Philosophy and Climate Change

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How Much Harm Does Each of Us Do?

John Broome

1. Sorts of Harm and Their Quantity

Several moral philosophers have argued that the greenhouse gas emissions of a single individual do no harm. I think they are mistaken, and I have opposed their arguments in a paper I called 'Against Denialism'.[1] Now I shall give some positive account of the quantity of harm that each of us does.

Many accounts already exist. First, there is a very large literature in economics on the 'social cost of carbon' (SCC), which is supposed to measure in terms of money the harm done by a tonne of carbon dioxide. Multiply the SCC by the total number of tonnes emitted by a person during her lifetime, and we get a money value for the total harm she does.

Estimates of the SCC vary greatly, but the average of all the estimates surveyed in a comprehensive meta-analysis is $55.[2] This implies that a person who emits 1200 tonnes over her lifetime, which is typical for an American, causes $66,000 of harm. But a lot is left out of calculations of the SCC.[3] Anything whose value cannot be made commensurate with money is inevitably omitted or poorly taken into account. This includes the wellbeing of animals and whatever intrinsic value natural objects—such as natural species and individual trees—may have. It may also include human cultural goods, such as the culture of Arctic peoples and monuments that may be lost to the sea.

Climate change kills very many people. It kills them directly in droughts, floods, and storms. It kills them less directly through increasing the range of tropical diseases and by impoverishing the people who struggle to live in less hospitable parts of the world. Estimates of the SCC in principle take into account the harm of killing, but in practice they generally do so badly. The value they assign to the loss of a life is generally based on people's willingness to pay for extending their lives, and it does not properly recognize the different value of money to different people. Poor people are willing to pay less than rich people to reduce their risk, but this is not because their lives are less valuable. It is because they have

[1] Broome (2019). [2] Wang Pei et al. (2019).
[3] See the full discussion in Fleurbaey et al. (2019).

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other, more pressing uses for their money. Economists often ignore this simple point.[4] Also, they generally discount for time, which means giving less value to later lives than earlier ones.

Some evidence will emerge in Section 2 that killing is a major part of the harm that climate change will do. Since existing estimates of the SCC take it into account badly, it is important to pay special, separate attention to this harm. The SCC conveys some information about the harm done by climate change, but we separately need information about killing. This chapter will focus on estimating the quantity of killing we do through climate change.

There are precedents for this estimation too. One figure for the amount of this harm is frequently quoted by moral philosophers. It originates from calculations of John Nolt's.[5] Nolt started by working out carefully that an average American is responsible for about the fraction 5×10^{-10} of the climate change caused by greenhouse gas emissions up to 2040. Next he calculated the number of people who will live during the next millennium as 100 billion. Then he says:

> If over the next millennium as few as four billion people (about 4% [of the number who will live during that period]) are harmed (that is, suffer and/or die) as a result of current and near-term global emissions, then the average American causes through his/her greenhouse gas emissions the serious suffering and/or deaths of two future people.[6]

Nolt did not try to justify the figure of 4% for the proportion of people who will be harmed. He was not aiming to estimate the amount of harm so much as to illustrate what it might be. Nevertheless 'the serious suffering and/or deaths of two future people' is frequently quoted as his estimate—recently in the *New York Times*.[7] We shall see that, as an estimate, it is far too big.

At about the same time, I published an estimate based on figures from the World Health Organization.[8] My estimate was that a typical Westerner takes away more than six months of human life altogether.[9]

2. New Data and Estimates

Those figures are now very much out of date. Much better ones are becoming available. A major report, 'Valuing the Global Mortality Consequences of Climate Change' (VGMC),[10] derives conclusions on the basis of extremely extensive and

[4] The IPCC asks them not to ignore it. See IPCC (2014), Summary for Policymakers, p. 5.
[5] Nolt (2011). [6] Nolt (2011: 9).
[7] Newman (2019). Thanks to Douglas MacLean for this reference. [8] WHO (2009).
[9] Broome (2012: 74). [10] Carleton et al. (2019).

detailed data about the effect of weather on death rates at a very local level. The authors divided the land surface of the Earth into 24,378 areas and assembled data on a 38% sample of them. By means of sophisticated statistical analysis, they have derived from their data authoritative estimates of the global effects of climate change on mortality. I shall base my conclusions on these estimates.

To put it very crudely, VGMC regresses death rates on temperature. This means it takes account of all causes of death—all the various means by which the warming of the planet kills people. It includes deaths in heat waves, deaths resulting from the spread of tropical diseases, and so on. It is not limited to particular causes of death, as are earlier studies from the World Health Organization.[11]

VGMC also takes account of the ages of people who die, so it can calculate the number of life-years lost as well as crude death rates. These are much more informative. Many people die in heat waves, and this is one of the significant ways in which climate change kills people. But many of those people are elderly[12] and many are already suffering from chronic diseases. When a heat wave kills them, it may be shortening their lives by only a few years, months, or days. Climate change also increases the prevalence of diarrheal diseases; this is another significant means by which it kills people. It is mainly children who die from these diseases,[13] and they lose many years of life. It would be misleading to count a child's death and an elderly person's death the same, and VGMC does not do so. All in all, VGMC data is very valuable.

Still, estimates of harm from climate change can never be certain. The science of climate change is very uncertain, and the spread of possibilities is very wide. For example, it is possible that climate change will lead to a catastrophe for humanity, and even to our extinction. It may even be that in responding to climate change we should care more about this unlikely possibility of catastrophe than about what is likely to happen. Quite generally, an unlikely but very bad event may be more important for our planning that what is likely to happen. That is why ships ought to carry lifeboats. A ship is unlikely to sink, so its lifeboats are unlikely to be used. But if it does sink the consequences of having no lifeboats will be so dire that they make the expense of carrying lifeboats worthwhile. The economist Martin Weitzman argues that our response to climate change should be like our response to the possibility of a ship's sinking: directed towards the unlikely but very bad consequences of catastrophe.[14]

I have no way to estimate the harm that a person's emissions will do if the results of climate change are catastrophic. I am therefore forced to limit my

[11] For example, WHO (2009, 2014). [12] WHO (2014: 17). [13] WHO (2014: 37).

[14] Weitzman (2009). See also Wagner and Weitzman (2015). My paper 'The Most Important Thing about Climate Change' (Broome 2010) explains that Weitzman's argument is insufficient for his conclusion.

estimates to the amount of harm that is likely, rather than take account of all the possibilities.

Even the likely harm done by a person's emissions is very contingent; it depends on the emissions of other people. This is because the relation between temperature and mortality is very non-linear. Its graph is U-shaped. Both low temperatures and high temperatures increase the number of deaths. As the temperature increases starting from a low level, the death rate decreases until it reaches a minimum at around 20°C. Then it starts to increase at an accelerating rate. Consequently, an increase in temperature when the temperature is very high causes much more harm than the same increase would do were the initial temperature lower. An emission of greenhouse gas therefore causes much more harm if other emissions are high than if they are low.

This contingency is handled in climate-change science by means of 'scenarios'. Each scenario describes a particular possible future development of emissions together with the growth of the world's population and economy. So when I refer to the harm that is likely to result from a person's emissions, I mean the harm that is likely given a particular scenario. The VGMC study works with two scenarios known as 'RCP 4.5' and 'RCP 8.5'.[15] Perforce, I copy it in this respect. RCP 4.5 is a moderate scenario in which emissions of greenhouse gases begin to decline around the middle of this century. Nevertheless, the temperature under RCP 4.5 is likely to reach 2.4°C above pre-industrial levels, which is well above the target set in the Paris Agreement negotiated in 2015 by the United Nations Framework on Climate Change. So this is by no means an optimistic scenario. RCP 8.5 is intended to be a baseline that might be considered 'business as usual'. It should be treated as a basis for comparison rather than a prediction of what will happen. It assumes high growth of population with slow economic growth, and limited technical progress. In RCP 8.5, emissions increase through the century, and the temperature is expected to reach almost 5°C above pre-industrial levels. This might fairly be counted as catastrophic. RCP 8.5 is a very pessimistic scenario.

VGMC calculates what it calls the 'mortality-related' harm that will result from emitting one tonne of carbon dioxide in 2020. By means I shall explain, it expresses the result in terms of dollars. To cut a long story short, its conclusion is that the dollar value of the harm is $18.9 under RCP 4.5 and $98.9 under RCP 8.5 (VGMC, p. 46). These are the figures I shall work with. They assume a 2.5% discount rate on commodities, and a 'globally uniform valuation of mortality risk'. I shall explain these two assumptions in Sections 4 and 3 respectively.

Compare these figures with $50, which is a typical estimate for the SCC as a whole. The comparison supports the assertion I made in Section 1, that mortality-related harm is at least a major part of the harm that climate change will do.

[15] See Wayne (2013).

3. Lives for Money

VGMC presents its conclusions in terms of money values. But many philosophers including me are dubious about translating the value of lives into money. We would prefer to see the result in terms of quantities of life itself. This raw information is embedded in the VGMC calculations, but not in a transparent way. The authors of the report are in a position to extract and present it, but only by means of a substantial amount of computation. I believe they will do so in due course.

In the meantime this volume goes to press. In order to give readers some rough idea of the quantity of life we take away through our emissions, I have extracted estimates of this quantity from the figures presented in the existing report, using the best means I have available. These means are frankly very crude. The outcome will be very approximate, but it is the best I can do. The authors of the report bear no responsibility for my figures, and mine will be totally superseded by theirs when they are published.

I first adjust the figures by subtracting adaptation costs from them. As temperatures increase, people adapt to them. Their bodies acclimatize and they take steps to avoid the heat. VGMC uses sophisticated methods to account for adaptation in its estimates of the number of people killed by climate change. It also recognizes that adaptation often costs money, and it includes this cost in its figures for mortality-related harm. I want to estimate the actual amount of killing that climate change does, so I need to subtract the adaptation costs. VGMC states that on average 14% of mortality-related costs are adaptation costs (VGMC, p. 5). I have to use this average figure because I cannot find figures in VGMC related to the particular costs I am working with. I therefore reduce those costs by 14% and get $16.3 for RCP 4.5 and $83.1 for RCP 8.5. These are now the dollar values of life actually lost.

Next I work back from these dollar values to calculate the actual quantities of life that they represent. The dollar values are based on the monetary value of life that is standardly used in cost–benefit analysis in the US. This is $10.95 million for a life (VGMC, p. 121). VGMC converts it to a value for a year of life by using the life expectancy of a median-aged American (VGMC, p. 120). The text does not state what this life expectancy is, so I have to recover it. The median age of Americans in 2018 was 38.2.[16] Life tables for 2016 show life expectancy at 38.2 as 40.23 for men and 44.20 for women.[17] I shall assume an average life expectancy of 42.2. The result is that a life-year is valued at $259,000.

In principle, VGMC values lives or life-years on the basis of what people are willing to pay for them, or more exactly what they are willing to pay to improve their chances of living longer. It assumes that what people are willing to pay is

[16] https://www.statista.com/statistics/241494/median-age-of-the-us-population/.
[17] https://www.ssa.gov/oact/STATS/table4c6.html.

proportional to their income (VGMC, p. 39). In practice, willingness to pay is averaged across the population. The value of $259,000 is the average across the US population. The VGMC figures for 'globally uniform valuation of mortality risk' are based on average willingness-to-pay across the whole world population, under the assumption that willingness to pay is proportional to income. This is what 'globally uniform' means. The consequence is that the figure of $259,000 needs to be reduced by the ratio of global average income to American average income. From World Bank data[18] in 2018 I find this ratio to be .287. This makes the value of a life-year $74,300.

This value allows us to take the above-quoted dollar values of killing caused by a tonne of carbon dioxide and convert them back into numbers of life-years. The result is .000219 life-years in RCP 4.5 and .00112 in RCP 8.5.

Those are rates per tonne. Next we have to multiply these quantities by the number of tonnes of carbon dioxide emitted by a person during her lifetime. There is a further complication here. These quantities I have derived from VGMC measure the harm done by a tonne of carbon dioxide that is emitted in 2020. Later emissions are done at a time when the global temperature is higher. Because of the non-linear relationship between temperature and deaths, later emissions therefore do more harm. Earlier emissions do less harm. People who are young now will do more harm by their emissions than older people who emit the same in total. Because I do not aim at precision, I shall ignore this complication. I shall focus on a person who emits 1200 tonnes during her lifetime, which is about average for an American. Multiplying the rates of death per tonne by this amount, we might conclude that this person's lifetime emissions cause the loss of .263 life-years in RCP 4.5 and 1.34 life-years in RCP 8.5.

4. The Consequences of Discounting

Sadly, this is still not correct. These figures are a serious underestimate because they incorporate some temporal discounting of life-years. So I turn to the difficult issue of discounting.

The VGMC figures assume a discount rate of 2.5% on commodities. Strictly, this is the discount rate on money values after canceling out inflation. This means it is the discount rate on the bundle of commodities that are used as the basis for measuring inflation. It is correct to discount future commodities—which means giving less value to future commodities than to present ones—because both scenarios RCP 4.5 and RCP 8.5 assume that economic growth will continue. That is to say, they assume people will become progressively richer. Therefore, the value of commodities to them at the margin (the value of adding to their stock of

[18] https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD.

commodities) will progressively diminish. This is the consequence of the diminishing marginal value of income, which has been recognized in economics at least since the time of Alfred Marshall. The more commodities you are already consuming, the less you will benefit from consuming more commodities.

VGMC does not discount life-years at 2.5%, because it gives a progressively increasing value to future life-years. I have not mentioned this before. The reason it does so is that it takes the value of life-years to be proportional to income, and income increases with economic growth. The average rate of economic growth through this century is 2% per year in RCP 4.5 and 1.35% in RCP 8.5.[19] The value of life-years is increased at these rates. So in effect VGMC discounts life-years at a rate equal to the difference between these rates and 2.5%. The upshot is that the figures for life-years I have been working with incorporate discount rates of 0.5% for RCP 4.5 and 1.15% for RCP 8.5.

The reason I gave for discounting commodities does not apply to life-years. It is most implausible that life-years lived later in history are really less valuable than ones that are lived earlier. Discounting life-years is an instance of what is called 'pure discounting'. Pure discounting has received some support from economic theorists—notably Kenneth Arrow—but not much.[20] It does not sit well with the globally uniform valuation embedded in the VGMC figures I have been using. If, at each date, everyone's life-years are given the same value, why should life-years at one date be given a different value from those at another date?

Moreover, VGMC's way of discounting has a peculiar consequence. The loss of a person's life-year is discounted according to the date of the person's death rather than the date when the life-year would have been lived. Suppose a 20-year-old dies now and loses 60 years of life. The loss of the years she would have lived between the ages of 60 and 80 gets full value in the calculation. But if someone else born at the same time as this 20-year-old lives to 60 and then dies, losing 20 years of life, the loss of those 20 years is given less value than the loss of the 20-year-old's, even though they would have been lived at exactly the same time.

A life-year plausibly has a constant value, whoever lives it and whenever it is lived. Because of this, it provides a plausible basis for interpersonal comparisons of the value of commodities, as the Intergovernmental Panel on Climate Change explains.[21] It also provides a plausible basis for the intertemporal comparisons of the value of commodities that appear in the discount rate. Plausibly, commodities should be discounted at whatever rate implies a constant value for a year of life. If we maintain VGMC's assumption that the value of a life-year is proportional to income, this means discounting commodities at the rate of growth of income. That is: 2% in RCP 4.5 and 1.35% in RCP 8.5.

[19] I derive these figures from Figure 12 of Wayne (2013).
[20] Arrow (1999). See the discussion in my 'The Wellbeing of Future Generations' (Broome 2016).
[21] IPCC (2014: 226 (box 3)).

I urge the authors to provide figures for years of life lost corresponding to these discount rates. At least, they should not treat the discount rate in the way they do, as exogenously given independently of the growth rate. The correct discount rate is a function of the growth rate, as the famous Ramsey equation shows.[22]

The estimates obtained at the end of Section 3 incorporate discount rates on life-years of 0.5% in RCP 4.5 and 1.15% in RCP 8.5. In the absence of undiscounted figures in VGMC, I need to cancel out the discounting as best I can. How badly do the discounted estimates underestimate the true quantity? This depends on how the killing caused by an emission of carbon dioxide is distributed over time. This information is implicit in the work of VGMC, but I cannot extract it from the paper. I can make only guesses.

When a tonne of carbon dioxide is emitted, it causes the atmosphere's temperature to rise soon afterwards, and that raises the death rate. The tonne begins immediately to be absorbed by the land and oceans, so its effect on the death rate will begin to fall too. About half the tonne will fall out of the atmosphere within 50 years. However, perhaps 20% of it will persist for hundreds and even thousands of years.[23] Furthermore, its effect on temperature will lag behind the quantity of carbon dioxide itself. I am not in a position to judge the extent of the lag; doing so would require running a model of the atmosphere.[24] But it is plain that, were the killing to decline only with temperature, it would continue for a very long time and its total would be very large.

But actually the killing will be progressively reduced by people's adaptation to the heat. The VGMC data contains some information about adaptation, but I have not been able to use it at this point in the calculation. In any case, it could tell us very little about the development of humanity several centuries from now. Human life will be so different in three hundred years that it is hard to know even how adaptation could be identified by then. I have to fall back on little more than guesswork. Bearing in mind that the quantity of an emitted tonne of carbon dioxide will be reduced by about a half in half a century, I shall assume that its effect on the death rate will be reduced to half within a century. I assume that the effect on the death rate will be very small after three centuries. (Three centuries is the horizon set on the calculations in VGMC.)

For RCP 4.5, the estimate I obtained at the end of Section 3 for the life-years taken away by a person who emits 1200 tonnes is .263. The discount rate is 0.5%. This amounts to a discount of 40% over 100 years, 63% over 200 years, and 78% over 300 years. This suggests to me that discounting at this rate is not likely to underestimate the total of harm by more than 50%. I guess therefore that in RCP 4.5 the amount of killing done by a person who emits 1200 tonnes is in the region of half a life-year.

[22] IPCC (2014: 229).
[23] See the graphs in box 6.1 on p. 473 of IPCC (2013).
[24] IPCC (2013: 1102–1105).

For RCP 8.5, the estimate I obtained at the end of Section 3 is 1.34 life-years. The discount rate is 1.15%, which amounts to 68% over 100 years, 89% over 200 years, and 96% over 300 years. This suggests an underestimate of perhaps 75% or 80% in the amount of killing done. I guess that in RCP 8.5 the amount of killing done by a person who emits 1200 tonnes is in the region of 6 or 7 life-years.

5. Conclusion and Why It Matters

My attempt in Section 4 to cancel out discounting from the figures is the most speculative part of my calculation. I was forced to speculate about the adaptive success of human beings centuries in the future. Since the VGMC estimates for RCP 4.5 imply only the small discount rate on life of 0.5%, they are less vulnerable to a mistake about this. The higher discount rate of 1.15% implied in the estimates for RCP 8.5 makes a much greater difference. Remember that in any case RCP 8.5 does not represent a prediction so much as a worst-case baseline. RCP 4.5 is more like a prediction, and I put much more trust in the RCP 4.5 figures.

There is anyway a great deal of uncertainty in any quantitative predictions involving climate change. I have tried to work out only the harm that is *likely* to arise from emissions; much greater harm is possible. Furthermore, remember I am only trying to produce interim results, while I wait in hope that the authors of VGMC will produce much more accurate ones in due course. With all these caveats, my best estimate of the amount of life you are likely to take away by emitting 1200 tonnes of carbon dioxide is half a year.

Why does it matter? It helps to position the harm we do through climate change on the scale of all the good and bad things we do. It is important to recognize that the harm an individual does by her emissions—and correspondingly the good she can do by reducing her emissions—though definitely significant, is not large in comparison to other means of doing good.

Some ways of reducing emissions, such as eating less meat and turning down the air conditioning, are easy and cheap. Others, such as insulating your house, are expensive. One of the cheaper ways is to offset your emissions. You can offset by planting trees or by paying for projects that reduce emissions elsewhere. The cost of offsetting is in the region of $10 per tonne. According to my figures, if you were to spend $12,000 on offsetting your lifetime emissions of 1,200 tonnes, you would save perhaps half a life-year in RCP 4.5 and 6 or 7 life-years in RCP 8.5. By contrast, the organization GiveWell lists on its website charities that, on its calculations, can save a person's whole life for a donation of $2,000 or $3,000.[25] Among

[25] https://www.givewell.org/how-we-work/our-criteria/cost-effectiveness/cost-effectiveness-models.

them are charities that fight malaria. These are plainly more effective ways of using money to do good.

Why, then, should you reduce your emissions? Mainly because justice requires it. You emit greenhouse gas to benefit yourself, but in doing so you harm other people. It is an elementary principle of common-sense justice that, with certain exceptions such as self-defense, you should not harm other people for your own benefit. On this point I agree with Nolt.[26]

It is also true that climate change is in aggregate doing immense harm in the world. Although reducing emissions is not the most effective way of doing good, it is well worth the cost. For you as an individual, this is not unqualifiedly so because you have better ways of using your money. If you use your money in the best ways, starting with the best means of doing good and working down to less good means, you will run out of money long before you get to reducing your emissions much. But governments are different because they control vastly greater resources. They have coercive power over their people's behavior, by means of taxes and regulations. It is true for a government as it is for an individual, that it should first direct resources in more effective ways such as fighting malaria. But when all that is done, a government should still direct a vast amount of further resources towards reducing emissions of greenhouse gas.

An appropriate means of doing good for an individual is therefore political action aimed at getting governments to reduce emissions. This is a further reason for reducing your own emissions. Doing so is a sort of political action. It shows that you care. It may induce others to follow you and to vote for reducing emissions.[27]

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[26] (Nolt 2011: 7). See my *Climate Matters* (Broome 2012), chapter 4.

[27] My thanks for very useful comments, information and advice from Mark Budolfson, Tamma Carleton, Maxwell Frye, Coby Gibson, Daniel Gun Lim, Douglas MacLean, Michael Morck, Tristram McPherson, John Nolt and Adrian Russian. Research for this paper was supported by ARC Discovery Grants DP140102468 and DP180100355.

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