Is An Individual’s Harmful Impact on Human Health via Climate Change Ethically Negligible?

SIMONE ROCCA, DES GASPER

International Institute of Social Studies (The Hague), of Erasmus University Rotterdam, Netherlands

Correspondence address: gasper@iss.nl

ABSTRACT:
This paper assesses whether an individual’s impact on the lives and health of other people through anthropogenic climate change is ethically significant. Using a methodology different to Nolt (2011), it estimates the impact on health harm for humans, in terms of DALYs lost due to a lifetime of greenhouse gas emissions. By adopting conservative (meaning minimalist) assumptions, the analysis confirms that individually attributable impact on health—which is only one part of total harmful impact—is clearly not negligible, in extent and ethical significance. It thereby refutes a common defence of inaction by or in relation to high-emissions individuals.

1. Introduction: Clarifying the project

> In discussions of global climate change, it is often assumed that the consequences of the choices of a single individual are negligibly small. I am not, however, aware of any serious attempt to justify that assumption. (Nolt, 2011, p. 1)

Climate change already has, and will increasingly have, a strong impact on our environment and on humans of current and future generations (IPCC, 2007, 2014). It will adversely affect possibly billions of people to the point that one can say that some of their human rights will be threatened, concluded the UN High Commission for Human Rights (UNHRC, 2009). Although there is a consensus that, to avoid catastrophic climate change-induced consequences, global GHG emissions should be reduced by around 50% by the year 2050, global emissions have been constantly rising in the last two centuries and especially in the last 20 years. Business-as-usual will bring large-scale suffering. In this context we should ask what is the role of individuals and how far they should be considered responsible for their greenhouse gas (GHG) emissions and for thereby hampering the enjoyment of human rights by other people.

One relevant step is to identify the GHG emissions attributable to an individual. It is for example possible to estimate the amount of CO_2 emitted for a flight and assign this amount among the passengers. Similarly one can estimate the emissions related to driving a vehicle. By collecting information about the GHG-emitting activities caused by an individual over one year, it is possible to estimate his/her attributable yearly emissions.[i] Less exact but simpler, one can estimate the per capita emissions in a certain country by dividing its total emissions by its number of citizens, as done in Nolt’s pioneering paper in this journal (2011).

A next step is to assess the impact of an individual’s attributable emissions on global warming, environmental degradation, and the enjoyment of human rights, such as through harm to health. However, evaluation of the global impacts of GHG emissions requires extremely complex analysis (IPCC, 2007, 2014), and assigning these global impacts to individuals' actions is not straightforward. Protected by this 'veil of uncertainty', the impact of individual behaviour is often, as Nolt noted (2011), assumed without sufficient justification to be negligibly small (see for example Sinnott-Armstrong, 2005).

Even if individual direct impact were negligible, that might not be sufficient reason to deny individual responsibilities, since each individual's action has also an indirect impact on the authority of norms for the behaviour of collectivities, whose actions in aggregate certainly have non-negligible impact (Hourdequin, 2010, rejecting Johnson, 2003). Nevertheless, since it is often assumed that individual impact is negligible, it is worth assessing that belief. We need to estimate the relation between a certain amount of greenhouse-gas emissions and the threat to human rights caused by the said emissions through the intermediate variable(s) of climate change. In this way, the person who is directly responsible for those emissions will know that he/she is also responsible for a certain negative impact on the enjoyment of human rights. This paper will focus exclusively on the impact on human health, because expert estimates exist for that aspect.

In order to confirm or refute that the consequences of individual behaviour for climate change are ethically negligible we should consider too the criterion of negligibility. For Nolt (2013, p. 118), for example, the threshold of non-negligibility is the level at which individual behaviour produces harm. We take a more pragmatic intuitive approach. If one finds that even the minimal estimate of impacts is definitely non-negligible, then one does not need to argue over the precise cut-off criterion of negligibility. So, identification of the broad order of magnitude of impacts may suffice for identifying whether impact is ethically negligible or not. And if it is not possible to sufficiently estimate the impact because of lack of knowledge, we should say that the impact is not known, not that it is negligible.

We will assess then the claim that the impact of an individual's GHG emissions on health is ethically negligible. The assessment involves estimating the impact of an individual's emissions on the climate; estimating the impact then on human health; and assessing the ethical significance of that health impact. In Section 2 we present the recent attempt by Nolt (2011) to quantify and value impacts, and propose an alternative method that overcomes some shortcomings of his approach. Section 3 discusses how and why our estimation is deliberately conservative: for that allows us to see whether, despite all remaining uncertainties regarding climate change and its impacts, the question of ethical negligibility of an individual's impact can be resolved. Section 4 reflects on the associated assumptions and the possible ethical and policy implications. Section 5 sums up

2. Estimation of harm caused by an individual's GHG emissions

Nolt's estimate

Nolt estimates the average US citizen's share of the total GHG emissions that have led and are leading to climate changes that are likely to adversely affect hundreds of millions of people, indeed billions over the generations ahead. He first estimates the yearly emissions of an average US citizen by dividing the annual GHG emissions of the entire country by the number of its citizens. The lifetime emissions of the average US citizen are calculated by multiplying his/her yearly emissions by average life expectancy.

Nolt then makes the assumption that harm is proportional to emissions. He acknowledges that the assumption is not based on detailed empirical evidence. If one queried his assumption it would though be because it very likely underestimates the harm caused. There are reasons to expect that harm will increase faster than emissions: when stability thresholds in existing ecological and socio-ecological systems are passed, the resulting shifts take us beyond the bounds to which the existing systems are well-adapted.

He estimates that GHGs remain in the atmosphere for a millennium, thus implying harm to all people living over the next thousand years. He reaches the indicative conclusion that 'the average American causes through his/her greenhouse gas emissions the serious suffering and/or deaths of two future people' (Nolt, 2011, p. 9). He acknowledges that the conclusion is based on controversial assumptions and is subject to a large degree of uncertainty; but it is intended to indicate a plausible order of magnitude.

The impact of the average US citizen's emissions is taken in this paper too as a central case. We too will adopt the principle, defended in the literature, that the harm produced is proportional to the emissions. Therefore the result obtained for the average US citizen can be scaled proportionally to any other individual by comparing his/her lifetime individual emissions with those of that average citizen. In countries with high income inequality like the US the lifetime emissions of a significant part of the population are much higher or very much higher than the average. Chakravarty et al. (2009) estimate that, within a country, individuals' emissions can be considered approximately proportional to individuals' income. Dunn (2012) reported that the average annual income of the top 1% of the US population was $717,000, while the national average individual annual income was around $51,000. This suggests that the top 1% of income recipients emit roughly 14 times more than the average US citizen, and cause roughly 14 times more harm through their GHG emissions.

Our approach: DALYs lost per unit of emission

We propose a method for estimation of the health impacts of climate change due to an individual's behaviour. A highly conservative approach is adopted, so that the results produced should be understood as the lowest-bound estimate of harm, whereas an estimate of the most likely harm would be substantially higher. The conservative nature of the assumptions made is explained below for each step.

Only the consequences of climate change for health will be considered here; we have found sufficient appropriate data only regarding health. Since other harms (e.g., forced migration, loss of properties, etc.) are not considered, the estimates produced are an under-estimation of the climate change-related impacts and the associated threats to enjoyment of human rights.

The impacts on health are evaluated in terms of Disability-Adjusted Life Years (DALYs), a metric introduced by Harvard University for the World Bank in 1990 and adopted by the World Health Organization, who give the following definition:

> One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.
> DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost due to premature mortality in the population and the Years Lost due to Disability for people living with the health condition or its consequences.
> (http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/)

Our first objective is to establish what is the relation between GHG emissions and the loss of DALYs through climate change that is caused by the emissions.

The proportionality of global warming to cumulative carbon emissions

Matthews et al. (2009, p. 829) summarize the working principle of proportionality of global warming to cumulative carbon emissions:

> Climate–carbon modelling experiments have shown that: (1) the warming per unit CO_2 emitted does not depend on the background CO_2 concentration; (2) the total allowable emissions for climate stabilization do not depend on the timing of those emissions; and (3) the temperature response to a pulse of CO_2 is approximately constant on timescales of decades to centuries. Here we generalize these results and show that the carbon–climate response (CCR), defined as the ratio of temperature change to cumulative carbon emissions, is approximately independent of both the atmospheric CO_2 concentration and its rate of change on these timescales.

This principle is presented also by Allen et al. (2009) and IPCC (2013, p. 63).

Matthews et al. observe further that the warming impact of the various non-CO_2 GHGs is counterbalanced by the effect of other emissions, notably of aerosols, hence: 'The current balance of positive and negative forcings is such that the best estimate of the net anthropogenic forcing is very close to the forcing from CO_2 alone.' (2012, p. 4371). Thus:

> the temperature response to cumulative carbon emissions remains a close approximation of the temperature response to cumulative carbon in combination with emissions of other greenhouse gases and aerosols. (2012: 4374-4375)

Matthews et al. (2012: 4371) conclude therefore that:

> The use [in analysis] of cumulative carbon emissions provides a simple and versatile approach to the problem of climate change mitigation. This is particularly true for longterm temperature targets; because of the very long lifetime of anthropogenic CO_2 in the atmosphere relative to most other climate-relevant gases [...], the climate warming signal will become increasingly CO_2-dominated as we move into the latter half of this

century and beyond. When considering nearer-term climate targets, however, and particularly if we are to restrict the overall rate of climate warming over the next several decades, it is not possible to ignore the effect of other greenhouse gases and aerosols.

Matthews et al. (2009) define the Carbon-Climate Response (CCR) as the ratio between the global mean temperature increase and the cumulative amount of anthropogenic CO_2 emissions:

$$CCR = \Delta T / E_t.$$ [ii]

Their calculations indicate that the CCR has a constant value in the range of 1.0 – 2.1°C per trillion tonnes of carbon emitted (or 0.3 – 0.6 °C per trillion tonnes of CO_2 emitted).

The structure of our estimation model

The estimation presented here is dependent on the following considerations:

- The above finding that global temperature increment is proportional to the cumulative amount of anthropogenic CO_2 emissions (Matthews et al. 2009). A corollary is that even if the (net) CO_2 emissions were reduced to 0 at time t, the eventual temperature increment would still be the level implied at time t (Matthews et al. 2009).
- Assumption: impact on human health, in terms of DALYs per year, is proportional to the global mean temperature increment. This is a clearly conservative assumption because one could expect that for high global mean temperature increments the harm produced will be more than proportional.[iii] Nevertheless, in the absence of better knowledge of the relation between temperature increment and impact on human health, including knowledge on the non-linearities, thresholds, or positive feedbacks, the relation of proportionality seems an appropriate assumption for purposes of the present argumentation. If we find that even with this clearly conservative assumption (i.e., probable substantial underestimation) the attributable health impact is substantial then some robust ethical and policy implications will follow.

We define the Climate-Health Response (ClHR) as the ratio between the DALYs lost each year due to climate change and the associated global mean temperature increase:

$$ClHR = \text{DALYs lost per year} / \Delta T.$$

This parameter expresses how many DALYs are lost each year for each °C of global warming. According to the assumption above, ClHR is constant.

We define the Carbon-Health Response (CHR) as the ratio between the DALYs lost each year due to climate change and the relative cumulative amount of carbon emissions, which as we saw can be a proxy for the amount of anthropogenic emissions:

$$CHR = \text{DALYs lost per year} / E_t$$

CHR can then be expressed as the product of ClHR and CCR:

$$CHR = CCR * ClHR = \Delta T / E_t * \text{DALYs lost per year} / \Delta T = \text{DALYs lost per year} / E_t$$

Since CCR and ClHR are constant, CHR is constant as well. So according to the finding and assumption above, to every emitted ton of CO_2 corresponds a specific impact on human health quantified by a specific number of DALYs per year. This impact is represented by the CHR.

Alternatively, instead of using the WHO (2002) data for DALYs lost, one could use their data for estimated deaths caused by climate change each year (see also McMichael et al. 2003). By replacing in the calculations above the DALYs per year with the deaths per year, one can estimate the deaths attributable to an individual’s emissions.

Application of the model to available data

The World Health Organization (WHO 2002) estimated that: '*Considering only better-studied climate and health causal relationships*, 150 000 deaths and 5.5 million DALYS can be attributed to climate change in 2000', as reported by McMichael et al. (2003, p.276, emphasis added; see also McMichael et al., 2004, pp. 1544-5). This means that the GHG emissions up to the year 2000 caused climate changes that brought a yearly global loss of at the very least 5.5 million life years equivalent, either due to disability/sickness or to premature death, as compared to what would have happened under 1961-90 weather conditions. As climate change is progressive these annual losses are likely to steadily increase. The 2002 WHO estimates are still widely cited (e.g.: Barnett 2010; Pinkerton and Rom, 2013; Sheffield and Landrigan 2011).

WHO (2002, p. 223) noted that 86% of these estimated deaths were for babies and children younger than 5 years, overwhelmingly amongst poorer families in poorer countries (see likewise Gibbons, 2014). Given this very early average age of the deaths, their DALY loss estimate was perhaps surprisingly low.[iv]

According to our assumption above, the impact of climate change on human health is proportional to the global mean temperature increment. As we saw, following Matthews et al. (2009, 2012) the global mean temperature increment can be considered approximately proportional to the cumulative CO_2 emissions. The Carbon Dioxide Information Analysis Center - Oak Ridge National Laboratory reports that the cumulative amount of anthropogenic emissions up to the year 2000 was 1016 Gt of CO_2.[v] It is then possible to estimate the value of CHR:

CHR = 5.5 million DALYs per year / 1016 Gt of CO_2 = 5413 DALYs per year / Gt of CO_2.

Now let us consider an average US citizen. He/she (currently) is responsible on average for emissions of about 22 t of CO_2 per year (Davis and Caldeira, 2010) and has a life expectancy of 80 years. This means that in his/her life he/she emits approximately 22 x 80 = 1760 t of CO_2, assuming current emission rates (a similar estimation is done by Nolt, 2011, p. 5). Since 'a given emission of carbon will lead to an approximately constant increment of global temperature, regardless of when or over how long this emission occurs' (Matthews et al., 2012, p. 4371), it does not centrally matter that the emissions are spread over 80 years, the eventual effect is the same as if they were emitted in one day.

By multiplying the individual's emissions by CHR we obtain the DALYs lost per year due to the emissions:

Individual-related DALYs per year = CHR * Individual life emissions = 5413 DALYs per year / Gt of CO_2 * 1760 t of CO_2 = 0.0095 DALYs per year.

This means that, according to this estimation, the average US citizen has with his/her life emissions caused at least that each year someone died 3.5 days earlier than he/she would have if the US citizen had zero net emissions throughout his/her life. For the top 1% of the US population the conservative estimate of the health-impact caused by an individual is 49 days of life lost each year.

The estimated impacts of the emissions are per year. The average US citizen's emissions cause the loss of 0.0095 DALYs each year for the time that his/her emissions remain in the atmosphere. Some GHGs, once emitted, have a very long permanence in the atmosphere before being reabsorbed by natural processes. CO_2, the most important among the GHGs, has an atmospheric lifetime that is still the object of investigation and is considered probably the 'least well understood part of the global warming issue' (Inman, 2008, p. 156). IPCC's 2007 Assessment Report gave the following estimate:

> While more than half of the CO_2 emitted is currently removed from the atmosphere within a century, some fraction (about 20%) of emitted CO_2 remains in the atmosphere for many millennia. [vi]

According to Archer and others, cited by Inman (2008), not only though has about 25% of emitted CO_2 by human standards a near infinite permanence, but much of the CO_2 that is initially absorbed by the oceans is then released back. So:

> The largest fraction of the CO_2 recovery will take place on time scales of centuries, as CO_2 invades the ocean, but a significant fraction of the fossil fuel CO_2, ranging in published models in the literature from 20–60%, remains airborne for a thousand years or longer. Ultimate recovery takes place on time scales of hundreds of thousands of years, a geologic longevity typically associated in public perceptions with nuclear waste. (Archer and Brovkin, 2008: Abstract)

To assign a plausible value of the CO_2 atmospheric lifetime, as needed here for evaluating the health impact of a certain amount of emitted CO_2, is difficult. It seems that any figure between 200 and 2000 years could be chosen with the same low level of confidence. Future progress on the physics of CO_2 atmospheric removal processes will help in defining with more confidence an appropriate number. Choosing a figure of 1000 years or more might be plausible but in our main calculation we will use a conservative figure of 200 years as the CO_2 atmospheric lifetime.

Assuming then that the global mean temperature increment and the sufferings caused by a US citizen's life emissions last 200 years, we could say that the average citizen has caused the loss of about 0.0095 x 200 = 1.9 DALY. For simplicity, we round this impact to 2 DALYs. Since the individual impact is proportional to the CO_2 atmospheric lifetime, it is easy to scale up or down the results obtained from using the assumption of a 200 years CO_2 atmospheric lifetime. For the richest 1% of the US population the figure is 26.6 DALYs, rounding to 27. Health damage is 0.001 DALY per ton of CO_2 if we take 200 years as the CO_2 atmospheric lifetime. If like Nolt (2011) we take 1000 years as CO_2 atmospheric lifetime, the estimated harm caused by the average US citizen would be 10 DALYs, and 133 DALYs for the richest 1%. If we take 5000 years it would be 50 DALYs for the average citizen, and 565 DALYs for the richest 1%.

As mentioned above WHO (2002) estimated that in the year 2000 at least 150,000 deaths were caused by climate change through direct impacts on health. Using this data (on impacts in terms of deaths rather than DALYs) similarly, one obtains the result that, on the basis of consistently conservative assumptions, the average US citizen causes through his/her lifetime emissions 0.05 deaths. Put in a different way, 20 average US citizens cause the death of one person by means of their emissions, and the current US population will cause during its lifetime the death of 15 million people, unless counteracting measures are undertaken. If instead of considering the average US citizen we consider the average top-1%-of-income-recipients amongst US citizen, the harm should be multiplied by a factor 14. This rich citizen causes, via direct health-impacts, a harm of 0.7 deaths, at least, in the absence of counteracting measures.

Comparison with Nolt's estimation

Nolt estimated that 'the average American causes through his/her greenhouse gas emissions the serious suffering and/or deaths of [at least] two future people' (2011, p.9). He builds on the IPCC warning that climate change will seriously adversely affect hundreds of millions of people already during the next century (IPCC, 2007, p.65; Nolt, 2011, p. 8). Like ours, his estimate was conservative in various ways.

The use in our estimation of the WHO figure of (at least) 5.5 million DALYs per year caused by climate change in the year 2000 brings some advantages over Nolt's estimation. The harm is expressed in a more exact way, in DALYs rather than by the vague expressions 'adversely affect' and 'serious suffering and/or death of two people'. Second, the WHO figure was based on specific medical research. Third, it was based on actual past experience rather than on a forecast for the future. Recently WHO have indeed produced a forecast for the future, but it is focused on deaths only; we will discuss it later. The new estimates are of the same broad order of magnitude as the 2002 estimates for harm caused in 2000 (WHO, 2014).

One reason why our main estimate above of the harm caused by an individual was lower than Nolt's is that it assumed the harmful consequences of one's emissions last for 200 years, whereas Nolt assumed 1000 years. If we use 1000 years our figure would be 10 DALYs. Secondly, our estimate and that of Nolt are complementary, for Nolt includes a wider range of impacts while we included only those types of health impact for which numerically exact estimates are available. Nolt (following IPCC, 2007, p. 65, and going further) considers harm in a larger sense, including due to coastal flooding, impacts on water and food supply, and in terms of displacement and conflict. We feel that proceeding in terms of DALY losses captures the special significance that Nolt himself articulates, of "Casualties as a moral measure of climate change" (Nolt 2015), and recognizes that deaths are not the only forms of casualty.

3. How and why our estimation is 'conservative'

The estimation above is based on assumptions, data and inferences some of which may be proved at least partially wrong in the future, as climate change science evolves. McMichael et al. (2004: 1556) themselves warned that it was not possible yet to precisely foresee the health impact of climate change in the longer term.

> It is not yet feasible to base future projections on observed long-term climate trends, for three reasons: (i) the lack of standardized long-term monitoring of climate sensitive diseases in many regions; (ii) methodological difficulties in measuring and controlling for non-climatic influences on long-term health trends; and (iii) the small (but significant) climate changes that have occurred so far are an inadequate proxy for the larger changes that are forecast for coming decades.

Related to this, our analysis is deliberately conservative.

Ten years after the earlier round of work, WHO has provided an updated estimate, of at least '250,000 additional deaths due to climate change per year between 2030 and 2050…, even with adaptation and under conditions of high economic growth' (WHO, 2014, p. 13). The estimate is broadly compatible with its earlier retrospective estimate of at least 150,000 additional deaths in the year 2000. The projection again explicitly excludes 'the effects of economic damage, major heatwave events, river flooding and water scarcity[; and] …the impacts of climate change on human security, for example through increases in migration' (pp. 1-2), because no established quantitative models exist. Similarly: 'Climate change may increase the burden of mortality from coastal flooding, but because these impacts are highly uncertain they are not included' (p.10). It uses 'the optimistic assumption that there will be no major discontinuities in the trajectory of socioeconomic development until at least the middle of the 21st century' (p. 5), and no tipping-points in 'climatic, social or ecological conditions' (p.2). Economic development, state capacity, inter-state peace and appropriate preventive adaptation are all assumed to continue advancing. After following these consistently optimistic assumptions, and 'considering only a subset of the expected health effects' (p. 15)—looking only at mortality not morbidity, only at some diseases and some causal paths—the finding still of 'substantial adverse impacts on future mortality' (p. 15) allows WHO to draw implications of serious required policy action despite the uncertainties. Our paper follows the same analytical strategy, extended to consider the question of the impacts attributable to an individual.

In climate change discussions optimistic assumptions, assumptions and figures that very likely underestimate the real risks, are called 'conservative'. In contrast, in engineering design a conservative approach is one that takes into account adverse scenarios seriously during the design phase, in order to minimize the possibility of a dangerous outcome later during operation. In climate change discussions using 'conservative' assumptions has meant checking whether one can be very confident that, regardless of the uncertainties, a dangerous hazard will indeed arise. In contrast, in engineering design 'conservative' assumptions are part of seeking to ensure that, despite the uncertainties, a dangerous outcome from possible hazards will not ensue.

Let us review how the harm estimation that we have made is conservative, in the climate change related sense of the term.

1) We have not included GHG emissions attributable to rich-country purchasers but generated by their foreign suppliers.
2) We assumed that GHGs will remain in the atmosphere and thus create harm for 200 years, whereas others besides Nolt (see sources cited in Inman, 2008 and in Nolt, 2013) argue that a much longer period is appropriate. An alternative estimation might reasonably take 1000 years as the CO_2 atmospheric lifetime, perhaps longer. Further, Nolt underlines that for this exercise the relevant issue is the duration of climate disruption, which is much longer still. However we focus on a conservative 200 years, to keep on board conservative observers such as Odenbaugh (2011).
3) We assumed that harm is proportional to global warming. As mentioned earlier, there are strong reasons to expect disproportionately increasing harm as various ecological and social thresholds are crossed. But in the absence of a widely persuasive specification of what that disproportionate impact might be, we adopted an assumption that is the one least open to objection by powerful audiences.
4) We estimate only the harm to human bodily health, but climate change causes major other kinds of harm (economic, societal, cultural, psychological, as well as harm to non-humans).
5) We have linked the health harm caused by climate change in the year 2000 with the cumulative carbon emissions up to that year. This could be a major underestimation of the harm attributable to the emissions, because the emissions up to 2000 continue to induce rising global mean temperature, and associated health harm, for decades beyond 2000 (Allen et al. 2009: 1165). A more realistic estimation might be to compare the harm suffered in the year 2000 with the emissions as of two decades before, i.e. 581 Gt of CO_2 in 1980; and a plausible high estimate might compare against the emissions as of four decades before, i.e. 297 Gt in 1960.
6) The WHO (2002) estimate that we have used included only health impacts for which a quantitative model was available. McMichael et al. (2004, pp. 1543-4,1605-10) explain that

they covered the impacts of increased thermal extremes, malaria, diarrhoea and crop failure, plus deaths and injuries from floods; but they excluded health impacts from other infectious diseases (for example, chikungunya; Meason & Paterson, 2014), agricultural pests and pathogens, air-pollutants, spores and pollens, salination, changed water availability, conflict, etc. and the longer-term effects of the destruction caused by weather disasters. They warned: 'It is likely that these health consequences will be larger than those estimated in this chapter'.[vii] Even for the consequences included, the WHO estimates were conservative. Patz et al. (2005: 313) point out assumptions such as that socio-economic conditions compensate for the spread of vector-borne diseases to temperate regions. We saw also how the DALY loss estimates might be low given the overwhelming concentration of harm among very young children (see endnote iv).

7) Much of the harm arising from climate change will arrive through increase in variance of temperature and rainfall, not only increase in mean temperatures. Disproportionately more frequent extreme weather events, as can confidently be expected, will bring disproportionately more harm. Our understanding of the associated dangers is fuller and more worrying now (IPCC, 2012; World Bank, 2012) than when the 2002 WHO estimate was compiled. However, due to absence of quantified models, 'The health impacts of extreme climate events are not included in [even the 2014 WHO] assessment' (WHO, 2014, p. 14).

So our estimates, such as of 2 DALYs for an individual's impact, can be considered overall as very conservative: in this case meaning known to be too low. One could easily present plausible scenarios in which harm is drastically higher. Our key point however is that even two life years is not negligible impact: it is clearly discernible and ethically significant.

Table 1 shows the results in terms of our very conservative estimate, a plausible middle estimate and a possible higher estimate. The last two estimates make some adjustment in light of reasons 1, 2 and 5 that were just mentioned, but not for the others.

Table 1: Three alternative estimations of climate-change induced harm to health by average US citizen[viii]

	Global harm [DALYs/year]	**Cumulative CO_2 global emissions that cause the harm [Gt]**	**CO_2 atmospheric lifetime [years]**	**Individual CC-induced harm [DALYs]**
'Conservative' estimate	5.5 M	1016	200	**2**
Middle estimate	8.25 M	581	1000	**25**
Possible higher estimate	11 M	297	1000	**65**

The meaning assigned in climate change discourse to the concept of 'conservative' reflects how in international climate change politics the burden of proof has been placed on the side of those who warn of the dangers. The precautionary principle is neglected, and actions are taken only (and then not necessarily) if there is a certainty of unacceptable climate change-related impacts. In the absence of such certainty, more evidence is demanded, to avoid the 'risk' that emissions might be unnecessarily reduced, while at the same time the risk of possible serious damage to the lives of vulnerable people is tolerated. The assumptions and estimates that we have made are the 'least objectionable' in a specific sense: not in the sense of 'most likely to be correct', but in the sense of 'least likely to be objected to by rich and highly-mobilized GHG emitters'. The assumptions are often ones that will be strongly objectionable for poor and non-mobilized potential victims – but these groups typically have little or no voice, and their interests are weakly represented and their objections little heard in the current world system.

So, the 'conservative' approach we have followed does not respect the precautionary principle as normally understood, namely to take due care not to endanger people's lives and health:

> As stated by WHO's Director-General, Dr. Brundtland, in this context, "having unintentionally initiated a global experiment, we cannot wait decades for sufficient empirical evidence to act. That would be too great a gamble with our children's future". (Corvalan, Gopalan, Llanso, 2003, p. 269).[ix]

Nor does even WHO's own recently updated estimation follow a precautionary approach. As we saw, it too considers 'only a subset of the expected health effects, under optimistic scenarios of future socioeconomic development and with adaptation' (WHO, 2014, p. 15). But it shows that, even with such restricted and 'conservative' premises, 'climate change is projected to have substantial adverse impacts on future mortality' (loc. cit.) – around 250,000 additional deaths per year between 2030 and 2050, let alone thereafter—so that policy action is essential. Our approach has sought similarly to answer the question whether, even when one is strongly conservative in the sense used in climate change discourse, rather than precautionary, the calculated impacts of an affluent individual are still demonstrably ethically non-negligible. That is what we have found.

4. Ethical and Policy Implications

Given the proportionality between CO_2 emissions and the diminished enjoyment of human rights, almost any individual is responsible for threatening human rights, because a vast majority of individuals cause GHG emissions – but to vastly differing degrees. For example an average Dutch person emits 14 t of CO_2 per year and has a life expectancy of 81.5 years, therefore he/she is, pro rata, responsible for (at least) 1.2 DALYs reduction. An average citizen of Ethiopia emits 0.12 t of CO_2 per year and has a life expectancy of 60 years, therefore he/she is responsible for 0.008 DALYs harm. While the Ethiopian's impact can plausibly be called negligible, the Netherlander's could not.

Since the burden of the emissions (e.g., loss of 2 DALYs) is borne by different persons than the person that causes and benefits from them, a utilitarian cost-benefit analysis is morally inadequate (except to utilitarians). The inadequacy is greater in cases where the cost-bearer is already less advantaged than the benefit-gainer – as in the present case. Detailed discussion of the ethical and policy implications of our findings would require many papers. This section points to some of the agendas arising, with special reference to the set of commentaries assessing Nolt's parallel arguments that appeared in the 2011issue of *Ethics, Policy and Environment* together with his paper. The pieces debated in particular the assumptions behind an ethics of individual responsibility. Nolt (2013) has responded incisively to many of the comments and criticisms. We here consider the issues that most significantly concern our own line of argumentation.

Which agents should be considered?

Hartzell argues that: 'If other actors such as corporations or states are responsible for some greenhouse gas emissions, Nolt's methodology may overestimate the harmfulness of the emissions individuals are responsible for.' (2011: 15). She rejects the idea of accounting emissions fully to individuals, holding that part of the emissions should be accounted to other actors. Nolt (2013: 116) answers: 'I hold that the actions of corporations, nations, and other aggregate entities supervene on the actions of individuals, who bear the ultimate moral responsibility.'

We agree with Nolt. Individuals that benefit from the systems of production and consumption organised and supervised by states and corporations can be considered as having ethical obligations related to the harm generated by those systems. The actions required to respect those ethical obligations may often have to be undertaken through supra-personal institutions, notably the states and corporations. But we must not let the ethical obligations be dissolved in a game in which individuals point to institutions and the representatives of the institutions point back to the individuals whose wishes they served. So, 'consistent with the liberal literature on global justice (e.g. … Nolt 2011), we hold that both individuals and collectives are subjects of climate justice' (Grasso & Markowize, 2015).

Seager et al. (2011, pp. 40-41) argue that individual action would even be counterproductive:

> In the absence of collective action and enforcement in a non-cooperative game, those individuals (or countries) that voluntarily curb climate emissions will have the practical effect of incentivising others to increase emissions. For example, Americans who reduce consumption of fossil fuel resources will undoubtedly reduce fossil fuel prices—thereby enabling increased consumption of fossil fuels by others. The end result may not in fact be beneficial to the future people for whom they are concerned, but instead transfer the greatest benefits to those individuals or countries that do not voluntarily curb emissions.

But a claim of ineffectiveness of individual actions against climate change should not be considered as an argument against individual moral responsibility, rather as an argument for collective action. An individual agent should be considered morally responsible if his/her actions (in isolation or collectively) cause harm. In case individual action to avoid the said harm is considered ineffective, the agent has the moral duty to support coordinated actions.

In addition, Seager et al.'s particular example is unpersuasive. Not only do the average emissions of Americans already vastly exceed those in most other rich countries, but according to classical supply-demand analysis a reduction in the global demand for fossil fuel (caused here by a decision by Americans to reduce their consumption) brings a reduction of not only the price but also the quantity of fossil fuel exchanged on the market and then consumed.

What is ethically significant impact?

Second, what is non-negligible impact? Seager et al. (2011) argue that Nolt fails to identify a threshold of negligibility for the harm caused by an individual. How, they seem to ask, can we judge that the 'serious suffering and/or death of two people' is non-negligible? 'Negligible' compared to what? Nolt (2013, p. 118) responds that for him a non-negligible impact is:

> [identified] relative to carbon neutrality, that is, zero net emissions. For only at zero net emissions do we cease doing harm. I do not think, of course, that many of us can by ourselves attain carbon neutrality within our lifetimes. For most, this goal is possible only as the result of a collective effort over decades, involving not only emissions reductions by

> individuals but the enactment of carbon taxes, the redesign of buildings and of energy and transportation systems, and so forth. Yet, thus construed, it is feasible.

This response is reasonable; carbon-neutrality is now a widely adopted target. However, Nolt perhaps sidesteps the question of what is ethical negligibility. The test of non-negligibility that we have used—what are the results of intuitive inspection—is less precise and ambitious than Nolt's response, but directly faces the ethical choice. To us, loss of two years of life, caused by one person and suffered by other persons, as calculated using very conservative assumptions, clearly represents ethically non-negligible impact.

Seager et al. (2011) demand instead an exact and formally theorized criterion. But we are dealing with an ethical question not an engineering question. They claim that: 'there exists no shared moral context for understanding the significance of a statistical climate death' (p. 40). We find this claim misleading: there can be consensus on the non-negligibility of two years of life, across the views from numerous different 'moral contexts', so a fully shared moral context is not required. The consensual judgement derives from a deeper element of consensus – regarding the ethical significance of human life – which does not require us to share a complete moral perspective. Our interpretation seems far less artificial and more persuasive than Seager et al.'s further suggestions, in effect, that implicitly the policy-making institutions of U.S. society have adjudged that the loss of considerable numbers of children's lives around the world as a result of fossil-fuel intensive consumption in the U.S. is acceptable (p. 40) *and* that therefore it is ethically fine for U.S. citizens to continue such consumption.

Should individuals be considered individually?

Third, if we do consider individuals, should we consider them one-by-one or only as a collectivity? Schinkel (2011: 36) argues that:

> [I]t is one thing to say that if the total amount of American GHG emissions causes a certain amount of harm, the average individual American has a certain 'share' in this amount, but another altogether to say that a certain amount of emissions causes a certain amount of harm—for the harm caused by an X amount of emissions by one individual depends, crucially, upon the total amount of emissions caused by the collective. As soon as one isolates one individual's emissions, there is no way of telling how much harm they (might) do. The harm depends on the total emissions; the same absolute amount of emissions by one individual may cause no harm or contribute to considerable harm, depending on the total.

This objection appears incorrect. As reported by Matthews et al. (2009: 829) and the IPCC (2013: 63), the global mean temperature change caused is proportional to total cumulative anthropogenic CO_2 emissions, and is independent of the background CO_2 atmospheric concentration. Further, as indicated earlier, climate change-related harm can be taken as proportional to the global mean temperature change, and so harm is proportional to emissions. We can estimate the harm caused by an individual's emissions, regardless of others' contribution. This answers also concerns raised by Sandler (2011), as Nolt (2013) noted too; and points raised by Kawall (2011).

Schinkel (2011) further disputes whether inflicting ethically non-negligible harm implies a duty to change one's individual behaviour. He argues that finding that an individual is causally responsible for a certain amount of harm due to his/her emissions does not necessarily mean that he/she is also morally responsible for it. The moral responsibility depends on the possibility an individual has to avoid harmful behaviour.

> No-one creates the society—the economic structures, the culture, the institutions—in which she is born and raised, and as an adult, at best, one has a tiny share of the responsibility for the kind of society one participates in. [...] People's ability to avoid (collectively) harmful behaviour is, to an important extent, beyond their (individual) control, and given their upbringing it would be disingenuous to require them individually to be able to give up (important aspects of) their 'normal' life in resistance of social pressure to the contrary. (Schinkel, 2011, pp. 36-37)

While Schinkel here implies that an individual has no moral culpability from following the lifestyle that is considered normal in his/her society—whatever that lifestyle is, apparently—his article elsewhere emphasises the size of the shifts that might be required: 'a dramatic change of lifestyle, with huge social, financial and emotional consequences' (p. 36). The more damaging one's lifestyle one is, the less supposedly then is the obligation on individuals to change it, for the change would be too dramatic. But his discussion concludes in more convincing fashion (2011, p. 37):

> As an individual, I have good moral reasons both to change my own behaviour where this does not require unreasonable sacrifices—I will have to leave 'unreasonable' undefined here—and to try to promote the kind of collective effort necessary to deal with the problem of climate change.

When is a lifestyle change ethically reasonable or instead too demanding? From a utilitarian perspective a sacrifice could be considered reasonable if it prevents a greater harm as a consequence of climate change. In the case of the average US citizen, one might compare the harm of (at the very minimum) 2 DALYs lost as against the sacrifice of living in the US at zero net emissions – or against the cost of other compensatory measures that would prevent or counterbalance the harm.[x] Differently, if we applied Rawls' second principle of justice to individuals worldwide, a sacrifice should be considered reasonable if it prevents harm to the least advantaged person.[xi] Since here the individual harmed is a vulnerable one living in a poor country, it seems that the relatively modest sacrifices required of the average US citizen in order to reduce emissions could be considered reasonable, and that where instant reduction of emissions is considered not reasonable, the average US citizen should support and engage in the progressive reduction of his/her emissions and/or investment in compensatory measures.

One proposed justification for not engaging in emission reduction as an isolated individual is is that emission reduction is only worthwhile if everybody else does it. This objection is weak unless individual impacts are negligible, for the impacts on climate are proportional to the emissions. Any reduction, even if done in isolation from other people, has a proportional effect. Still it could be claimed that individual emission reduction in isolation from other people would put the isolated individual at a competitive disadvantage with respect to the people who do not reduce their emissions. This suggests a desirable solution in which everybody is obliged to reduce his/her emissions together. Nonetheless, even in the case of individual emission reduction in isolation, the ethical principle of doing no harm indicates that an individual should accept the burden of reducing his/her emissions and the competitive disadvantage, rather than causing harm, when this harm involves significant human rights denial. The argument that some other people gain a competitive advantage by not paying taxes does not establish an ethical exemption for anyone to not pay taxes; similarly then, that some people gain a competitive advantage by inflicting ethically weighty harm on others through environmental damage does not remove the ethical prohibition on causing uncompensated such harm, but underlines the need to act to prevent the harm and/or to ensure adequate compensation.

What are reasonable levels of emission?

Assuming that GHG emissions are linked to a comfortable life, the question arises: how much should an individual reduce his/her comfortable lifestyle in order to prevent threatening the human rights of others?[xii] Bell (2013) analyses the right to emit and the idea of a subsistence emission level, i.e. a level of emissions necessary for an individual in order to achieve his/her basic needs. Baatz (2014) discusses emission quotas per individual, and endorses a principle of modified equal per capita emissions rights, for the subsistence emission level depends on many factors such as geographical location, the infrastructures, the society, and personal needs. Philosophers have commonly supported shifting the burden of emission reduction to developed countries, especially those with long histories of large GHG emissions (Gardiner 2004, p. 14). At individual level though, the burden should be very largely carried by the large emitters, regardless of in which country they live (Harris 2010).

Policy discussion must cover not only individuals' emissions reduction (individual mitigation) but also individuals' contributions to adaptation. The target of avoiding harm due to climate change can be reached both by actions of individual mitigation and by contributions to adaptation. For example an individual could reduce by 50% his/her emissions and also support, perhaps through an environmental tax, projects of adaptation like the construction of a barrier against sea level rise. This makes less stringent the required individual effort in reducing (net) emissions. Similarly, some win-win steps can be identified. For example, a 2014 estimate from the WHO attributes 4.3 million deaths per year to household air pollution (Robinson, 2014). Cleaner household energy sources for affluent families in developing country metropoli, for example, can reduce directly attributable deaths as well as reduce climate change and its eventual health impacts.

Baatz (2014) observes that individual emission reduction is an imperfect moral duty, i.e. it is not clear when one's duty is completely fulfilled. Further, an individual living in a carbon intensive society might not immediately be able to reduce his/her emissions to the level that they produce no harm and yet to sustain a decent life. But insofar as the cultural, economic and political institutions of one's society present major obstacles to achieving a no-harm pattern of emissions, an individual has the moral duty to engage for and/or support the progressive modification of those institutions.

5. Conclusion

An estimation of harm to health caused by an individual's GHG emissions has been made in this paper by comparing the cumulative anthropogenic carbon emissions up to 2000 with the WHO's estimate for the same year of harm to human health caused by climate change. According to the calculation an average US citizen is responsible throughout his/her life for emissions that cause health/mortality losses of other people, largely small children, including in future generations, quantifiable as at the very least 2 DALYs. The figure is at least 27 DALYs when considering the average individual impact caused by the top 1% of income-earners in the US population.

The estimates are the result of several assumptions and approximations. The assumptions made in this paper are consistently conservative and sometimes very conservative, leading to an underestimation of harm caused. This is done with the intention to avoid perceptions of overestimation of climate change-induced harm which could lead to rejection of any finding that individuals cause significant moral harm through their share of GHG emissions. The conservative assumptions used are not presented as most-likely-case estimates, nor as ‘conservative’ in the usual risk-management sense of favouring the interests of the main groups at risk, but instead as leading to an estimate of the lowest possible level of harm, leaving the real possibility that much greater harm is being caused, even very much greater. The estimates could be seen as favouring the interests of high emitters, by being so modest in calculating the harm resulting; but our rationale has been to test whether even the most modest plausible estimate indicates substantial resulting harm and grounds an ethical case for obligations by individuals. We suggest that the analysis in this paper, revising and strengthening the line of argument sketched by Nolt, does confirm that grounding.

The study also serves as a contribution to the mechanics of estimation of individually induced climate change harm. A deeper knowledge of the relation between climate change and health harm will help in strengthening the results presented; but we believe that the strategy of argumentation followed has sufficed to answer the central question and establish that the harm caused by an affluent individual is not negligible. The calculable impact in terms of DALYs -- a few years of human life -- even using a series of conservative and very conservative assumptions, means that the claim of ethical negligibility of an individual’s impact is not justified. This is even clearer for the highest emitting individuals.

We have not attempted to draw out detailed ethical implications for particular individuals or detailed policy implications for collectivities. Baatz (2014, p.10) argues that:

> on the level of abstract analysis we cannot say more than that individuals have the moral duty to reduce emissions as far as can reasonably be demanded of them. What ‘as far as can reasonably be demanded of them’ means depends on the circumstances and has to be decided on a case-by-case basis.

What we have attempted instead, deepening Nolt’s pioneering attempt, is to show that such ethical obligations do arise for affluent individuals from contemporary patterns of production and consumption via the damage that they cause through climate change, through establishing that the old defence of claiming that an individual’s impacts are negligible is false.

References

Archer, D., & Brovkin, V. (2008) The millennial atmospheric lifetime of anthropogenic CO_2, *Climatic Change*, 90(3), 283-297.

Allen, M., Frame, D., Huntingford, C., Jones, C., Lowe, J., Meinshausen, M., & Meinshausen, N. (2009) Warming caused by cumulative carbon emissions towards the trillionth tonne, *Nature*, 458(7242), 1163-1166.

Baatz, C. (2014) Climate Change and Individual Duties to Reduce GHG Emissions, *Ethics, Policy & Environment*, 17:1, 1-19.

Barnett, J. (2010). Environmental Security, in: J.P. Burgess (Ed.) *The Routledge Handbook of New Security Studies* (London: Routledge).

Bell, D. (2013) Climate Change and Human Rights, *WIRES Climate Change* 2013 4:159–170.

Chakravarty, S., Chikkatur, A., de Coninck, H., Pacala, S., Socolow, R., & Tavoni, M. (2009) Sharing global CO_2 emission reductions among one billion high emitters, *Proceedings of the National Academy of Sciences*, 106(29), 11884-11888.

Corvalán, C., H. Gopalan, P. Llansó (2003) Conclusions and recommendations for action, in: McMichael et al. (2003), 267-283.

Davis, S. J., & Caldeira, K. (2010) Consumption-based accounting of CO_2 emissions, *Proceedings of the National Academy of Sciences*, 107(12), 5687-5692.

Dunn, A. (2012) 'Average America vs the One Percent', *Forbes*, 21.03.2012, retrieved 25.01.2014 - http://www.forbes.com/sites/moneywisewomen/2012/03/21/average-america-vs-the-one-percent/

Gardiner, S.M. (2004) 'Ethics and Global Climate Change', in: Gardiner, S.M., S. Caney, D. Jamieson and H. Shue (eds) (2010) *Climate Ethics: Essential Readings*, pp 3-35 (Oxford: Oxford University Press).

Gibbons, E. (2014) Climate Change, Children's Rights, and the Pursuit of Intergenerational Climate Justice. *Health and Human Rights*, 16(1), 19-31.

Grasso, M. & E.M. Markowitz (2015) The moral complexity of climate change and the need for a multidisciplinary perspective on climate ethics, *Climatic Change*, DOI 10.1007/s10584-014-1323-9

Harris, P.G. (2010) *World Ethics and Climate Change – From International to Global Justice* (Edinburgh: Edinburgh University Press).

Hartzell, L. (2011) Responsibility for emissions: A commentary on John Nolt's 'How harmful are the average American's greenhouse gas emissions?', *Ethics, Policy & Environment*, 14(1), 15-17.

Hourdequin, M. (2010) Climate, collective action and individual ethical obligations, *Environmental Values*, 19, 443–464.

Inman, M. (2008) Carbon is forever, *Nature Reports Climate Change*, 2, 156-158.

IPCC (Intergovernmental Panel on Climate Change) (2007) *Climate Change 2007: Synthesis Report*. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

IPCC (2012) *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. http://ipcc-wg2.gov/SREX/

IPCC (Intergovernmental Panel on Climate Change, Working Group I) (2013) *Climate Change 2013: The physical science basis.*

IPCC (Intergovernmental Panel on Climate Change, Working Group II) (2014) *Climate Change 2014: Impacts, Adaptation, and Vulnerability – Summary For Policymakers.*

Johnson, B.L. (2003) Ethical obligations in a tragedy of the commons, *Environmental Values*, 12, 271–287.

Kawall, J. (2011), Future Harms and Current Offspring, *Ethics, Policy & Environment,* 14(1): 23-26.

Levy. M., & Sidel, V. (2014) Collective Violence Caused by Climate Change and How It Threatens Health and Human Rights, *Health and Human Rights* 16(1), 32-40.

Matthews, H.D., Gillett, N.P., Stott, P.A., & Zickfeld, K. (2009) The proportionality of global warming to cumulative carbon emissions, *Nature* 459(7248): 829-832.

Matthews, H.D., Solomon, S. & Pierrehumbert, R. (2012) Cumulative carbon as a policy framework for achieving climate stabilization, *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 370(1974): 4365-4379.

McMichael, A., Campbell-Lendrum, D., Corvalán, C., Ebi, K., Githeko, A., Scheraga, J., Woodward, A. (Eds.) (2003) *Climate change and human health: Risks and responses* (Geneva: World Health Organization).

McMichael, A. et al. (2004) Global Climate Change, in: *Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors* (Eds. Ezzati, M., Lopez, A. D., Rodgers, A. & Murray, C.) Ch. 20, 1543-1649 (Geneva: World Health Organization).

Meason, B., & Paterson, R. (2014). Chikungunya, Climate Change, and Human Rights. *Health and Human Rights*, 16(1), 105-112.

Nolt, J. (2011) How harmful are the average American's greenhouse gas emissions?, *Ethics, Policy & Environment,* 14(1): 3-10.

Nolt, J. (2013) Replies to Critics of ‘How Harmful are the Average American's Greenhouse Gas Emissions?’, *Ethics, Policy & Environment*, 16(1), 111-119.

Nolt, J. (2015) Casualties as a Moral Measure of Climate Change, *Climatic Change*, DOI 10.1007/s10584

Odenbaugh, J. (2011) This American Life, *Ethics, Policy & Environment* 14(1), 27-29.

Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005) Impact of regional climate change on human health, *Nature*, 438(7066), 310-317.

Pinkerton, K., Rom, W. (Eds.) (2013) *Global Climate Change and Public Health* (New York: Springer).

Pogge, T. (2008) *World Poverty and Human Rights* (Cambridge, UK: Polity Press).

Robinson, M. (2014) Foreword, to special issue on climate justice and the right to health. *Health and Human Rights*, 16(1).

Sandler, R. (2011) Beware of averages: a response to John Nolt's ‘How harmful are the average American's greenhouse gas emissions? *Ethics, Policy & Environment*, 14(1), 31-33.

Schinkel, A. (2011) Causal and Moral Responsibility of Individuals for (the Harmful Consequences of) Climate Change, *Ethics, Policy & Environment*, 14(1), 35-37.

Seager, T.P., E. Selinger & S. Spierre (2011) Determining moral responsibility for CO_2 emissions: A reply to Nolt, *Ethics, Policy & Environment* 14(1), 39-42.

Sheffield, P. E., & Landrigan, P. J. (2011) Global climate change and children’s health: threats and strategies for prevention. *Environmental health perspectives*, 119(3), 291.

Sinnott-Armstrong, W. (2005) It's Not My Fault, in: Gardiner, S.M., S. Caney, D. Jamieson and H.

Shue (eds) (2010) *Climate Ethics: Essential Readings*, pp. 332-346 (Oxford: Oxford University Press).
UN Human Rights Council (2009) Report of the Office of the United Nations High Commissioner for Human Rights on the relationship between climate change and human rights. http://www.refworld.org/docid/498811532.html [accessed 29 November 2014]
WHO (World Health Organization) (2002) *The World Health Report 2002* (Geneva: WHO).
WHO (World Health Organization) (2014) *Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s.* Hales, S., Kovats, S., Lloyd, S.. Campbell-Lendrum, D. (Eds.) (Geneva: World Health Organization).
World Bank (2012) *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided.* Washington DC: World Bank.

Notes

[i] Many CO_2 emission calculators exist online. One example is http://www.carbonfootprint.com/calculator.aspx.

[ii] A clearer acronym might be CClR; but we follow Matthews et al.'s choice of CCR.

[iii] For example, in the extreme case of a global warming of 100ºC we can expect that human life on the Earth would not be possible, whereas the relation of linearity used would predict a harm of 25 million deaths per year or of 1 billion DALYs caused by CC. These predictions are a huge underestimate of the harm caused.

[iv] If the average age of death was 3 years old and average life expectancy otherwise was 58 years, then the number of years of life lost per case was 55 years. For 150,000 deaths the loss of life years would be 8.25 million. Given the predominance of small children amongst the deaths, and the presence also of non-death DALY losses, the total estimate of 5.5 million DALYs lost in 2000 was thus surprisingly small.

[v] Source: Carbon Dioxide Information Analysis Center - Oak Ridge National Laboratory - http://cdiac.ornl.gov/ftp/ndp030/global.1751_2010.ems

[vi] http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-10-3.html

[vii] See e.g. Levy and Sidel (2014) on the health impacts from climate-change related violent conflict.

[viii] Individual CC-induced harm [DALYs] = Global harm [DALYs/year] / Cumulative CO_2 global emissions * CO_2 individual lifetime emissions * CO_2 atmospheric lifetime [years]

[ix] From Bruntland's speech to World Ecology Awards Ceremony, St Louis, Missouri, USA, 27 June 2001.

[x] Note that 2 DALYs represent only the health-related harm and not the total harm; for that an estimate is not available.

[xi] Although Rawls's second principle of justice seems to concern institutions and not individuals, Pogge (2008: 110-111) claims its applicability also to individuals.

[xii] This assumption is not automatic. One could reasonably claim that personal well-being can increase through a move to a less commodity-centred money-growth-fixated lifestyle.