

Environmental damages of the top ten percent consumers exceed global climate and biodiversity funding gaps

Corresponding Author: Mx Inge Schrijver

This file contains all editorial decision letters in order by version, followed by all author rebuttals in order by version.

Attachments originally included by the reviewers as part of their assessment can be found at the end of this file.

Version 0:

Decision Letter:

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Dear Ms Schrijver,

Please first accept our sincere apologies for the delay in reaching a decision on your submission.

Your manuscript titled "The environmental bill of the top 10% consumers" has now been seen by 3 reviewers, whose comments are appended below. You will see that they find your work of some potential interest. However, they have raised quite substantial concerns that must be addressed. In light of these comments, extensive revisions will be required before we can further consider the manuscript for publication. We would, however, be interested in considering a revised version that fully addresses these serious concerns.

For publication in Communications Sustainability to be appropriate, your study must:

- * provide a convincing valuation of environmental and biodiversity-related damage within a planetary boundary framework that can inform policy decision making;
- * reach robust conclusions with compelling metrics;
- * transparently report methods and data to enable reproducibility of the findings.

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Please do not hesitate to contact us if you have any questions or would like to discuss the required revisions further. Thank you for the opportunity to review your work.

Best regards,

Yann Benetreau, PhD
Deputy Editor, Communications Sustainability
Consulting Editor, Communications Earth & Environment
Nature Portfolio
ORCID: 0000-0002-1897-0887
New York Office

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REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

The paper estimates the environmental costs resulting from the environmental damages attributable to the top 10% of consumers in selected countries. This is a highly relevant topic. While the novelty does not lie in the observation that wealthier individuals generally have a higher environmental impact, the real contribution, in my view, is in quantifying these impacts. Additionally, the focus on planetary boundaries provides an interesting and valuable framework. I do, however, have several major comments, as well as some minor ones, primarily concerning the transparency of the methodology (to allow readers to assess whether the damage costs are truly comparable and to what extent) and the motivation regarding environmental taxation. My specific points are as follows:

1- The main aim of environmental taxes is not revenue but behavioural changes. Then, revenue comes as a second advantage. This is important because otherwise it seems, and this is problematic for public acceptance, that env-taxation only concern is to raise revenues. Is not. Actually, if the taxation works, the revenues will start decreasing at some point (as already happens in Sweden). Sweden environmental tax base has been eroded because of the effectiveness of their environmental taxes, reducing revenues accordingly. As it is written now, the paper puts too much emphasis on the revenue side while a more appropriate focus given the topic is that environmental taxes can be progressive (because richer households will end up paying more, i.e. non-regressive taxation). I think the motivation should focus more on this equity aspect of the taxing rather than the focus on revenues (which is of course also relevant and can actually be used to compensate poorer households)

2- The paper needs to be more transparent in the main text on how the costs are estimated. They discuss the problems monetizing could have (big debate) but forget referring how they do monetize. DO they apply the same methods for all boundaries? As I get clear from SI, the valuation is using willingness to pay methods. However, I am not sure this is detailed enough either in the SI sections. Yet, for a clear understanding of results, one needs to understand the basic assumptions behind the estimates in the main text. One reads the damages costs but keeps wondering where this numbers came from. Because of this, it is not clear if the results and the comparison across boundary' bills is driven by different underlying assumptions in calculating the bills. Certainly, it is not enough to just mention the "Environmental Prices Handbook" or the deflation rate used, as it is now in the main text. I don't know what assumptions are behind that handbook. Related to this, is this WTP survey based across all environmental damages? Are these country specific or averaged worldwide?

3- Figure 1b (and in the main text). Not clear what cumulative means since there is no time period referenced. DO they mean non-percapita or national or similar? Cumulative seems confusing unless I missed something

4- Related to previous point. Not clear if the consumption and derived footprint refers to a particular year or is the average along a certain period. Besides of main text, table notes should note this.

Reviewer #2 (Remarks to the Author):

The paper presents an interesting approach of quantifying environmental damage and linking it to an environmental tax as a means of meeting gaps in international transfers of funds for global environmental concerns. The analysis of the data broadly correlates to the contribution of countries to the climate problem, which makes it convincing to researchers and policymakers.

My suggestion would be, while retaining the reasoning, adding a paragraph, and a line in the summary, that ALSO stresses a finding that is currently not highlighted, namely, biodiversity loss. The responsibility of countries/top 10% population is not just for causing climate change but also for the impact, environmental damage on a global scale. The paper would then also contribute to the literature on linkages between climate change and biological diversity loss, that they need to be considered together, and thus address a broader range of researchers and policymakers.

Reviewer #3 (Remarks to the Author):

The manuscript quantifies the environmental damages of the top 10% of consumers by combining estimates of consumption-related impacts from Tian et al. (2024) with economic valuations of ecosystem services from the 2024 Environmental Prices Handbook. The authors estimate an environmental bill of USD 1.2–3.9 trillion for the top 10% of consumers globally. While the manuscript represents an interesting extension of Tian et al. by monetizing these damages, there are several areas where the contribution could be strengthened:

Motivation and contribution: The paper does not clearly advance our understanding of the environmental damages of the top 10% beyond the findings of Tian et al. (2024). It is therefore important to better motivate why the monetary value of the environmental bill matters. How is this relevant for policy? Does it provide a unique benchmark by combining different planetary boundary transgressions into a single metric? How should we judge whether the estimated bill is large or small?

MSA loss: A substantial share of the estimated damages is driven by the valuation of mean species abundance (MSA) loss. However, as the authors themselves acknowledge, the valuation of biodiversity impacts is particularly uncertain. This undermines the credibility of the overall results and calls for a more thorough discussion.

Scaling by GDP per capita: The decision to scale the value of each environmental damage by per capita GDP is critical. While this approach is recommended in the Handbook, it warrants deeper discussion. In particular, for global externalities such as climate change, the justification for such an adjustment is debatable.

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Dear Ms Schrijver,

Please allow us to express our sincere apologies for the delay in reaching a decision on your submission. One reviewer became unresponsive, which has caused some delays.

Your manuscript titled "The environmental bill of the top 10% consumers" has now been seen by 2 reviewers, and we include their comments at the end of this message. They find your work of interest, but some important points are raised. We are interested in the possibility of publishing your study in Communications Sustainability, but would like to consider your responses to these concerns and assess a revised manuscript before we make a final decision on publication.

Some key concerns already raised at the previous round of review remain unaddressed. Substantial revisions in rationale and justification of methods—possibly also in analyses—are necessary to address Reviewer 3's remaining concerns.

Please note that in the absence of compelling revisions, we will not send the manuscript back to review.

We therefore invite you to revise and resubmit your manuscript, along with a point-by-point response that takes into account the points raised. Please highlight all changes in the manuscript text file.

Please submit your point-by-point responses as a separate file, distinct from your cover letter where you can add responses to the Editors' comments that you do not want to be made available to the reviewers. Word files are preferred. We recommend that any figures, tables or graphs that are included in the response to reviewers are also included in the main article or Supplementary Information.

We are committed to providing a fair and constructive peer-review process. Please don't hesitate to contact us if you wish to discuss the revision in more detail.

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We hope to receive your revised paper within six weeks; please let us know if you aren't able to submit it within this time so that we can discuss how best to proceed. If we don't hear from you, and the revision process takes significantly longer, we may close your file. In this event, we will still be happy to reconsider your paper at a later date, as long as nothing similar has been accepted for publication at Communications Sustainability or published elsewhere in the meantime.

Please do not hesitate to contact us if you have any questions or would like to discuss these revisions further. We look forward to seeing the revised manuscript and thank you for the opportunity to review your work.

Best regards,

Yann Benetreau, PhD
Deputy Editor, Communications Sustainability
Consulting Editor, Communications Earth & Environment
Nature Portfolio
ORCID: 0000-0002-1897-0887
New York Office

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REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

The authors have addressed my concerns correctly. In my view the method is more transparent and the rationale behind environmental taxation is now clearer also

Reviewer #3 (Remarks to the Author):

Thank you for your reply. Below are my comments on your rebuttal letter:

Motivation: I am satisfied with the authors' reply.

MSA loss: I am satisfied with the authors' reply.

Prices: I am not satisfied with this point. Please better justify the statement that "the most important factor in such models (transfer benefits) is income levels." The citation provided seems to be incomplete, and this claim is debatable. Moreover, even if income levels were the most important factor, this does not imply that dividing by GDP per capita is the appropriate adjustment. Why this particular functional form? How do you justify it?

Regarding climate change, further discussion is needed. First, why are abatement costs used instead of the social cost of carbon? Are these the marginal costs of abatement? If so, these only equal the social cost of carbon at the optimal level of abatement—does the model you are considering satisfy this condition? Also, I do not see why this price should be divided by GDP per capita. You argue that this is "a translation of the European values to different countries rather than a change in the price of the impact itself," but you express all results in euros. I still think that, since this is a global damage, a constant

price should be used across the globe. This point is fundamental, because using a lower price for lower-income countries will mechanically inflate your global results on the contribution of the top 10% of earners.

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Decision Letter:

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Dear Ms Schrijver,

Your manuscript titled "The environmental bill of the top 10% consumers" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Sustainability.

We therefore invite you to revise your paper one last time to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

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We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Yann Benetreau, PhD
Deputy Editor, Communications Sustainability
Consulting Editor, Communications Earth & Environment
Nature Portfolio
ORCID: 0000-0002-1897-0887
New York Office

REVIEWERS' COMMENTS:

Reviewer #3 (Remarks to the Author):

I am satisfied with the reply to my previous comments and the modifications to the manuscript.

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Reviewer #1

Review comments	Response	Changes to the manuscript
<p>The paper estimates the environmental costs resulting from the environmental damages attributable to the top 10% of consumers in selected countries. This is a highly relevant topic. While the novelty does not lie in the observation that wealthier individuals generally have a higher environmental impact, the real contribution, in my view, is in quantifying these impacts. Additionally, the focus on planetary boundaries provides an interesting and valuable framework. I do, however, have several major comments, as well as some minor ones, primarily concerning the transparency of the methodology (to allow readers to assess whether the damage costs are truly comparable and to what extent) and the motivation regarding environmental taxation. My specific points are as follows:</p>	<p>Thank you for your review of our manuscript. We have addressed your points below and have improved the manuscript. We hope that these changes satisfy the queries you had about the paper. Thank you again.</p>	
<p>1- The main aim of environmental taxes is not revenue but behavioural changes. Then, revenue comes as a second advantage. This is important because otherwise it seems, and this is problematic for public acceptance, that env-taxation only concern is to raise revenues. Is not. Actually, if the taxation</p>	<p>Thank you for addressing this. Equity is indeed a major concern in this manuscript and one of the main issues on which we want to shine a light. Our main aim is to show the impact of the top 10% and that there is a clear policy rationale for intervention. We have</p>	<p><i>Introduction, p. 1:</i> Our main aim is to illustrate the size of their impacts and corresponding responsibility to signal that the top 10% and their high-polluting behaviour should be a major focus of mitigation policy. Monetisation helps to give a sense of the total impact, and to link environmental</p>

<p>works, the revenues will start decreasing at some point (as already happens in Sweden). Sweden environmental tax base has been eroded because of the effectiveness of their environmental taxes, reducing revenues accordingly. As it is written now, the paper puts too much emphasis on the revenue side while a more appropriate focus given the topic is that environmental taxes can be progressive (because richer households will end up paying more, i.e. non-regressive taxation). I think the motivation should focus more on this equity aspect of the taxing rather than the focus on revenues (which is of course also relevant and can actually be used to compensate poorer households)</p>	<p>emphasised the equity motivation and behaviour/consumption change further in the introduction and added and edited paragraphs in the “Results and discussion” section to discuss how environmental taxation can be done progressively to support equity (including newly added literature).</p> <p>We use the climate and biodiversity financing gaps mainly as a reference to show the size of the environmental bill, and have de-emphasised this revenue angle. It is now framed as providing an order-of-magnitude.</p>	<p>impacts to economic and financial concerns, providing justification for environmental taxation.</p> <p>[...]</p> <p>we aim to highlight the differentiated responsibility of society’s top decile and illustrate this with the potential revenue if they would pay their environmental bill.</p> <p>[...]</p> <p>environmental taxes are part of mitigation policy aiming to shift behaviour from polluting to more sustainable consumption. Tax revenue can help pay for necessary sustainability transitions while improving equity by putting the burden on the top 10% and compensating lower-income households. This targets one part of their behaviour as high-income individuals have multiple roles to play not just as consumer, but also as investor, citizen, role model and organisational participant³⁰.</p> <p><i>Results and discussion, p. 4:</i></p> <p>The size of the damage bill shows that the top 10% consumers is an important group on which to focus climate mitigation policy. We link the damage to the percentage of income or wealth and financing gaps as a reference, not to suggest that these should become tax rates. Such policies should be considered</p>
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		<p>in (sub)national or regional contextualised schemes.</p> <p>Environmental pricing or taxation aims to incentivise a shift from polluting to more sustainable consumption. Environmental taxation focussed on the top 10% simultaneously improves equity. Which kind of policies are progressive or regressive, depends on the country-specific context²⁶. In low-income countries, any carbon tax is progressive^{26,29}. In high-income countries, uniform taxation is regressive (if revenues are not recirculated), while higher taxes for luxury consumption rather than basic goods are progressive and reduce inequality²⁹. Usually, revenue is less with luxury taxation but emissions are reduced more, because more price-responsive goods are targeted so households are more likely to forego consumption²⁹. If revenues are redistributed towards lower incomes, then equity improves, but emissions also increase because of re-spending (i.e. increased consumption)²⁹. However, distribution can benefit some of the population without offsetting reduced emissions; the more unequal a country the more redistribution can occur without harming mitigation²⁹.</p>
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		<p>Public resistance against (carbon) taxes mainly comes from concerns for low-income households, so distributional effects are also important for policy support^{27,28}. If revenues are used for approaches such as green government investments, then public acceptance is generally higher³¹. Financing climate investments through a wealth tax on the top 1% would decrease wealth inequality (they would then own an estimated quarter of all wealth by 2050) while addressing the unequal burden of climate damages on lower income communities³⁰.</p> <p><i>Conclusion, p. 4</i> We show that the environmental damages caused by the consumption of the top 10% consumers are significant, exceeding funding gaps in biodiversity and climate finance. Mitigation policy directed at this group can reduce emissions/pollution, raise revenue for sustainability transitions, and improve equity simultaneously.</p>
2- The paper needs to be more transparent in the main text on how the costs are estimated. They discuss the problems monetizing could have (big	Thank you for this comment on methodology. We have added a subsection in the Methods section titled “Environmental prices” that explains how	<p><i>Methods, p. 5:</i> <u>Environmental prices</u></p>

<p>debate) but forget referring how they do monetize. DO they apply the same methods for all boundaries? As I get clear from SI, the valuation is using willingness to pay methods. However, I am not sure this is detailed enough either in the SI sections. Yet, for a clear understanding of results, one needs to understand the basic assumptions behind the estimates in the main text. One reads the damages costs but keeps wondering where this numbers came from. Because of this, it is not clear if the results and the comparison across boundary' bills is driven by different underlying assumptions in calculating the bills. Certainly, it is not enough to just mention the "Environmental Prices Handbook" or the deflation rate used, as it is now in the main text. I don't know what assumptions are behind that handbook. Related to this, is this WTP survey based across all environmental damages? Are these country specific or averaged worldwide?</p>	<p>the Environmental Prices Handbook arrives at their prices and how we use them. We have also added a section in the SI with a table that shows the valuation types used for each planetary boundary (please see the SI for the table as it is too big to include here).</p>	<p>Handbook prices are based on a model that traces monetary valuations of ultimate impacts (endpoints) such as on human health and ecosystems, back through midpoints, which include climate change, eutrophication and water consumption, to specific emissions/substances like CO₂, N and P to ensure comparability between prices. To determine which part of the endpoint damage cost is attributed to which midpoint and which emission, an impact pathway approach is taken using environmental and economic models and ReCiPe 2016 characterisation factors to arrive at a price per emission or midpoint. The ReCiPe 2016 characterisation factors used to weigh emissions to their impacts are representative for the global scale, but the monetary valuations represent an average location in the EU27.</p> <p>Different valuations are used for different substances and for lower, central and upper estimates, generally based on willingness-to-pay methodologies. For instance, some N and P values are based on housing price studies, while water consumption is connected to valuations of malnutrition, loss of fish species, and diminished plant productivity</p>
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		<p>due to water shortage. Biodiversity prices are based on a regression analysis of multiple (European) willingness-to-pay studies. Climate change is based on abatement costs instead of willingness to pay, using upper and lower values found in the literature with the central CO₂ price being the median price of an IPCC 1.5-degree scenario (converted to €₂₀₂₁).</p> <p>Ideally, a benefit transfer model is used for translating EU prices to other areas for all substances¹⁶. However, this is not available in this case. The most important factor in such models is income levels, with higher damages in higher income regions³⁶. We therefore scale prices based on GDP per capita (PPP). For local impacts such as biodiversity loss and nutrients, damage costs differ in different regions, depending on matters like population density and ecosystem type, state and location¹⁶. More research is needed to establish country- or region-specific prices.</p> <p>For climate change, the price is based on abatement costs which depends on climate targets set. The central value is based on median prices from the IPCC (2018) in a 1.5-degree scenario with limited overshoot. This is therefore a</p>
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		global value that has been translated to € ₂₀₂₁ by the handbook. Using GDP per capita to scale the prices to other countries, is more a translation of the European value to different countries rather than changing the price of the impact itself.
<p>3- Figure 1b (and in the main text). Not clear what cumulative means since there is no time period referenced. DO they mean non-percapita or national or similar? Cumulative seems confusing unless I missed something</p> <p>4- Related to previous point. Not clear if the consumption and derived footprint refers to a particular year or is the average along a certain period. Besides of main text, table notes should note this.</p>	<p>Thank you for indicating this omission and confusing terminology. The footprint refers to the year 2017. Figure 1b and cumulative in the text refer to the whole of the top 10% (as opposed to per person in the top 10% that is represented in 1a). We have updated the text to clarify.</p>	<p><i>Results and discussion, p. 3:</i> We find that the total environmental damage costs per person in the top 10% consumers worldwide is \$1.5k-\$5.1k for the year 2017 (in \$₂₀₁₇; see Figure 1A, and the Supplementary Information (SI) for data tables). The damages of the total global top 10% group are \$1.2-\$3.9tn.</p> <p><i>Figure 1, p. 2:</i> The environmental bill of the top 10% consumers in 6 countries and globally in 2017, in \$₂₀₁₇, a) per capita in the top 10%, b) for the whole top 10% group. Biodiversity and climate financing targets are added as a reference. Note that we have adjusted the prices per country based on GDP per capita. Therefore, each country has their own environmental prices and summing the country top 10% bills does not equal the world total.</p>

Reviewer #2

Review comments	Response	Changes to the manuscript
The paper presents an interesting approach of quantifying environmental damage and linking it to an environmental tax as a means of meeting gaps in international transfers of funds for global environmental concerns. The analysis of the data broadly correlates to the contribution of countries to the climate problem, which makes it convincing to researchers and policymakers.	Thank you for your valuable comments. They have helped improve the manuscript and please see our responses below.	
My suggestion would be, while retaining the reasoning, adding a paragraph, and a line in the summary, that ALSO stresses a finding that is currently not highlighted, namely, biodiversity loss. The responsibility of countries/top 10% population is not just for causing climate change but also for the impact, environmental damage on a global scale. The paper would then also contribute to the literature on linkages between climate change and biological diversity loss, that they need to be considered together, and thus address a broader range of researchers and policymakers.	Thank you for stressing the importance of biodiversity loss. Our results indeed show this is a large part of the damages. We have created several paragraphs in the “Results and discussion” section to put more emphasis on this theme. This includes a sentence and new references about the importance of linking climate change and biodiversity policy. Moreover, we have added a sentence in the abstract to say that biodiversity loss is the biggest factor.	<p><i>Abstract, p. 1:</i> Biodiversity loss is the biggest contributor to the damage bill at 63-71% of the total, followed by climate change at 19-26%.</p> <p><i>Results and discussion, p. 3:</i> Proportionally, the main component of the total bill is damage to biosphere integrity: biodiversity loss constitutes 63-71% of the global bill, depending on the price estimate used (see Figure 2 and the SI). Climate change is second largest at 19-26% of the bill, followed by nitrogen with 8-10%. For individual countries, the distribution is similar although the exact proportions vary. There have been several calls to address biodiversity and</p>

		<p>climate change in a joined-up fashion and these estimates only underline this need^{23,24}.</p> <p>Prices are also more uncertain for biodiversity loss. The indicator is (terrestrial) Mean Species Abundance (MSA) loss, which is the difference in species abundance of an ecosystem in its current versus its pristine state multiplied by the size of the ecosystem²⁶. The available footprint is in an aggregate form: global MSA-loss hectares. We do not know which biomes are impacted where, while biodiversity loss and its valuation are highly context-specific, dependent among others on ecosystem type, state and location¹⁸. Since there is no price for MSA loss in the literature, we converted the Environmental Prices Handbook's price for Potentially Disappeared Fraction which is based on European ecosystems and valuations (see SI).</p> <p>It is difficult to establish whether our results are an over- or underestimation of biodiversity loss prices. According to the handbook's sources, valuation is higher when population density is higher – a</p>
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		<p>reflection of recreational values¹⁸. For USA and Brazil, which have a substantially lower population density than the EU, the price might be adjusted downward, whereas for especially India and Germany, as well as China and Egypt, it might be adjusted upward. At the same time, prices are higher for forest and coastal systems compared to freshwater ecosystems, and for smaller ecosystems and those with already lower biodiversity¹⁸. As it is not possible for us to assess these factors across the countries, it is not possible to determine the direction of these influences.</p> <p>Regardless, it is clear that biodiversity loss is a major impact. Even if we use the lowest biodiversity price with the highest other prices, it accounts for 40% of global the bill. Seeing the price mainly represents recreational values, there are many other values that could even further increase the price. Some would argue such approaches are inherently an underestimation of the infinite value of ecosystems²⁷.</p>
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Reviewer #3

Review comments	Response	Changes to the manuscript
The manuscript quantifies the environmental damages of the top 10% of consumers by combining estimates of consumption-related impacts from Tian et al. (2024) with economic valuations of ecosystem services from the 2024 Environmental Prices Handbook. The authors estimate an environmental bill of USD 1.2–3.9 trillion for the top 10% of consumers globally. While the manuscript represents an interesting extension of Tian et al. by monetarizing these damages, there are several areas where the contribution could be strengthened:	Thank you for your efforts in reviewing our manuscript and your comments have improved it, thanks again. Please see our response to each point and how we addressed them in the manuscript below.	
Motivation and contribution: The paper does not clearly advance our understanding of the environmental damages of the top 10% beyond the findings of Tian et al. (2024). It is therefore important to better motivate why the monetary value of the environmental bill matters. How is this relevant for policy? Does it provide a unique benchmark by combining different planetary boundary transgressions into a single metric? How should we judge whether the estimated bill is large or small?	Thank you for this comment. The main aim of this study is to (re)emphasise the importance of focussing on high-emitting/polluting groups. We find that the benefit of monetisation is to have a sense of the total impact and centre the need for more policies that address the consumption of the highest decile income earners. This helps to communicate the responsibility of the top 10%, and this way it can also be linked to economic/financial questions, taxation and revenue raising for transitions. We have edited the introduction to reflect	<i>Introduction, p. 1:</i> Here, we monetise the environmental harm caused by the top decile of consumers on the planetary boundaries. Our main aim is to illustrate the size of their impacts and corresponding responsibility to signal that the top 10% and their high-polluting behaviour should be a major focus of mitigation policy. Monetisation helps to give a sense of the total impact, and to link environmental impacts to economic and financial concerns, providing justification for environmental taxation. [...]

	<p>this. To indicate the size of the bill, we use the climate and biodiversity financing gaps as a reference, which we have clarified in the text.</p>	<p>Rather, we aim to highlight the differentiated responsibility of society's top decile and illustrate this with the potential revenue if they would pay their environmental bill.</p>
<p>MSA loss: A substantial share of the estimated damages is driven by the valuation of mean species abundance (MSA) loss. However, as the authors themselves acknowledge, the valuation of biodiversity impacts is particularly uncertain. This undermines the credibility of the overall results and calls for a more thorough discussion.</p>	<p>Thank you for indicating this important point. We have added a paragraph in the "Results and discussion" section where we discuss the implications of the biodiversity pricing uncertainties.</p>	<p><i>Results and discussion, p. 3:</i> It is difficult to establish whether our results are an over- or underestimation of biodiversity loss prices. According to the handbook's sources, valuation is higher when population density is higher – a reflection of recreational values¹⁶. For USA and Brazil, which have a substantially lower population density than the EU, the price might be adjusted downward, whereas for especially India and Germany, as well as China and Egypt, it might be adjusted upward. At the same time, prices are higher for forest and coastal systems compared to freshwater ecosystems, and for smaller ecosystems and those with already lower biodiversity¹⁶. As it is not possible for us to assess these factors across the countries, it is not possible to determine the direction of these influences. Regardless, it is clear that biodiversity loss is a major impact. Even if we use the lowest biodiversity price with the highest other prices, it accounts for 40% of global the bill. Seeing the price mainly represents recreational values, there are</p>

		many other values that could even further increase the price. Some would argue such approaches are inherently an underestimation of the infinite value of ecosystems ²⁵ .
Scaling by GDP per capita: The decision to scale the value of each environmental damage by per capita GDP is critical. While this approach is recommended in the Handbook, it warrants deeper discussion. In particular, for global externalities such as climate change, the justification for such an adjustment is debatable.	Thank you for pointing this out. We have added several paragraphs in the “Methods” section to clarify the methodology, including two discussing transferring prices between countries and the carbon price.	<p><i>Methods, p. 4:</i> Ideally, a benefit transfer model is used for translating prices from the EU to other areas for all substances. However, this is not available. The most important factor in such models is income levels, with higher damages in higher income regions (CE Delft, 2011). We therefore scale prices based on GDP per capita (PPP). For local impacts like biodiversity loss and nutrients, damage costs differ in different regions, depending on matters like population density and ecosystem type, state and location. More research is therefore needed to establish country- or region-specific prices.</p> <p>For climate change, the price is based on abatement costs which depends on climate targets set. The central value is based on median prices from the IPCC (2018) in a 1.5-degree scenario with limited overshoot. This is therefore a global value that has been translated to €₂₀₂₁ by the handbook. Using GDP per capita (in PPP) to scale the prices to other countries, therefore represents</p>

		more translating the euro value to different countries rather than changing the price of the impact itself.
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Reviewer #3 comments, 2nd round

Thank you for your careful considerations. We have adjusted the methodology according to your suggestion and please find below our responses to your points.

Review comments	Response	Changes to the manuscript
Please better justify the statement that “the most important factor in such models (transfer benefits) is income levels.” The citation provided seems to be incomplete, and this claim is debatable. Moreover, even if income levels were the most important factor, this does not imply that dividing by GDP per capita is the appropriate adjustment. Why this particular functional form? How do you justify it?	Thank you for catching the incomplete reference, we have now updated it. It is the methodological description of the benefit transfer tool that was developed with a previous version of the environmental prices handbook to convert prices from the EU to other regions (the tool itself unfortunately does not seem to be publicly available and does not have the environmental impacts we need). They list five factors that are most important, with income at the top (p. 12). For human health (p. 19) and ecosystems (p. 20-21), the two endpoints that are relevant for our emissions/substances (see SI), they describe that the tool adjusts for income and population density, plus ecosystem type for ecosystems. As a proxy of individual income they use the level of GDP per capita at PPP and the adjustment formula: $Value_x = Value_E (Y_x / Y_E)^\beta$, with $Value_x$: adjusted damage value for the country X, $Value_E$: average damage value for the EU, Y_x : income level in country X expressed as GDP per capita at PPP, Y_E : average income in the EU expressed as GDP at PPP per capita, and β : income elasticity (0.85) – the functional form is a consequence of income elasticity estimates	In <i>Methods</i> , p. 5: Ideally, a benefit-transfer model is used for translating EU prices to other areas for all emissions/substances ¹⁸ . However, such a model is not available in this case. We follow the methodology of the value transfer tool developed with the previous handbook, which states that the most important factor is income levels (higher damages in higher income regions) ³⁵ . For human health and ecosystem impacts, the two endpoints relevant for our substances (see the SI), this tool uses GDP per capita at PPP as a proxy for individual income in the adjustment formula: $Value_x = Value_E (Y_x / Y_E)^\beta$, with $Value_x$: adjusted damage value for the country X, $Value_E$: average damage value for the EU, Y_x : income level in country X expressed as GDP per capita at PPP, Y_E : average income in the EU expressed as GDP at PPP per capita, and β : income elasticity (set at 0.85 based on literature review). We use this formula to scale the prices from the EU to the respective

	<p>that come as a standard from double-log models. In the process of revising, we discovered that we did not include the elasticity value correctly and have now corrected this. This change has resulted in a 2-4% lower bill for USA and Germany and 8-13% higher for Brazil, China, Egypt, India and the world. To adjust for population density, the relationship differs per substance and since P, N, MSA loss and water are not available, we did not include it (as noted in the results and discussion section). We have added this information to the methodology section.</p>	<p>countries. Another factor of importance is population density, but the relationship depends on the substance and the coefficients for our substances are not available, so we have not included this. For ecosystem damages, the ecosystem type, state and location are also relevant. In the best case, country- or region-specific prices would be calculated, for which more research is necessary.</p> <p>In <i>References</i> p.8: Markowska, A., van Valkengoed, M. & de Bruyn, S. <i>Benefito - Description of the Excel Tool and User Manual</i>. https://cedelft.eu/publications/benefito-description-of-the-excel-tool-and-user-manual/ (2011).</p>
<p>Regarding climate change, further discussion is needed. First, why are abatement costs used instead of the social cost of carbon? Are these the marginal costs of abatement? If so, these only equal the social cost of carbon at the optimal level of abatement—does the model you are considering satisfy this condition?</p>	<p>The environmental prices handbook uses abatement costs, because it finds that the SCC estimates in the literature have very large uncertainty, omit certain climate impacts and are highly sensitive to both the damage functions used and the discount rate. They follow Stern & Stiglitz (2021) who recommend using abatement costs rather than the SCC, which is also used by OECD (2018). We agree with these assessments of SCC. At the same time, the handbook indicates that most recent SCC studies have optimal reduction pathways that reach zero emissions by 2050, which aligns</p>	<p>In <i>SI, Extended methods, CO₂ price</i> p. 2: The handbook uses abatement costs instead of the social cost of carbon (SCC) as they find that SCC estimates in the literature have very large uncertainty, omit certain climate impacts and are highly sensitive to both the damage functions used and the discount rate. The handbook indicates that they follow Stern & Stiglitz¹¹ who recommend using abatement costs rather than the SCC, which is also used by OECD¹². Most recent SCC studies have optimal reduction pathways that reach</p>

	<p>with the IPCC scenario used for the central estimate and European targets. That is, targets used for setting the abatement costs correspond with optimal reduction pathways. We have added this clarification to the extended methods in the SI.</p>	<p>zero emissions by 2050, which aligns with the IPCC scenario used for the central estimate and European targets, so the targets used for setting the abatement costs correspond with optimal reduction pathways. The handbook therefore uses abatement costs as proxy for damage costs.</p> <p>References: OECD, 2018. The social cost of carbon Stern, N. & Stiglitz, J., 2021. The Social Cost of Carbon, Risk, Distribution, Market Failures: An Alternative Approach. NBER Working Papers.</p>
<p>Also, I do not see why this price should be divided by GDP per capita. You argue that this is “a translation of the European values to different countries rather than a change in the price of the impact itself,” but you express all results in euros. I still think that, since this is a global damage, a constant price should be used across the globe. This point is fundamental, because using a lower price for</p>	<p>We agree that climate change has global damages. We consulted with one of the co-authors of the environmental prices handbook, who confirmed the argument can be made for using a constant global price. We have adjusted the calculations, methods and results accordingly (only deflating the EU 2021 price to 2017 and assigning all countries that same price). There is also an argument for adjusting the prices per country, which we have now put in the SI together with the numerical difference between the two methods. Please see the changed text.</p>	<p>In <i>Methods</i>, p. 5: For climate change, we do not adjust the CO₂ prices based on GDP per capita. Climate change is different from the other impacts, because its damages are global instead of local and occur irrespective of where emissions take place. Therefore, we use one constant price for all countries. One could argue that prices should be differentiated per country because of the principle of common but differentiated responsibility and we have calculated this as well, see the SI for more information.</p>

<p>lower-income countries will mechanically inflate your global results on the contribution of the top 10% of earners.</p>		<p>For the new results, please see the <i>Results and discussion</i> section, p. 2-3.</p> <p>In <i>SI, Extended methods, CO₂ price</i> p. 2: Different from the other substances, we keep the CO₂ price constant rather than scaling based on GDP per capita. We do this because climate damages are global and irrespective of where emissions take place, rather than local as with the other impacts. Having one uniform carbon price reflects this. On the other hand, one can argue that prices should be differentiated per country because of the principle of common but differentiated responsibility. The abatement costs are associated with becoming net zero in 2050, which is an EU goal and IPCC scenario. However, for instance Global South countries do not need to have this goal. In this view, each country has its own price according to its own goal. The value transfer method used for the other substances can be a proxy for this. We have also calculated the bill with differentiated prices, see the excel sheet 2.CO₂ (Tables 2.4 and 2.5) and 7.Total bill (Table 7.6). As expected, the CO₂ bill for Brazil, China, Egypt, India and the world becomes lower (56-82% lower) and for Germany and USA higher (17-29%</p>
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		higher). The total environmental bill (central estimates) becomes 23-53% lower for Brazil, China, Egypt, India and the world, and 4-7% higher for Germany and USA. This does not alter the main conclusions of the paper, with the world and USA estimates still surpassing biodiversity and climate financing targets, and biodiversity loss and climate change still the biggest contributors to the bill.
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