The Carbon Debt of Countries. The methodological paper

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Introduction

One of the main goals of the research project Environmental Justice Organizations, Liabilities and Trade (Ejolt) is to empower Environmental Justice Organizations (EJOs) by a transfer of scientific methodologies of use in their struggles. Ecological debt, including climate debt, is identified as one of the key concepts. According to Ejolt's description, "[t]here is a demand from international EJOs and also from government officials for the instruction of the methodology of such calculations in terms that activists and citizens can understand" (Ejolt 2010: 20).

Following this aim, a calculation of the full carbon debt of the 154 major countries has been conducted and the result is available at the Ejolt web page, ejolt.org/CarbonDebt. Additionaly, an elaborated report on the history and applications of ecological debt and climate debt has been published by Ejolt (Warlenius et al. 2015), also available on Ejolt's webpage. In this paper, the chosen methodology for the carbon debt calculations is described.

The overall ambition has been to identify a method for quantifying climate debt that is a) in line with the definition of climate debt that has emerged from the environmental and climate justice movements, b) scientifically accurate, c) applicable on existing data, and d) user friendly, i.e. relatively easy to grasp and use by activists and citizens.

Inspiration

Starting in 1999, attempts att calculating the carbon debt has been published by mainly NGO's. In the run-up to the 2009 Copenhagen climate summit, large parts of the global justice movement united around a push for the concept of climate debt, and methodological papers were presented by e.g. Third World Network (TWN 2009). After the failure in Copenhagen, Bolivia invited to a large popular convergence in Cochabamba. The *People's agreement* approved at the conference (PWCCC 2010) also referred to climate debt and formed the basis for Bolivia's 2010 submission to UNFCCCC. There, climate debt was defined thus:

> [B]y over-consuming the available capacity of the Earth's atmosphere and climate system to absorb greenhouse gases the developed countries have run up a climate debt to developing countries and mother Earth (UNFCCC 2010:15)

The partition of the climate debt in two parts – for being unfair (to developing countries) and unsustainable ("over-consuming the available capacity", harming "mother Earth") is crucial also for a more precise method for calculating the carbon debt developed by Belgian scholars led by Eric Paredis. There, the carbon debt of country A is defined as

> (a) over-emission of CO_2 by country A over time with respect to a sustainable level; i.e. emission levels that overshoot the absorption capacity of the atmosphere and are thus causing ecological impact in other countries and ecosystems beyond national jurisdiction;
>
> (b) over-emission of CO_2 by country A over time at the expense of the equitable rights to the absorption capacity of the atmosphere of other countries or individuals. (Paredis et al. 2008:150)

The "equitable rights" of a country is based on a per capita interpretation of justice: responsibility for climate change is distributed among countries on their per capita contribution over time (Ibid.:152). Historically, high per capita emissions have resulted in a carbon debt, while low emissions have led to a negative debt (or a claim). In order to account for both of these factors – equity and sustainability – Paredis et al. differ between the Historical Carbon Debt (HCD), which is the *intra-generational interstate debt* referring to inequalities between countries and populations historically and today, and a Generational Carbon Debt (GCD) which is the *inter-generational debt* that our generation owes to coming generations, i.e. emissions above the sustainable level. Together, HCD and GCD make up the total Carbon Debt (CD).

To operationalize the concept, Paredis et al. propose two models, of which I have chosen Model 1 (for a motivation, see Warlenius 2012), expressed by the following formula (Ibid.: 154-156),

$$CD_C = \sum_{i=\delta}^{\varepsilon} \left[e_C(i) - \frac{Pop_C(i)}{Pop_W(i)} S_W(i) \right] \qquad (1)$$

where CD_C stands for the carbon debt of country C, δ is the start year of accounting the debt, ε the end year, $e_C(i)$ is C's CO_2 emissions year i, $Pop_C(i)$ is C's population year i, $Pop_W(i)$ is the world population year i, and $S_W(i)$ is the sustainable emission level for the world year i.

If a country has emitted *less* than its fair, per-capita quota of a sustainable limit of emissions, it has a negative carbon debt, i.e. a claim. All claims added together equals total Historical Carbon Debt (HCD) of all debtor countries. But total debt are even higher, and the rest consists of unsustainable emissions, owed to future generations; the Generational Carbon Debt (GCD). The ratio between HCD and CD of all debtor countries is multiplied with the CD of an individual debtor country to establish the HCD of a particular country. What remains constitutes the GCD. In formulas, the defintions are be expressed thus:

$$HCD_c = \frac{HCD_{debtors}}{CD_{debtors}} CD_c$$

and

$$GCD_c = CD_c - HCD_c$$

A modified model

Paredis et al's model is however not identical with the one used in this paper. Three modifications were made, whereas I resigned from my original aims in one respect.

Climate debt or carbon debt?

Whether to call the sum of these formulas *carbon debt* or *climate debt* is partly a question of connecting to a certain current of thought. Since one of the aims of this paper is to identify a method that is in line with the definition that has emerged from the environmental and climate justice movements, it would be logical to use their term, i.e. climate debt. But which term to use is also a question of what is ultimately measured: emissions of carbon or contribution to climate change. If the latter is the case, emissions of all greenhouse gases (GHGs) – such as methane, nitrous oxide and hydrocarbons besides carbon dioxide – should ideally be included. Doing so gives a scientifically more accurate picture of the causes of climate change. However, data on emissions of all greenhouse gases are very scarce up until the 1990s[1], and if one wants to have a long-term historical perspective, only data on CO_2-emissions from fossil fuels and cement are available. A sinister trade-off between data accuracy and historical depth thus have to be made. In this trade-off, I have decided to staying true to the definition of carbon/climate debt as including a deep historical perspective, which means that only

1 CAIT, the database used, only reports data on GHG emissions for 1990, 1995, 2000 and 2005.

emissions of carbon dioxide are included. I therefore regard as more honest to also name the result carbon debt rather than climate debt.

A sustainable level of emissions

Identifying a “sustainable level” of emissions is not a straightforward thing since “there is no such thing as an absolute level of sustainability, no absolute criterion for equity /.../ these will always have to be ’social constructs’” (Paredis et al 2008:154). Although I subscribe to this approach, we should of course aspire to make as accurate an assessment as possible. Paredis et al. base their choice on an IPCC (1990: XI) estimation that a 60 percent global cut of greenhouse gas emissions below the 1990 level is needed to stabilize the climate system. Rather than starting from reduction scenarios, however, finding an estimate for the sustainable level of annual emissions should start with an assessment of the absorption capacities of the global carbon sinks. The most reliable sinks are the oceans, which are believed to have absorbed about 8 GtCO_2 per year the last decades (Khativala et al. 2009). That the sink capacity of oceans hitherto has increased with higher emissions has eased global warming but with a clear downside: stronger acidification of the oceans which might lead to very severe consequences for sea life (Honish et al 2012). Also biomass, mainly forests, have acted as a sink of about the same size as the oceans for the latest decades. But biomass is an unreliable sink, whose net contribution to the carbon cycle varies greatly from year to year. The rising sink capacity of forests is largely due to the expansion of commercial forestry which have increased the amount of standing trees, but this is a development that logically can not continue forever. According to one estimate by IPCC (referred by Khativala et al 2009), ocean and land sinks used to absorb about 7.7 GtCO_2 per year, which rose to 11.7 during the 1990s and 12.8 after the millennium shift. But as shown above, the higher carbon uptake can not be regarded as long-term sustainable. UNDP (2007:34) is much closer to a definition of a *sustainable* level of emissions: “Over the long term, the Earth’s natural capacity to remove greenhouse gases without sustaining damage to the ecological systems of carbon sinks is probably between 1 and 5 GtCO_2e”. Although more research is wanted in this matter, the assessment of UNDP will be used. To be conservative, the highest figure in the range, i.e. 5 GtCO_2e per annum, is regarded a sustainable emission.

A modified formula

A remaining challenge is that the method developed by Paredis et al. requires a lot of data and a lot of calculations in order to be applied, which in effect harms the longer historical perspective. In order to apply their models, one needs data on emissions and population for every country and every year within the period of research, and one needs to make one calculation for every country and every year, before adding the results to the country's carbon debt. There are a lot of gaps in the historical data on emission and population. It however seems to be a close correlation between historical emissions and access to emissions data. Thus, for most industrialized countries – with great historical emissions – there is data going back to 1850 or longer, while for developing countries – with small, even negligible emissions before 1950 – the emissions data regularly starts in the 20th century. Even though the emissions data for, say, 1850 only cover 30 countries in the database used (Climate Analysis Indicator Tools, CAIT), one can assume that it covers a very large part of actual emissions that year. Data on population before 1950 is very patchy for many countries, and in order to fill in all the empty fields in the data base used – Maddisson 2010 – many uncertain assumptions has to be made. In an attempt to obviate this obstacle, I will propose a modification of Paredis et al.'s Model 1. The modified model uses the same principles for determining what is fair and sustainable, namely per capita-justice and a sustainable level of global emissions. The main difference is that instead of calculating the debts for every single year and summing the results, I propose to make the calculation only once per country, using cumulative emissions. Formally, the modified model can be put this way

$$CD_C = E_{CT} - \left[S_{WT} \frac{Pop_C}{Pop_W} \right] \qquad (5)$$

where CD_C is understood as carbon debt of country C, E_{CT} as C's cumulative emissions during the time period T, S_{WT} is the sustainable level of global, annual CO_2-emissions that are absorbed by the ecosystems without damaging their functions times the number of years of the time period of choice T, Pop_C is the population of C and Pop_W the world population. One remaining question is, though, when during T to measure population. If population is measured at the end of the period a bias occurs, since it would result in comparatively greater carbon debt for countries whose population as a rate of world population is decreasing; i.e. generally developed countries. If population is measured at the very start of T, we have the opposite problem. This bias can, however, largely be obviated by using the mean value of the population rates of the country at a few points spread out during the time period. In this study, the population of every country is divided with world population for three years—1870, 1950 and 2000—using the average percentage as the country's population rate. Thereby, most population trends during 200 years of industrialization should be taken into account[2].

For parts of Eastern Europe, Asia and Africa, no country statistics even for 1870 exists. But there is data on total population of subregions or continents, so in those cases, the 1950 distribution between countries within a region or continent have been projected on the 1870 totals (assuming that the population growth of every individual country has been the same as for the sub-region/continent as a whole).

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[2] The years chosen and the weighting of them is a matter of further consideration. For instance, 1850, 1900, 1950 and 2000 would have been more evenly spread out during the period, but unfortunately there is substantially less data for 1850 and 1900 than for 1870, which was therefore selected. That a relatively larger weight is put on the later part of the period also corresponds to the fact that total emissions have increased dramatically during the period.

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