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

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The top 10% of global consumers is disproportionately responsible for transgressing planetary boundaries, causing damages for which broader society bears the costs. Here we monetise the climate change, biosphere integrity, biogeochemical cycles and freshwater-use footprints of these consumers using prices of the Environmental Prices Handbook. We find annual damages owed by the global 10% to be \$1.7–\$5.7 trillion, equivalent to \$2.3k–\$7.5k per person (in \$2017). This surpasses international climate and biodiversity financing gaps. The top 10% US consumers see a bill of \$19k–\$63k, equal to 6–20% of their income or 0.8–3% of their wealth. The two biggest contributors to the damage bill are biodiversity loss at 47–56% of the total and climate change at 36–45%. These costs highlight the mitigation responsibility of the top 10% and illustrate the potential revenue of environmental taxes if the polluter-pays principle is adopted.

There are large inequalities in environmental damage inflicted both between and within countries[1–7]. The top 10% of consumers are disproportionately responsible for transgressing planetary boundaries, causing one to two thirds of the overshoot of any given boundary[7]. These environmental pressures cause drought, heat stress, eutrophication, ecosystem degradation and ultimately human and animal suffering[8–10]. According to both the 'common but differentiated responsibilities' and 'polluter pays' principles[11,12], those causing the damages should be responsible for solving them. 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.

There are conflicting views surrounding the monetising of nature. Proponents argue that it is a tool to raise awareness, that it can improve incentives and generate funds for sustainable practices and that monetisation is unavoidable since value is already implicit in any decision made, improving transparency[13,14]. Critics highlight that value depends on the method used, that approaches such as willingness to pay mirror the status-quo distribution of income and wealth, and that it is an instrumental rather than intrinsic understanding of nature and ignores the fact that it is a critical resource that is non-substitutable for other resources[15,16].

Here, we follow the rationale of Costanza et al.[14] that monetisation does not necessarily equal commodification nor provide support for market tradability. 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. This does not mean that environmental taxation or other monetary measures are the only, or even best policy. Levying environmental taxes does not justify or compensate for the damage.

However, environmental taxes are part of mitigation policy aiming to shift behaviour from polluting to more sustainable consumption. Tax revenue can help pay for the 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 participant[17].

We combine top decile consumption-based footprints[7] for the planetary boundaries of: climate change (CO_2), biosphere integrity (Mean Species Abundance (MSA) loss), biogeochemical cycles (nitrogen (N) and phosphorus (P)) and freshwater use with environmental costs from the literature. We calculate the environmental bill owed by the top decile consumers globally and of Brazil, China, Egypt, Germany, India and the USA—the biggest economies in the world and/or of their continent. We use the Environmental Prices Handbook 2024[18] for prices of CO_2, P, N and freshwater use. For MSA loss, we convert the Handbook's price for Potentially Disappeared Fraction (PDF) to MSA loss using a recent study[19]. We scale the prices, given for the EU in €$_{2021}$, to various countries based on GDP per capita (except for CO_2 for which all countries have the same prices) and deflate them to 2017, the year in which footprints are available[7].

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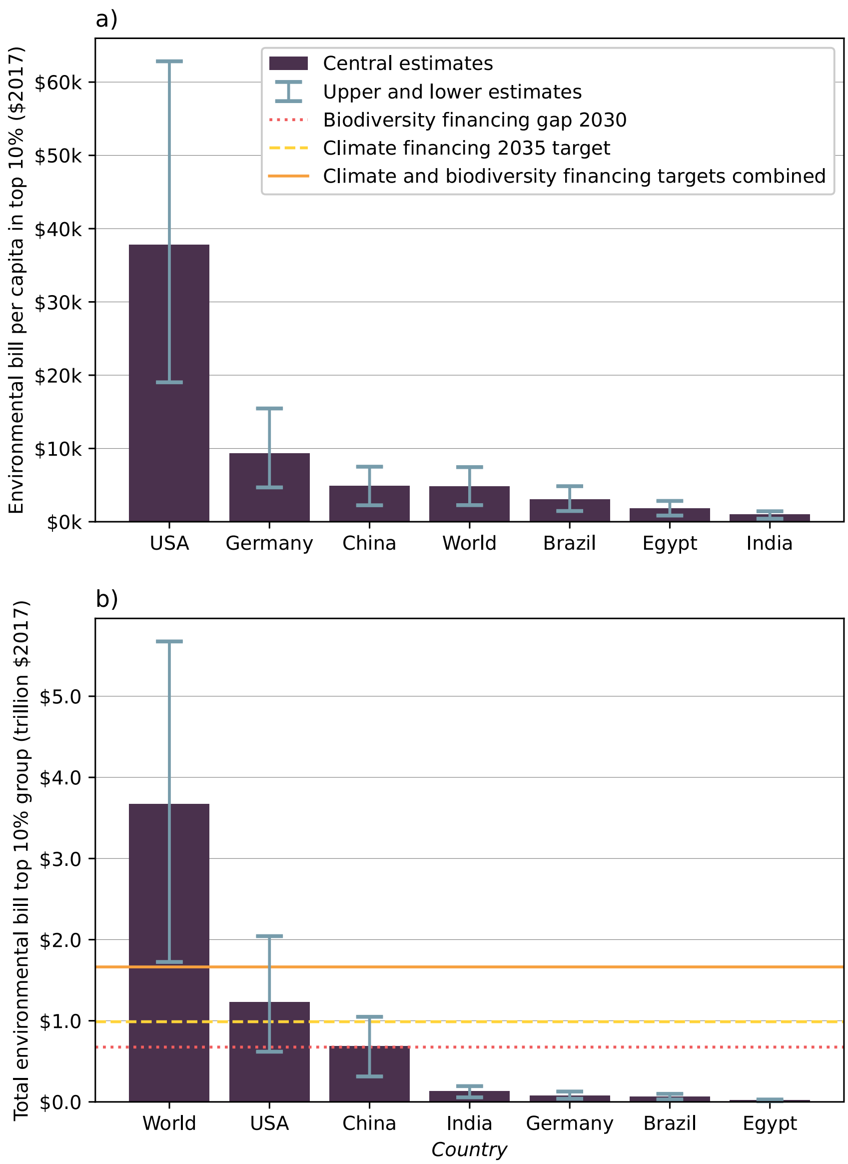

Fig. 1 | The environmental bill of the top 10% consumers. The environmental damage bill of the top 10% consumers in 6 countries and globally in 2017, in $\$_{2017}$, **a** per capita in the top 10%, **b** for the whole top 10% group. The purple bars are the central estimates; the blue error bars show the lower and upper estimates. Biodiversity (red dashed line) and climate (yellow striped line) financing targets are added as a reference (the orange solid line is the biodiversity and climate targets combined). Note that we have adjusted the prices per country based on GDP per capita (except for CO_2 for which all countries have the same prices). Therefore, each country has their own environmental prices and summing the country top 10% bills does not equal the world total.

Results and discussion

We find that the total environmental damage costs per person in the top 10% consumers worldwide is $2.3k-$7.5k per year (in $\$_{2017}$; see Fig. 1a, and the Supplementary Information (SI) Supplementary Data sheet 7. for data tables). The damages of the total global top 10% group are $1.7–$5.7tn per year (see Fig. 1b, and the SI Supplementary Data sheet 7. for data tables). There are big differences in the environmental costs of the top 10% between countries. The bill of the top consumers in the USA is consistently the highest, ranging $19k–$63k, equal to 6–20% of their income or 0.8–3% of their wealth. This is in contrast with a bill in India of $410–$1.4k, equivalent to 0.8–2.8% of income or 0.2–0.5% of wealth.

The total environmental damages of the top 10% are considerable. Both the lower USA and the lower Chinese estimates each already cover the $675 billion gap in biodiversity financing needed by 2030[20] (in $\$_{2017}$). The central USA estimate surpasses the $993 billion per year for climate action (in $\$_{2017}$) by 2035 agreed upon at the COP30[21]. The lower world estimate even matches the biodiversity and climate financing targets combined. In other words, the potential revenue of environmental taxes is high and can be used to finance necessary transitions. We could only include planetary boundaries for which top 10% footprints and prices were available and adding the missing boundaries (novel entities, land-system change, ocean acidification, atmospheric aerosol loading and stratospheric ozone depletion) would increase the damage bill. Moreover, our damage bill is based on consumption, while those with a higher income also accumulate savings[22] and for the top 10% about half of emissions originate from investments[5].

The difference in the bill between countries reflects the inequalities in consumption and emissions. Note that the top 10% consumers in each country are not necessarily in the top 10% globally. More than 60% of the global top 10% are located in the USA and EU while only about 2% are in India[7], as reflected in their respective higher and lower bill. We scaled environmental prices to the different countries based on GDP per capita (apart from CO_2, for which we use one constant price across all countries). As such, prices are higher in countries with a higher GDP.

Proportionally, the two main components of the total bill are damage to biosphere integrity and climate change. Of the global bill, biodiversity loss constitutes 47–56% and climate change 36-45%, depending on the price estimate used (see Fig. 2 and SI Supplementary Data sheet 9). Third is nitrogen with 6–8%. Water and phosphorus are both less than 2%. For individual countries, the distribution is similar although the exact proportions vary; for some biodiversity loss is the largest contributor, for others

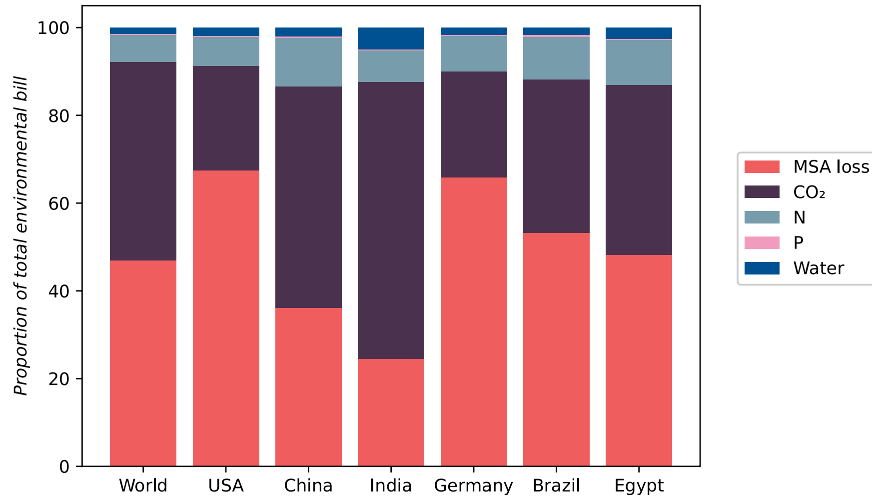

Fig. 2 | Contribution of each planetary boundary bill to the total environmental bill. Proportion of each planetary boundary of the total environmental bill, in the central estimates, for the world and six countries. See SI Supplementary Data sheet 9. for the proportions in the lower and upper estimates. MSA loss (biodiversity loss) is displayed in red, CO_2 (climate change) in purple, N (nitrogen biogeochemical cycle) in light blue, P (phosphorus biogeochemical cycle) in pink and freshwater use in dark blue.

climate change. There have been several calls to address biodiversity and climate change together and these estimates only underline this need[23,24].

Prices are more uncertain for biodiversity loss. The indicator is (terrestrial) 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 ecosystem[25]. 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 location[18]. Since there is no price for MSA loss in the literature, we converted the Environmental Prices Handbook's price for PDF which is based on European ecosystems and valuations (see SI Supplementary Methods section MSA loss prices).

It is difficult to establish whether our results are an over- or underestimation of biodiversity loss prices. Valuation is higher when population density is higher—a reflection of recreational values[18]. For USA and Brazil, which have a substantially lower population density than the EU, the price might be adjusted downward, whereas for 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 biodiversity[18]. As it is not possible for us to assess these factors across 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 27% of global the bill (and almost half of the USA's and Germany's). As 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 ecosystems[26].

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 in (sub)national or regional contextualised schemes.

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 context[27]. In low-income countries, any carbon tax is progressive[27,28]. 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 inequality[28]. 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 consumption[28]. If revenues are redistributed towards lower incomes, then equity improves, but emissions also increase because of re-spending (i.e. increased consumption)[28]. However, distribution can benefit some of the population without offsetting reduced emissions; the more unequal a country the more redistribution can occur without harming mitigation[28].

Public resistance against some environmental taxes such as carbon taxes mainly comes from concerns for low-income households, so distributional effects are also important for policy support[29,30]. Moreover, if revenues are used for approaches such as green government investments, then public acceptance is generally higher[31]. 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 communities[32].

Local conditions are very important for biodiversity loss, so pricing is less straightforward than with carbon taxation and emission trading where the location of emissions is less important for the damage caused. Nevertheless, many pricing mechanisms also exist for biodiversity conservation which can be implemented, adapted to the specific context[33].

Conclusions

We show that the environmental damages caused by the consumption of the top 10% consumers are substantial, 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.

Methods

Tian et al.[7] provide per capita consumption-based carbon (CO_2), phosphorus (P), nitrogen (N), freshwater use and (terrestrial) biodiversity loss (Mean Species Abundance loss, MSA loss) footprints per expenditure decile (based on household survey data). To monetise the footprints, we use environmental prices from the Environmental Prices Handbook 2024[18] (see below). The Handbook has prices for CO_2, N, P and water consumption, with lower, central and upper estimates. For biodiversity, the Handbook has prices for PDF rather than MSA loss. We convert the PDF prices into MSA loss prices using a recent study that finds a consistent positive relationship between PDF and MSA loss[19] (see SI Supplementary Methods section MSA loss prices and Supplementary Data sheet 6). Environmental prices are given in $€_{2021}$ for EU27, which we convert to $\$_{2017}$, the year for available footprints[7] and scale to countries/the world based on GDP per capita (except for CO_2, see below). We multiply each country's top 10% footprint[7] by the price of the respective substance and sum them to produce the total environmental damage costs per capita and for the whole top 10%. We compare this with the top 10% income and wealth as a reference for environmental taxation. Full methods and all calculations can be found in the SI Supplementary Methods and Supplementary Data.

Environmental prices

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 CO_2, N and P to ensure comparability between prices (see Table 1 in the SI). 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.

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 due to water shortage. Biodiversity prices are based on a regression analysis of multiple 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 CO_2 price being the median price of an IPCC 1.5-degree scenario with limited overshoot (converted to $€_{2021}$). See Table 1 in the SI for the valuation types used for each price.

Ideally, a benefit-transfer model is used for translating EU prices to other areas for all substances[18]. However, this 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)[34]. For human health and ecosystem impacts, the two endpoints relevant for our substances (see SI Table 1), this tool uses GDP per capita at PPP as a proxy for individual income. The adjustment formula is:

$$Value_{\mathrm{X}} = Value_{E}\left(\frac{\mathrm{Y}_{\mathrm{X}}}{\mathrm{Y}_{\mathrm{E}}}\right)^{\beta} \tag{1}$$

with $Value_{\mathrm{X}}$: adjusted damage value for the country X, $Value_{\mathrm{E}}$: 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). We use this formula to scale the prices from the EU to the respective 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.

For climate change, we do not adjust the CO_2 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 Supplementary Methods section on CO_2 prices for more information.

Data availability

The environmental footprints of the top 10% have been provided by the authors of the corresponding paper cited[7]. All other data used are publicly available and are cited in the Supplementary Information and Supplementary Data. All data used, the calculations and results can be found in the Supplementary Data file at https://doi.org/10.5281/zenodo.19348642.

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Author contributions

I.S.: conceptualisation, methodology, investigation, formal analysis, data curation, writing—original draft and editing, visualisation. R.H: conceptualisation, methodology, formal analysis, writing—review and editing, supervision. P.B.: conceptualisation, methodology, formal analysis, writing—review and editing, visualisation, supervision.

Competing interests

The authors declare no competing interests.

Additional information

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