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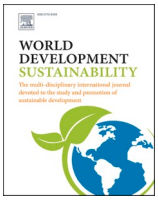

Is global human well-being peaking?

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ABSTRACT

We undertook multiple individual country time trend analyses using post 1990 data and estimated that real GDP per capita and life expectancy at birth, together, are projected to have peaked before 2050 for about two-thirds of the world's population and at levels far below their current values in upper high-income countries. We found there are 'flourishing' countries where human well-being is already high and will likely increase, but a much larger group of 'languishing' countries where human well-being has peaked, or will likely peak, before 2050. We estimated a positive time-series association between real per capita income and broader composite (e.g. Human Development Index) well-being indicators, but this association diminishes in the level of real per capita income. A mitigation response to peaking average global human well-being is cross-country monetary transfers from higher- to lower-income countries. Thus, we calculated two possible global transfers: one equal to 1.3 trillion/year USD in total and an alternative based on the projected climate change damage to low to middle-income countries. Each global transfer would impose only a relatively small proportional cost on the national income of contributing countries but could provide very large average human well-being benefits to the poor and most vulnerable in low-income countries.

1. Background

Human well-being is the experienced and self-perceived sense of overall health and happiness. It is multi-dimensional and determined by economic, social, environmental, and other factors [1]. Average global human well-being dramatically improved over the period 1950 to the early 2000s [2]. A common but contested [3] assumption is that this trend will continue. We test this assumption by asking: Is global human well-being peaking?

Our research question connects to three different world views about well-being and the future. First, a macroeconomic-growth or 'cornucopian' view [4] whereby, under appropriate policy conditions, there can be increasing per capita income across countries with the potential for per capita income convergence between low and high-income countries, promoted by increases in capital per worker [5]. The cornucopian view may be supported by some theoretical economic growth models while macroeconomic-growth approaches can use Dynamic Stochastic General Equilibrium (DSGE) models [6]—principally for economic forecasting and, typically, without economic-bio-physical linkages. Second, a 'Green Growth' view, supported by Integrated Environment-Society-Economy (ESE) Models that, typically, do not adequately measure well-being [7]. Green Growth models frequently project improving global human-well-being if countries implement 'sustainable' or green economic policies (e.g., polluter pays, energy transition, etc.) ([8] & [9]). Third, a 'Limits to Growth' view, supported primarily by bio-physical-economic system dynamic models and occasionally agent-based models [10]. Limits to Growth models, typically, project average human well-being peaking in the coming decades, or sooner, and then declining because of bio-physical limits [11]. A common perspective of Limits to Growth is that a decline in average global human well-being can only be avoided by a rapid reduction in the world material throughput [12].

Our estimates of average human well-being over time and across countries differ from existing methods used to project social and economic measures. Our approach is atheoretical, statistical, and is based on *individual* and historical country time trend analyses of the most widely used available measures of average well-being: one, real per capita Gross Domestic Product (GDPP) with purchasing power parity (PPP), denoted by GDPP which is highly correlated over time, for most countries, with national measures of consumption (see Supplementary

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Material, SM), and two, Life Expectancy at Birth (LEB). These two measures are incomplete and inadequate indicators of well-being [13] and, thus, we complemented them with widely used multi-dimensional well-being indexes [14,15]—the Human Development Index (HDI) [16] and Quality of Life Index (QLI)—and a self-perception-based Life Evaluation Index (LEI) that measures overall 'life satisfaction' in response to survey questions [17].

For LEB, HDI, QLI and LEI, we tested their association with GDPP

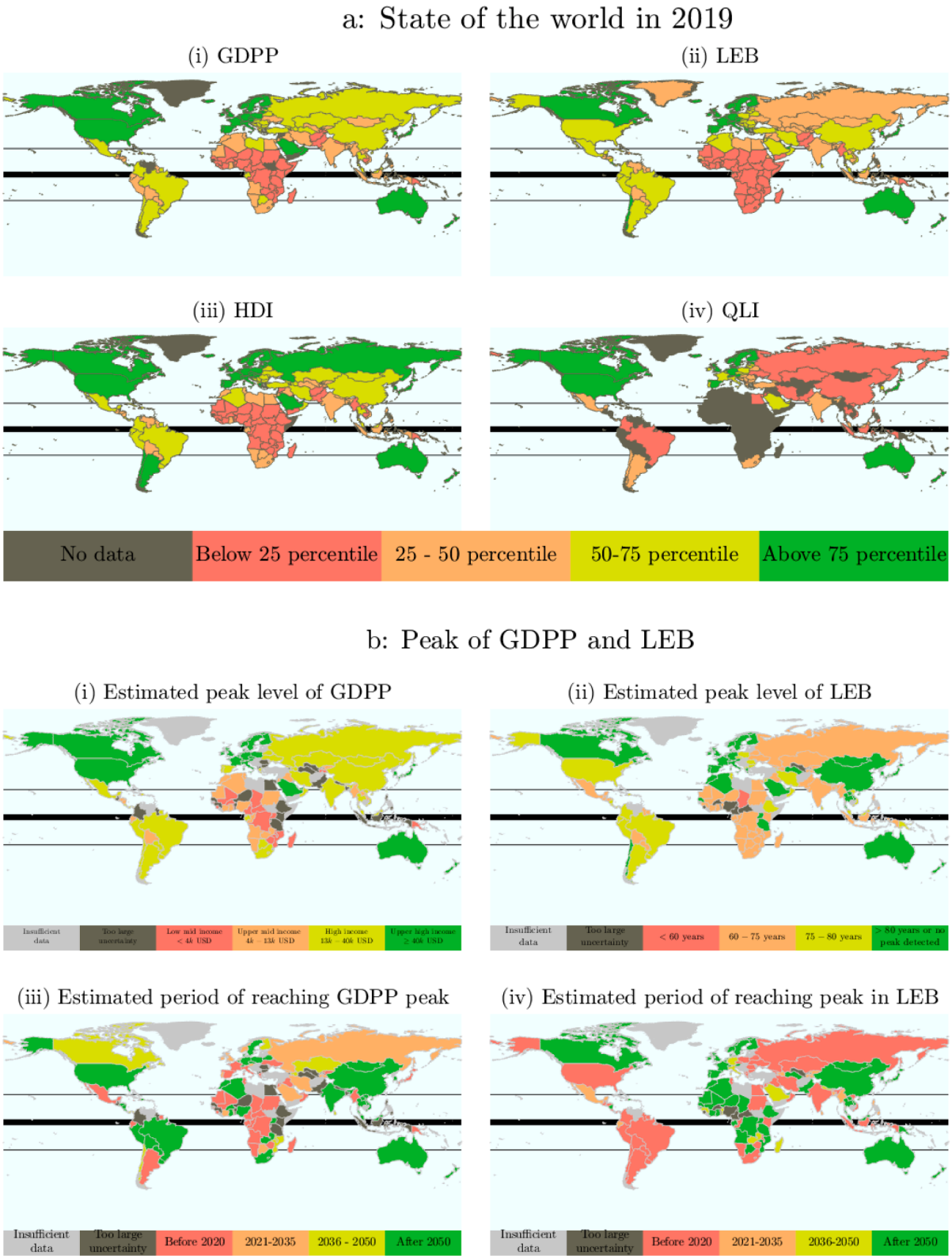

Fig. 1. Human well-being Indicators (GDPP, LEB, HDI, QLI) in 2019 and estimated peak level and period (GDPP, LEB).
Fig. 1a shows the actual levels of (i) GDPP, (ii) LEB, (iii) HDI and (iv) QLI in 2019. Fig. 1b presents the estimated peak levels for (i) GDPP and (ii) LEB by country (top panel) and peak year (bottom panel) for (iii) GDPP and (iv) LEB where country time trends are calculated with sufficient precision (see SM).

over time for *each* country (see SM) and found, in general, a *positive* time-series association (measured at an individual country level) between real per capita income and LEB, HDI, QLI, the rate of which *diminishes* in the level of GDPP. Our individual country time-trend analyses indicated that average global human well-being, as measured by both GDPP and LEB and based on historical trends, is likely to have peaked for about two-thirds of the world's population by 2050.

2. Level and time of peak average human well-being

Fig. 1a maps the 2019 (pre-pandemic) levels of average country human well-being, as measured by GDPP, LEB, HDI and QLI. It shows, one, divergence; Europe, North America, and Australasia are in the top quartile for all well-being indicators while most African countries are in the lowest quartiles and two, positive cross-country correlation across well-being indicators. Fig. 1b maps the cross-country peak level (top panel), and period (bottom panel) when the estimated peak occurs, for GDPP and LEB. Both the peak level and peak period were separately estimated for *each* country by fitting historical data (1990–2022) to six possible trend equations—without imposing overly restrictive modelling assumptions (see SM). The reported peak level and peak period are the most efficient estimates for each country from the six trend equations. All our estimates are fully replicable with the data downloadable from our Data Availability Statement and SM.

Fig. 1b top panel shows that most countries in Western Europe, North America, Japan, South Korea and Australasia, have peak levels of GDPP at upper high levels of per capita income. High and upper high-income countries, excluding the US [18] and 12 other countries, have estimated peak levels of LEB $>$ 80 years. Fig. 1b top panel shows permanent cross-country divergence for both GDPP and LEB. That is, peak GDPP occurs for 29 countries (about 5 % of global population) below 4000 USD; for 30 countries (about 9 % of global population) at between 4000–13,000 USD; and for 32 countries (about 52 % of global population) at between 13,000–40,000 USD. Peak LEB occurs for 31 countries (about 7 % of global population) at $<$70 years; for 69 countries (about 56 % of global population) between 70 and 80 years; and for 44 countries (about 32 % of global population) at greater than 80 years.

Fig. 1b bottom panel shows most upper high-income countries have not yet reached peak GDPP and LEB. Nevertheless, some G20 countries (e.g., Italy, Japan) are estimated to have reached peak GDPP, and some (e.g., Canada, United Kingdom) are likely to reach peak GDPP before 2050 if their post 1990 country-specific trends continue. By comparison, most low-income countries appear to reach peak GDPP before 2050 with 59 countries (13 % of global population) estimated to be at their peak GDPP. Of the original BRICS, only Russia reaches peak GDPP before 2050. Some 75 countries (52 % of global population) appear to have already reached peak LEB based on post-1990 trends, and another 13 other countries (4 % of global population) will do so by 2050. In sum, the high and upper high-income countries, in general, reach peak GDPP and LEB after 2050, and at much greater levels than the peak levels of low-income countries, many of which peak before 2050.

3. Climate change and peak human well-being

Our human well-being peak estimates can be linked to climate change projections [19] by estimating the association between projected GDP climate change damage with current and peak levels of GDPP, LEB, HDI, and QLI. Based on updated estimates from [19], total climate change damage projections (see SM) for low and low-middle income countries ranged from 680 to 1490 billion USD per year to 2050 (USD 2017 value). The 'best-fit' time-series correlations between *each* country's projected climate change impacts and its 2022 levels of human well-being indicators are all positive for the estimated peak levels of GDPP and LEB. That is, on average, countries with *lower current* values of the four indicators (GDPP, LEB, HDI, and QLI) have a *higher* projected proportional decline in their current GDP due to climate change. Further, we found a lower estimated *peak* in GDPP and LEB is associated with higher proportional climate change costs (see SM). For countries that have already, or will soon have peaked GDPP, the proportional negative impact of climate change damages will be even greater than for those countries even with the same projected climate change impact but which are likely to have peak GDPP after 2050.

4. Per capita income and human well-being

Given the importance attached to GDPP by policymakers [20,21], we estimated *each* country's time-series association between GDPP and broader-based human well-being indicators (LEB, HDI, QLI, LEI). Most countries in Fig. 2a, b, and c (but not d) show a positive time-series association between GDPP and LEB, HDI and QLI. This means GDPP increases over time at an individual country level are, typically, associated with increases in LEB, HDI and QLI. This positive association between GDPP and these human well-being indicators (LEB, HDI, QLI), however, diminishes with the level of GDPP. That is, for countries with the highest GDPP levels, further increases in GDPP are likely to have only a small, or very small, positive impact on LEB, HDI, and QLI.

Fig. 2d shows a similar number of countries, across all income levels, with either a positive or a negative time-series association between GDPP and LEI—a survey response measure of overall 'life satisfaction'. This means there is no global country-level and time-series relationship between GDPP and LEI. That is, increases in GDPP are *not* typically associated, at a global level, with either higher or lower levels of life satisfaction, as expressed by individuals in direct surveys [22].

The declining positive association between increases in GDPP and LEB, HDI and QLI, and the lack of an overall association between GDPP and LEI, means that there is an opportunity to go beyond existing Green Growth policies [23,24] to respond to peaking average human well-being. That is, to implement average well-being improving cross-country monetary transfers from upper high-income to low-income countries to offset likely peaking in average well-being before 2050 in most countries.

5. Cross-country financial transfers

Global monetary transfers to increase average human well-being are consistent with, one, a utilitarian goal of human well-being that seeks 'the greatest good for the greatest number' without imposing instrumental harm [25] and two, a 'Max-Min' rule—a Rawlsian social welfare measure—that seeks to maximize the well-being of the worst off [26]. We contend that to be politically feasible and achieve both well-being goals, cross-country monetary transfers should not change the existing cross-country rank ordering by GDPP.

North-South transfers have been proposed for climate change compensation with respect to 'loss and damage' [27]. They include the New Collective Quantified Goal on Climate Finance (NCQG), agreed to at the 29th Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC), when countries committed to "…scale up finance to developing countries…, to the amount of USD 1.3 trillion per year by 2035″ [28]. Using this aspirational 1.3 trillion USD annual target by 2035 from 2022 onwards, we calculated the total and per capita monetary transfers per country, and as a percentage of GDPP, from contributing (all with $>$ 40,000 USD GDPP) to beneficiary countries (all with $<$ 4000 USD GDPP) to increase average human well-being. For this global transfer, costs to contributing countries are about 3 % to 4 % of their current GDPP, while the payments to recipient countries are much larger proportion of their current GDPP (see SM).

Separately, we calculated climate change damages for low and low-middle income countries that range from 680 to 1490 billion USD per year to 2050, depending on the climate change scenario. To fully compensate for climate change damage, we calculated a second global transfer scheme where the annual transfers from upper high-income

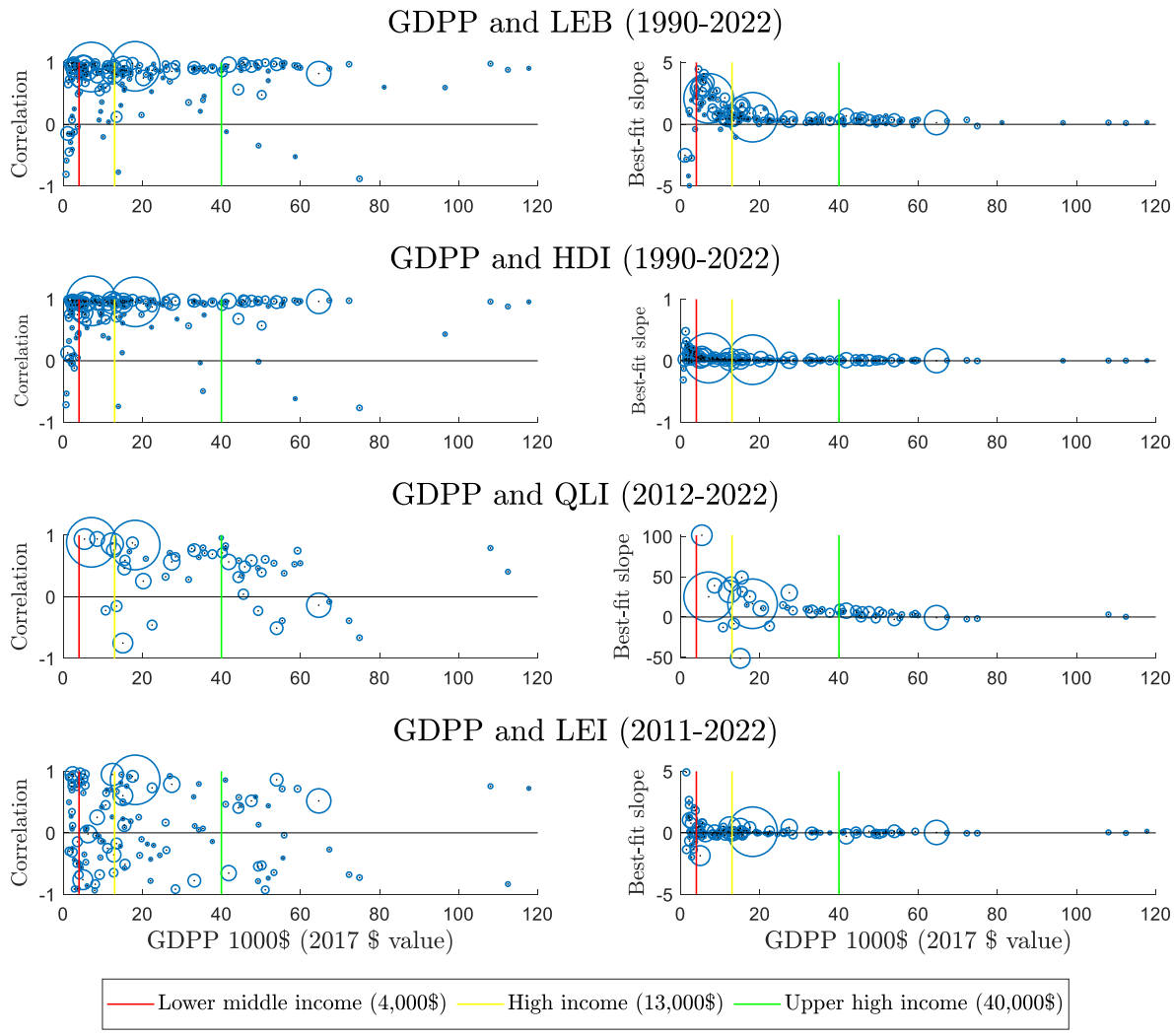

Fig. 2. Individual Country Time-series Correlation and Association between GDPP and LEB, HDI, QLI, and LEI.
Fig. 2a (GDPP and LEB), b (GDPP and HDI), c (GDPP and QLI), d (GDPP and LEI) has two panels per human well-being indicator that represent, respectively, the correlation (left panel) and the slope of the best-fit line (right panel) between each country's GDPP and the well-being indicator. In both panels, and for all human well-being indicators, country-level GDPP in 2022 is displayed along the horizonal axis while each country is represented by an individual circle where its diameter is the relative size of a country's population in 2022.

countries (GDPP>40,000USD) would range from 1.2–2.7 % of the national income of contributing countries (See SM). How effective such transfers would be at supporting average well-being and providing additional benefits (e.g. climate change mitigation) would depend on multiple factors including, but not limited to: institutional capacity (e.g. level of corruption), quality and enforcement of existing regulations (e.g. national limits on of GHG emissions) to avoid or to mitigate moral hazard [29], 'crowding out' effects of government expenditures, and Dutch Disease effects [30].

6. Global consequences

We estimated, based on historical trends, that at least 60 countries have likely reached peak GDPP *or* LEB and around two-thirds of the world's population will likely reach peak GDPP *and* LEB by 2050. Most of the countries that have already peaked GDPP are low-income countries. Thus, our findings are contrary to a cornucopian view that low-income countries are converging to the current levels of GDPP of high-income countries [5,2].

We found that most of the countries with peak GDPP or LEB *after* 2050 are predominantly middle, high and upper high-income countries. Nevertheless, some upper high-income countries (e.g., Canada, France, Italy, Spain, and the United Kingdom) are likely to reach peak GDPP before 2050 based on their post-1990 individual country GDPP time trends.

Our findings have several important social and economic implications. First, we found a re-emergence of divergence. Namely, there are 'flourishing' countries where average human well-being is already high and is expected to increase further beyond 2050. This group includes most high and upper high-income countries, with some notable exceptions, and the BRICS (except Russia). Second, there is a much larger group of 'languishing' countries where GDPP or LEB have already peaked, or will peak before 2050, well below the current levels of flourishing countries. Third, low to middle income countries, including some countries with the lowest current levels of human well-being, are projected to have some of the highest estimated climate change damages as a proportion of their GDP by 2050. Further, for those countries with peak or peaking GDPP before 2050, the economic burden of climate change will, proportionally, be even greater compared to countries with peaking GDPP after 2050.

Those countries most impacted by projected climate change to 2050, predominantly 78 low and low-middle income countries, comprise about half of the global population and have generated only about 10 % of historical carbon emissions. By comparison, upper high-income

countries have contributed to about half of global historical carbon emissions yet represent only 14 % of the global population. This globally unequal burden of responsibility represents a profound social, economic and environmental injustice [31,32]. Based on our analyses, this injustice will most likely worsen, especially if the impediments and delays to already agreed-to global climate finance commitments continue [33] and/or if the poorest countries, in general, have peak GDPP before 2050.

7. Conclusions

Our projections, based on historical time trend analyses, are that average well-being for most of humanity is likely to have peaked by 2050. Whatever individual countries may do to improve their own human well-being and adapt to climate change, and which may make a substantial improvement in national well-being, we argue for global policy responses to peaked, or peaking, average global human well-being.

In our view, multiple responses are needed [34–38] to peaking average well-being. We argue for, one, much more effective mitigation of global environmental threats (e.g., climate change) that pose a much greater proportional burden on poor countries and two, large monetary transfers from upper high (> USD 40,000 GDP per capita) to low-income (< 4000 USD GDP per capita) countries to help offset climate damages and peaking GDPP before 2050.

To assess the burdens and benefits of such global transfers, we calculated the individual country outcomes of, one, an aspirational transfer target of 1.3 trillion/year USD and, two, compensation for projected global climate change damages to 2050 of 740 billion/year USD (consistent with an average surface temperature rise of 3.13 °C by 2100). Such global transfers are consistent with a utilitarian goal that seeks 'the greatest good for the greatest number'. If such global transfers were 'pro-poor' and promoted effective climate change adaptation, especially for the most vulnerable in poor countries, they potentially could make a very large and positive impact on global average human well-being, now and into the future.

Data availability

The analysis in this Discussion uses secondary data from publicly available sources; no new data were used. The sources of the data are listed in the tables below. The MATLAB code and all data are available at: https://osf.io/k3m7z/?view_only=6b721e760e8542a685c6d9058eb947bc.

Data used in the main text

Variables	Name and Sources
GDP per capita PPP (USD$ 2017), GDPPP	World Development Indicators database, World Bank
Average Life Expectancy (years at birth), LEB	Human Development Reports, UNDP
Human Development Index, HDI	Human Development Reports, UNDP
Quality of Life Index, QLI	Numbeo database
Life Evaluation Index, LEI	The World Happiness Reports

Additional data used in the supplementary information

Variables	Data Sources
GNI PPP 2021	World Development Indicators database, World Bank
Population	World Development Indicators database, World Bank
Climate change damage	[19]: https://doi.org/10.1029/2018EF000922 Waidelich et al. (2024): https://doi.org/10.1038/s41558-024-01990-8

CRediT authorship contribution statement

R. Quentin Grafton: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Investigation, Funding acquisition, Conceptualization. **Long Chu:** Writing – original draft, Visualization, Software, Investigation, Formal analysis, Data curation. **Tom Kompas:** Writing – original draft, Investigation, Formal analysis. **Safa Fanaian:** Writing – original draft.

Declaration of competing interest

All authors declare that there is no conflict of interest related to this work, the work is original and unpublished, and is not under review at any other journal.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.wds.2025.100265.

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