

The role of population growth in global CO₂ emissions

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Abstract

The principle of "differentiated responsibilities" of North and South in protecting the climate system against global warming is recognized in the Rio Framework Convention on Climate Change. We focus here on the quantification of one aspect of this issue: population growth versus growth in CO₂/capita emissions. We first mention several problems raised by the way the Ehrlich-Holdren equation (Environmental impact = Population times Per capita impact) is used in the context of greenhouse gas emissions. In particular, we remind the importance of using the lowest possible aggregation level with this equation. We then apply this equation to population and fossil fuel-related CO₂-emission data for nine regions of the world over the 1950-1990 period. The results of a scenario analysis using these data show that the increase in developed countries CO₂ emission per capita had a significantly larger impact on world total emission increase than LDC's (Less Developed Countries) population growth during that period. It is also shown that population growth in developed countries had a larger effect than LDC's population growth.

1. INTRODUCTION

In order to allow a 'sustainable climate' (Gouzée and van Ypersele, 1992), i.e., a climate that does not change faster than the speed at which the economy, and the natural and agricultural ecosystems can adapt, the concentration of greenhouse gases in the atmosphere must be stabilized as soon as possible, which implies a global reduction of emissions. To achieve this, the Rio Framework Convention on Climate Change (FCCC) states in its Article 3: 'The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities.'

This principle of differentiated responsibilities raises the question of the role of population growth as a factor in increasing global emissions of greenhouse gases. This paper explores a way of quantifying the importance of this factor compared to the CO₂/capita increases observed over the 1950-1990 period.

2. USE AND MISUSE OF THE EHRlich-HOLDREN EQUATION ($I = PF$)

A classical way of quantifying the links between environmental issues and population size is illustrated by the following equation, originally published by Ehrlich and Holdren (1971): $I = PF$, where I is a negative impact on the environment, P the population size, and F is a function which measures the per capita impact. That equation was subsequently rewritten as (Ehrlich and Ehrlich, 1990, p. 58): $I = PAT$, where I is a negative impact on the environment, P the population size, A stands for affluence or per capita consumption, and T is 'an index of the environmental disruptiveness of the technologies that provide the goods consumed.' Although the $I=PAT$ equation relates CO_2 emissions to *three* factors, population is often seen as the main one. It may be because population statistics are more readily available to climatologists and ecologists than economic data, or because many MDCs (More Developed Countries) writers believe that it is more important or easier to control LDCs population growth than consumption patterns in their own countries.

For example: '[...]The atmospheric concentrations of these [greenhouse] gases are tightly tied to population size. Consequently, there is no practical way to achieve the necessary reduction in greenhouse emissions without population control' (Ehrlich and Ehrlich, 1990, p. 58-59). However, this 'consequence' cannot be justified: statistical association does not necessarily mean a causation. Indeed, the fact that population and carbon dioxide emissions grew over the same period does not imply that there is a simple causal link between the two.

This logical error is related to the problem of *aggregation*. The $I = PAT$ equation can certainly yield useful indications on the roots of environmental degradation, but only if applied to a specific homogeneous region or country. If it is applied to the world as a whole, average values will hide the deviations from the mean and the variations of the distributions. Since the fraction of the world population which grows at the fastest rate is also the one with the lowest per capita emissions, using average population growth rate and average per capita emissions will overestimate world emissions.

An example of faulty aggregation made by the Ehrlichs is again taken as granted and cited in full in a recent UNFPA-published book (UNFPA, 1991, p. 17): the Ehrlichs (1990, p. 59) say: 'to illustrate how this interaction [between reduction in greenhouse emissions and population control] works, suppose that, by dint of great effort, humanity managed to reduce the average per-capita consumption of resources on the planet (A in the $I=PAT$ equation) by 5 percent and improved its technologies (T) so they did 5 percent less damage, on the average. This would reduce the total impact (I) of humanity by roughly 10 percent.' This calculation is meaningful only if one assumes the distribution of technology and per capita consumption to be uniformly distributed among every humans, which is not presently the case. But the Ehrlichs continue with: 'unless population growth (P) were restrained, however, its growth would bring the total impact back to the previous level in less than six years.' Since the main part of the population growth occurs in developing countries, it is incorrect to multiply this increasing population by a decreasing consumption and an improving technology that are both supposedly occurring in a developed country in this example. A similar faulty aggregation is made in 'Earth in the Balance', the book written by US Vice-President Gore (1992, p. 309-310).

3. THE ROLE OF POPULATION GROWTH IN PAST CO₂ EMISSIONS

To try to quantify the role of population growth in past CO₂ emissions, we now present the results of a set of scenarios that show how important the world CO₂ emissions from fossil fuel and cement would have been had the population and/or the CO₂ per capita followed different paths of evolution during the period 1950-1990.

The observed emissions used as a basis for the simulations come from Marland and Boden (1991). They are given for nine regions¹ of the world between 1950 and 1990. Figure 1 displays the evolution of population and CO₂ emissions in MDCs and in LDCs during the period of study.

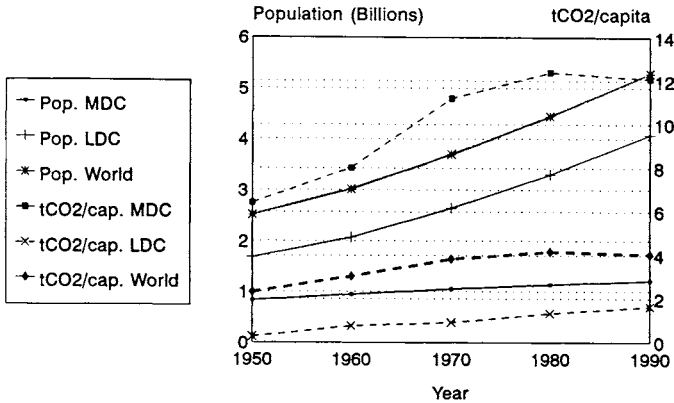


Figure 1. Evolution of population (continuous lines) and CO₂ emissions per capita (dashed) in MDCs and in LDCs from 1950 to 1990 (based on data from Marland and Boden, 1991).

Table 1 presents the results for four scenarios (additional scenarios and background analysis can be found in Bartiaux and van Ypersele, 1993). Although the results are summed up for the MDCs and LDCs, the simulations were performed separately for the nine regions with their corresponding population figures and CO₂ emissions per capita. This disaggregation into nine regions is more accurate than performing the calculations for two groups only (MDCs and LDCs) but is yet probably too crude to fully avoid the heterogeneity within the nine regions (see Lutz (1992) for additional comments on the aggregation problem). For each scenario Table 1 also compares the simulated total CO₂ emission to the

¹ Marland and Boden (1991) subdivided the world into the following nine regions: North America (USA and Canada), Western Europe, Eastern Europe (including former Soviet Union), Centrally Planned Asia (including People's Republic of China, Viet Nam, North Korea, and Mongolia), Far East (including India, South Korea, Indonesia, Taiwan, Thailand, Pakistan, Malaysia, the Philippines,...), Oceania (mostly: Japan, Australia, and New Zealand), Developing America (the American continent less USA and Canada), Middle East (Saudi Arabia, Iran, Turkey, ...), and Africa.

observed value for the corresponding year and the difference is indicated in per cent. It thus gives the influence of the factor(s) considered in that scenario. Admittedly, these simulations also neglect a number of factors, including emissions from deforestation (for which data are more uncertain), emissions of other greenhouse gases, and the effect of trade.

Table 1. The role of population growth in past CO₂ emissions: scenarios

For each scenario and for each year, CO₂ emissions from fossil fuel and cement are given in million tonnes of CO₂ (MtCO₂) for the more developed countries (MDC), the less developed countries (LDC), and the world total (TOT). The calculations have been made with nine separate regions. The last line (D%) shows the relative change in world emissions compared to the observed data for the same year.

	Year	1950 MtCO ₂	1960 MtCO ₂	1970 MtCO ₂	1980 MtCO ₂	1990 MtCO ₂
Observed data	MDC	5358	7604	11781	14152	14665
	LDC	462	1589	2411	4415	6676
Source: Marland and Boden (1991)	TOT	5821	9193	14192	18567	21341
1. Pop. MDC = real data	MDC	5358	7604	11781	14152	14665
Pop. LDC = 1950 value	LDC	462	1301	1517	2223	2786
CO ₂ /cap MDC = real data	TOT	5821	8905	13297	16375	17452
CO ₂ /cap LDC = real data	D%	0	-3.1	-6.3	-11.8	-18.2
2. Pop. MDC = 1950 value	MDC	5358	6608	9171	10123	9778
Pop. LDC = real data	LDC	462	1589	2411	4415	6676
CO ₂ /cap MDC = real data	TOT	5821	8197	11582	14538	16454
CO ₂ /cap LDC = real data	D%	0	-10.8	-18.4	-21.7	-22.9
3. Pop. MDC = 1950 value	MDC	5358	6608	9171	10123	9778
Pop. LDC = 1950 value	LDC	462	1301	1517	2223	2786
CO ₂ /cap MDC = real data	TOT	5821	7909	10687	12346	12565
CO ₂ /cap LDC = real data	D%	0	-14.0	-24.7	-33.5	-41.1
4. Pop. MDC = real data	MDC	5358	6195	6944	7586	8149
Pop. LDC = real data	LDC	462	1589	2411	4415	6676
CO ₂ /cap MDC = 1950 value	TOT	5821	7785	9355	12001	14825
CO ₂ /cap LDC = real data	D%	0	-15.3	-34.1	-35.4	-30.5

The first set of scenarios deals with the effect of population growth alone. Scenario 1 tests the effect on the CO₂ emissions of an hypothetical stationarity of the LDCs populations at their 1950 level, with the observed evolution of the CO₂ per capita emissions in the different regions: the result would have been 18% less world emissions than the real figure for 1990. Conversely if the MDCs populations had not grown since 1950, the difference would have been higher: -23%, as shown by scenario 2. Of course these two gains would be added to each other had both the LDCs and MDCs populations been blocked (scenario 3). Thus for the period 1950-1990, the MDCs population growth played a greater role in the increase of the world CO₂ emissions than the LDCs population growth did, because the CO₂ emissions per capita multiplier is so large in MDCs. To demonstrate the effect that aggregating can have on such calculations, we also computed scenario 3 without disaggregating the world in nine regions, by using a world average for CO₂/capita: the decrease in total emissions in 1990 compared to 1950 is then -52.5% (instead of -41.1% without aggregation). This shows clearly how aggregation contributes to overestimate the role of population growth.

The fourth scenario addresses the effect of CO₂ per capita. If we block the CO₂ per capita in the MDCs at their 1950 values and have the MDCs and LDCs populations grow as they really did, the world emissions would have been significantly less than observed: -15% in 1960, -30% or more since 1970 (scenario 4). The comparison between scenarios 4 and 3 indicates that the effect of the populations growth in both MDCs and LDCs could have been offset until 1980 by the sole blocking of MDCs CO₂ per capita rates to their 1950 values.

4. CONCLUSION

These scenarios results illustrate in a striking manner the concept of 'differentiated responsibilities' introduced in the Rio Convention. They tend to show that, for fossil fuel CO₂ emissions between 1950 and 1990, past population increases in developing countries have contributed much less to CO₂ increases than either increases in consumption in MDCs or even population growth in MDCs did (scenario 1 compared to scenarios 4 and 2, respectively). Since changes in consumption patterns are affected by a weaker structural inertia than population is, it may be argued (see Meadows et al., 1992) that it would be more rapidly effective to put the emphasis on changing the energy and resource consumption patterns, specially in rich countries. By doing so, the growth of the world CO₂ emissions could be braked while waiting for the outcome of the reduction of population growth.

Such reduction may indeed be necessary, not as much because of past responsibilities of population growth in global warming, as shown by Table 1, but to allow a sustainable development. As most demographers have long recognized, the relationships between demographic, social, economic, and environmental factors are complex. In a report made in preparation of the Rio Conference, the Overseas Development Administration of the United Kingdom Government (1992), addresses the issue of population growth in the following terms: 'the more the scope for an induced reduction in population growth is seen to be real and significant -- for example by meeting an unmet demand for family planning -- the more this encourages the view that population is a direct causal factor which should be manipulated. On the other hand, the more the fertility decisions are seen to be a function of a complex of structural socio-economic factors, the less it can be seen as a simple lever to be used, and therefore the less population growth can be seen as an independent cause' (p. 10). [...] 'Indeed, there are risks attached in tying the rationale for family planning too closely to poorly understood relationship between population growth and environmental degradation. The links are too complex and uncertain, and risks of overemphasis too great, for environment to be highlighted as a major reinforcing rationale for family planning. In these circumstances it may be better to recognize that slowing population growth does not constitute a short-term solution to environmental degradation, and that working with the multiplicity of positive linkages between measures which benefit women and environmental management represent the constructive way forward' (p. 21).

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5. REFERENCES

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