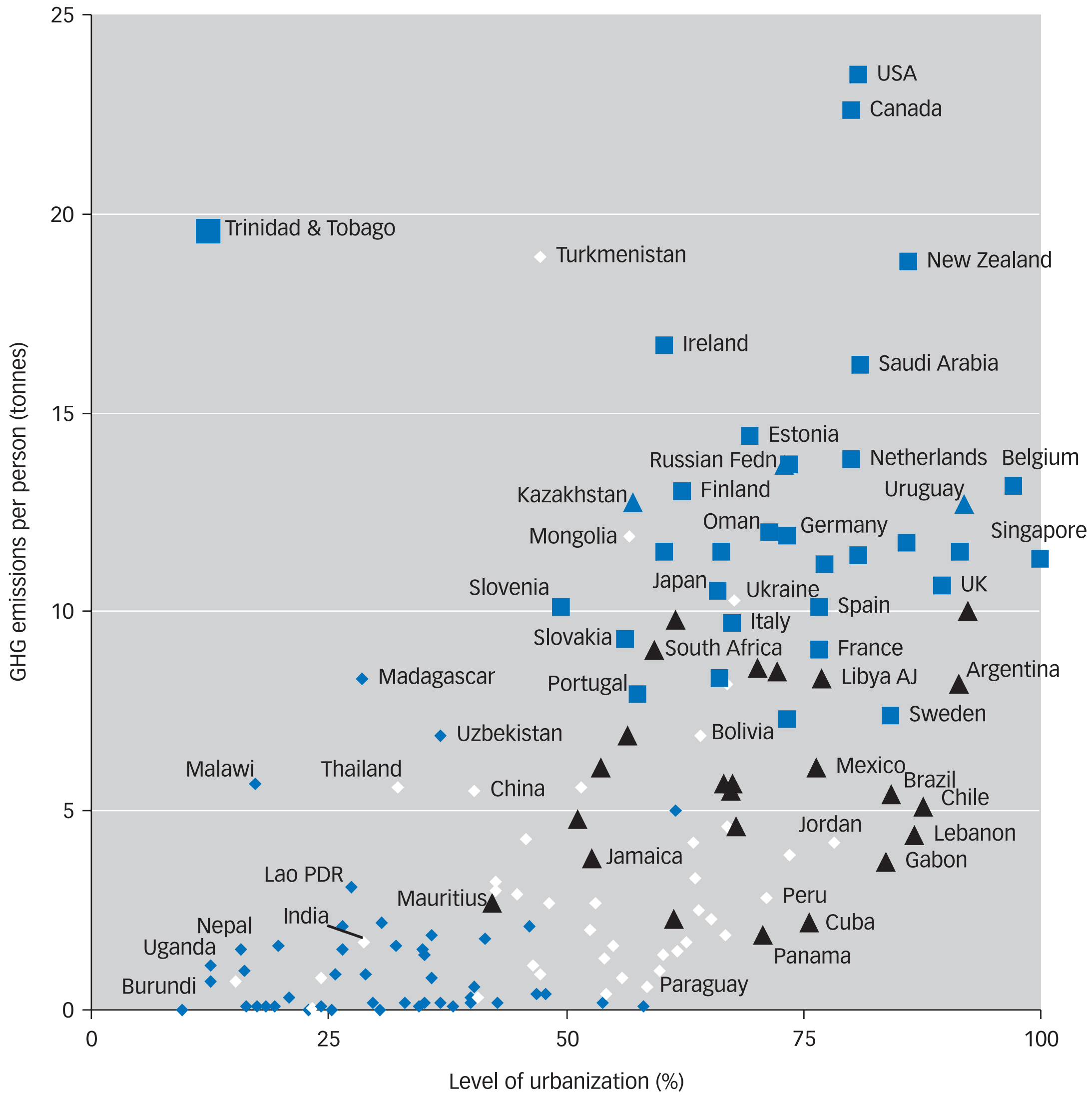

FIGURE 3

Nations' level of urbanization plotted against per capita greenhouse gas emissions for 2005 (CO_2e)

NOTE: The small black diamonds represent low-income nations, the small white diamonds lower-middle income nations, the black triangles upper-middle income nations and the large black squares high-income nations.

The figures include not only CO_2 but also the other greenhouse gases included in the Kyoto Protocol (methane, nitrous oxide, sulphur hexafluoride, hydrofluorocarbons and perfluorocarbons). Their contributions to global warming are converted into CO_2e.

person per year within the 7–15 tonnes range. Of course, part of the large variations in GHG emissions 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 un-urbanized in relation to its high GHG emissions 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. But note that all of the upper-middle and high-income nations and many of the lower-middle income nations had GHG emissions per person above the "fair share" level, with the USA and Canada having more than 10 times the "fair share" level.

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 investment patterns that have increased the proportion of production in industry and services (mostly located in urban areas) and 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 therein.[31] 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 by the colonial government. Thus, much urbanization just pre- or post- Independence was the movement of individuals or households to urban centres that previously had controls on their right to live or work there, together with 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.[32]

From the production perspective, what drives the growth in GHG emissions in low-income and most lower-middle income nations is the 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 GHG emissions in cities such as Beijing and Shanghai are driven in large part by the very large expansion in manufacturing there.[33] Low-income nations that have little or no economic growth probably have little or no growth in GHGs in their urban areas, just as they generally have little or no increase in their urbanization levels.[34] But for low- and middle-income nations that become wealthier (which also means becoming more urbanized), so the location of consumers and their consumption behaviour become increasingly important contributors to GHG emissions. What increasingly drives GHG emissions in wealthy cities or cities that are rapidly becoming wealthier is the consumption behaviour of those who 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 GHG emissions 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

31. This is discussed in detail in reference 21.

32. 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), see reference 21.

33. Dhakal, Shobhakar (2004), *Urban Energy Use and Greenhouse Gas Emissions in Asian Cities: Policies for a Sustainable Future*, Institute for Global Environmental Strategies (IGES), Kitakyushu, 170 pages.

34. Potts, Deborah (2009), "The slowing of sub-Saharan Africa's urbanization: evidence and implications for urban livelihoods" *Environment and Urbanization* Vol 21, No 1, April, pages 253–260.

higher-income groups (although this will only become fully apparent if city-based GHG emissions inventories can be done from the consumption perspective).

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 the city boundaries, in small urban centres or rural areas. In 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 GHG emissions and very little or no increase in urbanization levels.

If the real driver of climate change is rising consumption,[35] how do we arrive at a more accurate understanding of the links between urbanization and climate change? We know that allocating responsibility for GHG emissions through average per capita emissions figures for nations is misleading for at least two reasons. The first is that these figures are based on where GHGs are emitted and not on what caused them to be emitted. If GHG emissions were allocated to the home place of the consumers whose consumption was the root cause of these GHG emissions, it would considerably increase the GHG emissions per person in most high-income nations (and cities) and considerably decrease the GHG emissions per person in nations (and cities) that 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 responsibility for GHG emissions per person using national averages because of the very large differences in per capita emissions within each nation between the highest-income and lowest-income groups – perhaps a 100-fold or more difference between GHG emissions per person if we could compare the wealthiest 1 per cent and the poorest 1 per cent in many nations? As noted earlier, a proportion of the lowest-income households in rural and urban areas in many nations may not even have any net contribution to GHG emissions.

So to return to the real driver of GHG emissions growth: high consumption and rapid growth in consumption, not population (or rapid population growth) or urbanization. If it was possible to assess the GHG emissions implications of households' consumption and lifestyles, it is likely that the very rich would have GHG emissions per person that were thousands 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 lived 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, where the world's richest 20 per cent of the population get at least 150 times the income of the poorest 20 per cent.[36] If GHG emissions were allocated to people (not nations) on the basis of the contribution of their consumption to GHG emissions, it is likely that the wealthiest one-fifth of the world's population would account for more than 80 per cent of all GHG emissions (they have more than 80 per cent of the world's income) and an even higher proportion of

35. Including the embedded energy in buildings and infrastructure

36. United Nations Development Programme (1992), *Human Development Report 1992*, Oxford University Press, Oxford and New York, 232 pages.

historical contributions to GHG emissions. The consumption of the one-fifth of the world's population with the lowest income levels may account for only around 1 per cent of all GHG emissions.

Thus, it is very simplistic and misleading to apply the "I = P*A*T formula" (impact being a function of number of people, their level of affluence and technology) to GHG emissions when a large part of the world's population generates such a tiny proportion of total GHG emissions, and a very small part generates such a large proportion of total GHG emissions. It is also misleading to compare growth in emissions per person without separating those people below and above the "fair share" level. However, it serves a range of interests to do so, especially those individuals with high consumption lifestyles whose responsibility for GHG emissions is masked by GHG inventories based on the production perspective. 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 GHG emissions ascribed to them by importing most of the goods whose fabrication and materials inputs have high GHG emissions.

V. CONCLUSIONS

It is not correct to suggest that it is the increase in population that drives the growth in GHG emissions, when the lifetime contribution to GHG emissions of a person added to the world's population varies by a factor of more than 1,000 depending on the circumstances into which they are born and their life possibilities and choices. So it is not the growth in the number of people, but rather the growth in the number of consumers and the GHG implications of their consumption patterns that are the issue. In theory (leaving aside the difficulties in measurement), responsibility for GHG emissions should be with individuals and households and based on the GHG implications of their consumption, and not with nations (or cities) based on GHG inventories from the production perspective. From the consumption perspective, globally, the 20 per cent of the population with the highest consumption levels is likely to account for more than 80 per cent of all human-induced GHG emissions and an even higher proportion of historical contributions. In considering how to reduce emissions globally, far more attention should be directed to reducing this group's GHG emissions. And as responsibilities for addressing this are allocated to national and local governments (with city governments having particularly important roles), consider how this 20 per cent of the world's population is distributed between nations (obviously most, but certainly not all, are in high-income nations).

To get the much-needed rapid decrease in GHG emissions globally, there is an obvious need to focus on rapidly changing the consumption patterns of present (and future) consumers with "above fair share" GHG emissions. With regard to development, the priority within energy policy is to support those living with "energy poverty" (and its very serious health consequences) to move to cleaner, more convenient fuels and access to electricity. This will increase GHG emissions but this can be achieved at emissions per person far below the "fair share" level. It is only the high current and historical contributions of wealthy people's consumption to

GHGs in the atmosphere that make the modest increases sought by low-income groups appear to be a problem.

This emphasis on allocating GHG emissions to consumers does not invalidate emissions inventories for cities based on the production perspective, as these serve to highlight particular sectors or activities with high GHG emissions and high potential for reducing these. And as noted earlier, this production perspective has aspects of the consumption perspective, including GHG emissions linked to household energy use and transport (and usually also to electricity generation). There is also work underway to develop a common methodology for undertaking GHG emissions inventories that includes the consumption perspective,(37) although this needs to be careful to subtract from city GHG emissions inventories the GHGs emitted in the production of goods that are exported from the city. Many of the key technologies for reducing GHG emissions, such as photovoltaic cells, windmills and motor vehicles with much reduced GHG emissions implications, will be made in cities, and it would be misleading to allocate to these cities the GHG emissions used in their fabrication while the places where they are used are credited with lower GHG emissions.

37. Kennedy, C A, A Ramaswami, S Carney and S Dhakal (2009), "Greenhouse gas emission baselines for global cities and metropolitan regions", Paper presented at the Fifth Urban Research Symposium 2009, "Cities and Climate Change: Responding to an Urgent Agenda", Marseille, 28–30 June, 26 pages.

How the link between population growth and climate change is understood influences what is suggested as policy responses. Leaving aside the extreme positions – on one side, those opposing the provision of sexual and reproductive health services, including family planning; on the other, those demanding large reductions in population numbers as the only possibility for a "sustainable" future – there is agreement on everyone's right to and need for good quality, available, affordable sexual and reproductive health services that includes family planning. There is also a shared abhorrence for past coercive "population control" measures. But beyond this, there are important differences.(38)

38. See the discussion on population and climate change by a range of authors in the *Bulletin of the Atomic Scientists* in 2008, http://www.thebulletin.org/web-edition/roundtables/population-and-climate-change.

One is the different emphasis within development programmes between those who stress above all the need for more funding for family planning to those who stress the need for far more effective development (that includes good quality housing with good provision for water, sanitation, drainage, schools and health care and also greater protection from the law for low-income groups and more possibilities for them to influence policies and hold government to account). Of course, this focus on development includes support for family planning – but within a recognition that this is part of a good health care system and also that unintended pregnancies are not simply the result of a lack of family planning but also of "*…entrenched, gendered power dynamics at work within households, communities and nations worldwide.*"(39) A second difference is the stress on where investment in promoting behaviour change is needed, from those who stress the need for media campaigns to increase awareness of contraception and a desire to use it, to those who stress the need for campaigns to "*…challenge the overconsumption logic of global capitalism*"(40) and its GHG implications.

39. See reference 38, Betsy Hartmann.

40. See reference 38, Betsy Hartmann.

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 present 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 perhaps in some middle-income nations (or areas within them). And it is mostly in (responsibly governed) urban areas that it is possible to delink a high quality of life from high GHG emissions per person. Whether or not population growth contributes to GHG emissions depends on the consumption patterns of those who make up this population growth.

Of course, from the perspective of adaptation to climate change, the critical issue in low- and middle-income nations is to reduce risks, with particular attention to doing so for vulnerable populations.[41] But this has very strong complementarities with a successful development agenda and with the components noted above.[42] Of course, this has an important "population" component, in that it includes a high priority for ensuring that all individuals have good quality, affordable, easily available sexual and reproductive health services, within a larger commitment to ensuring other health care services, good environmental health, secure homes, adequate incomes and other services. But this would not necessarily reduce GHG emissions.[43]

41. See Bartlett, Sheridan (2008), "Climate change and urban children: implications for adaptation in low- and middle-income countries", *Environment and Urbanization* Vol 20, No 2, October, pages 501–520.

42. This was a point emphasized by Adger, W Neil, Saleemul Huq, Katrina Brown, Declan Conway and Mike Hulme (2003), "Adaptation to climate change in the developing world", *Progress in Development Studies* Vol 3, No 3, pages 179–195. For a discussion of this for urban areas, see reference 29, Bicknell et al. (2009).

43. The GHG emissions implications of directly meeting such needs would not be substantial and are unlikely to drive low-income nations into having per capita emissions above the "fair share" level; however, if it is assumed that such needs are met by trickle down from economic growth, the GHG emissions implications would be far more serious.

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