COMMENTARY:

Climate impacts of poverty eradication

Narasimha D. Rao, Keywan Riahi and Arnulf Grubler

Raising basic living standards and growing affluence aren't equivalent, and neither are their respective climate impacts.

The recently released Intergovernmental Panel on Climate Change report confirms the sobering fact that humans could cause the planet to warm by over 4 °C above pre-industrial levels. This is more than double the target of limiting warming to 2 °C set in the Cancún Agreement of 2010[1]. Achieving this target not only requires aggressive decarbonization of industrialized societies, but also permits little room for energy growth. Whether developing countries can raise the living standards of the world's poor within these limits is a serious concern[2]. While much issue has been made of this 'climate–development' conflict, scientists understand surprisingly little about the greenhouse-gas (GHG) emissions pathways that are compatible with poverty eradication.

Part of the reason for this knowledge gap is that, with few exceptions, climate researchers still view poverty in income terms, often as gross domestic product (GDP), despite its limitations in characterizing basic human well-being[3,4]. In this view, GHG emissions would appear highly coupled with poverty alleviation (Fig. 1a), which presents a rather bleak outlook for low-carbon growth. Addressing the climate–development conflict through energy also has its limitations, as we understand quantitatively little of how energy growth contributes to poverty alleviation[5,6]. The GHG impacts of alleviating energy poverty — the use of traditional fuels for cooking and the lack of electricity — would have a relatively small impact on GHGs[7,8]. But even in its broadest interpretation, energy poverty does not capture the full extent of human deprivation.

Basic needs and emissions decoupled

The idea of 'environmentally efficient' well-being has recently been put forward, which demonstrates that human well-being can be, and has been, advanced without environmental exploitation[9]. Recently, a number of studies have shown that countries' GHG emissions and energy growth, in particular, are also relatively decoupled from human development[10,11]. This literature focuses on the Human Development Index (HDI) and its non-income components, literacy and life expectancy. The human development–GHG emissions relationship is best represented as a 'saturation curve' — at low levels of HDI, gains in HDI are 'cheap' with respect to energy or emissions, and get increasingly expensive up to a threshold, above which returns to increasing energy or emissions disappear. Thus, as countries grow out of poverty, the emissions intensity of achieving higher life expectancy or HDI increases[12]. On the other hand, there are a cluster of countries that seem to buck the trend and achieve high HDI indicators with relatively low GHG emissions[13,14].

However, GHG emissions pathways have not been examined with a broader set of poverty indicators. In this commentary, we show that this decoupling holds to an even stronger extent with nourishment, water, sanitation and electricity access. Indeed, many upper-middle-income countries (US$4K–12K GDP per capita) have almost universal access to a broader set of living standards with relatively low average per capita emissions. These trends offer some optimism, though there is still a lot to learn before one can draw lessons for developing countries. Climate research would move in this direction if, just as the development community has learned not to equate human well-being with income, researchers learn to distinguish the climate impacts of meeting basic human needs from that of rising affluence.

The United Nations Millennium Development Goals, Sustainable Energy for All and the soon-to-be-declared Sustainable Development Goals reflect the widely accepted aims of poverty eradication, including providing for people's basic needs for nourishment, health, education and shelter. These goals and their progress indicators also include access to infrastructure services such as water, sanitation and energy services, which are instrumental to fulfil basic needs ('means' rather than 'ends' indicators)[15], and relevant for climate change impacts due to the heavy use of energy-intensive cement and steel to build supply networks. We present both qualitatively and quantitatively the nonlinear relationship between some of these indicators with country GHG emissions.

Figure 1b–e illustrates the relationship of GHG per capita emissions with food nourishment (using the traditional Food and Agricultural Organization hunger indicator), and with electricity, water and sanitation access. We exclude health indicators, due to data limitations. Several upper-middle-income countries have achieved over 90% access in the past two decades with relatively flat emissions trajectories, and at levels below the world average of 6.3 tons per capita of CO_2 equivalent (Table 1). High-income countries have close to full access with a wide range of GHG emissions well above the world average. We verify this nonlinear relationship statistically by measuring the 'goodness of fit' of a linear model, a log–log model and that of a saturation curve with the abovementioned characteristics (see Supplementary Information for details). We find that the linear model has a goodness of fit of 52–70% for GDP, and 9–35% for all the other indicators. The log–log model has a better fit than the linear model for all indicators. However, for the non-GDP indicators the saturation curve has the best fit, which exceeds that of the linear model by a margin of 50% to a factor of 3.6. For GDP, the saturation curve fit is worse than the log–log and linear model fits. Notably, the overall goodness of fit is lower than that found with HDI indicators in previous studies. This is because a larger number of countries have achieved close to full access without facing any emissions thresholds.

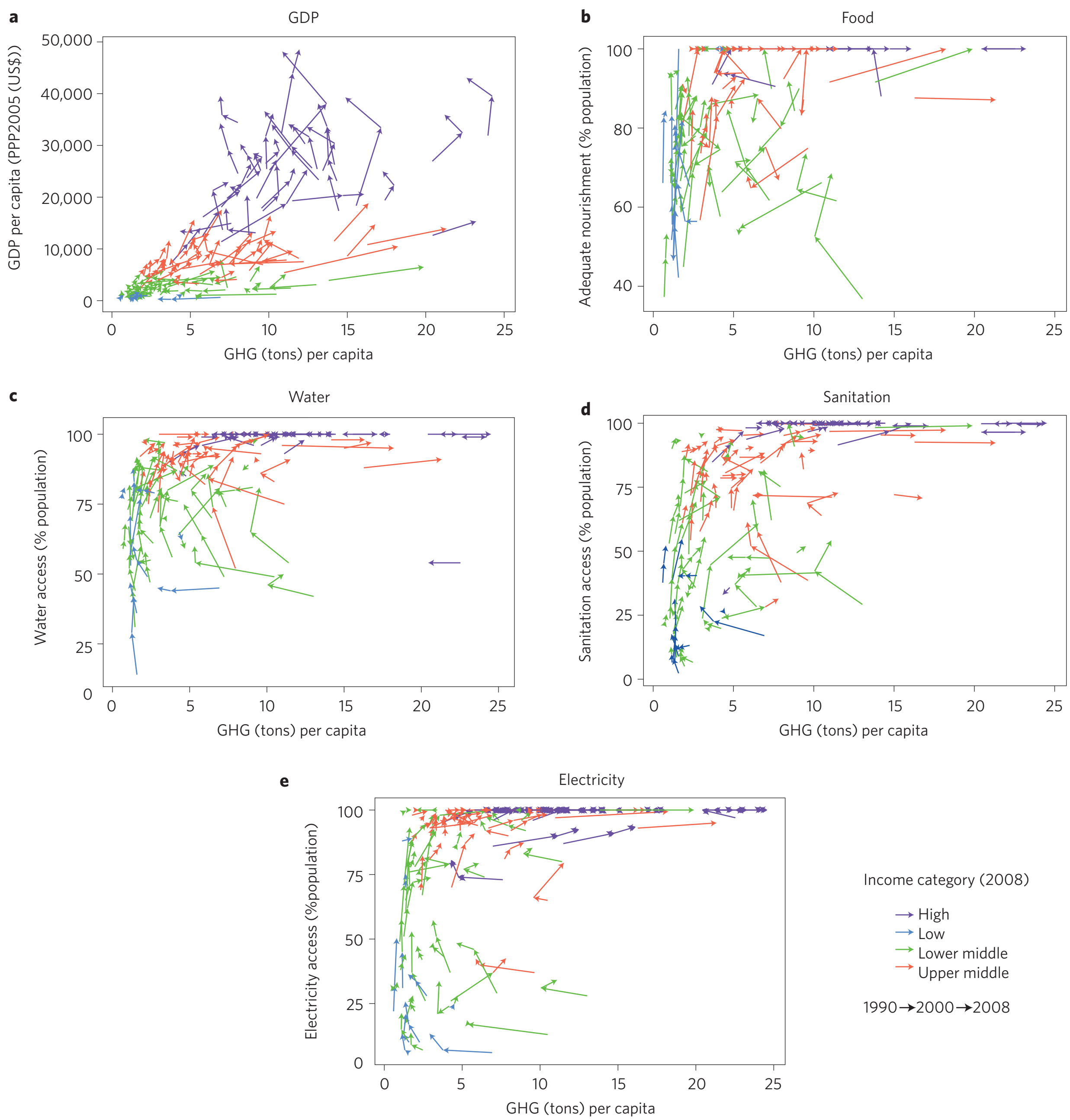

Figure 1 | Four-dimensional view of human development indicators against greenhouse-gas (GHG) emissions. **a**–**e**, GHG emissions against gross domestic product (GDP) per capita. Purchasing power parity with constant 2005 US dollars (PPP2005 (US$)) (**a**), adequate nourishment (**b**), water access (**c**), sanitation access (**d**) and electricity access (**e**). Colours indicate country income categories in 2008: blue, low income (<US$1K); green, lower-middle income (US$1K–4K); red, upper-middle income (US$4K–12K); purple, high income (>US$12K). Countries with GHG emissions >25 tons per capita are excluded. Data: GHG emissions, Climate Analysis Indicators Toolkit, World Resources Institute; GDP, electricity, water and sanitation access, World Development Indicators; food nourishment, calculated as '1 minus the undernourished share', where the undernourished share is assumed to be zero when shown as <5%, Food and Agricultural Organization Statistics.

Low-carbon providers of basic needs

We also relate countries' emissions to the progress in achieving all these living conditions together. We define a 'decent living' standard as the minimum level of access to five material dimensions of basic needs — nourishment, water, sanitation, electricity and non-slum urban housing (a proxy for secure shelter in Millennium Development Goal 7). With this composite index too, a saturation curve has a better goodness of fit of 43% versus 18% for a linear model. We further examine the range of emissions for countries at different stages of decent living. We group countries into those that in 2008 provided decent living standards to at least 90% (DL90), 75% (DL75) and 50% (DL50) of the population, respectively (Table 1a). If there were no data for a country for a particular dimension of decent living (mostly non-slum housing

Table 1 | Countries' greenhouse gas emissions characteristics by decent living conditions (2008).

	(a) Greenhouse-gas per capita emissions range (tons CO_2e)		(b) Low emitters' characteristics (average, unweighted)						
					Sectoral carbon emissions				
	Low emitters	High emitters	Number of countries	Gross domestic product per capita PPP2005 (US$)	Agriculture (CO_2e per capita	Electricity and heat (CO_2e per capita)	Transport (CO_2e per capita)	Industry (CO_2e per capita)	Energy use (GJ per capita)
DL90	2.9	23.4	5	5,875	0.75	0.42	0.41	0.54	31
DL75	3.6	15.5	11	6,439	0.66	0.76	0.59	0.60	37
DL50	2.4	9.9	11	4,765	0.96	0.36	0.36	0.38	25
World average	-	-	-	-	0.88	2.02	0.83	1.22	76

Decent living (DL) groups represent the subset of countries where at least 90, 75 or 50% of the population have access to adequate nourishment, electricity, water supply, sanitation and non-slum housing in urban areas. Data sources: Same as Fig. 1a–e; urban non-slum housing, UN Habitat. 'Low emitters' shows averages for countries with greenhouse-gas per capita emissions <5 tons CO_2 equivalent. 'High emitters' shows the 90th percentile per capita emissions. Low emitters DL90: Albania, Georgia, Cuba, Kyrgyzstan, Armenia. Low emitters DL75: Costa Rica, Jordan, Moldova, Algeria, Egypt, Syria, Tunisia, Colombia, Sri Lanka, Ecuador, Dominican Republic. Low emitters DL50: Panama, Nicaragua, El Salvador, Honduras, Tajikistan, Vietnam, Guatemala, Philippines, Indonesia, Peru, Morocco. Agriculture emissions are all non-CO_2 greenhouse gases. Industrial emissions include those from manufacturing and construction and industrial processes (for example, cement). Emissions not shown include those from land-use change and forests, and other forms of fuel combustion, such as biomass, fugitive emissions and waste. CO_2e, CO_2 equivalent; PPP2005 (US$), purchasing power parity with constant 2005 US dollars; GJ, gigajoules.

for Central European and former Soviet bloc countries), we assumed that the same share of the population had access to that dimension as the share that had access to all the other basic needs. We show the range of emissions for each group, bounded by the emissions of 'low emitters' and 'high emitters', the former being countries with per capita emissions below 5 tons CO_2 equivalent and the latter representing the 90th percentile emitters (to avoid outliers from the Middle East with high export-related emissions). The emissions for the DL90 group span a wider range than that for the DL75 group, implying that providing higher living standards doesn't limit the diversity of emissions paths that countries have followed. Furthermore, many countries with higher standards (DL90) have lower emissions than those with lower standards (DL75). Table 1b shows the average per capita GDP, energy use, and sectoral carbon emissions for the low emitters at all three levels of living standards. All indicators are unsurprisingly higher for DL75 relative to DL50, but also relative to those in DL90. These observations argue against an increasing 'minimum' emissions level required to achieve higher living standards. There are five countries in DL90 and another five from DL75 (that would classify as DL90 if the average, rather than the minimum, access level was used) with comparably low emissions.

What stands out about these low emitters? Taken together, these countries have moderate incomes, with only Costa Rica, Cuba and Panama having a per capita GDP higher than US$10K. Their energy use per capita is less than half the world average. Most have warm or temperate climates, which require less home heating energy. Besides Cuba, they all have a high share of hydro in their electricity mix. All have low transport emissions, and less than half the world average for per capita industrial emissions. They are also a subset of the countries identified as low carbon emitters with life expectancy higher than 70 years (aside from Kyrgyzstan and Algeria, which have life expectancies of 68) after accounting for trade-related emissions[14], which confirms that explicitly accounting for people's living conditions is indeed revealing. Interestingly, most of them have relatively high income inequality (Gini coefficients of 40 or higher), which suggests that an equitable income distribution is neither reflective of, nor a precondition for basic needs provision. To be sure, further work is required to understand the replicability of these conditions elsewhere.

We have also not considered several other linkages between carbon intensity and human development. For instance, other resource needs for basic living standards (for example, transport infrastructure, land use) need to be quantified; the data on access to services doesn't capture actual service conditions; other institutional, climatic or cultural factors may contribute to both better living standards and low emissions; the contributions of CO_2 and methane need to be distinguished, as they contribute differently to human development and to countries' total GHGs[16]. The role of non-GHG climate-forcing pollutants, such as organic and black carbon and aerosols, in both human development and climate forcing also needs to be better understood.

Nevertheless, applying a broader lens of human development suggests a greater compatibility between raising basic living standards and low-carbon growth than that indicated by the traditional income–emissions relationship. By the same token, without applying this lens to countries' emissions, one risks attributing emissions growth to poverty alleviation, which may instead be driven by growing affluence. In a resource-constrained world, this is a crucial distinction. ❒

Narasimha D. Rao, Keywan Riahi, Arnulf Grubler are at the International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg, Austria.*
**e-mail: nrao@iiasa.ac.at*

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Additional information

Supplementary information is available in the online version of the paper.